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Field Research in HCI: A Case Study

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ABSTRACT
This paper presents an example of how different field research techniques were combined to understand the demands placed on the human operator in the complex dynamic environment of an emergency ambulance control centre. Careful selection of techniques can ensure that particular kinds of information are gathered; the order in which techniques are applied can also improve both the quality of data gathered and the efficiency of data collection. This is particularly important when studying complex information systems where the risk of being overwhelmed by data is high. Qualitative and quantitative techniques can profitably be applied together and triangulated to give added confidence to findings.

Keywords
Field research, methods, ambulance control, human-systems interaction

INTRODUCTION
When faced with the study of complex systems involving teams of workers with multiple information systems, the possible approaches to data collection and analysis can be overwhelming. Ambulance control is an example of such a complex system; here, we present and discuss our selection and use of various techniques for understanding the work and the design and use of technological support systems within the team setting. The field study was conducted at the Welsh Ambulance Service Gwent Regional Control Centre, in Mamhilad, Wales. The study involved 13.5 hours of interviews and 34.5 hours of observations using various field research techniques, and 4.5 hours of video recordings of actual events in the control centre. The goal of the research was to understand the nature of ambulance control so that better information displays can be designed to support work in dynamic and complex work domains. However, the focus of this paper is on the selection and use of techniques, rather than on redesign. This is work in progress. In this paper, we describe how five different field research techniques were applied to investigate related aspects of dynamic decision making needs, present some of the initial findings, and discuss the interaction between the methods when conducting field research.

Control centres present demanding challenges for the design of computer systems used to control industrial processes or human activities. Control centres exist because the demands of the task far exceed the capabilities of a single individual. Different members of the team are required to make decisions that coordinate their actions. To coordinate their actions, team members need to share an understanding of the situation. This raises issues of distributed cognition and team decision making [8], situation awareness [1, 6], and non-formal information flows. Identifying how these issues impact on control centre work can contribute to better control systems designs, allowing such workers to respond faster and make fewer mistakes – critical aspects of work in naturalistic decision making environments [10]. Our own studies have shown that ensuring that information presentation is compatible with decision strategies can improve operator decision response times [13].

THE AMBULANCE CONTROL CENTRE
To set the context for this study, we first describe the control centre that is the focus for this work. The ambulance control centre at Mamhilad receives about 350 emergency calls per day (as compared with 3,400 calls a day in London), and is responsible for all ambulance operations in central and south east Wales. This covers a landmass of about 14,000 square kilometres, serving a population of approximately 1.5 million people.

Depending on the time of day, the centre controls between 35 to 46 ambulances at a time. Within the control centre, there are three control desks that mirror the three regions (each manned by an allocator, a dispatcher and a call-taker); a Rapid Response Vehicle desk that controls single-crewed, paramedic vehicles that can travel faster than ambulances to provide initial medical attention; a separate call-taking desk; and the control room manager's desk. All control positions use the same computer system and each monitor can be set up to view ambulance control information specific to each region.

All emergency calls and calls from doctors' surgeries ("doctors' urgents") are generally received by the call taking operators. During high workload periods, calls can also be answered by anyone at any control desk, giving flexibility to resource utilization in the control room. Details of the calls are keyed into the computer system and, based on the region that the call came from, the relevant control desk is notified. At each control desk, the allocator is in charge of the region, and is assisted by a dispatcher. The allocator is responsible for deciding which ambulances are sent to which jobs, and the dispatcher is responsible for communicating with and coordinating the ambulances. During busy times, the allocator often assists in the dispatcher role as well.

Each allocator and dispatcher has on their desk a set of three monitors: a display set up to show vehicle availability, another to show a summary of unallocated and allocated jobs, and a touch-screen display for the radio and landline communications systems. In addition, there is also a computer-based map display that shows ambulance locations in real-time, with a map zoom function that allows the user to view the region at different levels of detail, from whole area down to house-level resolution; this screen is shared by the allocator and dispatcher.

METHODS USED

As noted above, this field research was undertaken to identify and understand the demands faced by the allocators and dispatchers so that systems can be redesigned to improve the allocators' and dispatchers' information handling ability. Information handling activities include the perception and assimilation of information, the consideration and the reasoning about it in a situation, and the communication of that information to others. The methodology involved a combination of different techniques to triangulate our understanding of the nature of the work and its demands. The methods adopted in this study are reported next. The interactions between methods, i.e. how the outcomes from one method direct the application of another method, are described later in the Discussion section.

In-depth Interviews

In-depth, one-to-one interviews were conducted using the Critical Decision Method [7, 14]. This is a retrospective protocol-based, cognitive task analysis approach. Each interviewee was asked to recall and describe a memorable incident. A timeline of the decisions made was created and then used as a framework to probe the interviewee's memory about the information used, attended to, and considered. This technique served two particular purposes; the first was to obtain the interviewees' perspectives on what they do and how they think about their work in detail; the second was to investigate in particular the kinds of critical decisions that cannot readily be studied directly, for reasons of practicality (they do not occur frequently) and safety (staff need to work uninterrupted during such incidents). However, such interviews focus on information of which interviewees are explicitly aware, and do not cover aspects for which their knowledge is semi-tacit or tacit. As discussed by Blandford and Rugg [3], other techniques are needed to elicit such information from users; in this study, these included concurrent video protocols and field observation.

Concurrent video protocol analysis.

A number of video recordings were made of how work at the control desks were actually carried out. In some recordings, the allocator or dispatcher (depending on who was the subject of the recording at the time) was asked to 'think aloud' as they performed some of their routine information handling tasks. They were asked to explain as they worked through an actual task, what information they were searching for, attending to, and their reasoning with that information. The researcher was careful to ensure that this only occurred during relatively quiet periods. During these recordings, verbal cues from the 'think aloud' procedure were used to direct the video camera towards screens that were being worked on or referred to. In this manner, it is possible to trace visual scan and workflow patterns. While there is significantly less detail than one would capture with head-mounted eye-tracking devices, such an approach can provide broad scan patterns, difficulties with use, and effort needed to access information, that can guide the design of the new information displays and their relationships across distributed screens.

Field observations.

Drawing from an ethnographic tradition, field observations are useful for identifying and describing routine behaviours [11], and for identifying where actual behaviour diverges from, or elaborates on, official procedures. Some of these behaviours have significant informational value that is often not identified or articulated during interviews. Detailed observations can also reveal mismatches between the way work is actually carried out and the technology designed to support that work [2]. The researcher must, however, be very directed in his or her observations, lest he or she be overwhelmed by the sheer volume of data that is presented by the situation. Direction or focus of observation can be provided by targeting specific behaviours to observe. In this study, one of the target behaviours was the interactions between an allocator and a dispatcher – in particular, focusing on their nature and frequency. This was conducted at a control desk, and between control desks. All interactions observed were recorded in a three-column table: time of occurrence, allocator actions, and dispatcher actions. Actions were recorded at a task level, eg. "Check through Vehicle Summary, Job Summary and Job Details screens", or "Contact doctor to advise that no ambulance available and that the transfer will be delayed by one hour", rather than at a keystroke level of detail. These actions are necessary to give context to the recorded interactions between the allocator and dispatcher. Such interactions include verbal interactions such as providing each other with updates on the situation, or visual interactions such as leaning over to see if they can help. Some of these actions and interactions are reproduced from actual field notes in Figure 1.

Such data can be analysed to reveal behaviour patterns such as the type and nature of interaction (e.g. a quick discussion to plan ambulance deployment), frequency and durations of the interactions, and the type of technology used during the interaction such as the shared computer-based map display. These are behaviours that contribute to a shared team awareness, so understanding how these interactions occur is crucial for guiding future designs that support team awareness.

Time	Allocator	Dispatcher
1436	Discusses with dispatcher , an incident coming up – shortness of breath	
	Contact a crew to send to new address / location (Panasonic shop)	Dispatcher told allocator some more details while he was on the phone.
1437	Contacted Traffic Control to lower the traffic bollards at the road to allow ambulance access	
1438	Discusses current state of vehicles and jobs with dispatcher	
1440	Steps out	
1441		Monitors 999 call. Checks screens for vehicle and job status
1442	Back in	Checks for an available vehicle, retrieves the job, contacts the ambulance
		Discusses location of incident with allocator using map display.
1443		Speaks with crew
1444	Speaks with Tredegar crew	Speaks with another crew. Sets screen back to job summary.
	Acknowledges a verbal query from Gwent desk on status of arriving vehicle	
1445	Contacts Amb #1081 to check status and to coordinate return to station and where to head next.	Keys in details for a doctor's urgent call
1446	Advises a Rapid Response Vehicle is enroute (since he is in the area) but may need assistance .	Dispatch an ambulance. Advises allocator of action to transport patient from doctor's surgery.

Figure 1. Field notes reproduced from observations about allocator-dispatcher interactions over 10 minutes.

Video recording was not used for the field observations because it is difficult to capture significant interactions that occur outside the narrow field of view of the video camera. Often, events are over before the camera can be directed to it. Furthermore, the video-camera is unable to distinguish between the many on-going conversations and sounds commonly encountered in a control room. Thus, the information collected is likely to be incomplete and difficult to decipher, making it difficult to make sense of the video data during subsequent data analysis. As noted above, video data can be used effectively when there is a narrower focus for the data collection, and then it provides more detail than simple observation.

"Status snapshot"

One particular issue for ambulance control is understanding workers' level of situation awareness. To investigate this, a tailored "status snapshot" technique was applied. The technique we used was based on that of SAGAT, or the Situation Awareness Global Assessment Technique [4] but with a different set of probes. The original SAGAT probes were specific to fighter pilots and addressed factors such as aircraft position, weapon and fuel state. In this study, subjects were asked to report, without looking at their displays, ambulance availability, location of the ambulance (e.g. en-route to a call or at the scene), location of the call that the ambulance was travelling to, nature of task that each ambulance was on (e.g. attending to a three-car accident or baby that has stopped breathing), what jobs are being done, what jobs are outstanding, and what the ambulance's immediate next job might be. A total of six allocators and dispatchers from a on-duty shift of nine allocators and dispatchers were asked to report on the "status snapshot". This provided an indication of situation awareness at Level 2 (understanding of the situation) and Level 3 (ability to project in the immediate future what will or could be happening) [5]. To do this, the allocators and the dispatchers needed to be familiar with what was happening in three broad areas that define a situation: (i) environmental awareness (i.e. what is happening in the environment in which the ambulances operated), (ii) system awareness (i.e. the state in which the information system is in), and (iii) task awareness (i.e. the states of the tasks and their mental job queues) [12]. They were then asked to review what they had reported, and to show to the researcher whether what they reported was correct. The number of correct answers was used as an measure of performance. The allocators and dispatchers surveyed were later asked to describe the conceptual framework they used to remember what ambulances they had and what they were doing.

Performance and Workload Measures

The findings from qualitative data can usefully be related to quantitative measures of overall control centre performance. While field research examines how people actually work in their natural settings, the resulting qualitative descriptions need to be couched within the context of workload levels and performance trends. To help us understand the impact of workload on information handling capacity, and hence the effect on operator performance, we compared the average allocators' and dispatchers' time taken to activate an ambulance and time taken by the ambulances to respond to an emergency call, against the workload as represented by the average total number of emergency calls they were working with, during each hour of the day. Then plotting a trend of this workload analysis over a period of time can yield useful early warning signs about potential problems in information handling capacity of the control centre. These quantitative measures tell us what is happening, but does not explain why those patterns of behaviours were observed – for this, qualitative approaches, as discussed above, are needed.

RESULTS AND OBSERVATIONS

Here, we outline some of the initial and work-in-progress findings, to illustrate the kinds of analysis that can be done using the data-collection methods described above.

Response Times and Workloads

To provide a context for the study, performance reports from 2000-2002 were analysed. One of the measures studied was the average time taken by an allocator or dispatcher to activate or instruct the ambulances to respond to an emergency. These times were compared against workloads over the hours of a day and over a period of time. A study of the average activation times against workload is a useful indicator of the information handling capacity of the control centre. Removing the outliers, the results show that there is no difference in the average activation times under both low (less than ten calls an hour) and high workload (more than 10 calls an hour) conditions. The average activation times is generally within the three minutes limit of acceptable performance (see Figure 2). This suggests that the control centre has the ability to handle sudden increases in information processing, such as the situation encountered during a major incident.

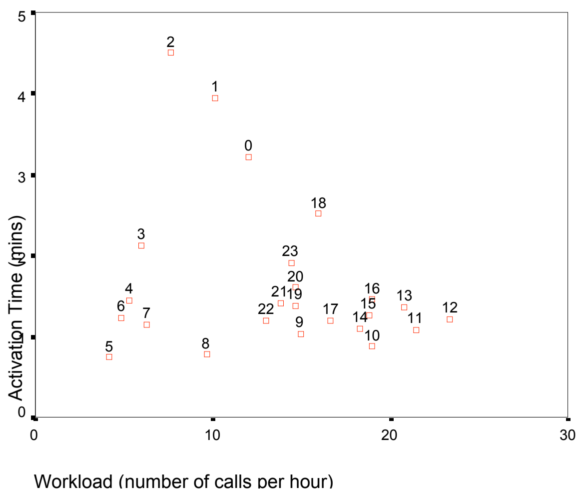

Figure 2. Workload Analysis for July 2002.

Team Interactions.

The nature of awareness and team work between the allocator and dispatcher on the same control desk, and between different control desks, were studied through field observations. We found that there was constant sharing of information about the current state of play. The allocator and dispatcher frequently pushed information to each other, updating each other – especially after periods when they had to work independently. On average, there was one interaction between the allocator and dispatcher at one control desk every 3.5 min (34 within a two hour period). Allocators and dispatchers were observed watching and listening to what each other was doing, pre-empting each others' actions, and carrying out complementary tasks for the other without having the other communicate an instruction or request. Many subtle non-verbal and verbal cues were attended to; for example, the dispatcher observes that the allocator is having to override the gazetteer system, so initiates a search for the address/location on her own and then finds the location on the map display. The fact that the allocator and dispatcher share the map display also helps them to work together to develop a plan for deployment and direction of vehicles, and hence to develop a common awareness of the situation. Non-verbal body language, such as sliding the chair over or watching how a call progresses, are cues that inform them of their partner's actions and intentions. The current open environment affords the ability to easily notice and respond to these cues.

As well as interactions between team members on the same sector desk, there were numerous communications across greater distances within the control room. Interactions between the RRV (Rapid Response Vehicle) desk and the other division desks occurred about one every 7 min (17 interactions over a 2 hour period). Allocators and dispatchers used eye contact, and their ability to listen selectively for problematic cases or other critical cues, to focus attention on specific issues. One example observed was a case where a call taker was talking a caller through the CPR (cardio-pulmonary resuscitation) procedure over the phone, and was therefore looking at the screen containing this information, and could not quickly access their dispatch-related screens; it was not practical to interrupt via intercom, so the allocator used eye contact and said something softly about vehicle availability, e.g. vehicle is on its way, to inform the call taker of actions they have taken that are relevant to the task. We refer to these informal communications as 'soft' communications; they are vital to control room coordination. They are typically taken for granted by control room staff, and are therefore best studied through observation rather than interview.

Awareness.

As noted above, the "status snapshot" technique was used to assess how well the allocators and dispatchers knew what was going on and what would happen next. It was found that the majority had a good awareness and knowledge of what their ambulances were doing, and where they were due to be. The lowest correct score reported for the "status snapshot" was for nine of the 12 ambulances that the allocator was responsible for. This allocator was supervising a trainee allocator and thus did not have a current snapshot of the status. The rest were 100% correctly reported. What this suggests is that awareness needs to be developed and maintained over a period of time. When an allocator or dispatcher has been away for a short period of time, they would have missed or are not aware of changes until they re-build their mental state of play. For experts, this picture can be re-built very quickly by glancing at the vehicle status screen.

2.

Figure 3. Clusters of stations as a framework for remembering ambulances, hand drawn by an allocator.

When asked to describe how they remembered the status of their ambulances, most reported a mental framework that was "… like a picture of a map in their head." eg stations grouped into 3+1 clusters (Figure 3). They then remembered what calls they had given to each ambulance, which stations they were based at, where they were and where they were going to. They would then use the mental framework as an index to "poll" the status of the vehicles.

Usability Issues

Usability problems often arise as a result of mismatches between the technology and the nature of the work. Some of these mismatches were observed in the study, and are described below.

Allocators and dispatchers need displays that allow them to scan and easily see what new jobs have arrived while they are working on other screens. This affects their awareness of the situation and influences their resource allocation decisions. To do this, they currently have to 'flick' between screens, i.e. to rapidly change between screens. For example, the current interface design requires them to exit, say, the call details screen to see summary screens (Vehicle Status and Job summary screens) where new calls are displayed, and when they are working on the call-taking and prioritisation screen, they cannot exit to view the Vehicle Summary or Job Summary screens until they have completed taking the call. To read required details of a call, e.g. medical condition of doctor's urgent calls, allocators and dispatchers have to frequently 'flick' or switch between a overview screen and a details screen. Switching time takes between 4 and 11 seconds. This includes the time to switch, locate and then read the medical condition details, and 'drill down' to another screen if the details are in the patient notes. While it is time consuming to do, allocators and dispatchers have to flick between these screens to maintain an updated awareness of the situation.

Another usability issue is that of the "spill-over" screen. While scanning their displays, allocators and dispatchers may observe the indicator that there are more calls on the ACTIVE Only or the WAITING Only screen. They then have to drill down again to see the additional jobs that cannot be displayed in the space available on the combined summary 'Waiting and Active' screen. Calls can easily be overlooked during busy periods.

As well as maintaining awareness and responding to calls, a large part of the allocator's and dispatcher's task is documenting what had happened and what actions they have taken in an incident they are controlling. This information includes crew reports on a patient's condition, directions to a job from a caller, the patient's symptoms, notes on history, information from the crew to pass to hospital, and anything else pertinent to a job. This takes up a lot of the allocator and dispatcher's attention and time; for example, they often have to find the line number of the job, type in that line number, switch screens, access a notes field, key in details, and so on. Users who are not trained to think about the design of their computer systems cannot present this level of detail in an interview; therefore, this is most appropriately studied through video or field observations.

DISCUSSION

This study set out to develop a better understanding of the nature of work in this domain. In particular, we were interested in describing how shared awareness is maintained and how team decisions are made between the operators in a complex and dynamic environment such as the ambulance control centre so that better, and perhaps novel, interaction and interfaces may be designed. The focus of this paper has been on how different techniques were used to focus on particular issues, and why those techniques were selected.

As discussed above, five different field research techniques were used: the in-depth Critical Decision Method (CDM) interviews to provide detailed descriptions of how decisions were made and hence to identify information needs; the performance and workload measures to give a context to the work; field observations that show how work is actually carried out; status snapshots to assess level of awareness; and concurrent video protocol analysis to identify how the operators interacted with their systems. The techniques were not applied in isolation but, rather, applied as issues emerged through the study, and selected to further probe issues that emerged.

Initial field observations allowed the researchers to familiarize themselves with general work flows and procedures. This allowed a more meaningful discussion to occur during the CDM interviews. In this way, the interview did not have to be interrupted for the interviewee to explain a concept or procedure. During interviews, a concern about the effects of high workloads emerged. Therefore, a performance and workload analysis was conducted to ascertain actual levels of work and their impact on performance, as measured by activation times. The interviewees also suggested a level of coordinated team work arising from a shared awareness between the allocators and dispatchers. This prompted the use of field observations to note how the interactions occurred. Then, during the field observations, it became apparent that some activities such as documenting decisions and actions were taking a lot of the allocators' and dispatchers' time and effort. A more detailed observation study using the concurrent video protocol technique was used to trace the work in order to localize the problems, and will provide data for measurement, eg number of keystrokes or time taken, at a later stage of this study.

Techniques can be integrated in different ways, depending on the purpose of the study. It is common to move from a qualitative study, which gathers detailed information about a few subjects, to a large-scale quantitative study (e.g. based on questionnaires) to check the generality of the findings; however, as shown in the study reported here, there is no single correct pattern for integrating techniques. For example, a broad-brush investigation of activities can be followed up by a focused study – still qualitative – that further probes a particular feature of the larger study.

Field research techniques should not be used in isolation, but collectively to 'triangulate', checking the findings from one approach against those and developing a more complete understanding of the work domain being studied [9]. Then the outcomes from the different field research techniques provide prompts for subsequent investigations, such as identification of real problems to address, and hypotheses for more detailed empirical testing [3].

CONCLUSION

In this paper we have reported on work in progress. In particular we have described how research techniques can be used selectively to study key aspects of human-human and human-computer interactions practiced by ambulance allocators and dispatchers in naturalistic settings. Earlier studies have highlighted the key role that awareness plays in making sound decisions; this study has further investigated the quality of operators' situation awareness and roles for the work systems in helping maintain that awareness. We have also seen how vital 'soft' information channels are for maintaining awareness. From a HCI and workstation design perspective, these 'soft' channels need to be preserved or augmented. We have also seen how the concept of "drill down" can get in the way of the allocators and dispatchers. Future work needs to develop new and alternative interface designs to reduce the number of "clicks and flicks" while helping the operator maintain awareness and visible linkages between summaries and details.

In this paper, we have shown how findings from different techniques can be used together to create useful and fuller descriptions of actual work environments, and to identify requirements on future work systems.

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