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A case study of co-ordinative decision-making in disaster management

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A persistent problem in the management of response to disasters is the lack of co-ordination between the various agencies involved. This paper reports a case study of inter-agency co-ordination during the response to a railway accident in the UK. The case study examined two potential sources of difficulty for co-ordination: first, poorly shared mental models; and, second, a possible conflict between the requirements of distributed decision-making and the nature of individual decision-making. Interviews were conducted with six individuals from three response agencies. Analysis of reported events suggested that inter-agency co-ordination suffered through a widespread difficulty in constructing a *reflexive shared mental model*; that is, a shared mental representation of the distributed decision-making process itself, and its participants. This difficulty may be an inherent problem in the flexible development of temporary multi-agency organizations. The analysis focused on a distributed decision over how to transport casualties from an isolated location to hospital. This decision invoked a technique identified here as the *progression of multiple options*, which contrasts with both recognition-primed and analytical models of individual decision-making. The progression of multiple options appeared to be an effective technique for dealing with uncertainty, but was a further source of difficulty for inter-agency co-ordination.

1. Introduction

1.1. *The problem of inter-agency co-ordination in disaster management*

A recurring problem in the management of response to natural and technological disasters, such as extensive bushfires and major transport accidents, is the lack of co-ordination between the various rescue agencies involved (Auf der Heide 1989, Denis 1995). These agencies include not only the emergency services (e.g. police, fire and ambulance), but also local and national government bodies, private sector organizations and volunteer groups. To take one example from the UK, the public inquiry into the King's Cross underground fire in 1987 concluded: 'The court was left with the impression that there had been a breakdown of communication at command level between the emergency services. Each diligently pursued its own duty

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but there was a lack of liaison between them' (Fennell 1987: 83). Conversely, successful operations are often attributed to effective inter-agency co-ordination. For example, the inquiry into the Clapham railway accident commented that the emergency services worked together at the site in an 'exemplary manner' to carry out the rescue operation (Hidden 1989: 34).

Each disaster gives rise to the formation of what can be called an *incident organization*; that is, a temporary configuration of otherwise disparate resources drawn from many agencies. Within the incident organization, those distributed people, technologies and procedures concerned with directing resources can be identified collectively as the *disaster management system*. The problem of inter-agency co-ordination lies in the interaction between the structure of this emerging disaster management system, and techniques of individual and team decision-making. At this organizational level, considerable effort has gone into the development of special interorganizational schemes for liaison between agencies. Poor co-ordination in the response to extensive wildfires in the USA in the 1970s, for example, led to the development of the Incident Command System (Irwin 1989), which is now widely used. Similarly, riots and public disturbances in the UK in the 1980s, prompted the London Metropolitan Police Force to develop and advocate a unified model of management based on hierarchical levels of 'gold', 'silver' and 'bronze'.

This paper reports a case study of the response to a railway accident in the UK which investigated possible sources of difficulty for inter-agency co-ordination. The focus was on decision-making by individuals and teams, and its relationship with the interorganizational structures of the UK's disaster management scheme (Home Office 1997). While generalization from a single incident is problematic, the approach yields a rich account of both the context of co-ordinative decision-making and its ultimate effect on the rescue operation (see Numagami (1998), for a recent discussion on the value of the case study approach). Section 1.2 describes the specific issues of co-ordinative decision-making investigated in the study, and the case study itself is presented in §2.

1.2. *Issues of co-ordinative decision-making*

Co-ordination, in general, can be identified as the resolution of *interdependencies* between the activities of different organizational units (March and Simon 1958, Mintzberg 1979). In this view, inter-agency co-ordination in disaster management is the resolution of interdependencies between activities of the disparate resources of the incident organization. It requires 'dynamic and distributed decision-making' (Brehmer 1991): as the disaster situation unfolds *dynamically*, efforts are made to co-ordinate resources by personnel who are *distributed* across different agencies and locations. These participants in the multi-agency disaster management system can be regarded as a special kind of *team* (Dyer 1984), in the sense that they share common goals, such as those defined by the UK government (table 1), and have distinct roles determined by their agency, rank and location in relation to the disaster. Unlike expert teams, however, such as cockpit flight crews (Stout *et al.* 1999) or ship navigators (Hutchins 1995), managers of a disaster situation may not have worked together prior to the incident.

Drawing on research into teamwork, then, one possible source of difficulty for inter-agency co-ordination, might be the absence of an adequate *shared mental model* (SMM) between participants in the disaster management system (for a review of SMMs and associated concepts see Cannon-Bowers *et al.* 1993). Existence of a SMM

Table 1. Nine 'common objectives' for disaster response, as defined by the UK Government (Home Office 1997).

Common objective
1. To save life.
2. To prevent escalation of the disaster.
3. To relieve suffering.
4. To safeguard the environment.
5. To protect property.
6. To facilitate criminal investigation and judicial, public, technical, or other inquiries.
7. To inform the public.
8. To promote self-help and recovery.
9. To restore normality as soon as possible.

would imply a degree of consistency between the various mental models of the disaster held by different individuals. In general, a SMM enables team members to generate similar expectations about a dynamic situation (Rouse *et al.* 1992), with demonstrable benefits for co-ordination (Stout *et al.* 1999). The case study set out to examine for the particular incident studied, first, to what extent a SMM was held between personnel in different agencies and whether this affected co-ordination; and, second, what factors within the disaster management system facilitated or inhibited the construction and maintenance of a SMM. These questions were applied to two types of SMM that might be held by participants in the disaster management system, referred to here as: task-oriented SMMs, which are models of the situation to be directed encompassing hazards, victims, operational resources and working conditions; and *reflexive* SMMs, which are models of the disaster management system itself, and are equivalent to Etin and Serfaty's (1999) notion of a 'mutual mental model'.

A second potential source of difficulty for inter-agency co-ordination is a possible conflict between the required form of effective distributed decision-making and the nature of individual decision-making. It has been reported (Flin 1996) that decisions by individual emergency managers conform to a Recognition-Primed Decision model (Klein 1997), proposed for 'naturalistic' situations characterized by high uncertainty, time pressure and high stakes. In this model, decisions are typically based on the recognition of familiar scenarios that trigger appropriate 'action schema'. If recognition fails initially, decision-makers resort to greater 'situation assessment' until recognition can occur, eventually constructing a new sequence of actions if an appropriate schema is not available. Decision-makers consider alternative courses of actions only if the current option fails. This Recognition-Primed Decision model contrasts with the analytical, or classical, model underlying much laboratory work on decision-making (e.g. Tversky and Kahneman 1974), in which many alternative options are mentally compared before one option is chosen for implementation.

The case study aimed to compare an instance of multi-agency distributed decision-making with these broad general models of individual decision-making. The need to negotiate between agencies may mean that distributed decisions would contrast with the recognition-primed nature of individual decisions, and might instead fit an analytical model in which alternative options are made explicit and analysed before one option is chosen by mutual agreement. The specific questions addressed here, then, were whether distributed decisions at the incident studied were indeed analytical in form, and whether this caused any difficulty for disaster managers whose individual decisions were likely to be recognition-primed.

2. The case study

2.1. *The method of the case study*

2.1.1. *Approach*: The case study investigated a multi-agency response to a railway accident at Ais Gill in Cumbria, UK in January 1995. The Ais Gill incident was chosen because it was a small-scale disaster for which an account could be constructed with an acceptable level of validation. The definition of disaster used here was any harmful situation that demands large-scale operations by more than one responding agency (Home Office 1997). Interviews were conducted with individuals who played a key managerial role in the incident, and various documents were examined. All interviews were audio-recorded and later documented as a series of discrete assertions by interviewees. These assertions formed the basis of the account reported here, which has two parts. First, §2.2 presents a chronology of events with a sketch of the disaster management system as it was implemented at Ais Gill. This account was corroborated against documented evidence and through overlaps between the assertions of different interviewees. Second, §2.3 presents a more interpretive account of co-ordinative processes at Ais Gill in terms of the theoretical questions raised in §1.2.

2.1.2. *Participants*: The study focused on the three chief responding agencies at Ais Gill: the Cumbrian Fire Brigade, the British Transport Police and the Cumbrian Ambulance Service. Two individuals who played a significant managerial role in the disaster response were interviewed from each agency: (1) *from the Cumbrian Fire Brigade*—an Assistant Divisional Officer (ADO) based at Penrith and a Divisional Officer (DO) based at Barrow-in-Furness; (2) *from the British Transport Police*—a sergeant based at Lancaster and a superintendent based at Manchester; (3) *from the Cumbrian Ambulance Service*—a paramedic based at Brough and an ambulance controller based at Carlisle.

2.1.3. *Interview procedure*: The interview process was a simplified version of Klein *et al.*'s (1989) Critical Decision Method (see also Hoffman *et al.* 1998). Interviewees were first asked to provide an account of the incident from the point of view of their own involvement, while the interviewer wrote down the main events including situation assessments and decisions. The interviewer then reviewed the account and 'probed' the interviewee to recall further information concerning each event. Probes were context-specific and chosen to reveal the circumstances of both task-oriented decision-making (for example, 'What did you see when you entered the carriage?' and 'Why did you attend to the injured driver first?') and co-ordinative processes (for example, 'What were the police doing at this point?' and 'Who should have kept the media from entering the accident site?'). The interviews took place approximately 18 months after the incident had occurred.

2.1.4. *Documents studied*: The following documents were examined: (1) a Railtrack report on the circumstances and causes of the accident; (2) a Fire Brigade communications log that recorded every message passed via their communication centre; (3) Ambulance Service message forms used at Carlisle communications centre

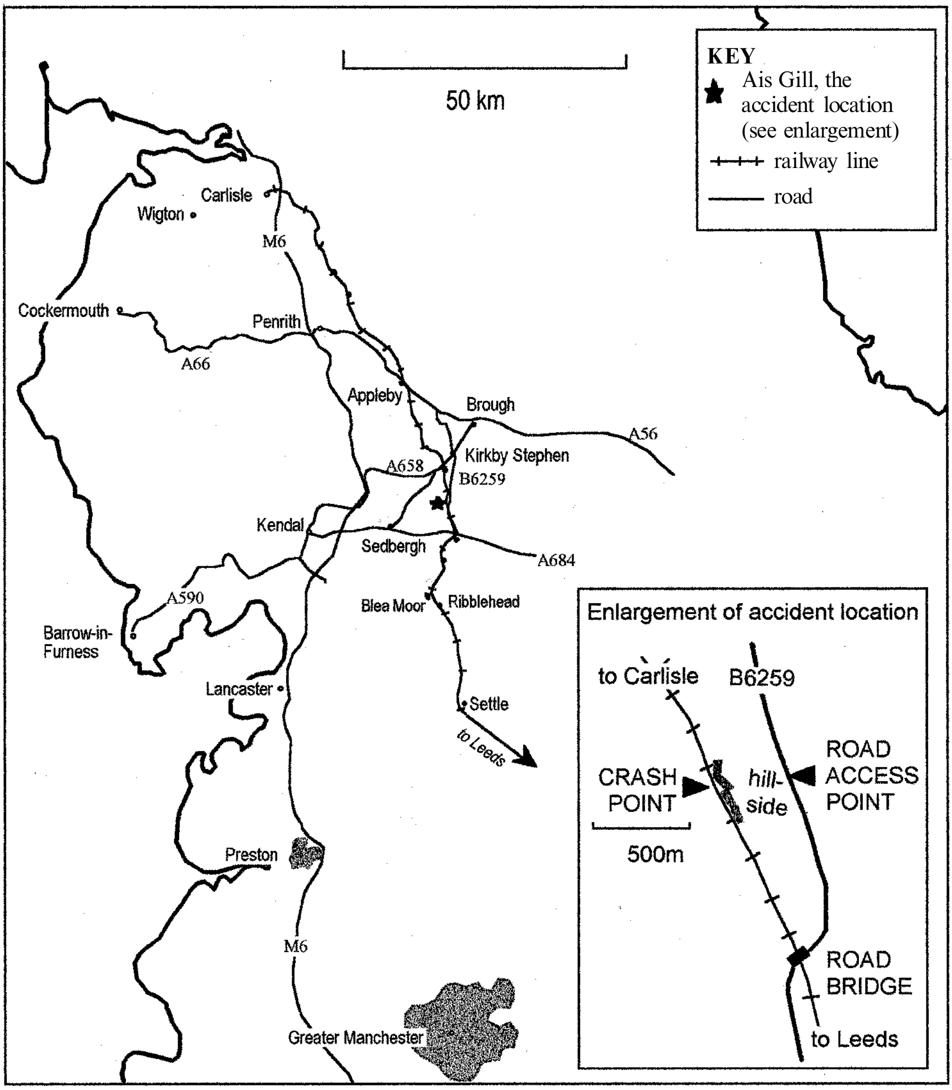

Figure 1. The area of the Ais Gill railway accident showing the locations of all responding resources referred to in the text.

to record information received and instructions sent out; and (4) information from the British Transport Police log, reported by interviewees, but not accessed directly by the researchers.

2.2. *The events of the Ais Gill railway accident*

2.2.1. *The disaster and the rescue operation*: On 31 January 1995, the two-car 16:23 h Carlisle-to-Leeds train service was about 2 hours out of Carlisle when it was turned back because of flooding on the track ahead (figure 1 shows the area of the accident). On its return journey, the train became derailed after hitting a landslide on the track caused by torrential rain. It came to rest across both the 'up' and 'down' lines of a remote section of track on an embankment near the summit of Ais Gill, a hill on the county border between Cumbria and West Yorkshire. At approximately 18:55 h, a second two-car Carlisle-to-Leeds train travelling towards Leeds collided at high speed with the derailed train.

The disaster elicited large-scale operations by three emergency services: the Cumbrian Fire Brigade, the Cumbrian Ambulance Service, and the British Transport Police (BTP). Large-scale operations were also mounted by the owners of the track, Railtrack, and by the train operating company, Regional Railways North-East, although these are not reported in detail here. Further responders attended the incident from: the local Cumbrian Police (referred to as *police*); three local doctors; local mountain rescue teams (referred to as *volunteers*); and the Health and Safety Executive. Two hospitals, in Carlisle and Lancaster, were placed on standby. The incident was also attended by television, radio and newspaper reporters.

All responders had difficulty in locating the accident. At 19:20 h, six fire-fighters from Kirkby Stephen were the first rescuers to reach the site. Following this, resources of the incident organization continued to arrive over the following 4 h. Further fire brigade vehicles arrived during the hour after 19:20 h from Kendal and Sedbergh, and more senior officers attended from Penrith, Barrow-in-Furness and Cockermouth. The first ambulance crew, comprising one paramedic and one ambulance technician from Brough, arrived at 19:44 h and other crews started to arrive after 20:00 h from Sedbergh, Kendal, Brough, and one from the neighbouring authority of West Yorkshire. The first contingent of BTP officers reached the site by car from Carlisle at about 21:40 h, with others arriving later from Lancaster, followed by more senior officers from Preston and Manchester. Special units also arrived later for crime scene investigation and to search the area for evidence and people. Prior to this, a local police sergeant and inspector attended the incident.

The location of the collision (referred to as the *crash point*) was accessible from the B6259 road, which was several hundred metres away down a hillside (see inset of figure 1). All units arriving at the scene had to leave their vehicles at the *road access point* on the B6259, and from there climb by foot up the muddy hillside to the crash point. The response was made difficult by the remoteness and inaccessibility of the location, and by the darkness, cold and torrential rain. However, most of the initial tasks confronting the incident organization were relatively straightforward once the situation had been established. There was no fire in the crashed trains, and fire risks were quickly reduced to an acceptable level. Dangers from the landslide and the instability of the train wreckage, to both casualties and rescue workers, were also quickly established as being acceptable by the fire brigade. Investigation of the accident did not present a difficult challenge as the witnesses could not leave the crash point for an extended period. The conductor of the first train had been killed in the collision, and immediate medical care was administered as far as possible to the other 27 passengers and crew who were left in various states of injury; all needed hospitalization, for examination at least.

The badly injured driver of the first train was taken to Carlisle hospital by ambulance, arriving there at 23:11 h. The remaining casualties were transported to Carlisle hospital using a third train (referred to as the *rescue train*), which arrived at the site at 21:42 h. Casualties were transhipped from the crashed trains to the rescue train by the fire-fighters, mountain rescue volunteers and ambulance staff. The loaded rescue train left the site at 22:30 h, reaching Carlisle railway station at

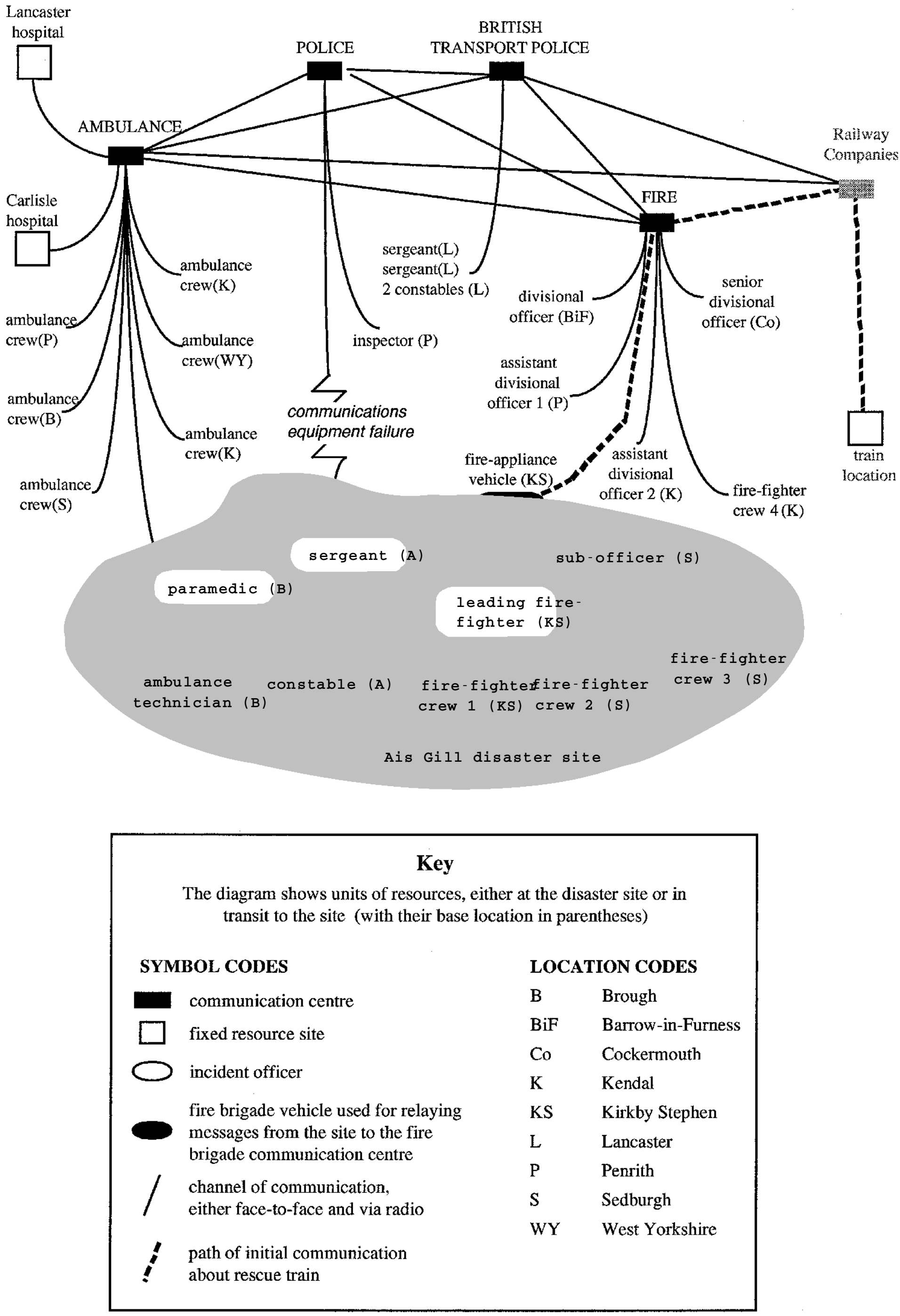

Figure 2. Part of the communication network of the disaster management system, as implemented at the Ais Gill railway accident, between 19:55 and 20:00 h on 31 January 1995 when the possibility of a rescue train was first suggested.

23:29 h, from where casualties were taken by ambulance to the nearby hospital. Six passengers were treated in hospital for between two to eight days. The rest were discharged and accommodated overnight in a hotel by the train company.

2.2.2. *The disaster management system at Ais Gill*: Figure 2 shows the network of communications within the incident organization at Ais Gill as it existed between 19:55 and 20:00 h on 31 January 1995. This structure is consistent with the UK's disaster management scheme (Home Office 1997). Each agency had a remote *communication centre*; located at Carlisle for the ambulance service and BTP, and at Cockermouth for the fire brigade. All intra-agency communications between individuals at different locations passed via their communications centre. Also shown in figure 2, are communication centres for the local police and for the railway companies. Figure 2 is in fact a great simplification because a number of other communication centres were involved. For example, Railtrack and the train company used centres at Crewe, Carlisle and York during the incident. For simplicity, these are depicted as a single communication centre in figure 2, with the label 'train location' used to signify the source of the rescue train at Carlisle.

Also following the UK's disaster management scheme, and seen in figure 2, one individual from each agency assumed the status of *incident officer* at the disaster site, and was responsible for directing and controlling that agency's resources 'on the ground'. All agencies used a command hierarchy based on rank, with the more senior officers successively taking over the role of incident officer on arrival at the disaster site. Incident officers from the different agencies (fire brigade, ambulance, BTP, police, Railtrack, and the train operating company) liaised with each other frequently during the incident, although not all at once. Liaison was made easier through the proximity of working in the confined area of the crash point. Communication centres of different agencies also passed relevant information and messages to each other, forming another formal structure of inter-agency communication.

The physical implementation of the communication network was significant at Ais Gill. The fire brigade were equipped with radios based in their vehicles, which could not reach the crash point but had to be left at the road access point (figure 1). Messages from the fire incident officer at the crash point were passed first via short-range hand-held radio to a fire-fighter in a vehicle at the road access point, and from there relayed to the remote fire communications centre. The police, BTP and railway companies all experienced difficulty with communications equipment and sent their messages via the fire brigade. Ambulances were equipped with 'repeater' radios which automatically relayed messages from hand-held sets at the crash point to the ambulance communications centre, via their vehicles at the road access point.

2.3. *Co-ordinative processes at Ais Gill*

The Ais Gill incident is now examined in terms of the theoretical questions raised in §1.2; namely, the role of SMMs in inter-agency co-ordination, and the nature of distributed decisions relative to individual decision-making. The decision over casualty transport was selected as the main focus of analysis here because it was highly distributed across different agencies and locations, and demanded considerable co-ordination. A brief account of this distributed decision now follows.

2.3.1. *The casualty transport decision*: At around 19:55 h the problem of how to transport casualties to hospital was discussed by the first paramedic, a police sergeant and a leading fire-fighter; these individuals formed the early group of incident officers. The decision involved the consideration of three different options.

- *Option 1*. The first option considered was to carry casualties back down the muddy hillside (used to access the crash point by rescuers) to the road access point where ambulances would soon arrive. This route was discounted by the paramedic because the hillside was steep and slippery, and in the darkness would likely lead to the aggravation of the (as yet unknown) injuries.

- *Option 2*. A second option was suggested that casualties might be removed using a third train (the *rescue train*). At 20:00 h, a message was sent via the fire brigade vehicle at the road access point to their communication centre (see figure 2 in which the path of this communication is highlighted): 'Any possibility of British Rail putting on a train to transport 30 walking wounded and 1 foxtrot'. At 20:10 h, without further communication, the following message was received in reply: 'From BR ETA train 60 minutes and also coach from Robinson of Appleby is mobile'. ('British Rail' and 'BR' refer to the railway companies, by the name of the former nationalized railway industry; and 'ETA' stands for 'estimated time of arrival'.) However, notification of the rescue train did not fully resolve the casualty transport decision because uncertainties still existed: would the rescue train arrive at the time stated? and, did the casualties need more speedy hospitalization than the rescue train could provide?

- *Option 3*. A third option was suggested by a rescue-worker with local knowledge. This was to carry casualties along the level railway track to a nearby road bridge where ambulances could collect them (figure 1). Once the viability of the new route had been checked by a mountain rescue volunteer, the ambulance incident officer requested a stretcher party of volunteers, fire-fighters and paramedics to take the badly injured driver of the first train, whose condition was judged to be most critical, along the railway track. The paramedic arranged for the Kendal ambulance, waiting at the road access point, to meet the stretcher party at the road bridge and take the driver to hospital. The experience of carrying the driver along the track was harder and more hazardous than anticipated. Movement of casualties was especially difficult where drips had been set up, as was the case for six casualties, including the driver in question. Passengers were warm and dry inside the carriages, and moving them was now seen as precarious. Gradually, it was decided to pursue option 2, and to wait for the rescue train.

The distributed processing of these three options for casualty transport had significant consequences for inter-agency co-ordination. First, there was a prolonged deployment of ambulances towards the accident site by the ambulance controller in Carlisle who knew that the rescue train was to be used only at 20:55 h, about 45 min after it was known as a potential option at the disaster site. During this 45 min, further ambulance crews and Public Transport Service vehicles were mobilized and despatched towards the accident site where they were not all needed. Instead, some were needed at Carlisle railway station to transfer casualties to the hospital. Second, Lancaster hospital casualty department was held on standby between 20:27 and 21:00 h when in fact it could not have been used once the rescue train option was chosen, as the train could return only to Carlisle. Third, BTP officers, based at Carlisle railway station, were not aware of the option to use the rescue train as a means of travelling to the accident site. Fourth, BTP officers were not aware, early on, of the need to provide police protection for casualties being transhipped into ambulances at Carlisle railway station, where they were harassed to some degree by media reporters.

2.3.2. *The problem of constructing reflexive shared mental models*: Questions can now be addressed concerning the role of SMMs, their effect on co-ordination, and factors that affect their use. The individuals from the three agencies studied held a basic consensus on the broad activities to be carried out, the assignment of agencies to those activities, and their relative priorities. The main elements of this consensus are consistent with the ordering of general disaster goals in table 1, and can be summarized as the following list of activity assignments in descending order of priority:

(1) reduce the risk of further collisions (railway companies, including train crew);
(2) reduce the risks of fire and instability of the wreckage (fire brigade);
(3) provide immediate medical care (ambulance service, doctors);
(4) transport casualties to hospital (ambulance service);
(5) collect evidence for investigation (BTP);
(6) brief media (all agencies); and
(7) repair the railway (railway companies).

This consensus on broad priorities and the delineation of responsibilities may be regarded as a simple task-oriented SMM, and appeared to underlie a basic level of co-ordination at the disaster site. For example, BTP officers who interviewed casualties, as part of collecting evidence about the incident, 'worked around' the more urgent provision of immediate medical care by ambulance staff.

In contrast, a simple reflexive SMM appeared to be elusive at Ais Gill. That is, each decision-maker could not form an adequate mental model of the interoganizational structure comprising all decision-makers, their inter-connections and their roles. The problem was greatest for co-ordination between agents at different locations. In the case of the casualty transport decision, although incident officers at the crash point had originally suggested the possibility of using a rescue train, they were not aware of who made the decision to act on their suggestion, its state of authorization, nor how widely it had been disseminated. The routeing of all messages through remote communication centres, as prescribed by the UK's disaster management scheme, appeared to inhibit performance in this situation. In general, it promotes the consistency of information and offers a means for its widest possible dissemination. However, in this case it inhibited the development of a reflexive SMM because it resulted in the identities of participants being obscured from each other. Widespread uncertainty persisted over the organizational basis of the decision concerning the rescue train, as confirmed by the ambulance controller at Carlisle: 'Who actually made the decision about the relief train I am not one hundred per cent sure to this day, I don't think anybody is'.

The existence of the rescue train was not rapidly disseminated beyond the path of the initial enquiry in the communication network (figure 2). Problems in appreciating the organizational basis of the distributed decision, appeared to inhibit efforts to establish and disseminate such issues as: how long the train would take; whether it would need special personnel and equipment onboard; and where it would take the casualties. The consequence of a weak reflexive SMM, therefore, was a weaker task-oriented SMM, as partly evidenced by a fire officer's following testimony: 'then it went to, don't know if it went to Railtrack or Regional Railways, and they said yes we can get a train, and nobody said where it was coming from, I only knew where it was going much later on'.

Similarly, the ambulance controller reported: 'right up to last minute I don't think anybody knew the train was going to arrive, nobody seemed to know'.

A weak reflexive SMM may be an inherent problem in disaster management. An incident organization develops organically, both in the sense of growing and transforming during the incident, and in the sense (Burns and Stalker 1961) that individual roles are determined and adjusted flexibly. Further, organizational structures are often improvised (Turner, 1994), as seen with parts of the communication network at Ais Gill. Both flexibility and improvisation within the incident organization create an elusive situation for decision-makers to capture in a reflexive SMM.

2.3.3. *Distributed decisions within agencies*: Turning to the second question raised in §1.2, concerning the nature of distributed decisions relative to models of individual decision-making, an observation is first needed about co-ordination *within* agencies. Decision-making about how to carry out operational tasks at Ais Gill was entirely restricted to personnel 'on the ground'. Irrespective of their rank, remote agents did not attempt to direct the activities of resources from afar. For example, the remote ambulance controller stated in connection with the decision over the means of casualty transport:

> We left it to the lads on the scene to make that decision, we can't make that decision, you can't see what's happening, you don't know what it's like under foot, you get mixed reports on how far it was off the road, what the train was like, and so we actually left it to the people on the scene to make the decision where the casualties were going to go and how they were going to be removed at the end of the day.

Similar patterns were seen in the fire brigade and BTP, where senior individuals desisted from directing operations until they had arrived at the accident site and had been briefed by their existing incident officer. Remote agents confined their efforts to mobilizing an appropriate level and type of resources, based on information received.

This principle of *decision-making on the ground* assisted intra-agency co-ordination, in that it created a 'division of cognitive labour' (Hutchins 1995), which prescribed who should make which type of decision. The principle appears to embody a realization of the value of recognition-primed decision-making in emergency management (Flin 1996); allocating task-oriented decisions to those with direct perceptual access to the situation, rather than on the basis of seniority.

2.3.4. *Distributed decisions between agencies—the progression of multiple options*: The nature of distributed decisions *between* agencies is now considered. The technique used by the disaster management system at Ais Gill, with respect to the casualty transport decision, can be identified as the *progression of multiple options*; this implies that a number of alternative options were actively pursued in parallel. The three options pursued in parallel for transporting casualties were *removal via the hillside to ambulances*, *removal by a rescue train*, and *removal via the railway track to ambulances*. While removal via the hillside was discounted early on by the ambulance incident officer, the prolonged dispatching of ambulances towards the site can be interpreted as the continued implicit pursuit of this option by the disaster management system as a whole.

The technique of progressing multiple options in parallel contrasts with recognition-primed and analytical models of individual decision-making which both involve only a single option being implemented. The occurrence of this technique at Ais Gill makes it difficult to obtain a clear answer to questions over whether demands of the distributed decision conflicted with the recognition-primed decision-making of individuals. However, the progression of multiple options is of significance in itself, and is likely to be a common feature of distributed decision-making in disaster management for the following reasons. First, where disaster managers have weak reflexive SMMs, they are likely to generate or assume courses of action in isolation. Consequently the disaster management system, as a whole, is likely to develop alternative options in parallel. Second, remote managers err on the side of mobilizing extra resources in case they are needed. This was seen at Ais Gill where, for example, the ambulance controller put *both* Carlisle and Lancaster hospitals on standby, and the railway companies made available *both* a rescue train and a road coach. Greater numbers of resources create more possible courses of action. Third, the progression of multiple options is an effective technique for dealing with the uncertainty associated with the rescue operation, because the alternative options serve as 'back-ups' in case others fail.

The progression of multiple options, while desirable in itself, may create several problems for co-ordination. It demands that managers must co-ordinate their resources within multiple alternative options, and must keep up to date with the current status of each option. As with breadth-first problem-solving, this reduces the extent to which any one option can be fully elaborated and its resourcing requirements realized and disseminated. The analysis of the casualty transport decision showed the need to disseminate the potential use of the rescue train sooner and more widely. As reported by the ambulance controller, concerning the news that a rescue train had arrived at the site and the realization that ambulances were now needed in Carlisle to ferry casualties to the hospital: 'really quite a bit of shock to us because we had to set off a lot of resources towards the scene, and now they were all coming back this way'.

Part of the difficulty of managing multiple options is likely to be in unambiguously communicating the status of each option. It might have been desirable at Ais Gill, although very difficult in practice, to flag the rescue train option with universally understood labels such as 'preferred', 'no longer under consideration' or 'awaiting confirmation'. This reflects March and Simon's (1958) general point concerning the co-ordinative value of appropriate 'technical languages'.

3. Summary and conclusions

The case study of the Ais Gill railway accident provides a rich account of a single instance of inter-agency co-ordination in disaster management. In this incident, co-ordination difficulties were seen to be associated with a weak reflexive SMM; that is, a weak SMM of the disaster management system itself. This difficulty may be an inherent problem in disaster management because of the flexible and often improvised development of the incident organization (Turner 1994). One particular factor seen to inhibit the development of a reflexive SMM at Ais Gill was the relaying of messages through many agents in the extensive communication network of the disaster management system (figure 2). This relaying of messages obscured the identities of key participants from each other during the distributed decision over the use of a rescue train to transport casualties to hospital. As a consequence of a weak reflexive SMM, the formation of a task-oriented SMM was also inhibited, in that the potential use of the rescue train was not rapidly and widely disseminated throughout the disaster management system.

The casualty transport decision was characterized by a technique identified here as the progression of multiple options, in which many alternative courses of action were implemented and evaluated in parallel. This technique contrasts with both the analytical and recognition-primed models of individual decision-making. While being an effective technique for dealing with uncertainty, the progression of multiple options was seen to create considerable demands for co-ordination. The technique is likely to be common in disaster management, and is possibly therefore a more general contributor to the problem of inter-agency co-ordination.

The case study was carried out to inform the ongoing development of a conceptual framework of inter-agency co-ordination that has not been presented here. Such a framework is needed, however, if the observations reported in this paper, and others, are to be translated into the design of new training approaches (Smith *et al.*, 1999) or other means of improving the practice of disaster management.

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