What Makes Emergency Ambulance Command and Control Complex?

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Abstract: This paper reports initial findings from a comparative analysis of complexity between two emergency ambulance command and control centers in New Zealand. The two centers studied differ significantly in a number of areas including size, urban-ness of their areas of responsibility, and the dispatch technologies used. An earlier study focusing on the decision making strategies of the ambulance dispatchers in these centers led to the identification of 38 factors thought to contribute to complexity. To examine the effect of these factors, 24 ambulance dispatchers participated in a survey that assessed both the perceived complexity and frequency of occurrence for each factor. Our findings show that despite similarities in the task, many of the process-inherent complexities can be traced back to environmental and technology factors and their interaction. Surprisingly, the perception of complexity in process-inherent factors such as determining the next quickest ambulance appears higher in the control centre with a modern map-based dispatch system, than in the one without. This and other findings raise a number of questions which will be reported here but are still being investigated.

Keywords: complexity, emergency ambulance dispatch, emergency medical dispatch, command and control

Introduction

Emergency ambulance command and control, more formally known as Emergency Medical Dispatch, deals with the receipt of calls for medical emergencies, the medical prioritization of the calls, and the coordination and dispatching of medical assistance to the incident location (Clawson & Dernocoeur, 1998). Superficially, the process appears rather straightforward – answer a call, assess the urgency, locate the quickest available ambulance, and dispatch it – but is it that simple? Regularly, complications arise due to: uncertain, out of sequence or incomplete information; information arriving from different sources, such as multiple calls reporting on the same major accident, that needs integration; having to manage many incidents occurring simultaneously; having to allocate resources between competing incidents and thus having to know where each ambulance is so that decisions can be made about their most effective deployment; all combined with the presence of time pressure. For example, every delay of one minute can reduce the chances of a favorable outcome for a person suffering a heart attack by 10% (National Center for Early Defibrillation, 2002). In addition, (Vicente, 1999) describes several characteristics of complex socio-technical systems that are applicable to ambulance command and control. These include the need for social interaction between distributed system components, heterogeneous perspectives in regards to the goals of workers within the system, the dynamic and hazardous nature of the work environment, and the requirement for a computer interface to act as a window into the state of the system.

This paper reports on our initial findings from a survey to identify the specific factors that contribute to complexity in command and control at two ambulance control centers in New Zealand. We conducted a comparative analysis of the factors in order to identify those that negatively affect dispatch performance. We envisaged that by identifying these factors and by understanding how they affect dispatch performance, we might be able to help design systems that would reduce the complexity, reduce assessment and planning efforts, and therefore accelerate the process of getting medical assistance to people in need.

In an earlier study we used the Critical Decision Method to investigate the nature of decision making in the two control centers. We identified 18 decision strategies invoked by ambulance dispatchers in these two control centers. While this work has been reported in more detail elsewhere (Hayes, Moore, Benwell, & Wong, 2004), an example of one such strategy is described next: Dispatchers try to match the severity of an incident with the skills of a particular ambulance crew. For a priority one call when there are multiple choices of vehicles to send, dispatchers will normally send the vehicles with a crew that will best match the requirements at the scene. However dispatchers are obliged to balance the workload of the crews and this often dictates the dispatch decisions.

Another example of a mental strategy identified in earlier studies of decision making in ambulance dispatching, is the "focus and compare" strategy for locating the next available ambulance resource. We found that the dispatcher combines information about the location of the incident and location of the stations to first determine the set of nearest ambulances. The dispatcher focuses only on those closest and eliminates from consideration those possible but further away, and compares between the candidate stations, spiraling outwards from the closest, and then dispatches the most appropriate based on availability, quickest to scene and crew qualification (Wong, 2000).

Whilst strategies such as the one above are useful in describing how dispatchers make decisions and the difficulties encountered in, for example, how they assess situations, collate information, and make trade-off decisions, they provided little insight into the severity of the problems dispatchers face in carrying out that strategy, and the extent to which such problems occur, and hence their impact on dispatch performance. These problems are often representative of the complexities that underlie the strategies. Therefore in order to appreciate this, we decided to conduct a follow-up study, asking the question of "What makes their dispatching jobs complex and therefore difficult, and to what extent do they occur?" We used the Emergent Themes Analysis, or ETA (Wong & Blandford, 2002) to extract from the decision strategies and observations in the communication centres, 38 factors that were considered to contribute to the complexity of the dispatch task were identified. These factors include the number of possible routes to an accident, traffic congestion, and determining the next quickest ambulance. Using an approach similar to that taken by (Koros, Rocco, Panjwani, Ingurgio, & D'Arcy, 2003) to study complexity in air traffic control, we administered a questionnaire to 24 dispatchers, who collectively represented over 50% of the total ambulance dispatch staff at the two centers. The following sections will provide some background to ambulance dispatching in New Zealand, a description of the methodology, the results and a discussion of those findings, highlighting some interesting issues for further investigation.

Background: Ambulance dispatching in New Zealand

The ambulance dispatchers surveyed in this study are based in Southern Regional Communications Centre (RCC) in Dunedin in the south of the country and the Northern RCC in Auckland in the north.

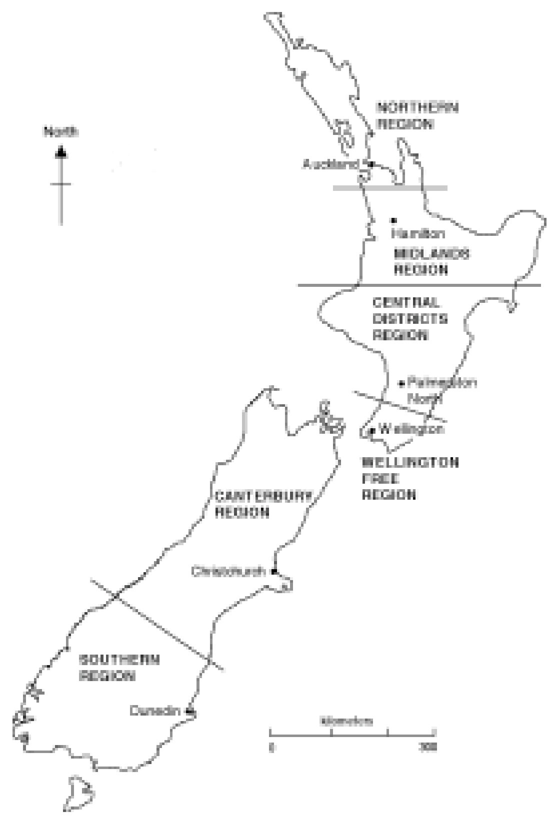

Figure 1 – Ambulance control regions.

The Southern RCC is responsible for a very large geographical area covering a significant part of the South Island of New Zealand. The land area is approximately 54,000 square km and encompasses mountain ranges, lakes and rugged coastline to the west and undulating coastal farming areas to the east. The area has a population of 273,500 people. The towns and cities are generally small and distributed across the region and connected by highways. Travel times between these towns is generally in the vicinity of one hours driving. The Southern RCC controls 48 ambulances, deployed in stations located within the towns and cities. The Southern RCC receives over 20,000 emergency calls a year, and uses an older text-based computer-aided dispatch (CAD) system to record calls, track jobs, and coordinate and dispatch ambulances. While the Advanced Medical Priority Dispatch System or AMPDS, is available, it is not integrated into the CAD system. The AMPDS is a set of medical protocols or structured questions that help a dispatcher determine the severity of a medical emergency. A simpler variant of the AMPDS is currently being used in a manual mode. The Southern RCC was one of the earliest Centers to incorporate computerized systems, but as plans are underway to rationalize the communications centers throughout the country, it has not been upgraded, and will be amalgamated with another communication centre in the near future.

The Northern RCC is based in the North Island city of Auckland, and is responsible for much smaller land area of approximately 21,000 sq km. While the region is hilly and also has a lot of farm land, the main bulk of the over 1.2 million residents in the region live within the main urban area of the city of Auckland. Within the urban areas, the road network is significantly more complex than the rural road network of the Southern RCC. The Northern RCC is responsible for controlling 74 ambulances and responds to over 100,000 emergency calls a year. The Centre is equipped with a newer generation map-based CAD system, which provides a spatial representation of the location of ambulances when they are at their stations, at emergency incidents, or other fixed points. The current system, due to be upgraded, does not incorporate real time vehicle tracking and as such when resources are in transit the dispatchers are not able to immediately determine their location. This Centre also has a computerized version of the AMPDS for prioritization of urgency.

The Dispatch Process: Whilst similar in many regards, there are a number of notable differences in terms of the dispatch process in each centre. This includes the team of dedicated call takers in the Northern centre. When an emergency call arrives in this centre it is usually answered by any one of a number of call takers. It is the job of the call taker to get the details from the caller regarding the incident. This is in the first instance the location of the incident and the condition of the patient so as the response priority can be determined. When this information has been entered into the CAD system, the job appears on the screen of the dispatcher responsible for the specific area within the region. They are then able to allocate resources to this incident. In many instances this information alone is not sufficient to make a dispatch decision and the dispatcher is able to view additional details about the incident as they are entered by the call taker and/or listen in as the call taker gathers additional details from the caller about the incident. In comparison the Southern centre does not have a team of call takers and instead the dispatchers work in unison. One dispatcher plays the role of the call taker and therefore collects details from the caller similar to those taken in the Northern centre, recording details such as location and patient injuries, followed by additional information such as telephone number, caller name, whilst the other dispatcher works in parallel to assess the resource situation and determine which resource is best suited to the needs of the patient.

In both centers, at the same time as making dispatch decisions – which ambulance is the nearest available? which ambulance is the next quickest? where are the ambulances in transit and returning that could be quicker to send? – the dispatcher will also be managing additional incidents and resources to provide the best level of ambulance coverage across the region. Gaps in coverage, or areas with poor ambulance coverage, are to be avoided as they will increase response times to callers within those gaps. The call taker (or dispatcher taking the call) can also end up engaged with the caller for a considerable amount of time. For instance, call takers and dispatchers have been known to keep in communication with distraught callers until the ambulance arrives, or to provide "telephone CPR" (instructions over the telephone to the caller on how to perform cardio-pulmonary resuscitation).

Dispatchers also often have to deal with multiple calls to the same incident, e.g. major crash on a highway, where each caller reports variations and the dispatcher has to determine if the many calls are for the same incident. Often during periods of high workload, the dispatchers have to deal with many simultaneous incidents with varying levels of urgency and size, in different parts of the region. Effective management of the situation will require a good awareness of many factors (Blandford & Wong, 2004), including knowledge of the jobs and their locations, the road network, traffic conditions, tracking the whereabouts of ambulances, intentions and planned next activities of each ambulance, e.g. upon completion of a job, ambulance A could be planned to be sent to job B. Such intentions are often not recorded in the system until it actually happens, as re-planning occurs quite frequently due to changing situations.

Collectively, all this makes the dispatch process difficult. In this study, we wanted to find out what these factors are and to what extent they contribute to dispatch task complexity.

Methodology

We conducted a questionnaire survey of 24 emergency ambulance dispatchers. 10 from the Southern centre and 14 from the Northern centre. This represents a sample size that is in excess of half the total number of dispatchers at the two Centers. In addition to collecting demographic data such as age, sex and experience in control, participants in the survey were asked to rate 38 factors thought to contribute to complexity in emergency ambulance command and control. Participants rated each factor on a 5-point Likert scale, assessing the factor's perceived contribution to complexity, and the frequency with which that factor was thought to have occurred. There were additional spaces for the participant to include other factors not in the list. The questionnaire approach was selected instead of other measures such as NASA TLX (Hart & Staveland, 1988), as while well established, the TLX is principally used to measure perceived mental workload, rather than to estimate the effect and frequency that a set of factors has on task complexity. Furthermore, one of the 38 factors considered to contribute to complexity was workload, and measuring workload only would not be representative.

A series of ANOVA (analysis of variance) tests were conducted on the data from the returned questionnaires using SPSS, a statistical analysis software. We tested the data for differences in the Complexity, C, and Frequency, F, scores between the Centers. We also used a measure similar to Koros, et al (2003), called the Complexity Index (CI) where CI = C + F, to reflect each factors overall Complexity and Frequency scores, which was then tested for differences between centers. The CI was a convenient measure as it made it possible to easily compare factors that are say, high on complexity and high on frequency, with factors that are high on complexity but low on frequency. CI was also tested for differences between the two Centers. The next section will present some of the results.

Results

An ANOVA procedure was conducted on the data to determine if there were significant differences between what dispatchers at each Centre considered to contribute to task complexity, the frequency with which they occurred, and on CI. The results of the ANOVA procedure of the CI of the 38 variables are presented in Tables 1, 2 and 3. They have been organized according to three bands of complexity. Band 1 which we will call High Complexity factors, shows those factors where the CI is greater than 7.0; Band 2 Moderate Complexity, where CI scores are greater than 6.0 and less than 7.0; and Band 3, Low Complexity, where CI scores are less than 6.0.

In addition, the factors have been categorized into several groupings. These categories are listed and explained below.

a. <u>Ambulance factors</u> refer to the factors that relate to the ambulance dispatch process such as identifying the vehicle that can be expected to arrive at the scene the fastest, identifying the next quickest, and locating vehicles that are in transit.
b. <u>Crew factors</u> refer to keeping track of the ambulance crews, their workloads, planning for breaks, and their suitability for an incident in terms of skill levels.
c. <u>Incident factors</u> relate to factors like awareness of the location and what is happening with each incident and therefore being able to anticipate and cater for future needs. Also ensuring adequate resources have been dispatched fits within this category.
d. <u>Patient factors</u> include determining and prioritizing the medical conditions of the patients.
e. <u>Geography factors</u> refer to the nature of the terrain in which the ambulances operate, and includes access to incident scenes, dispatch alternatives, familiarity of the area, and traffic congestion.
f. <u>Equipment factors</u> relate to the systems in use in general, e.g. radio dead spots and hence the likelihood of non-responses to radio calls when an ambulance is in an area, or malfunctioning systems.

Table 1 – Band 1 High Complexity CI > 7.0 for each Centre.

Category	Southern RCC	CI	Northern RCC	CI	Mean	F	Sig.
General Factors	05. High workload	7.2	05. High workload	8.15	7.74	2.283	0.146
	36. Managing patient transfers	7	36. Managing patient transfers	7.62	7.36	0.706	0.411
			08. Time pressure	7.69	7.22	1.99	0.173
			06. Unpredictability of future events	7.25	6.95	0.376	0.547
Ambulance Factors			18. Quickest vehicle†	7.54	6.87	3.836	0.064
			19. Quickest Additional vehicles*	7.31	6.7	4.383	0.049
			28. Location of resources in transit*	8	6.57	12.913	0.002
	24. Determining next available resource	7.5	24. Determining next available resource	7.77	7.65	0.184	0.672
			27. Providing coverage*	7.69	5.32	42.821	0
Crew Factors			20. Matching crew to incident	7.15	6.78	1.357	0.257
			26. Determining crew status	7.54	6.87	3.148	0.091
			29. Managing crew workload	7.46	7.09	0.749	0.397
Incident Factors	12. Uncertain location	7.4	12. Uncertain location	7.23	7.3	0.07	0.794
	16. Determining priority*	7.9					
	17. Incident awareness	7.8					
	25. Ensuring required resources at incident	7					
Policy/Orgn Factors	09. Different resource allocation procedures for diff areas	7.5					

g. <u>Policy and Organizational factors</u> refer to how work needs to be done and includes the use of different terminology when dealing with different services e.g. police and fire, or different procedures for handling dangerous situations, e.g. dealing with patients at a domestic dispute versus dealing with patients at a chemical spill.

Table 1 Band 1 High Complexity (CI > 7.0) shows that for those factors considered to contribute significantly to complexity, i.e. high complexity and high frequency, dispatchers in the more urban Auckland centre have identified 13 factors as compared to the eight factors identified by dispatchers in the more rural Southern RCC. There are only four factors common to both Centers at this level. These were high workload, uncertain location, determining the next available resource, and managing patient transfers. ANOVA tests show no significant differences in these factors between Centers.

However ANOVA tests on another four factors within this band showed differences that were significant (p<0.05). These factors were determining priority for the Southern RCC dispatchers; and identifying the quickest additional vehicles, providing coverage, and locating ambulances in transit for the dispatchers at the Northern RCC.

The dispatchers at the Northern RCC also found their work further complicated by the unpredictability of future events, time pressure, identifying the quickest ambulance, matching an appropriate crew to an incident, and managing crew workload.

Table 2 – Band 2 Moderate Complexity 6.0 < CI < 7.0 for each Centre.

Category	Southern RCC	CI	Northern RCC	CI	Mean	F	Sig.
General Factors	07. Rate of change	6.78	07. Rate of change	6.62	6.68	0.023	0.882
	06. Unpredictability of future events	6.6					
	08. Time pressure	6.6					
			14. Information collation*	6.85	6.39	5.136	0.034
	35. Fatigue	6.5	35. Fatigue	6.38	6.43	0.016	0.9
Ambulance Factors	18. Quickest vehicle†	6					
Crew Factors	29. Managing crew workload	6.6					
	20. Matching crew to incident	6.3					
	26. Determining crew status	6					
Incident Factors			17. Incident awareness	6.69	7.17	2.012	0.171
			25. Ensuring required resources at incident	6.62	6.78	0.297	0.591
Patient Factors	15. Not talking with caller	6.4	15. Not talking with caller	6.77	6.61	0.466	0.502
	13. Uncertain patient condition	6.3	13. Uncertain patient condition	6.67	6.5	0.241	0.629
Geography Factors	04. Limited access†	6.2	23. Low number of dispatch alternatives	6.23	5.74	1.341	0.26
			02. Traffic congestion*	6.23	5.45	5.153	0.034
	21. Unfamiliar with area	6.2	21. Unfamiliar with area	6.15	6.17	0.008	0.929
Equipment Factors	37. Other distractions	6.5	37. Other distractions	6	6.23	0.387	0.541
			30. Radio dead spots	6.69	6.35	1.563	0.225
			31. Equipment malfunctions*	6.15	5.74	4.636	0.043
Policy/Orgn Factors	34. Different terminology between services†	6					
	10. Different response procedures for diff incident types	6.7	10. Different response procedures for diff incident types	6.85	6.78	0.037	0.849
			09. Different resource allocation procedures for diff areas	6.77	7.09	0.765	0.392

Table 2 Band 2Moderate Complexity (6.0 < CI < 7.0) shows those complexity factors that had a CI score of between 6.0 and 7.0. This CI indicates that these factors are less significant contributors to complexity, suggesting moderate complexity and moderate frequency ratings. Although the factors are different, there are approximately equal numbers of factors cited by both Southern and the Auckland RCCs. Dispatchers in the Southern RCC identified 15 factors while their Auckland counterparts identified 14 factors in this band, of which only six factors are common. Both groups felt that the rate of change or the tempo of events, the need for different procedures for different incident types, uncertainty in patient's condition, not being able to speak directly to the caller (when one is not taking the call), unfamiliarity with the area, fatigue and other distractions, contribute to complexity.

Other factors that were significantly different ($p<0.05$) were traffic congestion that was more likely to be experienced in the urban Auckland areas than in the more rural Southern region, the need to collate more information from more sources, and the apparently more consequences from equipment malfunctions in the Northern region. Dispatchers in the Southern centre rated unpredictability of future events, time pressure, determining the quickest ambulance, matching the appropriate crews to incidents, determining crew status, managing crew workload, and different terminology between services as other factors that contributed to complexity within this band.

Table 3 – Band 3 Low Complexity CI < 6.0 for each Centre.

Category	Southern RCC	CI	Northern RCC	CI	Mean	F	Sig.
General Factors	11. Low workload*	4.6	11. Low workload*	2.69	3.52	5.072	0.035
	14. Information collation*	5.8					
Ambulance Factors	19. Quickest Additional vehicles*	5.9					
	28. Location of resources in transit*	4.7					
	27. Providing coverage*	1.89					
Incident Factors			16. Determining priority*	5.77	6.7	4.521	0.046
Geography Factors	01. Road works/road conditions	5.3	01. Road works/road conditions	5	5.13	0.197	0.661
	03. Number of possible routes	4.6	03. Number of possible routes	5.17	4.91	0.7	0.413
			04. Limited access†	5	5.55	3.967	0.06
	02. Traffic congestion*	4.33					
	23. Low number of dispatch alternatives	5.1					
	22. High number of dispatch alternatives	4.56	22. High number of dispatch alternatives	5.31	5	1.02	0.325
Equipment Factors	30. Radio dead spots	5.9					
	32. Equipment distractions	5.8	32. Equipment distractions	4.23	4.91	2.868	0.105
	31. Equipment malfunctions*	5.2					
Policy/Orgn Factors	33. Joint responses with other regions	5.63	33. Joint responses with other regions	4.77	5.1	1.715	0.206
			34. Different terminology between services†	4.38	5.09	3.557	0.073
	38. Training exercises	4.3	38. Training exercises	3.85	4.04	0.472	0.5

Table 3 Band 3 Low Complexity (CI < 6.0). Dispatchers in the Southern RCC rated 15 factors as not contributing significantly to complexity, in comparison with 10 identified by their Northern counterparts. Of these, the following seven factors are common: low workload, road conditions, number of possible routes, having high number of dispatch alternatives (since it does not occur frequently as limited resources often limit the options available), equipment distractions such as poor interfaces, joint responses with other regions, and training exercises.

What is interesting is that the ambulance factors – identifying the quickest additional ambulances, locating ambulances in transit and providing coverage – were identified in this low significance band by the Southern dispatchers. In contrast, the Northern dispatchers ranked these factors as the among the highest contributors to complexity. While traffic congestion was highlighted as a high contributor by the Northern dispatchers, it is a low factor in the south. Determining the medical priority of emergency calls is a low contributor in the North as they do have a system, called ProQA, that automates the prioritization decisions.

Discussion

What do the results tell us? In this section, we will discuss some of the differences between the two Centers and the lessons that we can learn from them.

Partial solutions can add significantly to complexity. We mentioned earlier that the Northern Centre has a map-based CAD system which, graphically shows on the computer-generated map of the region, the location of the ambulances and the location of the emergency calls. We also mentioned that, due to a variety of reasons, the system only tracks the position of the vehicles at fixed points and not in transit. Our survey suggests that such partial implementations of systems can make the task more difficult than is necessary. Locating the quickest additional vehicles, determining which ambulances are likely to be available next, locating ambulances in transit, and providing coverage, are rated as high contributors to complexity by the Northern dispatchers. In contrast, the Southern dispatchers who do not have a computerized map-based CAD system, do not consider this aspect of the dispatch task a significant factor. Similarly, crew management – planning their workload, determining crew status – is also not a significant problem for the Southern dispatchers, but does present some challenges to the Northern dispatchers.

On the other hand, what the Southern dispatchers found complex was maintaining incident awareness. Being able to understand the nature of the emergencies and having a current awareness of the situation allows the dispatcher to anticipate the need for additional resources (Blandford & Wong, 2004). Without the computerised map-based CAD system, the Southern dispatchers appear to be able to focus on managing the incidents, a key aspect of dispatch work, which they find represents the greatest source of complexity for them. Knowing where their ambulances are, keeping track of their movements, estimating which will be the next quickest to an incident, are not significant issues to the Southern dispatchers who have to maintain this mental picture of the situation (Blandford and Wong 2004) in their heads. Whereas the Northern dispatchers who have only part of this task supported by the computer, find that the they have to focus significant effort to developing and maintaining that mental picture of both the vehicle and crew situation.

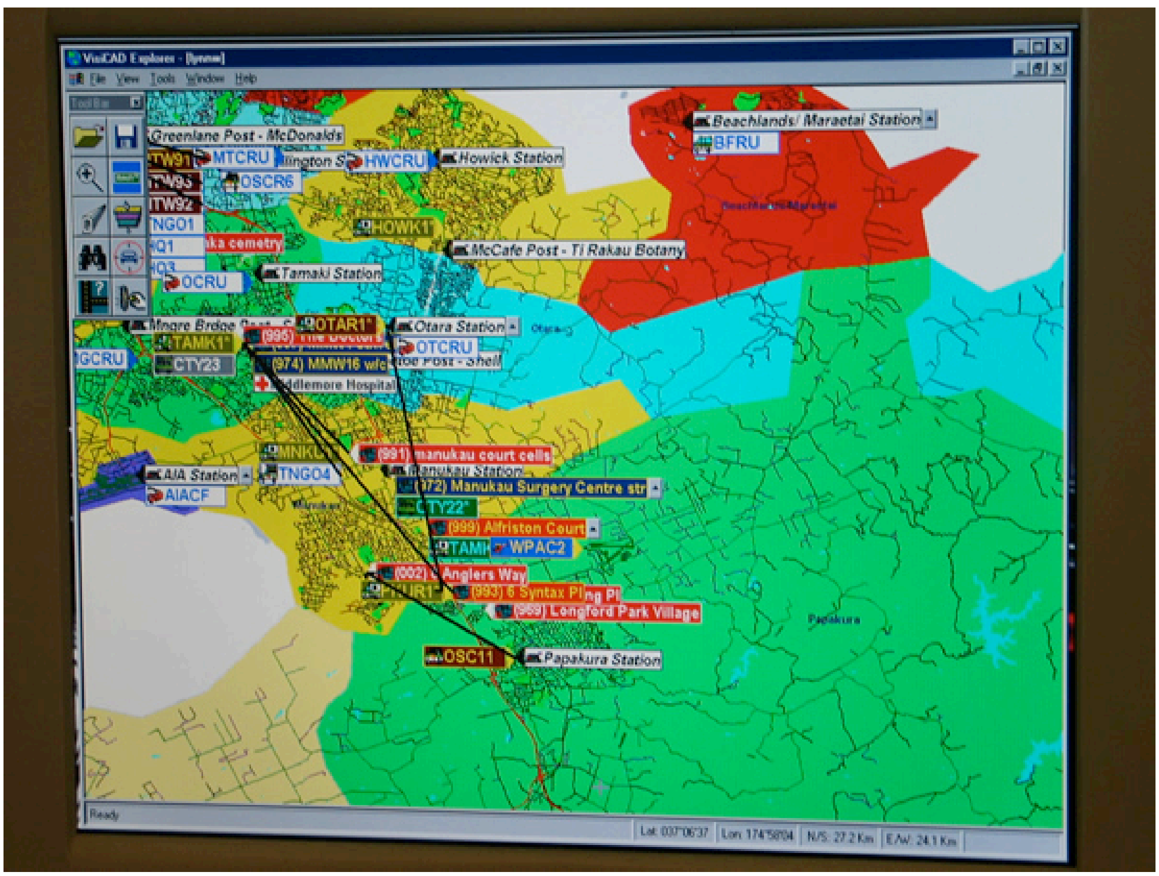

Figure 1 – Photograph of map-based CAD display in use in the Northern centre.

Figure 1 shows a photograph of the computer map-based CAD screen in use. The screen shows allocated and un-allocated jobs, ambulance stations, hospitals and standby points, and ambulances that have been assigned to a job, are on station, or at an incident. The straight black lines are used to show the job that an ambulance has been allocated or the destination of that ambulance. The display appears to suffer from the data overload problems of visual clutter leading to workload bottlenecks of the kind described by (Woods, Patterson, & Roth, 2002). The high rating of complexity in controlling the ambulances and crew, represents complexities that are imposed as a result of mismatches in the implementation of technology, rather than due to the inherent complexities in the dispatch task.

Interaction between workload, technology and task-environment characteristics. Workload is also a serious contributor to complexity. Its effects on complexity are due to having more parallel activities to co-ordinate, i.e. more simultaneous emergency calls to attend, more trade-offs to make within a given time, less time to give to each decision and activity. Under the same workload conditions as the dispatchers in the Southern centre the Northern dispatchers may be better able to manage their resources. Therefore it is perhaps not the partial technology solution alone that results in complexity but rather the interaction between the partial technology solution within the context of the characteristics of the Northern region, such as a 'tighter' road network and higher volume of jobs requiring, but the technology not providing an adequate level of support to the dispatchers to keep track of the resources. While the need to consider the human, task and environment in designing systems is not novel (Bailey, 1996), in isolation the factors may be manageable, but placed in context of each, these problems often multiply. More significantly, it can divert the attention from the prime task of managing incidents and the situation, forcing the dispatcher to attend more to the basics of the task, tracking vehicles and crew resources. Other aspects of the dispatch planning process that interact with the above are the planning and re-planning processes which result in many intermediate outputs, such as intentions to send ambulance A upon completion of job 1, to job 2 instead of returning to station. The firming up of such a decision may be dependent on other conditions becoming certain. In some ambulance centers, such fluid intermediate planning is catered for by dispatchers simply writing notes or placing the printed emergency call tickets in a particular semantically meaningful spatial arrangement on the desk. Such arrangements are easy enough to change, yet crucial for planning and tracking of very fluid situations (Wong & Blandford, 2004), but needs to be catered for in systems design. Their omission will lead to similar problems highlighted above.

Separating the roles can reduce complexity. Both Centers indicated that managing non-emergency patient transfers as one of their greatest sources of complexities. Managing patient transfer refer to the dispatching of usually single-crewed ambulances to ferry patients between hospitals or hospitals and home. The ambulances are largely drawn from the same fleet of vehicles used for emergency call-outs. Dispatchers have to balance off the need to ferry patients against unpredictable emergency calls. These are two very distinct roles which have very different time constraints. For emergency calls, ambulances need to arrive at the scene within eight minutes of the call in urban areas. Whereas for patient transfers, the time horizon is much longer at two hours. There are also staffing and vehicle equipment differences. Paramedic qualified staff would not be needed to ferry patients between hospitals. If for organizational or economic reasons, the patient transfers has to be managed by the same dispatchers, one solution is to segregate the information in a way that reflects the two roles. New representation design techniques being developed – information layering and segregation (Nees, Joyekurun, Villanueva, Amaldi, & Wong, 2005) using novel multi-layered display technology – could segregate the information regarding the two roles in separate and overlapping layers, but within the same visual field of view, so that when needed, an overall and integrated situation picture of the two roles can be presented.

Conclusion

This study has identified 38 factors that are thought to contribute to task complexity in emergency ambulance command and control. It has also provided a quantitative basis on which to assess the extent that the factors contribute complexity in ambulance command and control. What have we learnt? It provided a comparison of the level of complexities between the different regions, suggesting that the support systems might need to be configured differently to accommodate regional differences. We have also seen how factors can interact to create complexities which may not be apparent by themselves. Finally, we also discussed that if multiple roles cannot be separated, then, while yet to be tested, perhaps how new display techniques and technology can be used to segregate the information about them, providing the system designers another avenue for addressing the complexities of the situation.

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