PERFORMANCE MODELLING IN THE DOMAIN OF EMERGENCY MANAGEMENT

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The Emergency Management Combined Response System (EMCRS) is the co-ordination system which plans and controls, agencies, such as fire and police, when they respond to major emergencies. An initial combined agency (CA) model of the EMCRS describes its overall 'actual' performance, as concerns its plans. This model supports the diagnosis of co-ordination problems between agencies. However, at present, it fails to take individual agency plans into account. This paper describes an attempt to improve diagnosis of co-ordination problems by decomposing the EMCRS into its parts and modelling each individually, with respect to their plans. The CA model is then used, with individual agency models, to re-interpret overall EMCRS performance. It is concluded that EMCRS decomposition supports more accurate diagnosis of the effect of the co-ordination problems on its overall performance.

Introduction

This paper presents work intended to develop a model to diagnose the ineffective planning and control performance of the EMCRS, as occasioned by co-ordination problems between the Police, Fire, and Ambulance emergency service agencies. Section 1 describes the EMCRS and the initial CA model thereof. The need is identified to decompose the system into its parts and to model each individually. Section 2 outlines the single agency model for the fire agency, with respect to an example co-ordination problem. Section 3 relates the CA model to the single agency model. This relationship provides a more accurate expression of EMCRS overall planning and control performance, and so more accurate diagnosis of the effect of the co-ordination problems. Section 4 presents a summary of the work and future plans.

EMCRS and the Initial CA model

The EMCRS is composed of agencies required for a disaster response, and has a three level planning and control structure. The EMCRS has objectives (plans), common to all agencies, whatever their individual responsibilities. These objectives are (in descending priority): to save life; to prevent escalation of the disaster; to relieve suffering; to safeguard the environment; to protect property; to facilitate criminal investigation and judicial, public, technical or other inquiries; and to restore normality as soon as possible (Home Office, 1994). The EMCRS was set up to support better co-ordination between agencies responding to disasters, such as explosions, aircrashes etc.. The individual agencies relate their own plans by means of those of the EMCRS, to interact effectively with each other. Each agency plan specifies a set of functions, for example: fire service - rescuing trapped casualties; preventing escalation of the disaster; etc..

An initial CA model of EMCRS planning and control has been developed elsewhere (Hill and Long, 1996) from the Planning and Control for Multiple task work (PCMT) framework (Smith *et al* 1997), and data from an EMCRS training exercise. This model distinguishes the interactive worksystem (here the EMCRS, comprising one or more users and computers/ devices/equipment), from its domain of application, constituting its work (that is stabilising a disaster). The effectiveness (performance) with which work is carried out, is a function of: the quality of the task (i.e. whether the goals have been achieved), and the resource costs to the worksystem (i.e. the effort etc. required to achieve the work goals) (Dowell and Long, 1989). Overall EMCRS performance thus expresses whether goals, e.g. preventing escalation of the disaster, have been achieved.

The CA model has been used to describe tasks carried out by the combined response system, in terms of the planning, control, perception and execution behaviours and the transformations these behaviours perform in the domain see Figure 1. (A complete description of the behaviours and the domain object transformations for the EMCRS tasks can be found elsewhere (Hill and Long, 1995)). These descriptions have been used to identify planning and control co-ordination problems between agencies, by identifying 'conflict' behaviours. These conflicts constitute the 'co-ordination problem'. A behaviour conflict may reduce overall EMCRS performance by either hindering goal achievement, for example, reducing life saving capabilities, and/or by rendering resource costs un-acceptable, for example, requiring extra personnel, that are not available. However, defining accurately effects of these problems is difficult, due to trade-offs between individual agencies' performances. For example, the police service wish to preserve the disaster site as a 'crime scene' (vandalism is suspected), and to catch the criminals, and so require the fire service not to trample the site; and the fire service, who slow the rescue of casualties, and are less effective in fire prevention, if they do not trample the site. The CA model describes the 'actual' overall CA performance with respect to EMCRS common objectives. The co-ordination problems identified thus do not take account of the performance trade-offs between agencies. For the above example, the CA model describes an overall EMCRS performance deficit which derives from the police and fire services. Trampling by the fire service reduces the chances of the vandals being caught. Carrying out minimal trampling reduces rescue of casualties and control of the fire. These overall deficits derive from the common objectives, i.e. to save life (casualties not rescued); prevent escalation of disaster; (fire not controlled); and to facilitate criminal investigation (vandals not caught).

However, each agency has its own disaster plan. These plans describe agency functions/tasks and their priorities. To express accurately overall EMCRS performance, account must be taken of these plans. For example, the fire service plan states: 'Investigation work will not take precedence over the necessity to rescue casualties, fight fires, or the protection of lives and property from fire or further deterioration. Every effort must be made by the Fire and Rescue Commander to preserve the scene intact.' (Chief and Assistant Chief Fire Officers' Association, 1994). Thus, the fire service should keep their trampling to a minimum, to preserve other fire service behaviours. Thus, for this co-ordination problem, there is no fire service performance deficit, as the actual performance effected by minimal trampling, is equal to the planned performance, which allows effects of minimal trampling. Thus, although there is still a police service performance deficit (minimal trampling still reduces vandal apprehension), the overall EMCRS performance deficit is less than was identified by the CA model.

There is a need, therefore, to decompose the EMCRS into its parts and each agency to be modelled individually with respect to its plans. These single agency (SA) models describe planned individual agency performance with respect to CA actual performance, that is, overall EMCRS actual performance. The CA model can then be re-interpreted with the help of the SA models, to diagnose more effectively overall EMCRS performance, as concerns planning and control co-ordination problems.

Single Agency Models

SA models have been developed for the fire, police and ambulance agencies. They describe 'planned' performance of an individual agency with respect to the CA 'actual' performance. The data are a subset of the CA data. Six training exercise behaviour conflicts have been identified as co-ordination problems. The models describe only planned performance, as it relates to behaviour conflicts and their effects. Only one behaviour conflict is described here, involving fire and police and ambulance services, due to space limitations.

Behaviour Conflict: Trampling
The police declare the site a 'crime scene', because there is some suggestion of vandalism. The fire service and the ambulance service are thus expected not to trample what might be evidence. The CA model describes 'actual' behaviours of the fire and ambulance services as minimal trampling, without affecting their other behaviours (and so the associated performance). For the fire service performance is: expeditious rescue of casualties, and effective fire containment; and for the ambulance service performance is: expeditious casualty access and subsequent transferral to hospital. The fire service SA model shows that actual performance (P_A) is equal to planned performance (P_P), as their plan specifies that minimal trampling may be carried out, but should not hinder rescue or other fire service behaviours. Such behaviours are not hindered, hence $P_A = P_P$. In contrast, for the ambulance service $P_A < P_P$. Their plan does not mention trampling, so minimal trampling reduces their performance to less expeditious casualty access and transferral to hospital.

Relating the Models

The initial CA model describes CA P_A < CA Pp, as a performance deficit is identified for both police and fire services; and police and ambulance services. The overall performance deficit can be re-interpreted using the SA models as follows:

Trampling (fire service)
If SA1 P_A = Pp and SA2 P_A < P_P,

then CA P_A < CA (SA) Pp
and (CA P_A < CA (SA) Pp) < (CA P_A < CA Pp)
If the fire service (SA1) actual performance equals its planned performance (their trampling behaviours not reducing their effective fire containment and casualty rescue), but the police service (SA2) actual performance is less than its planned performance (their crime scene preservation behaviours hindered by fire service trampling, which reduce their effective vandal apprehension), then CA actual performance (CA P_A) is less than the CA planned performance, given SA planned performance (CA (SA) Pp). However, the performance deficit (CA P_A < CA (SA) Pp) from the CA (SA) model is less than the performance deficit (CA P_A < CA Pp) of the CA model (the CA (SA) model identifies only the police service as having a performance deficit). Thus, the overall EMCRS performance deficit is less than originally identified by the CA model above.

Trampling (ambulance service)
If SA1 P_A< Pp and SA2 P_A < P_P,

then CA P_A < CA (SA) Pp
and (CA P_A < CA (SA) Pp) = (CA P_A < CA Pp)
If the ambulance service (SA1) actual performance is less than its planned performance (their trampling behaviours reduce expeditious casualty access and recovery), and the police service (SA2) actual performance is less than its planned performance (their crime scene preservation behaviours hindered by ambulance service trampling, reducing their effective vandal apprehension), then CA actual performance (CA P_A) is less than the CA planned performance, given SA performance (CA (SA) Pp). The performance deficit (CA P_A < CA (SA) Pp) of the CA (SA) model is equal to the performance deficit (CA P_A < CA Pp) of the CA model. A deficit occurs for both the police and the ambulance services. Thus, the overall EMCRS performance deficit, identified by the CA model, in this instance, is accurate. However, the ambulance service SA model has identified that trampling behaviour is not specified in their plan. Were trampling behaviour to be specified, as in the fire service plan, then their performance would not be in deficit.

Summary and Future Work

This paper has described an attempt to improve the diagnosis of overall EMCRS performance by decomposing the system into its individual parts (agencies) and modelling

each, with respect to their agency plans. It is concluded that EMCRS decomposition supports more accurate diagnosis of the effect of the co-ordination problems on overall EMCRS performance. Future work will acquire additional data to validate further this modelling and decomposition technique.

References

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