

Multi-agency operations: Cooperation during flooding.

McMaster, Richard; Baber, Christopher

DOI:

[10.1016/j.apergo.2011.03.006](https://doi.org/10.1016/j.apergo.2011.03.006)

Document Version

Early version, also known as pre-print

Citation for published version (Harvard):

McMaster, R & Baber, C 2012, 'Multi-agency operations: Cooperation during flooding.', *Applied Ergonomics*, vol. 43, pp. 38-47. <https://doi.org/10.1016/j.apergo.2011.03.006>

[Link to publication on Research at Birmingham portal](#)

General rights

Unless a licence is specified above, all rights (including copyright and moral rights) in this document are retained by the authors and/or the copyright holders. The express permission of the copyright holder must be obtained for any use of this material other than for purposes permitted by law.

- Users may freely distribute the URL that is used to identify this publication.
- Users may download and/or print one copy of the publication from the University of Birmingham research portal for the purpose of private study or non-commercial research.
- User may use extracts from the document in line with the concept of 'fair dealing' under the Copyright, Designs and Patents Act 1988 (?)
- Users may not further distribute the material nor use it for the purposes of commercial gain.

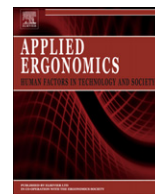
Where a licence is displayed above, please note the terms and conditions of the licence govern your use of this document.

When citing, please reference the published version.

Take down policy

While the University of Birmingham exercises care and attention in making items available there are rare occasions when an item has been uploaded in error or has been deemed to be commercially or otherwise sensitive.

If you believe that this is the case for this document, please contact UBIRA@lists.bham.ac.uk providing details and we will remove access to the work immediately and investigate.



Multi-agency operations: Cooperation during flooding

Richard McMaster*, Chris Baber

School of Electronic, Electrical and Computer Engineering, The University of Birmingham, Edgbaston, Birmingham B15 2TT, UK

ARTICLE INFO

Article history:

Received 25 August 2009

Accepted 16 March 2011

Keywords:

Command and control
Communications
Emergency services
Sociotechnical systems

ABSTRACT

This paper presents an investigation of command and control during Multi-Agency Operations; the purpose of this study was to elaborate on known themes associated with multi-agency emergency response, through a study of the successful combined military and civilian defence of Walham electricity substation from rising flood water in July 2007.

This case study demonstrates that effective coordination during major emergencies requires the development of a deeper, shared understanding of the incident and a high level of trust between responding organisations, both of which are effortful to achieve and difficult to support with current communications systems. Adoption of a sociotechnical systems approach during the development process may enable future communications systems to support these important social processes.

© 2011 Elsevier Ltd and The Ergonomics Society. All rights reserved.

1. Introduction

1.1. Overview

The significant body of work within the field of disaster research has identified a number of problem areas associated with the coordination of large-scale emergencies, though much of the previous work on floods and other disasters concentrates more on the high-level (strategic) response. The current study is concerned with the coordination of a relatively small and well defined incident, which was part of a wider emergency; it might therefore be expected that the response would proceed in an entirely straightforward manner. Consequently, the difficulties encountered by the responding agencies during the successful resolution of this 'simple' incident have implications for the future management of larger and more complex disasters.

1.2. Features of major emergencies

Major emergencies typically feature high levels of complexity and ambiguity. Recognizing that large-scale emergencies occur with little or no notice, involve temporary organisations of agencies who rarely (if ever) work together and improvised organisational

structures (Smith and Dowell, 2000), effective management of major emergencies would appear to be an impossible task (Boin and T'Hart, 2003). Major emergencies have been defined in terms of their "un-ness", i.e. unexpected, unprecedented and unmanageable (Hewitt, 1983). Thus, multi-agency emergency operations share a number of potentially problematical features, including:

- Ad hoc teams that work together only when responding to an emergency incident;
- Multiple objectives which have to be achieved in parallel for the incident to be successfully contained;
- High psychological demands, with people working under time pressure and stressful conditions;
- Role specialisation, with the need to pool different types of expertise.

(Crichton et al., 2000, p. 208)

During the initial stages of an incident, it is unlikely that any single organisation will be in possession of all available information – various organisations will hold 'pieces of the puzzle' (McMaster et al., 2007). First responders to the incident will seek to gather as much local information as they can, in order to both assess the situation and determine an appropriate response. However, these activities of assessment and response generation will be defined by the training, Standard Operating Procedures (SOPs) and experience of the first responder. When personnel from other agencies arrive and seek briefings from the first responder, there is a challenge in developing a shared understanding of the incident. Close cooperation between responding agencies is therefore required, in order to enable a coherent response to the emergency. However, cooperation does not

Abbreviations: CDM, Critical Decision Method; COP, Common Operational Picture; DCFO, Deputy Chief Fire Officer; NGO, Non-Governmental Organisation; PPE, Personal Protective Equipment; RNLI, Royal National Lifeboat Institute; SOP, Standard Operating Procedure.

* Corresponding author. Tel.: +44 (0) 121 414 7511; fax: +44 (0) 121 414 4291.

E-mail address: r.mcmaster@bham.ac.uk (R. McMaster).

appear to come easily in crisis situations, with problems of mistrust between agencies and disagreement over who is in charge (Boin and T'Hart, 2007). Improvisation, in terms of developing novel, situation-specific organisational structures, coordination mechanisms and individual roles, has also been identified as a recurring response to the unique demands of crisis situations (Mendonça et al., 2007; Auf der Heide, 1989). This requires the application of knowledge outside of traditional emergency response domains and the coordination of interdependent tasks, with high levels of uncertainty (Dynes, 1970; de Marchi, 1995; Boin, 2004; Becerra-Fernandez et al., 2008; von Lubitz et al., 2008).

1.3. Multi-agency incident response to floods: previous research

Environmental disasters are having an increasing impact globally, in terms of the rising numbers of incidents, people affected and the economic cost (Boulle et al., 1997). The multi-agency responses to two recent crises – the South Asian Tsunami and Hurricane Katrina have both received criticism. Both of these disasters required improvisation on the part of the responding agencies, including the adaptation of procedures and the development of ad hoc coordination structures, though this was achieved with limited success in each case (Bennett et al., 2006; Chua et al., 2007). Additionally, military resources and logistical capabilities were invaluable in the immediate aftermath of the South Asian tsunami and Hurricane Katrina, though in both instances there was a failure to fully integrate the military into the response, which reduced their effectiveness (Bennett et al., 2006; Chua et al., 2007; Telford, 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 (Rahman, 1996). In summary, there are eleven broad issues that these studies raise:

- (1) Lack of coordination between Agencies;
- (2) Failure to communicate warnings and other information;
- (3) Competitive practices;
- (4) Lack of trust between Agencies;
- (5) Slow mobilization of response;
- (6) Response systems overwhelmed by the scale of the emergency;
- (7) Failure to share information between Agencies;
- (8) Poorly defined chains of command;
- (9) Interoperability failures;
- (10) Lack of awareness of the presence and activity of other Agencies in the area;
- (11) Failure to fully integrate military into the response.

The fact that these issues recur so often imply that there are inherent challenges associated with the coordination of multi-agency emergency responses; given that the failure of agencies to coordinate their activities during emergency responses is hampering their effectiveness, what is it that is preventing them from cooperating?

1.4. Government response to major emergencies

Following any major emergency, there will be reviews and enquiries culminating in lessons learned and, in some instances, recommendations for new legislation and requirements on the Services involved in Emergency Response. For example, an inquiry into the fire at King's Cross London Underground station in November 1987 (Fennell, 1988) identified a lack of coordination amongst agencies involved and recommended the use of inter-agency training exercises (which are now held on an annual basis in the UK) and

improvements in joint planning and communication. The UK Government recently implemented the 2004 Civil Contingencies Act which defines multi-agency Integrated Emergency Management in terms of six activities: Anticipate, Assess, Prevent, Prepare, Respond and Recover (HM Government, 2005a). These activities are supported by eight guiding principles for emergency response, which can be related to the conclusions drawn from investigations into previous emergency responses:

- Direction: clarity of purpose defined by a strategic aim and objectives;
 - Integration: effective and efficient coordination between agencies involved in the response;
 - Subsidiarity: coordination occurs at the lowest appropriate level;
 - Preparedness: all agencies, and their members, have clear understanding of their role and appropriate knowledge and abilities to undertake these roles;
 - Continuity: organisations should be able to employ Standard Operating Procedures such that their response to the emergency involves well-drilled activities, albeit at a greater tempo;
 - Communication: reliable information is passed as efficiently as possible to all agencies who need it, including the public;
 - Cooperation: agencies cooperate in a spirit of mutual trust and understanding;
 - Anticipation: risk assessment and identification is performed in an ongoing manner in order to ascertain any possible changes in level of risk so that the response can be managed as appropriately and flexibly as possible.
- (HM Government, 2005b, p. 6)

1.5. Overarching themes

The 8 principles of the 2004 Civil Contingencies Act can be combined with the 11 issues raised earlier to produce four overarching themes of multi-agency emergency responses which might be used to guide further research:

- Organisational structures and practices;
- Communications, information sharing and shared awareness of the incident;
- Cooperation and coordination of response activities;
- Command, strategy (command intent) and decision making.

Table 1 indicates how these broad themes have been derived.

2. Investigation

2.1. Case study: Gloucestershire floods July 2007

The summer of 2007 saw widespread flooding in several regions of the UK; the floods of June and July were the most costly in UK history and some of the most expensive disasters worldwide in 2007, with losses of over £2 billion for each month (Munich Re, 2008). One of the worst affected areas was Gloucestershire in the South West of England, with widespread flooding across the county. In addition to the extensive damage caused to businesses and residential properties, travel became difficult as roads and towns flooded, trapping hundreds of people in their homes. The electricity supply to large parts of the county was put at risk when both the Walham and Castlemeads substations came under threat from rising flood water (Elliott and Brown, 2007). Walham substation is a site of critical national importance, supplying electricity to over 500,000 homes (an estimated 2,000,000 people) in

Table 1

Derivation of the four themes of multi-agency emergency responses from issues highlighted in earlier research and recent legislation.

Theme	Organisational structures and practices	Communications, information sharing and shared awareness of the incident	Cooperation and coordination of response activities	Command, strategy (command intent) and decision making
2004 Civil Contingencies Act principles	<ul style="list-style-type: none"> • Continuity 	<ul style="list-style-type: none"> • Communication 	<ul style="list-style-type: none"> • Subsidiarity • Cooperation • Integration 	<ul style="list-style-type: none"> • Direction • Anticipation • Preparedness
Issues identified from previous emergency response studies	<ul style="list-style-type: none"> • Response systems overwhelmed by the scale of the emergency • Poorly defined chains of command • Slow mobilization of response 	<ul style="list-style-type: none"> • Failure to communicate warnings and other information • Failure to share information between Agencies • Lack of awareness of the presence and activity of other Agencies in the area 	<ul style="list-style-type: none"> • Lack of coordination between Agencies • Competitive practices • Lack of trust between Agencies • Interoperability failures • Failure to integrate civil and military responses 	

England and Wales (Snow and Manning, 2007); if the site had flooded, then this may have forced the mass evacuation of the county, due to the resulting failures of essential infrastructure (Griffin, 2007).

On Sunday 22nd July, a multi-agency operation was launched to prevent rising flood water from overwhelming Walham substation at high tide 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 flood water from forcing the shutdown of the substation, buying time for semi-permanent flood defences to be constructed around the site. In comparison, the nearby Castlemead substation had to be shutdown, cutting power to around 50,000 homes, before flood defences could be established and power restored (Environment Agency, 2007).

2.2. Aims of the research

This study aims to follow on from previous research, by using the themes identified from the literature (as summarised in Section 1.5) to provide a structure for this specific case study, in order to elaborate on these themes and to identify any further issues. In order to do this, four aspects of multi-agency command and control were examined:

- The various organisational structures and work practices employed during the response;
- Communication and the development and maintenance of shared awareness within and across agencies;
- Inter-agency cooperation and coordination;
- Decision making and the formulation and communication of command intent.

What makes this study a little different from previous work is that we focus on a relatively small, well-focussed incident. Further, rather than attempting to learn lessons from failures, our focus was on an incident that had been successfully resolved. One would assume that the shared focus (i.e., protect the electrical substation) would lead to a fairly straightforward approach to the incident. However, this does not factor in the effects of the weather or of the need to combine activity across several different agencies.

2.3. Method

Whilst it is extremely difficult to conduct data collection 'live' during major emergencies, it is important to acknowledge that there are several limitations to the approach taken in this paper; firstly, the low number of interviewees increases the risk that the research findings do not accurately reflect this incident, or relate more widely to other emergency responses. Secondly, the interval between the incident and the subsequent interviews risks the participants forgetting important details and the introduction of bias into their interpretations of events. Despite these drawbacks, it is felt that the case study presented here provides a useful description of the problems associated with multi-agency response work. Additionally, the method adopted for this study closely resembles that of Smith and Dowell's (2000) investigation of a railway accident.

This retrospective case study was concerned with the coordination of the response at the scene of the incident, which is known as the Bronze level of command. Whilst a large number of organisations were actively involved in the response to the flooding of Walham substation, we have further concentrated our analysis on the main agencies involved in the construction of flood defences and the extraction of water from the site. The military and emergency services worked at the site for several days, protecting the substation until the immediate risk from the flood water lessened and more permanent defences could be put in place. We focussed our attention on the crucial initial period of activity, during which the agencies involved were notified of the problem, resources and equipment were mobilised, the emergency defences were constructed and the substation was successfully protected during the first high tide that threatened to inundate it. This activity all took place over an approximately 12 hour period, during the night of Sunday 22nd July 2007.

Interviews were conducted with six individuals that were directly involved in the planning and execution of the incident response for the three main agencies involved (Fire and Rescue, Environment Agency and Military); their roles and organisational affiliations are listed in Table 2. These semi-structured interviews began by asking participants to provide an account of the events that occurred that day. The participants were then asked for more detailed descriptions of and reflections on particular features of the emergency response relating to the issues identified in the literature review, including: organisational structures, inter-agency communication and cooperation, command intent, significant decision points and difficulties encountered during the response. The high-level question set used during the initial interviews is shown in Appendix 1. The semi-structured nature of the interviews allowed for the identification and discussion of issues not specifically identified in advance which arose during the interviews, for example the use of liaison roles and adaptation to changing circumstances. These issues are discussed within the framework of the four main aspects of command and control. The revised Critical

Table 2
Roles of the six interviewees and the Agencies that they represented.

Agency	Interviewee/Role
Avon Fire and Rescue Service	■ Incident Commander – ‘Bronze’ (during the Consolidation Phase)
Gloucestershire Fire and Rescue Service	■ Deputy Chief Fire Officer – ‘Gold Liaison’
43 (Wessex) Brigade	■ Joint Regional Liaison Officer ■ Walham Site Liaison Officer (Brigade Reinforcement Team)
Environment Agency	■ Team Leader (Operations Delivery) ■ Specialist Team Member (Operations Delivery)

Decision Method (CDM) probes developed by O’Hare et al. (2000) were then used to explore the decision making processes which were applied during the incident.

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. Publicly available documentation on the incident was also used to verify the accounts provided. The interview process took place over a 3 month period, which began 3 months after the incident took place.

3. Results

3.1. Overview

Table 3 presents a summary of the responses by personnel from each agency across the four themes under investigation. These themes are discussed in the following sections of the paper and four vignettes – short passages of text describing the incident,

produced from the combined accounts of the interviewees – are provided to illustrate the arguments being made.

3.2. Organisational structures and practices

During the operation to save Walham substation, a number of alterations were made to standard command structures in order to cope with unique features of the situation; for example, the Fire and Rescue Service command structure for the incident was substantially more complex than the basic Gold, Silver, Bronze structure intended for use during Major Incidents in the UK (Fig. 1). Whilst some of these changes were pre arranged, many were made

Vignette 1: Requests for diesel

Due to the protracted nature of the county-wide emergency and the high numbers of resources involved, the refuelling of Fire and Rescue appliances became a priority concern. In response, the Gloucestershire Fire and Rescue command structure was modified, by creating the role of ‘Pseudo Silver’ – a tactical command function entirely dedicated to the specific problem of coordinating the refuelling operation.

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. As a lack of diesel for the pump generators had the potential to lead to the substation flooding (with the potential consequence of a full-scale evacuation of the county), the Incident 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.

Table 3
Summary of responses by personnel from the three agencies for each theme.

Themes	Agency		
	Fire and Rescue	Environment Agency (EA)	Military
Organisational structures	Adaptations at strategic, tactical and operational command levels, due to the scale of the wider emergency. ‘Rule breaking’ on-site command structures necessary due to local conditions.	Simple on-site command structure: two teams, with one team leader liaising with Fire Commander and military Liaison Officer.	Coordinated centrally by Brigade personnel in Gold Command at Police HQ. Ad hoc organisational structure established on-site.
Shared awareness	Risk assessment based on pooled information from different agencies. Not able to book people off and on from the inner cordon, so dealt with site safety instead of individual safety.	National Grid personnel gave EA the parameters within which they could work. “Experience would tell our guys when the risk was becoming too great. All the men are empowered to do dynamic risk assessments throughout the operation.”	Liaison Officer remained with Fire Commander, to gain an understanding of the situation: “...stick to Bronze Commander like a leech.” Regular status reports sent back to Gold Command.
Cooperation	“Very good work ethic from everyone on site... everyone was focussed.” “Environment Agency had the critical equipment, therefore their requirements had precedence. They wanted to bring in dam components on big articulated lorries...all work had to stop to allow this, as it was time-critical.” “The military were deployed in support of the Environment Agency.”	“Military were really good – couldn’t fault them...we told them what to do, they got on with it.” “Fire brigade took control of site but were hard to get hold of... hard at times to get to speak to – very busy...by the time the request had been put through the chain of command, it was too late to get [the lorry] through the gap.”	Liaison Officer briefed and acted as a broker between the Fire Commander and the RAF teams. RAF teams were assigned to work under the direction of the Environment Agency.
Command intent	“There was a common goal – to prevent the substation flooding. Incident objective didn’t progress –was very simple.” The Commander was concerned with a number of priorities, including site drainage, completion of the EA barrier and the level of risk to personnel.	“We needed to get the barrier put up by high tide.” EA were familiar with the task, having used the barrier 6 times in the last 12 months.	Briefed to provide the maximum support to the Bronze Commander – within their abilities and whilst taking into consideration the safety of personnel

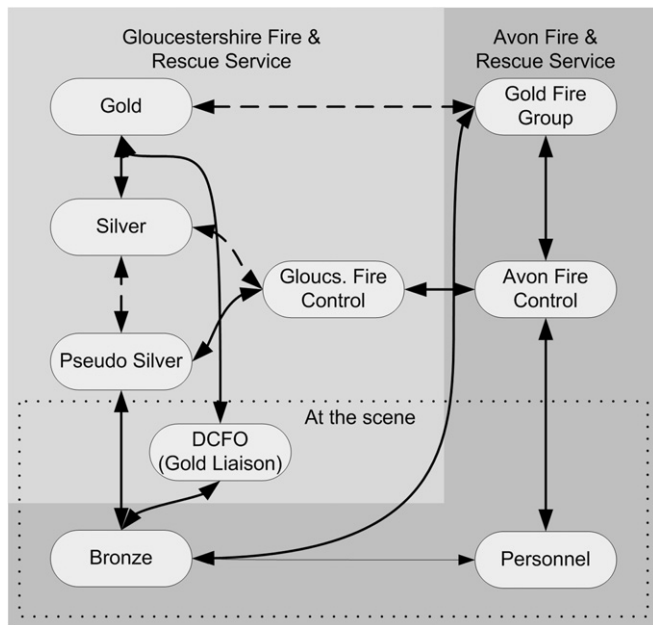


Fig. 1. Fire and Rescue Major Incident command structure adopted during the response to the flooding of Walham electricity substation, from the perspective of the Incident Commander (further probable lines of communication not observed by the Incident Commander are indicated by dashed lines).

on an ad hoc basis – as demonstrated in Vignette 1 – illustrating how constraints of the emergency situation may force commanders to adapt their organisations to better suit the environment in which they have to work.

Due to the scale of the emergency, Gloucestershire Fire and Rescue drew support from neighbouring Fire services under the established 'Mutual Aid' scheme; at Walham, many of the personnel on-site – including the Incident Commander – were from the neighbouring Avon Fire and Rescue Service, meaning that the Incident Commander was 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 deployed on-site, to act as 'Gold Liaison' – a non-standard role created for this situation. The DCFO was 'hands off', i.e. he was not directly involved in the command of the incident response, but did provide direct input to Gloucestershire Fire and Rescue Gold Command on the progress of the response to the emergency situation, acting as "eyes and ears" for Gloucestershire Gold Command, who had overall command of the strategic response to the flooding emergency. The DCFO also provided advice and support to the Incident Commander when he experienced problems due to working in an unfamiliar county; Vignette 1 provides an example of this. The overall Fire and Rescue Command structure in relation to the response to the Walham substation flooding is shown in Fig. 1, with lines of communication shown by the arrows.

Whilst it is clear that the Fire and Rescue Services needed to modify their standard organisational structures to take account of the use of multi-county resources and the wider flooding emergency, this resulted in the bypassing of Silver (tactical) Command, which appears to have led to a loss of situation awareness at this level of Gloucestershire Fire and Rescue's major incident command structure. The critical role of Walham substation was recognised at both Gold and Bronze Command levels, though this seems not to have been the case at the Silver level, at least in terms of the prioritisation of refuelling requirements by Pseudo Silver, as can be seen from Vignette 1. It would appear that Pseudo Silver

Table 4

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

CDM question	Fire and rescue	Environment Agency	Military
<i>Goal specification</i> What was your overall goal?	Prevent the substation from flooding.	Construction of the flood barrier before high tide.	Told to report to the incident site and provide maximum support to the Incident Commander.
<i>Cue identification</i> What features were you looking at when you formulated your decision?	Hazard conditions (advice from RNLI, National Grid, reports from fire fighters). Predicted time and height of flood water at high tide. Lack of PPE for the military. Control measures. Improvised evacuation signals.	Dynamic risk assessment – deemed safe to work on-site, safe to walk on and off 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 flood water across approach road – determined this necessitated vehicular transport on and off site.
<i>Conceptual model</i> 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 Incident Commander.
<i>Influence of uncertainty</i> 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 Incident Commander was hesitant about military commitment to an unpleasant task
<i>Situation awareness</i> 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.

Command considered Walham to be ‘one of many incidents’, rather than ‘the top priority incident’.

3.3. Communications, information sharing and shared awareness of the incident

Table 4 summarises the responses to CDM probes from the three organisations interviewed in relation to the decision to keep personnel working on the site.

During this incident, one of the key decisions was the ongoing assessment of whether it was safe for personnel to work on-site. In order to do this, information on a number of factors was collected and combined to produce an overall risk assessment for the site, as is summarised in Table 4. The National Grid established safe working practices for personnel operating in live electrical areas and defined a maximum depth for flood water to reach before it would become too dangerous to remain on-site. Royal National Lifeboat Institute (RNLI) crews monitored water depths around the site and assessed flood water risk to personnel, as well as reporting on compliance with the use of Personal Protective Equipment (PPE) by personnel on-site. The Fire and Rescue Service took information from all sources, and the Incident Commander assessed the overall risk to personnel working on the site. On the face of it, all agencies shared the same overall goal (i.e. to prevent the substation from flooding) and were clear on what needed to be done. However, Table 4 suggests that the responding organisations were actually working to slightly different priorities and making decisions based on different environmental cues, as well as on their own experience and expertise; whilst these priorities were broadly the same, their perspectives as to how these objectives were to be achieved differed to the extent that they conflicted.

The different personnel involved in multi-agency operations can also produce different interpretations of the incident, both across organisations and between levels of command. At Walham, this was most notable in the contrasting perceptions described in Vignette 2. The Environment Agency and Fire and Rescue Service were concerned with similar elements of the incident, but formed very different perceptions of the problem and the appropriate multi-agency response. The Environment Agency felt that they were being obstructed by the Fire and Rescue Service, who were trying to balance the competing requirements of different aspects of the response. In addition, both the Fire and Rescue Service and Environment Agency are Category 1 responders (under the Civil Contingencies Act, 2004) and 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”, that the Environment Agency were “outnumbered 50:1” and that in their opinion the Fire Service told them where to go to be “out of the way.”

3.4. Cooperation and coordination of response activities

The flooding incident at Walham substation featured multiple agencies working on the same tasks simultaneously (such as the construction of flood defences and the drainage of flood water from the site) and towards a common goal (i.e. to save the substation from flooding). This commonality of goals and tasks meant that close cooperation across the responding organisations was necessary in order to effectively deal with the incident and to prevent them from working at cross purposes to each other. The different agencies operated their own communications equipment: the Environment

Vignette 2: Perceptions of the incident

The Environment Agency team had a specialist role in the response, namely the deployment of their flood barrier equipment – a task which 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, but they felt that the Fire and Rescue Service were slow to adapt to the pace and nature of the incident; during the early stages, the Environment Agency considered the Fire and Rescue Service to be ‘in the way’, as they were having difficulty in getting the vehicles bringing their barrier components onto the site. 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 they were already dealing with the incident appropriately. The Environment Agency personnel spoken to asserted that it was their equipment, personnel and knowledge that had been crucial in the defence of Walham and that this was not sufficiently recognised either by the Fire and Rescue Service or 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 the incident was much more complex, with many factors to consider, including numerous hazards and a number of equally critical aspects to the flood defences, of which the Environment Agency barrier was one part. Due to the rising groundwater, 8 specialist high volume pumps were brought in from Fire and Rescue Services around the country to keep the flood water level within the substation down; this was one of the reasons for the large number of Fire appliances at the scene. 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.

Agency and Fire and Rescue Services each had their own 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 engaged in different tasks around the site and movement was restricted by flood water, electrical hazards, construction activity and a constant flow of heavy machinery in and out of the site.

Coordination of site access between the responding agencies also appears to have been problematical, with apparent failures to request information from and present information to other agencies, as is described in Vignette 3. This failure to ‘push’ and ‘pull’ information likely stems in part from a lack of awareness between the responding organisations (namely the Environment Agency and Fire and Rescue Service) regarding each other’s roles, methods and processes. This is likely to be exacerbated during a Major Incident, where the organisations are faced with a unique problem and it may not be immediately apparent what factors should be concentrated on. In addition, as can be seen from Vignette 2, unfamiliarity between agencies led the Environment Agency to interpret the Fire and Rescue Service’s actions as having selfish or malign intentions, which is unlikely to have motivated them to cooperate. Thus, there are also mental barriers to cooperation between responding agencies.

Vignette 3: Coordination of activity

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. However, the large articulated vehicles bringing Environment Agency equipment had been held up in the queue of traffic outside the incident cordon. 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 their size meant that all other vehicles 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 approached the Fire Commander and they discussed the problem, agreeing that, given the need to complete the barrier on time, these lorries had to be given priority access. All other work and site traffic was stopped to allow the lorries into the site to be unloaded.

Vignette 4: On-site improvisation

The Fire and Rescue Service would normally track individual people entering and leaving the inner cordon (hazard zone) of an incident; however, the large numbers of people continually moving on and off site meant that this was not possible, so safety was managed at the site rather than the individual level, with the RNLI boat crews being used to monitor the welfare of personnel on-site and compliance with PPE (where 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 flood water became too great. Instead, an emergency services vehicle parked in a prominent position on a raised area of ground was nominated and all personnel were told that if the emergency lights and sirens on this vehicle were activated, then this was the signal to evacuate the site.

water level rose, the concern became that water might suddenly break through the temporary defences and inundate the site. The decision to have staff remain on-site was therefore regularly reassessed and all non-essential staff were evacuated prior to high tide.

4. Discussion

It is clear that during major incidents, all agencies concentrate their efforts on resolving the emergency, but despite this there are some problems that are inherent within the nature of the situation and of multi-agency operations; our findings can be summarised as follows:

4.1. The context of the situation forced responding agencies away from formal structures and procedures

As a result of the severe limitations imposed by the restricted location, numerous hazards, short timeframe and environmental conditions, the responding agencies were forced to adapt almost every aspect of their response, from ad hoc alterations of organisational structures, to adaptation of procedures, roles and the use of equipment. In order to meet the demands of an exceptional incident, conventional rules that are enshrined in Standard Operating Procedures (SOPs) had to be circumvented or 'broken'. Whilst this is not a new finding (see [Auf der Heide, 1989](#); [Smith and Dowell, 2000](#)), this study has shown that such adaptations can result in problems, such as misunderstandings with other agencies which can jeopardize the incident response. [Mendonça et al. \(2007\)](#) also note that both organisational and individual level improvisation demand high levels of communication. It is therefore necessary to ensure close coordination and negotiation between organisations in order to achieve and maintain a position of shared understanding of the situation and the appropriate response – something which was not aided during the Walham emergency by the incompatibility of communications technologies in use by the responding agencies.

Whilst modifications to organisational structures were felt necessary as a result of the nature of the emergency, there were unintended consequences of this reorganisation, as could be seen with the Fire and Rescue Service, where a loss of situation awareness at the Silver level of command may have been related to the 'short-circuit' made between the incident site and Gold Command. Given the safety-critical nature of the emergency response environment, making ad hoc alterations is therefore inherently risky and – where possible – steps should be taken to minimise the unintended consequences of any changes. This may be achieved through the adoption of command and control networks and

Military involvement in the Gloucestershire floods featured the use of Liaison Officers. The role of Liaison Officer appears to function as an interface between different organisations, bridging their different languages, practices and perspectives on an incident and helping to build trust between organisations. Indeed, the Military Liaison Officer working on-site commented that his role was to understand and communicate the needs of each agency on-site. The value of this role 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, in order to address the particular needs of this incident and to ensure continuity of purpose across organisations and levels of command.

3.5. Command, strategy (command intent) and decision making

The large numbers of responding agencies, combined with communications problems and a lack of on-site command support meant that events began to overwhelm the 'control' aspect of the command and control capability. The Fire and Rescue Service therefore adapted their working practices to the situation: command roles, reporting lines and procedures were altered to take account of the situation they were faced with. In addition to the organisational changes already discussed, a number of adaptations were required to minimise risks to the individuals involved in the response, as described in Vignette 4. These examples demonstrate how the constraints of an emergency situation may force decision-makers to adapt virtually everything else and the consequent requirement for command structures to be able to adapt to extraordinary situations.

Given the hazards posed by the live electricity substation and the presence of flood water, one of the key decisions during the incident was the risk assessment for personnel working on the site. As the flood

processes which are more amenable to adaptation, for example, by limiting their complexity, introducing redundancy and making information links and lines of communication more explicit. Software may also be able to assist with this process, by providing a simple form of error checking, for example, by indicating where a node or agent has become disconnected from the source of the information it requires.

4.2. Problems with the management of command intent across ad hoc and fragmented systems

The high levels of uncertainty and multi-domain nature of major emergencies requires effective communication and sharing of information between agencies; though awareness of even a 'simple' incident can vary widely and achieving shared understanding across different organisations is labour intensive. This helps explain why common goals at the strategic level can still lead to different (conflicting) tactical and operational responses. Separate command structures may act as a barrier to cooperation, which is something that organisations attempt to overcome through the use of liaison roles and shared command facilities. It would appear that the separate incident command structures adopted during multi-agency operations do not reflect the co-dependency of cooperating organisations during multi-agency incident responses and appear not to foster the coordination of activity and development of shared awareness.

Different perspectives on the nature of the problem and the role of each agency in the response can lead to misinterpretation of intentions and a loss of trust across organisations. This may be due to a lack of experience of working together, which means an unfamiliarity with different agencies' working practices, knowledge and requirements, though there may be potentially more fundamental questions over who is 'in charge' of the incident response. This lack of trust may well adversely impact on inter-agency cooperation during future multi-agency operations.

4.3. The potential for technology to support multi-agency operations

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 (Department of Defense, 2001). The recent adoption of the Airwave secure digital communications network by the emergency services in England and Wales could enable the development of a COP, as it allows for the formation of multi-user talk groups and the sharing of data; this may then lead to faster and more appropriate joint service responses by reducing the level of uncertainty surrounding factors of the incident. In their discussion of the role of knowledge management in disaster responses, von Lubitz et al. (2008) highlight the difficulties experienced during large-scale disasters of not only knowing where to look for information but also in knowing that it exists; a COP could not only provide a resource for sharing relevant information, but also a means for contacting the other agencies involved to request specific details of the incident. A COP might be useful during the emergency response incident, in order to share statements of intent amongst the responding agencies and to improve information exchange. However, examination of the Waltham incident response has illustrated the difficulty of developing a shared understanding of an incident, particularly between organisations that are not familiar with each other's domains of expertise and work practices. This has implications for the development of a COP, as the presentation of information alone would appear insufficient to enable the development of a common understanding. Additionally, Mendonça et al. (2007) argue that an

attempt to consolidate information in order to facilitate the development of shared situation awareness is liable to miss out information which is relevant to one or more of the agencies involved. Thus, one might instead argue for a Common Relevant Operational Picture, which would present information in the format familiar to specific agencies. This might require additional functions to 'translate' terms, concepts and procedures. The question therefore becomes one of whether a COP or other networking technology can be used to facilitate the development of a common understanding of an emergency. Mendonça et al. (2007) again caution that the desire to develop a COP is based on the assumption that a shared awareness (or understanding) of the situation actually exists; in this paper, we have attempted to demonstrate that in order to coordinate multi-agency operations, a level of shared understanding between organisations and levels of command is a necessary feature. Finally, Mendonça et al. (2007) argues that technological systems must enhance organisational agility. Given the important role played by both formal and ad hoc Liaison Officers in bridging the gap between different organisations and levels of command, building trust and enabling effective cooperation, it may therefore be advisable to use the COP to support or further enhance this role, making the Liaison Officer the link between different layers of the operational picture.

This case study has demonstrated the requirement for responding organisations to be able to adapt themselves to exceptional circumstances and lends weight to the argument that any supporting technologies must be sufficiently flexible to be able to cope with the implementation of innovative working practices (Jul, 2007).

4.4. Civil Contingencies Act

Returning to the eight guiding principles for emergency response as defined in the Civil Contingencies Act 2004 (HM Government, 2005b), it is possible to summarise the findings of this report in relation to each one:

1. *Direction – clarity of purpose defined by a strategic aim and objectives (i.e. Command Intent):* A common strategic aim may still translate into conflicting tasks and activities at the operational level, requiring the recognition of a single point of command across all organisations. Technologies (such as a COP) may be used to make operational level planning and activities more easily visible and understandable to different agencies, enabling the rapid identification and resolution of points of conflict.
2. *Integration – effective and efficient coordination between agencies involved in the response:* Coordination may be more or less effective at different levels of the multi-agency C2 structure and individual organisations' goals, priorities and understanding of the situation may present a barrier to coordination.
3. *Subsidiarity – coordination occurs at the lowest appropriate level:* Responding organisations each have unique organisational structures and work to different operational tempos, making effective coordination of activity difficult, especially where they are working on the same task, or are sharing the same physical or temporal space.
4. *Preparedness – all agencies, and their members, have clear understanding of their role and appropriate knowledge and abilities to undertake these roles:* The constraints of an incident may force individuals and agencies to work outside of their standard roles and knowledge areas and to closely cooperate with new partners; this may lead to a level of uncertainty surrounding who is doing what and who knows what, which requires close coordination across agencies to resolve.

5. *Continuity – organisations should be able to employ Standard Operating Procedures such that their response to the emergency involves well-drilled activities, albeit at a greater tempo:* Multi-agency operations may well involve groups and individuals who have never worked together before, are unfamiliar with each others' practices and do not share a common language or set of procedures for dealing with an incident. In addition, the inherently unpredictable and unique nature of large-scale crises means that innovation may be necessary and should therefore be expected and supported, rather than avoided at all costs.
6. *Communication – reliable information is passed as efficiently as possible to all agencies who need it, including the public:* There are a number of barriers to effective communication of information, both within organisations and between them; communication is therefore not automatic and requires organisational structures, roles and technologies which support the sharing of information.
7. *Cooperation – agencies cooperate in a spirit of mutual trust and understanding:* Where agencies are unfamiliar with each other's work practices, misunderstandings and mistrust may result. The need for one-off, ad hoc response collaborations limits the practicality of training exercises in building trust between organisations; therefore, the means to rapidly share understandings and develop effective working practices must be designed into the processes and technologies intended to support multi-agency cooperation.
8. *Anticipation – risk assessment and identification is performed in an ongoing manner in order to ascertain any possible changes in level of risk so that the response can be managed as appropriately and flexibly as possible:* As no single agency is likely to be in possession of all of the relevant facts about the incident, risk assessment is reliant on effective communication and cooperation between the responding agencies and an acknowledgement of the authority of the decision-maker.

The findings of this report indicate that multi-agency emergency response may not be as easy or straightforward as the Civil Contingencies Act envisages; whilst these eight guiding principles are entirely appropriate to the domain, our research has found that there are a number of social, organisational and technological barriers to coordination and cooperation between agencies and that these principles are unlikely to be achieved during all subsequent multi-agency Major Incidents until these problems are addressed.

5. Conclusions

Whilst the response to this emergency was a success, a number of adaptations to standard organisational structures, processes and procedures were necessary; some difficulties in terms of Shared Awareness and Inter-agency Cooperation have been identified, which related to inexperience of personnel and organisations in working together, though which may also stem from a more fundamental question over the recognition of command authority. These findings have implications for future training for major emergencies; whilst UK emergency services already conduct periodical large-scale multi-agency training scenarios, personnel should also be trained to adapt to the requirement to work with new partner agencies at short notice and to recognise and prepare for the need for improvisation in exceptional circumstances.

One of the recommendations of the report into the Federal response to Hurricane Katrina was the establishment of “a *National Operations Centre to coordinate the national response and provide situational awareness and a common operating picture for the entire*

Federal government” (Townsend, 2006). Whilst this may bring some improvements to the coordination of multi-agency operations, the current research suggests that the sharing of information alone is insufficient to result in a coordinated approach to an incident; instead, a deeper, shared understanding of the relevant factors in the incident is required.

Historically, implementations of communications technology have failed to account for social processes and accommodate them within the solution, with the result that the ‘improved’ process is actually less effective, for example in the case of the London Ambulance Service's computer-aided dispatch system (LASCAD) project failure (Beynon-Davies, 1999). Oversimplification of the process of crisis management could lead to similar failures, for example Comfort (1993) stated that in disaster environments: “...common training and skills enable multiple units to work readily in coordinated action...”; something which we have demonstrated is clearly not always the case and which must be taken into account when designing technologies to support multi-agency operations. It is therefore suggested that a more sociotechnical systems view, i.e. the optimisation of both social and technical systems (Cherns, 1976; Clegg, 2000; Trist and Bamforth, 1951), should be taken during the design of future networking technologies and the reorganisation of response agencies, to ensure that the relevance of complex social issues, such as trust, to multi-agency operations is identified and that the unanticipated consequences of even small changes to command and control networks is recognised. For example: in terms of training, this research suggests that in addition to preparing for particular types of emergencies or practicing SOPs, there is a need to provide opportunities for emergency response personnel to practice generic skills related to information sharing and collaborative sense-making.

This study has shown that effective cooperation across agencies requires more than merely the exchange of information and that developing shared understanding is a crucial – but labour intensive – process. It also highlights the necessity for command and control structures and technologies to be flexible, in order to accommodate the changing demands of unique situations and multi-agency associations.

Acknowledgements

This work is supported by a grant from the Human Factors Integration Defence Technology Centre, part-funded by the Human Capability Domain of the UK Ministry of Defence Scientific Research Programme. The authors would like to thank personnel from Avon Fire and Rescue Service, Gloucestershire Fire and Rescue Service, The Environment Agency (Operations Delivery team) and 43 (Wessex) Brigade for their assistance with this research.

Appendix

A.1. High-level question sets used during interviews

Background

- What is your role within your organisation?
- What was your role during the floods in Gloucestershire?

Timeline #1: general flood emergency

- Brief description of events – what happened, where, when?

Timeline #2: electricity substation defence in detail

- Description of events – what happened, where, when?

How was the response organised #1: within your agency?

- Describe your organisational structure
- Does your agency have a process that they follow for dealing with these types of incidents?
- What were your overall goals during the incident?

- How were you organised on-site
- How was the response organised #2: across services?
- What was the command structure?
 - Which agency was in overall command?
- How was communication managed?
- What communications systems were in use within and across agencies?
 - Were they compatible?
- How was activity coordinated/commanded across agencies?
- What other agencies were involved?
 - What were other agencies doing?
 - What were their goals?
 - Who decided on priorities?
- What were the main decision points?
- #1 For you/your agency?
 - #2 For other agencies?
 - At what level were various decisions made – strategic, tactical or operational?
 - What were your specific goals at the various decision points?
- What were the main difficulties that you/your agency experienced?
- #1 In resolving the incident?
 - #2 In working with other agencies?

References

- Auf der Heide, E., 1989. *Disaster Response: Principles of Preparation and Coordination*. Mosby-Year Book, St Louis, Missouri.
- Becerra-Fernandez, I., Xia, W., Gudi, A., Rocha, J., 2008. Task characteristics, knowledge sharing and integration, and emergency management performance: research agenda and challenges. In: *Proceedings of the 5th International ISCRAM Conference*, Washington, DC, USA, May 2008, pp. 88–92.
- Bennett, J., Bertrand, W., Harkin, C., Samarasinghe, S., Wickramatillake, H., 2006. *Coordination of International Humanitarian Assistance in Tsunami-Affected Countries*. Tsunami Evaluation Coalition, London.
- Beynon-Davies, P., 1999. Human error and information systems failure: the case of the London ambulance service computer-aided dispatch system project. *Interacting with Computers* 11 (6), 699–720.
- Boin, A., 2004. Lessons from crisis research. *International Studies Review* 6 (1), 164–194.
- Boin, A., T'Hart, P., 2003. Public leadership in times of crisis: mission impossible? *Public Administration Review* 63 (5), 544–553.
- Boin, A., T'Hart, P., 2007. The crisis approach. In: Rodríguez, H., Quarantelli, E.L., Dynes, R.R. (Eds.), *Handbook of Disaster Research*. Springer, New York, New York, pp. 42–54.
- Boulle, P., Vrolijk, L., Palm, E., 1997. Vulnerability reduction for sustainable urban development. *Journal of Contingencies and Crisis Management* 5 (3), 179–188.
- Cherns, A., 1976. The principles of sociotechnical design. *Human Relations* 29, 783–792.
- Chua, A.Y.K., Kaynak, S., Foo, S.S.B., 2007. An analysis of the delayed response to Hurricane Katrina through the lens of knowledge management. *Journal of the American Society for Information Science and Technology* 58 (3), 391–403.
- Clegg, C.W., 2000. Sociotechnical principles for system design. *Applied Ergonomics* 31, 463–477.
- Comfort, L.K., 1993. Integrating information technology into international crisis management and policy. *Journal of Contingencies and Crisis Management* 1 (1), 15–26.
- Crichton, M.T., Flin, R., Rattray, W.A.R., 2000. Training decision makers – tactical decision games. *Journal of Contingencies and Crisis Management* 8 (4), 208–217.
- de Marchi, B., 1995. Uncertainty in environmental emergencies: a diagnostic tool. *Journal of Contingencies and Crisis Management* 3 (2), 103–112.
- Department of Defense, 2001. *DoD Dictionary of Military and Associated Terms*, 12 April 2001, as Amended Through 17 March 2009. US Government Printing Office (GPO), Washington, DC. Joint Publication 1-02.
- Dynes, R.R., 1970. *Organized Behaviour in Disaster*. Heath Lexington Books, Lexington, Massachusetts.
- Available from Elliott, V., Brown, D., 2007. 10,000 homes flooded, 50,000 without power and 150,000 have no water. *Times* [Online]. <http://timesonline.co.uk/tol/news/weather/article2127616.ece> (accessed January 2009).
- Environment Agency, 2007. Case study: 2007 summer floods. Available. http://www.environmentagency.gov.uk/commdata/acrobat/infrastructurestudy_1917458.pdf (accessed March 2008).
- Fennell, D., 1988. Investigation into the King's Cross Underground Fire. Her Majesty's Stationery Office, London.
- Griffin, C., Winter 2007. The battle for Walham. *Glosfire*, 12–13. Benham Publishing, Liverpool.
- Hewitt, K., 1983. *Interpretations of Calamity from the Viewpoint of Human Ecology*. Allen and Unwin, Boston.
- HM Government, 2005a. *Emergency Preparedness: Guidance on Part 1 of the Civil Contingencies Act 2004, Its Associated Regulations and Non-Statutory Arrangements*. Cabinet Office, London.
- HM Government, 2005b. *Emergency Response and Recovery: Non-Statutory Guidance to Complement Emergency Preparedness*. Cabinet Office, London.
- Jul, S., 2007. Who's really on first? A domain-level user, task and context analysis for response technology. In: *Proceedings of the 4th International ISCRAM Conference*, Delft, the Netherlands, May 2007.
- McMaster, R., Baber, C., Houghton, R., 2007. Analysis of multi-agency intent: an example from the emergency services, HFI DTC report, HFIDTC/2/WP3.1.4/1. Available from. <http://www.hfidtc.com/pdf/reports/New%2520Reports/HFIDTC-2-3.1.4-1.pdf> (accessed January 2009).
- Mendonça, D., Jefferson, T., Harrauld, J., 2007. Collaborative adhocracies and mix-and-match technologies in emergency management. *Communications of the ACM* 50 (3), 44–49.
- Munich Re, 2008. *Topics Geo – Natural Catastrophes 2007*. Munich Re Group, Munich.
- O'Hare, D., Wiggins, M., Williams, A., Wong, W., 2000. Cognitive task analyses for decision centred design and training. In: Annett, J., Stanton, N.A. (Eds.), *Task Analysis*. Taylor & Francis, London, pp. 170–190.
- Rahman, A., 1996. Peoples' perception and response to floodings: the Bangladesh experience. *Journal of Contingencies and Crisis Management* 4 (4), 198–207.
- Smith, W., Dowell, J., 2000. A case study of co-ordinative decision-making in disaster management. *Ergonomics* 43 (8), 1153–1166.
- Snow, J., Manning, L., 2007. Saving Walham. Channel 4 News Available from. <http://www.channel4.com/news/articles/society/environment/saving+walham/624157#fold> (accessed January 2009).
- Telford, J., 2007. The international humanitarian system and the 2004 Indian Ocean earthquake and tsunamis. *Disasters* 31 (1), 1–28.
- Trist, E., Bamforth, K., 1951. Some social and psychological consequences of the longwall method of coal getting. *Human Relations* 4, 3–38.
- Townsend, F.F., 2006. *The Federal Response to Hurricane Katrina: Lessons Learned*. White House, Washington, D.C.
- von Lubitz, D.K.J.E., Beakley, J.E., Patricelli, F., 2008. 'All hazards approach' to disaster management: the role of information and knowledge management, Boyd's OODA loop, and network-centrality. *Disasters* 32 (4), 561–585.