HCI'97

Title of submission: Issues with Modelling a Complex Dynamic Planning and Control system

Category of submission: Short paper

Contact details for the authors:

Address:

Ergonomics & HCI Unit,
University College London
26 Bedford Way, London
WC1H 0AP UK.

Telephone:

Becky Hill +44-171-387-7050 ext. 5312
John Long +44-171-387-7050 ext. 7557

Fax:

+44-171-580-1100

E-mail:

b.hill@ucl.ac.uk
j.long@ucl.ac.uk

Contact person for the submission:

Becky Hill

Issues with Modelling a Complex Dynamic Planning and Control system

Becky Hill and John Long

Ergonomics & HCI Unit, University College London
26 Bedford Way, London
WC1H 0AP

ABSTRACT
This paper raises a number of issues, identified by research attempting to model a complex dynamic planning and control system. The system of concern is the Emergency Management Combined Response system, which is set up to manage disasters. A preliminary model was derived by applying a framework for modelling planning and control in multiple task work to data from an emergency management training scenario. The issues raised by the current model are how to represent: a changing worksystem; a system with more than one level of operation, and with interactions between the levels; system performance with trade-offs between different parts of the system. These issues are considered common to modelling such complex systems. The issues are described and generalised. Ways forward to address the issues are proposed.

KEYWORDS
Emergency management; planning and control.

INTRODUCTION
This paper outlines the preliminary model of the Emergency Management Combined Response (EMCR) worksystem, based on a framework for modelling planning and control of multiple task work (PCMT) (Smith, Hill, Long and Whitefield, in press), and describes and generalises issues that the model raises.

PCMT-EMCR MODEL
The EMCR domain is conceptualised as having a single **disaster object** comprising other abstract objects, such as **lives**, **property** etc. The work carried out by the EMCR worksystem is the transformation of a 'disaster object's' attribute values, by manipulation of the values of the attributes of the sub-objects of the domain. The model of the EMCR worksystem identifies the cognitive structures of the PCMT framework. These structures comprise four processes (**planning, controlling, perceiving and executing)**, and two representational structures (**plans** and **knowledge-of-tasks**).

USE OF THE MODEL
The 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. These descriptions help to identify potential conflicts within the combined response system behaviours, and so highlight co-ordination problems that affect performance. They also identify the issues related to using the PCMT framework for modelling EMCR, which will be discussed later.

Due to space limitations, a complete description of the behaviours and the domain object transformations for these tasks are not described, two tasks are outlined to show how the model can be used, and to identify issues raised by its use (for a complete description of these tasks see Hill and Long 1995).
Two tasks carried out during the training scenario were the fire service task of setting up an inner safety cordon around the disaster scene, and the ambulance service task of locating and transporting casualties to hospital. These two tasks have a conflict of behaviours between the two agencies. Once the inner cordon has been set up, it is the fire service's responsibility to maintain the safety of everyone within the inner cordon, which entails excluding anyone unprotected by the regulation safety equipment. In the training scenario, the ambulance service arrive at the scene without the regulation safety equipment, and so are not allowed to enter the inner cordon. As a result, the ambulance personnel cannot carry out their execution behaviours of transporting casualties. They cannot transform the abstract 'lives object' attributes, and consequently, cannot transform the 'disaster object' to a more desired level of stability. So, the fire service behaviours of containing the scene conflict with the ambulance service behaviours which results in a co-ordination problem, affecting performance. The primary objective of EMCR is to save life. In order to increase the desired level of stability of the 'disaster object', the 'lives object' attribute values need to be changed. Hence, the fire service needs to carry out rescue execution behaviours to move the survivors to the edge of the inner cordon, so that the ambulance service can carry out their execution behaviours, so increasing stability. However, the fire service, carrying out rescue execution behaviours, decrease the resources available for carrying out the execution behaviours of controlling the hazard, so decreasing the effectiveness of the response to the secondary objective of preventing escalation of disaster. Thus, there is a knock-on effect, with the conflicting behaviours resulting in ineffective co-ordination and reducing the performance of the system. As the disaster progresses, more resources are required to bring the disaster under control, so as time progresses the number of structures within the EMCR worksystem increase. In this example, there is interaction between the different levels of the EMCR within an agency, in that the tactical officers for an agency allocate resources and specify the plans carried out by the operational personnel. The tactical officers do not carry out execution behaviours directly. The information about the state of the domain is 'perceived' by means of the operational commanders and passed to the tactical officers. The tactical officers, thus, do not perceive the domain directly either. Liaison should

take place between the tactical officers of each agency, for example the fire service tactical incident officer should have informed the ambulance service tactical incident officer of the safety regulations, so resolving the problem of co-ordination.

SPECIFIC ISSUES RAISED BY THE MODEL AND WAYS FORWARD

The PCMT framework is for modelling planning and control for multiple task domains. EMCR is such a domain, but there are differences between this domain and the other domains modelled so far. First, EMCR has a changing worksystem, and the PCMT framework presumes a stable worksystem. In the current model, for the example tasks described above, the changing worksystem is currently represented by using a time-line and '+' for the additional structures. Thus, 'snapshots' of the worksystem structures are taken within specified time periods, which relate to specific tasks being carried out. This representation would be an extension to the PCMT framework to accommodate a changing worksystem. The time-slicing periods would need to be carefully specified with respect to the domain, so the actual worksystem structures, required for particular tasks, are represented. Second, EMCR is made up of multiple agents within a complex three-tier command structure. The PCMT framework has so far only modelled domains with a single level of operation. Thus, interactions between the different horizontal layers and different vertical layers of the system are presumed by the present framework. The issue can be illustrated in the example, by the different commanders liaising, at the same horizontal level, and information flowing between vertical levels. Thus, the PCMT framework needs to be further developed to accommodate these additional interactions. To represent the interactions between the horizontal and vertical levels of this system, the different structures of the different levels also need to be taken into account. That is, the tactical level does not carry out execution behaviours directly and only 'perceives' by means of the operational level. Thus, the structures of the tactical level would not require an executing process as such. They would, however, require some form of output communication to the operational level to guide execution, and some form of input communication, in order to perceive information from the operational level. These input and output communication structures would also be required for interaction between the horizontal levels of the worksystem, to allow for communication between the different agencies.

Lastly, conflict of behaviours has been described by means of the model as a co-ordination problem. However, it is assumed that ineffective co-ordination leads to ineffective performance. Within this system, defining effective performance is complex, because there are trade-offs between different parts of the system. For example, it may be more important for the fire service to put out fires than to rescue people. In the earlier example, the fire service stop fighting fires to rescue casualties, which can be interpreted as ineffective performance. However, this performance may not be ineffective. Each agency have their own responsibilities with weightings for each task, some of which are specified in their plans. It may be that the fire service interpret rescue behaviours as primary within this situation, as the fire service are responsible for the safety of everyone within the inner cordon. The primary objective of saving life needs to be maintained, so excluding the ambulance service from the inner cordon ensures that none of the ambulance service are injured. As a result, the level of stability of the disaster, is not decreased with respect to loss of life. In this case, then, some conflict or interaction of behaviours may not lead to ineffective performance. How to specify what is ineffective performance of the whole system is an issue which needs to be addressed. Some representation of what is deemed ineffective by each agency needs to be identified. This identification can be achieved by modelling each agency separately, i.e. specifying the tasks and their associated transformations for each agency for this disaster. This representation should allow an assessment of the weightings of particular behaviours, as it would allow identification of those behaviours which are deemed primary for a particular agency. When all three agencies have been modelled, the system and domain can be remodelled, using the individual models for guidance. This remodelling will allow specification of ineffective performance with respect to the conflicts in the behaviours of the different agencies, and so lead to a justified identification of co-ordination issues, which affect performance of the EMCR system.

GENERAL ISSUES AND WAYS FORWARD

Within this paper we have identified three specific issues and ways forward with respect to modelling a complex dynamic domain. Each of these issues and ways forward will now be generalised. First, there is the issue of how to represent a changing worksystem. This issue is to be found in any complex system that does not have stable membership, e.g. Changing battle-field formations; public services with peak demands etc. Time-slicing and a way of representing additional structures have been proposed as a means of describing such systems. Second, there is the issue of how to represent different levels of operation, and interaction between horizontal and vertical levels of the system. This issue is be found in any complex system, where only certain parts of the worksystem interact directly with the domain, and where there are different levels of management, e.g. a hospital; military formations etc. The way forward for this issue is to specify within the representation the different structures at the different levels of management, and to include a specific structure to represent interactions within and between levels. The last issue is how to represent effective system performance, when there are trade-offs between different parts of the system. This last issue is to be found in any system, where there are trade-offs between different parts of the system, which affect performance, e.g. a university; system development etc. Performance can be expressed with respect to the resource costs required by the worksystem and the desired quality of the work carried out by the worksystem. Thus, the way forward for this last issue, is to break down the system into its component agencies and model each separately. The result will provide an expression of performance in terms of the resource costs and the quality of the work carried out (with respect to domain object transformations) for the tasks of each agency. Then, by remodelling the complete system using these performance expressions, the system trade-offs become specified and ineffective performance of the whole system identified.

REFERENCES

Smith, M.W., Hill, B., Long, J.B. and Whitefield, A.D., A Design-Oriented Framework of the Planning and Control of Multiple Task Work in Secretarial Office Administration. *Behaviour and Information technology 1997* - in press.

Hill, B., and Long, J.B., A preliminary model of the planning and control of the combined response to disaster. *Proceedings of the Eight European conference on cognitive ergonomics (ECCE8) Granada Spain 1996.*