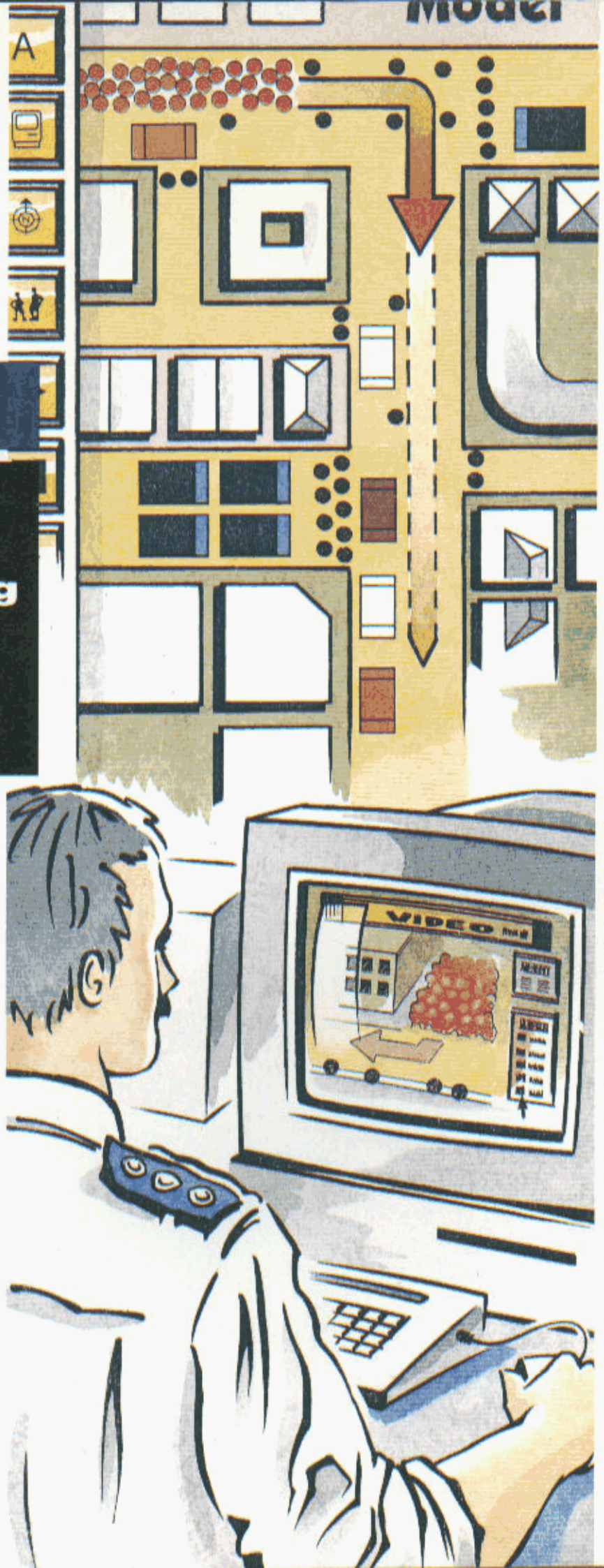
CACTUS

Command and control training using knowledge based simulations



LEARNING METHODS PROJECT REPORT

EMPLOYMENT DEPARTMENT GROUP

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1. INTRODUCTION

The Project was concerned with command and control training of large incidents where public order may be at risk, such as during demonstrations and marches. The work extended over two years, was funded by the Department of Employment and was a collaboration between the Public Order Training Centre of the Metropolitan Police Office and the Computer Based Learning Unit at the University of Leeds, with additional assistance from the West Yorkshire Police Training School at Wakefield.

In its first sections, the report sets out the needs and requirements of current Public Order Training and thus justifies the objectives of the project and the use of knowledge based computer methods to support and consolidate conventional training techniques. The main body of the report then describes the main characteristics of the software designs which were developed from extensive discussions with Police staff, and which were secured by formative/evaluative trials. A key feature is the flexibility of the software in its support of training (which includes pre-event planning, incident management and debriefing evaluation), for it not only provides a robust working program but a methodology and software tools for customising such programs to suit particular circumstances and training needs. This theme is further underlined in the report's final section which covers dissemination and exploitation.

2. THE CONTEXT AND REQUIREMENTS OF PUBLIC ORDER TRAINING

Public Order Training for Senior Officers has to keep pace with the ever developing complexities of command in this type of situation.

In order to ensure that the levels of command in a public order event are exercised responsibly, it is essential that the training provided is of the highest quality.

Traditional forms of theoretical command training, using paperfeed or table top exercises, are no longer able to totally satisfy the training needs of the modern day public order commander. High quality, technically based training is seen as a way forward for teaching and exercising public order command skills. It allows for greater flexibility and innovation on the part of the trainers and an opportunity for more realistic and demanding scenarios for the trainees. The ability of this form of Technically Based Training (TBT) to provide accurate, synthesised debriefing records satisfies the final link of the training chain, that of objective feedback for further development of the individual participant.

3. PROJECT OBJECTIVES AND REQUIREMENTS

Typically, Command and Control Training takes place at several levels, from on-the-ground tactics to the strategic management of large events through control room map-based simulation exercises. The latter are not easy to run and present the simulation manager with several difficulties, eg controlling the sequence of incidents in response to the decisions and communicated instructions of the trainees. Indeed, keeping track of the movements and actions of the police resources, and providing plausible event messages that exercise the trainees' competence, is extremely complex. Also, debriefing discussions rely on the memories of the participants and on notes taken by independent observers: the simulation cannot be recomposed and rerun. However, the control simulation has atmosphere and a certain realism: it is much valued by those taking part.

The aim of this command and control project was not to replace but to complement the large scale simulation with a computer based program that would not only serve as a useful training experience in its own right, but also allow trainees to gain greater advantage from the limited time they are able to spend participating in the larger exercise. A prime objective, therefore, was to design, implement, and test such a computer based training program, and there were clear requirements. The program must encompass and support training on: (i) pre-incident logistic planning; (ii) large event management, particularly the link between strategic and tactical decision making; and (iii) the debriefing experience. Further, the trainer should be able to customise the instruction by placing the simulation event in a locality and controlling its size, type and complexity to suit both specific learning objectives and the experience and background of trainees.

Careful preparation for the management of a large march/demonstration is critical. It involves route-fixing, 'noting locations that may be at risk' or which might attract the interest of demonstrators, or cause march 'hold-ups'; placing of police resources including reserve and specialist units; and contingency planning to deal with hypothesized 'what-if' scenarios. Indeed the controlling role of 'Silver' in managing the event, should operate within this prepared framework. However, there is unpredictability, particularly in large scale demonstrations that generate strong feelings; and incident management training, as well as clarifying the strategic and tactical levels of decision making, must also allow for the unexpected ie the training should include reactive decision making.

Evidence reported in the research literature shows that learning from simulation presents difficulties. Although in this context the previous experience of trainees will ensure an adequate framework for guiding decisions, the complexity of the exercise (which will run in real time) and the quantity of information during high-activity periods will leave little time for reflection. Hence, debriefing sessions where the event scenarios can be re-constituted and discussed at a controlled pace are clearly important. [Our later experience showed that it was useful to allow debriefing at any time during the simulation - as well as after the management session was completed - and this facility has been incorporated into the software.]

4. MAIN DATA COMPONENTS OF THE SIMULATION

It is impractical to design simulation programs of this type and complexity from a pre-stored calendar of anticipated actions, reactions and consequences. Instead a *World*-model was required to provide the sequence of events to be managed by the learner, and to assume responsibilities akin to those of the Operation Room Controller. Hence, the main data components of the simulation are those outlined below and summarised in figure 1.

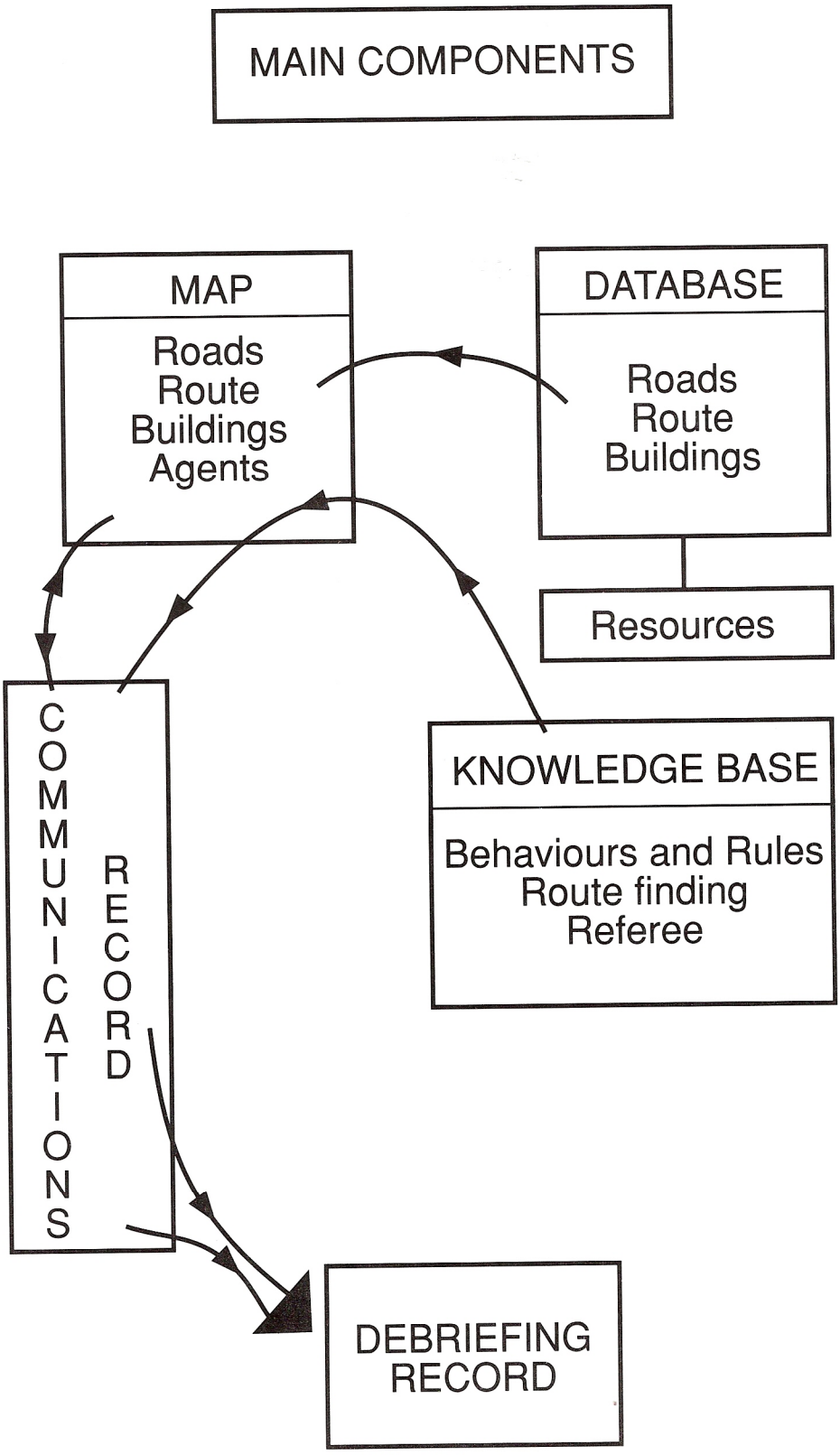


FIGURE 1: MAIN COMPONENTS

The location is displayed through a map (digitised and obtained from the Ordnance Survey) showing centre-line road markings, and the outlines of buildings and open spaces. [The trainee is able to use two different map scales for scanning, and to use the mouse-pointer to control the area of view in the map window of the computer display screen.] An associated database contains information about road names, the arranged route of the demonstration and any premises of interest. The important point is that this information is linked to the map ie the premises 'know' where they are located on the display.

This map with its roads and buildings provides the setting for the events, but the active agents, the crowd groups and police units which interact have also to be specified. The crowd is conceived as a loose conglomerate of various types of sub-groups, for example, 'leader groups' of the march who 'know' the route and are likely to be well-behaved , and 'other demonstrator' groups forming the bulk of the march. These demonstrators tend to follow the groups in front of them but may cause disorder by sitting down, attempting to enter or damage buildings that have a particular significance, and harassing or even attacking police units that try to restrain them. Each group has a set of localised methods which determine how their behaviours change in relation to other nearby objects, groups and units which they sense. These behaviours (which can be extended or reduced by the trainer) are linked in a network, so that escalation and de-escalation of their activity is plausible and takes account of the level and type of police response.

The Police resources (specified by the trainer) will be distributed, usually by the trainee, on the display map along or near the demonstrator route. Specialist groups (eg with shields or horses) can be used, and the trainee may place them in reserve. The police units, which are able to route-find their way about the map in real time when given a destination, also have a repertoire of actions/tactics. Some will be undertaken autonomously in response to crowd behaviours (eg marching cordon, reporting, arresting), but others (eg shield cordon) must be instructed by the trainee so that the demonstration can be properly controlled. All these behaviours, together with the conditions that activate them, are held in a knowledge base, and a referee program is available to adjudicate on conflicts between irreconcilable crowd and police behaviours. [A selection of these behavioural rules is provided in the Appendix.]

Although this *World*-model will enact its behaviours through time, the trainee will not see the crowd agents directly displayed but will receive communication reports of their behaviour. The police unit identifiers are, however, shown on the map, and their reports, together with the instructions given to them by the trainee, are stored in the communication log. The complete sequence of

information reports and trainee instructions, together with the referee's decisions, form the record which is used as a data source by the debriefing program.

5. FURTHER EXPLANATION OF THE SIMULATION COMPONENTS

The knowledge base of the simulation and its functional design were the result of extensive collaboration with the Metropolitan Police Office, who made available demonstration reports, pre-event planning briefings, and selected control room attendance during the management of large events. Also, the training practices at the Hounslow Public Order Centre were observed and, during the project, there were extensive conversations, demonstrations and critical reviews of the simulation components and software prototypes with the trainers. Particular features of the developed system, named CACTUS, are more fully explained below.

At any point in time the *World* is described by the behaviours of the crowd groups and police agents, and their locations on the Ordnance Survey digitised map (with its database of routes, road names and state descriptions of buildings). Note that the crowd groups act and react as autonomous agents, adopting behaviours as they sense police tactics, the behaviours of other groups and 'interesting' types of building (eg those of political significance or which may be a source of weapons) in their sector of the map. As behaviours change in response to these sense-data, so the description or state of the *World* changes. Similarly, the police units adopt actions in response to the crowd behaviours they sense and the instructions they receive. Some of the crowd behaviours (for example, vandalising or looting premises) if not checked by the police may result in damage or injury, again changing the *World*-state. Occasionally the crowd and the police intend to pursue actions that will lead to inconsistencies in the *World*-state, for example, the crowd wishing to attack and damage a building, and the police mounting a cordon to protect it. In these cases a referee employs arbitration rules that are probabilistic but which attempt to judge the consequence of these intentions. The interactive system is shown schematically in figure 2.

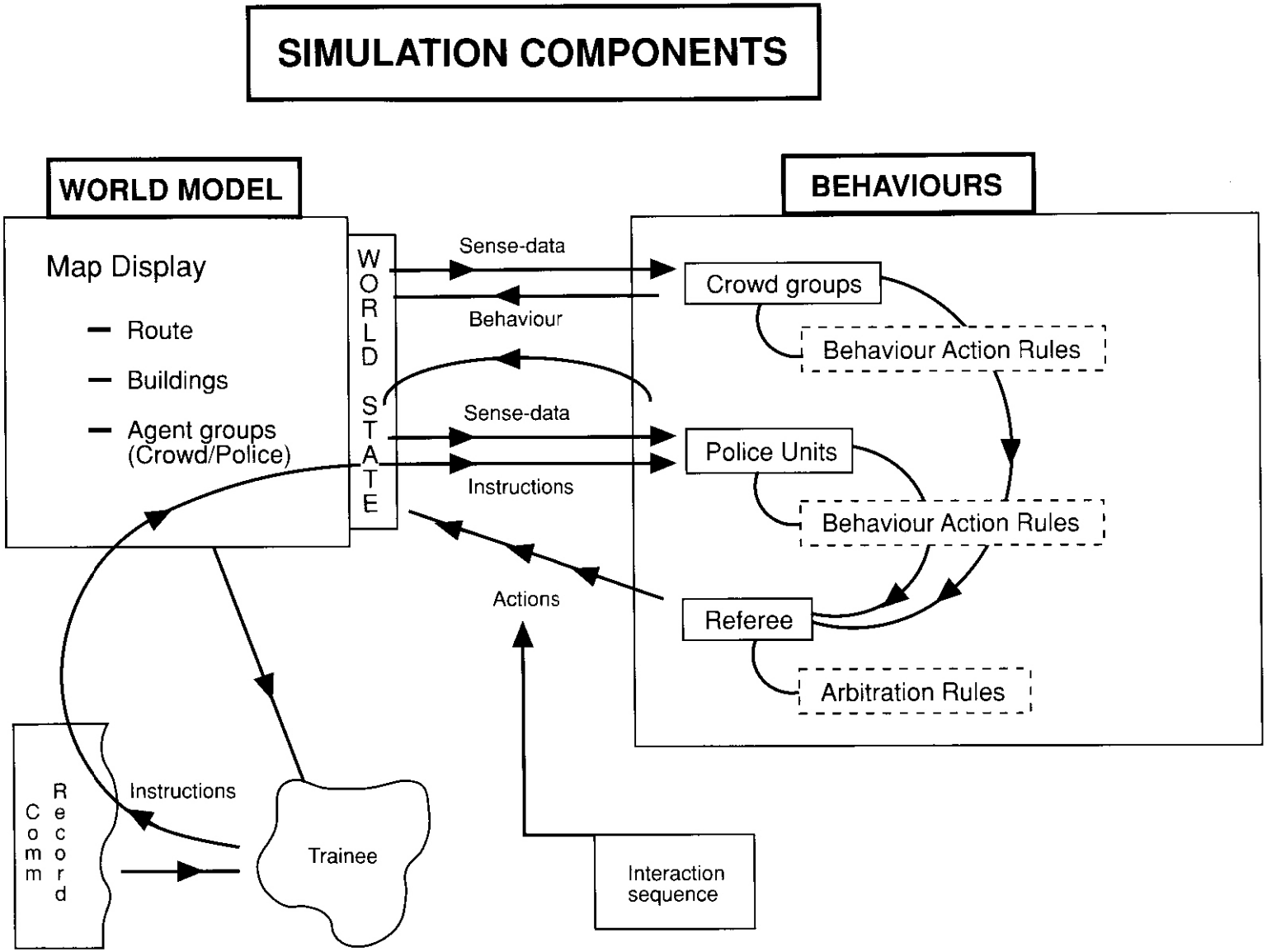


Figure 2: Simulation Component

The behaviours the groups can assume, and their inter-relations, are shown in figure 3. Note that these behaviours are specified by the trainer and can be extended or reduced, or specialised to other types of group (eg anti-march groups) if so required by the simulation exercise. In the diagram and in the current system, sixteen behaviours can be adopted by the demonstrator groups, and these are linked in a network so that escalation and de-escalation of their behaviour appears plausible. Thus, behaviour 1 (marching) can escalate to behaviours 2,3 or 4 which are relatively mild forms of protest; demonstrating (behaviour 3) can lead to more angry and violent behaviours (5,6,7) or return to the marching behaviour.

Which of these options is chosen depends on a group's current behaviour and the behaviours that are sensed from other nearby groups. There is a tendency to join and participate in these 'adjacent' actions, but the group might also sense a 'significant building' in the sector and decide to make an attempt to reach it, or it might react to the tactics of the police units which are also sensed. These behavioural rules, which accompany each group, are probabilistic but take account of all these influences including current behaviour. Where changes do take place, a time band is attached to the action so that further opportunities to initiate change only occur when this interval has passed.

The police agents and the reserve units who may have particular specialisms or equipment operate in a similar manner. The first six behaviours (see figure 3) will be undertaken autonomously in response to crowd behaviour (following probabilistic rules), but the shield cordoning and associated tactics (behaviours 7,8 and 9) will only be carried out following instructions from the trainee. Of course, the trainee can give orders at any time to any of the police units taking part in the exercise. [Note that the allocation of autonomous behaviours assigned to the police agents is the decision of the trainer. He might wish, for example, to deny them the 'arrest' action (behaviour 3) in which case the trainee would have to authorise this behaviour on all occasions.]

The simulation manages itself in real time, and the potential behaviour changes take place at a fixed time interval which, in the current version, is usually set at twenty seconds. The system is explained in figure 4. At a particular time point the agents (including all crowd groups and police units) sense any data they receive from other agents and buildings in their sector, apply their rules, and decide if they wish to adopt a new behaviour or action. [Note that the police units may receive instructions from the trainee and, in general, these will take precedence and override any proposed autonomous decisions.] A distinction is

BEHAVIOUR NETWORKS

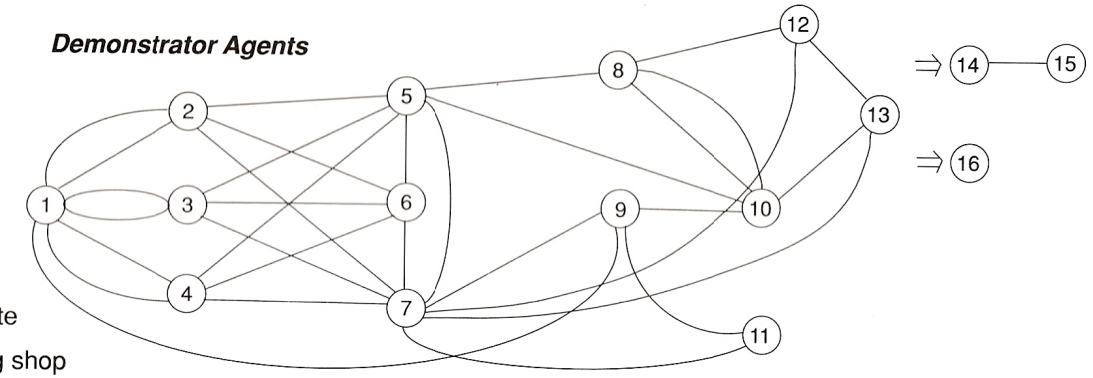
Demonstrator Behaviour

1. Marching
2. Standing Still
3. Demonstrating
4. Sitting Down
5. Dismantling building site
6. Vandalising and looting shop
7. Marching angrily
8. Marching with arms
9. Throwing Missiles
10. Throwing Heavy Missiles
11. Standing around angrily
12. Attacking Police
13. Burning building
14. Dispersing
15. Disappear
16. Arrested

KEY

o Behaviour/Tactic
---> Transition
= => Transition permissible from any behaviour

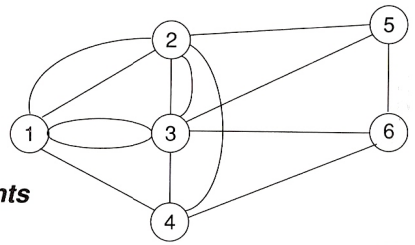
Demonstrator Agents



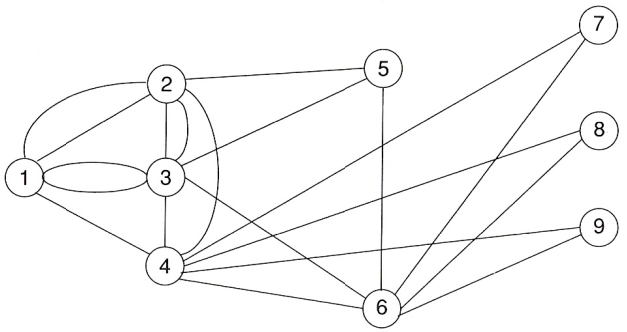
Agents React to:

1. The Behaviour/Tactics of other Agents
2. The presence of other Agents
3. Buildings/Locations of interest

Police Agents



Reserve Unit Agents



Police Tactics

1. Marching Cordon
2. Static Cordon
3. Arresting
4. Awaiting Orders
5. Tactical Withdrawal
6. Proceeding to
7. Addressing Crowd
8. Cordoning Road
9. Advancing Shield Cordon

Figure 3: Behaviour Networks

made between behaviours which only affect the group requesting them, and actions where the consequences will interact or run counter to proposals from another group. In these circumstances the referee has to arbitrate. When changes are made, the group behaviours are updated with the referee's permission or instructions, and the necessary amendments made to the *World*-state. At this point the police agents may generate a report either routinely or because of instructions from the trainee, and these reports are posted to the communications record. [Note that the messages are generated from templates to suit the particular circumstances being noted and are not pre-stored; also they can be delivered in text or in audio-form through Text-to-Speech equipment.] The behaviours are then put into effect and the process is repeated at the end of the next (20 second) time-cycle.

In carrying out their behaviours, the groups may move (in real time) and alter their locations on the map. The crowd groups tend to follow those in front of them (with the leader groups 'knowing' the route), but if a significant building or particular police tactic is sensed a march breakout may be attempted. If this action is successful then other neighbouring groups may follow and the march may become hijacked.

The police units, when instructed by the trainee to proceed to a map destination (shown by mouse clicking on the map location) and perhaps carry out some tactic, are able to route find and at each time-cycle their traverse is shown on the map. If a route is blocked then a way will be found round this obstruction and, during the journey, the unit may send routine reports on behaviours they observe; indeed, they may autonomously decide to take action in response to what they sense. Of course the trainee, on receiving these reports, may choose to override their decisions.

The trainer is able to increase the complexity of the exercise by increasing the number of crowd groups, regulating the police resources, altering the behaviour rules, or increasing the activity (ie the behaviour probabilities) of the demonstrator agents. Further, if the trainer wished to be more specialised and concentrate on particular forms or biases of behaviour, for example, attacking buildings, he could have those specific behavioural probabilities increased.

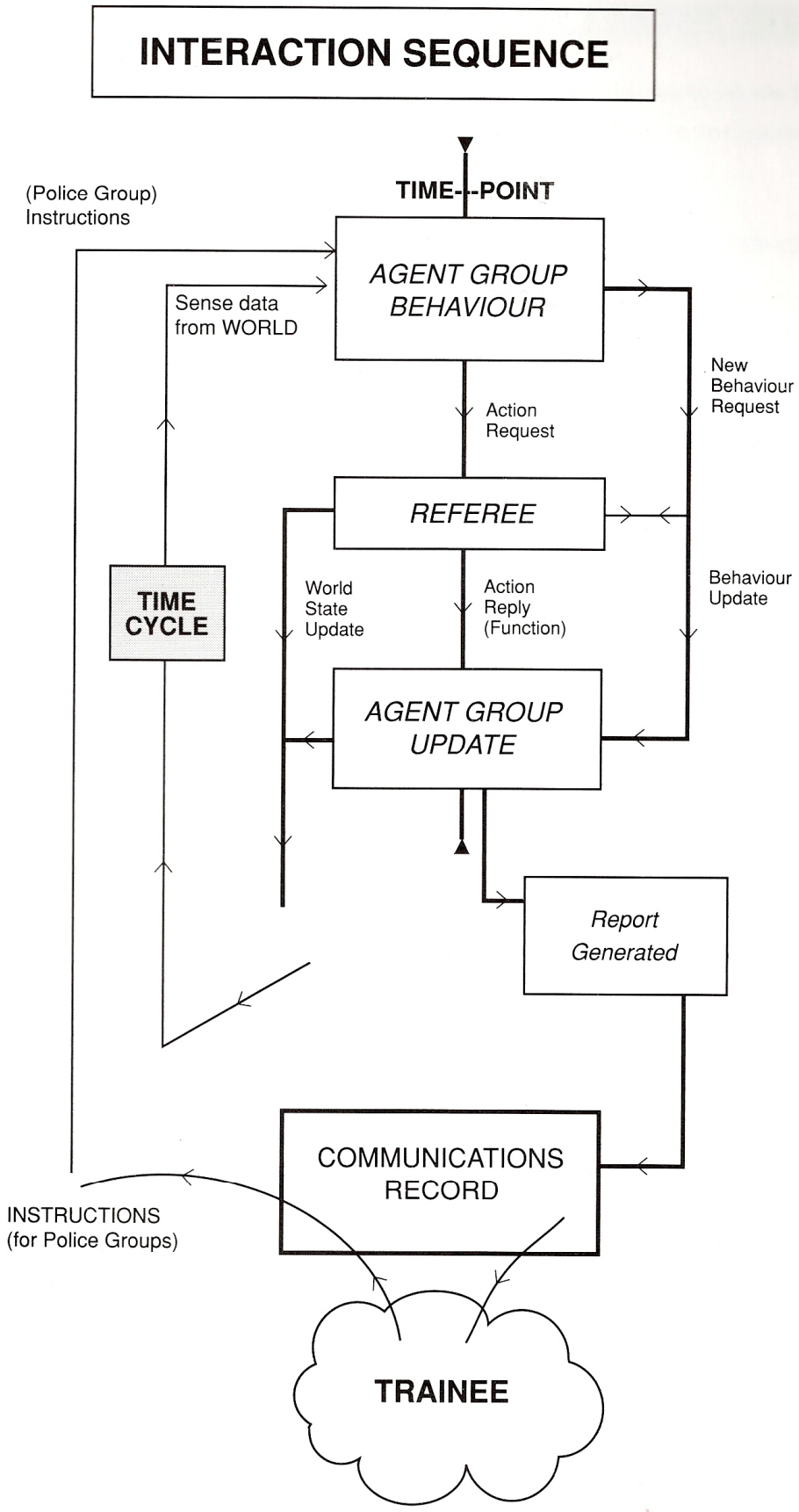


Figure 4: Interaction Sequence

6. THE SIMULATION IN USE

It was noted above that the simulation should encompass pre-event planning, incident management and debriefing, and these aspects will be considered in turn.

6.1. Pre-event planning

The trainer is able to set the type and complexity of the simulation exercises to suit his particular requirements. In fact this specification and placing of resources for the policing of large demonstrations can become a pre-event planning task and part of the training programme. For the specification, the digitised map is displayed on the screen, the route marked by mouse clicking road segments (displayed in bold), after which the buildings or locations of interest can be marked ie those premises that might attract the attention of the crowd groups. *The Building Editor* is used for this purpose (see figure 5A below) and, in the example, the locations include building-site, shops and vulnerable premises.

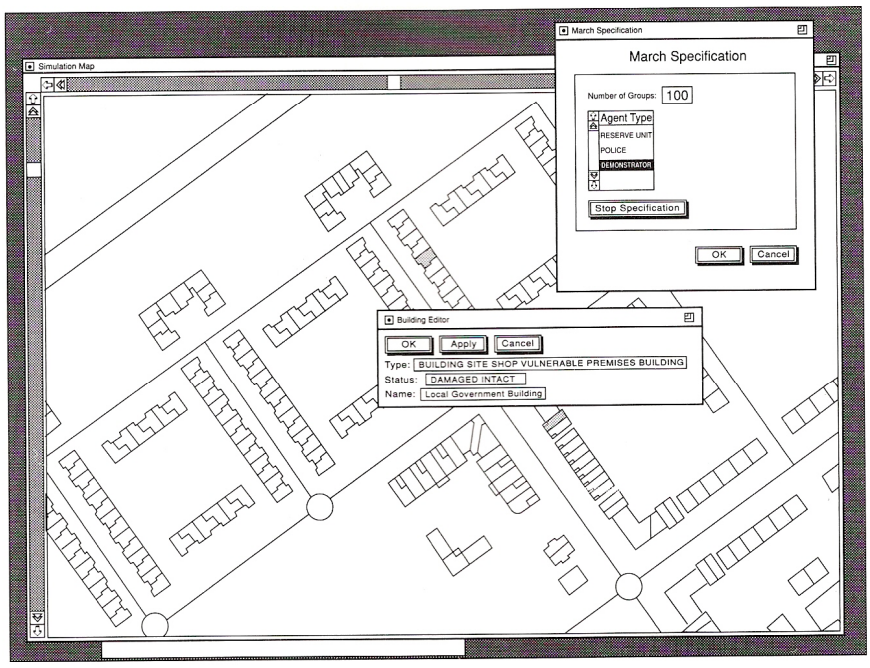


Figure 5A: Setting Up The Simualtion: Screen 1

A descriptive name is given for each building, its position is indicated by mouse clicking on the map, and that location is then automatically shaded. If the map district is local and of particular interest, video output may be required so that a 3-D realistic perspective can be given to the 2-D outlines provided by the digitised map, and to the information provided by the database.

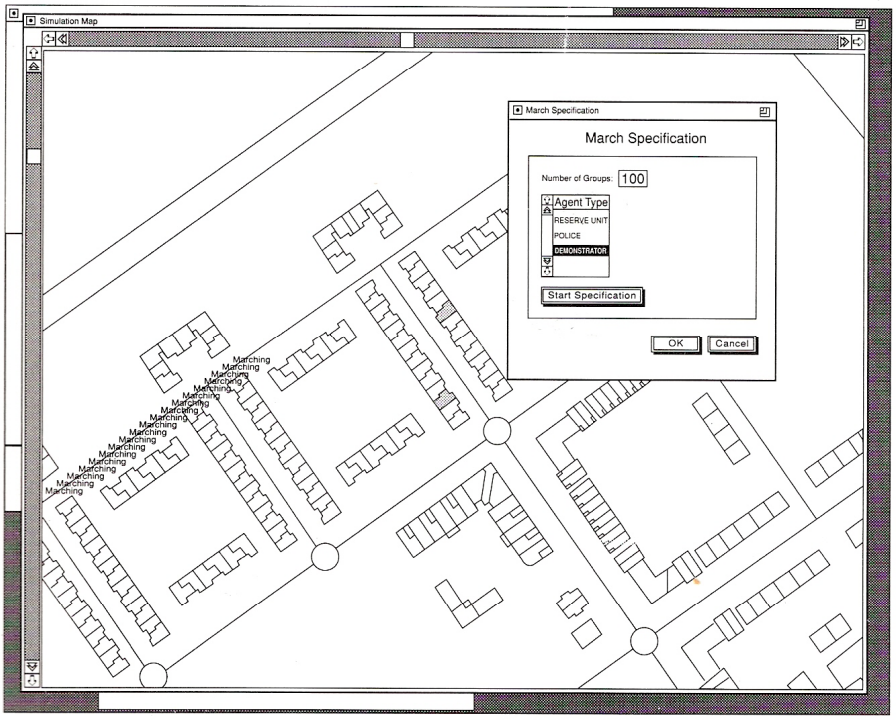


Figure 5B: Setting Up The Simulation: Screen 2

The crowd groups and police units are specified in a similar manner using the *Specification Editor*. In figure 5B, one hundred demonstration units have been called and the display shows some of them placed on the march route. [Notionally, a crowd group is a collection of people close enough to influence each other and thus act in a homogenous manner: in practice, the crowd group size (noted by the simulation) will usually vary between twenty and eighty people, although the trainer can choose any number that suits his purposes.] The police units (and the reserve goups) are also specified and distributed (by mouse clicking on map locations). Figure 5C (next page) shows police groups with the march and two reserve units (awaiting orders) that have been placed in a side-road relatively near the vulnerable premises. Thus the designated route, contingency plans and diversions, and the placing of resources and specialist units can become useful discusion points between the trainer and trainees as they are justified against various 'what-if' scenarios.

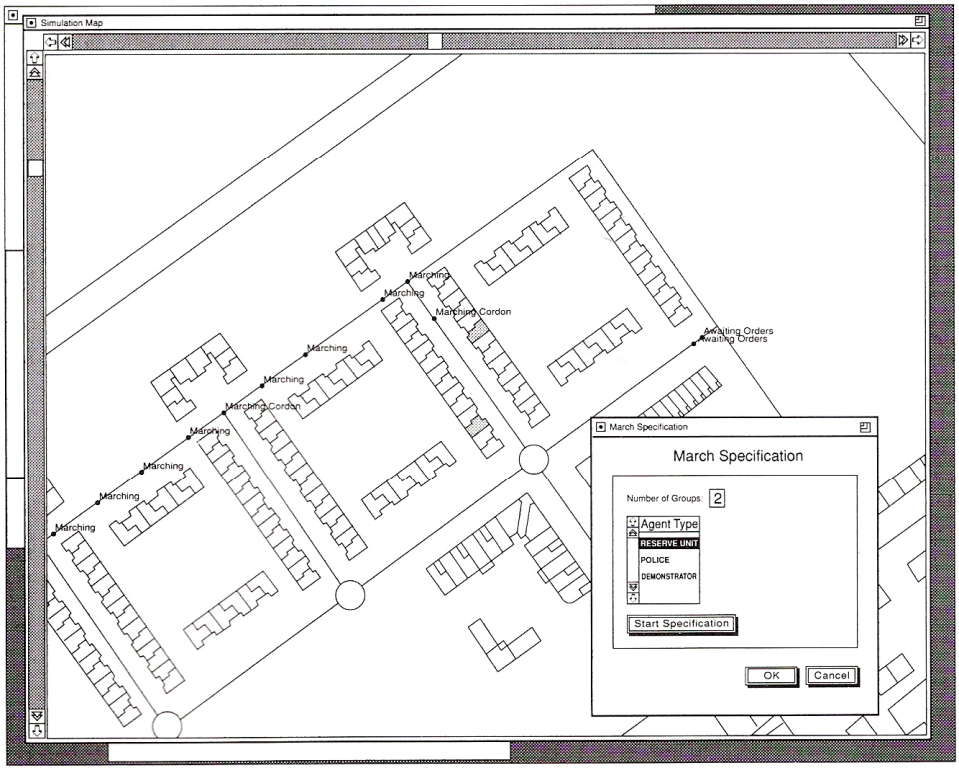


Figure 5C: Setting Up The Simulation: Screen 3

6.2 Managing incidents

Once a demonstration event has been initialised with a route, significant buildings/locations and police resources, the management exercise can begin when it will be run by the simulator in real time. Note that the crowd units will not be shown on the trainee's display screen, but information of events will be transmitted through reports by police units either autonomously or in direct response to the trainee's instructions. [The 'significant locations' markings can also be removed from the screen if the trainer prefers.]

A typical display, as seen by the trainee some time into the event, is shown in figure 6A. The bottom right window contains the map - though all the windows can be manoeuvred and resized indepcndcntly - with the locations of 'significant buildings' and some of the police units marked. [Some other units have moved to another part of the map, which the trainee can locate by using the window bars to follow the progress of the march: the map has two scales to aid this scanning process - the one illustrated is the larger scale.]

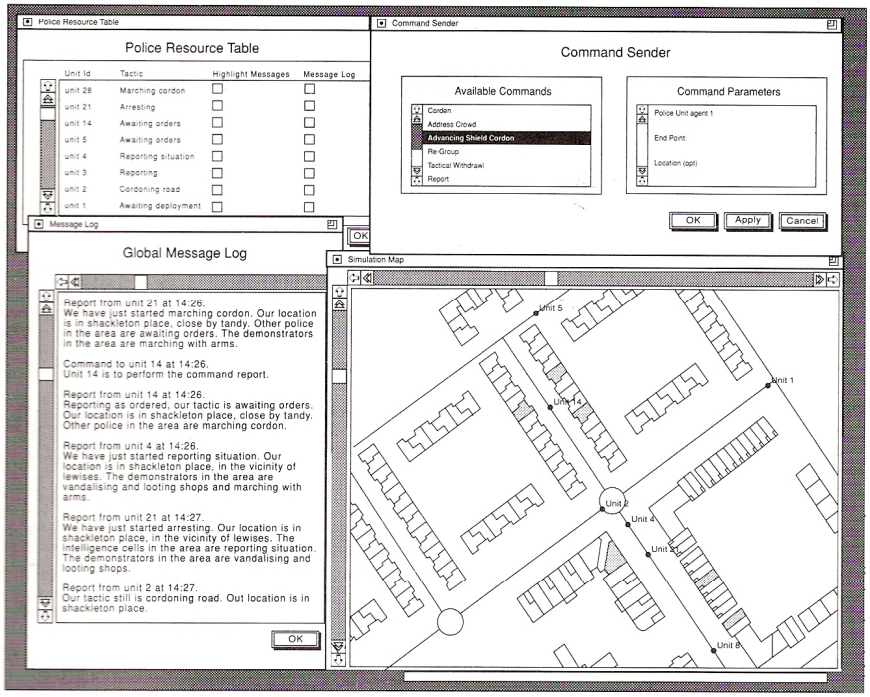


Figure 6A: Running The Simulation: Screen 1

The top left window shows, for each police unit, the current tactic (automatically updated from reports in the communication record), and gives the trainee the option to highlight messages to and from any unit, thus enabling him to quickly reference the reports of their activity. The global message-log is shown in the lower left-hand window; each record is time-stamped and provides its police unit of origin together with its location and current tactic and other information of crowd behaviour. The messages are presented sequentially with the window bar position showing the proportion of (unread) reports being delivered. Thus, when communication traffic is becoming heavy, the trainee can quickly scroll messages to concentrate on those that are considered important. As well as providing a global communications log, which is the normal information source, each message is also filed under its source/destination unit so that when the trainee mouse clicks the message-log box of that unit (in the top right-hand window), its particular communications record is desplayed. [In the current system messages can also be delivered as (digitised) audio output using Text-to-Speech equipment eg that produced by APTECH.]

When the trainee wishes to send instructions to a police unit, either to ask for a report or to move the unit to a location and/or carry out a particular tactic, the 'Command Sender' (shown in the top right-hand window) is used. Mouse-clicking on one of the available commands - which the trainee can scroll to cover the full range of options - activates the appropriate tactic, and the command is completed by clicking the chosen locations and units.

In figure 6A the situation at time 14.27 is summarised on the simulation map. The global message-log shows two incidents developing within the march. Unit 21, forming a marching cordon with the crowd, is moving down to Shackleton Place and begins arresting those vandalising and looting shops. Unit 4 close by, can be used in support and is also near unit 2 which is cordoning the road. The Police Resource Table gives an automatically updated summary of units and current tactics; some of these units are with the crowd and are not shown in the displayed portion of the map currently being attended to by the trainee. In a second concurrent incident, demonstrators are obtaining 'arms' from a building site near to the Shackleton Place/Tandy shop reported by unit 14 (so the reports from units 14 and 21 have been highlighted) and the trainee decides to call reserve unit 1 to use an advancing shield cordon to clear and disperse the crowd in this area. He starts to do this at 14.27, and figure 6B shows the completed message and the situation some three minutes later. Unit 1 is completing its shield cordon with some success at the lower end of the map (Shackleton/Olympus). Unit 3 reports that the troublesome demonstrators being dealt with by unit 21 (arresting) is also having some success. The main demonstration is proceeding off the area currently displayed and other units, eg 28 and 34, are in marching cordon with them and reporting no disturbance.

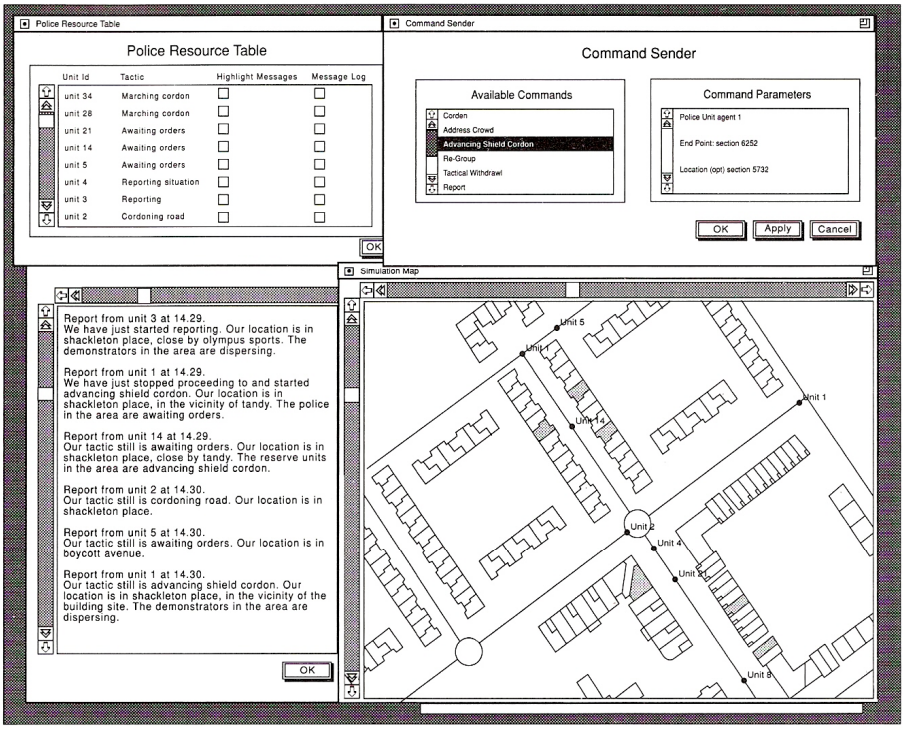


Figure 6B: Running the Simulation: Screen 2

[To obtain an understanding of this debriefing, to note its origins and to see and debate the reactions of the trainee, requires a debriefing study of the report-log and map at an earlier time period; actually, a static cordon was set up by the trainee round the building site but this was judged an inadequate and unsuccessful response by the referee.]

Note: (i) the actual units and tactics shown in figures 6A and 6B, in the Police Resource Table and the Command Sender, are only a sub-set of what is available; the scroll-bars are used to obtain other units and command options; (ii) if the trainer wants to interrupt and discuss a particular situation, he can halt the simulation and have the crowd locations and behaviours displayed as well as the police actions, indeed he can enter the debrief mode.

6.3 Debriefing

Debriefing discussions can be engaged at any time during and after the simulation exercise. In general, the trainer (or trainee) might want to reflect on the overall conduct of the demonstration and identify the time periods and locations of high activity, before concentrating on the actual management of these incidents. All the interactions from the communication record (together with the referee's decisions) are stored for the debriefing. From this record the program provides a time-sequenced (brief) synopsis of each message identifying the unit involved, its location and tactic. The debriefer automatically focuses this record to cover the time period set, and shows the actual number of messages produced during this period (thus indicating the level of activity).

For closer follow-up, conditions of specific tactics, crowd behaviours, units and locations show the sequences of actions during particular time periods of high activity. Since messages can be 'posted' to the map, the state of the simulations (as seen by the trainee) can be quickly reconstructed. Detailed discussions and replays can follow.

All the interactions shown in the communciations record (together with the referee's decisions) are stored for the debriefing. The display is shown in figure 7 (next page). The bottom left window contains a synopsis of the communications, labelling each message and noting the time it was sent, the type of report and its origin, and the tactic/behaviour ongoing at that time. The record is arranged in time-sequence, it can be scrolled and messages 'posted' to the map (ie the position of the unit at the time a message was sent is displayed) and the full text of any message can also be shown. Thus, the state of the simualtion can be quickly reconstructed.

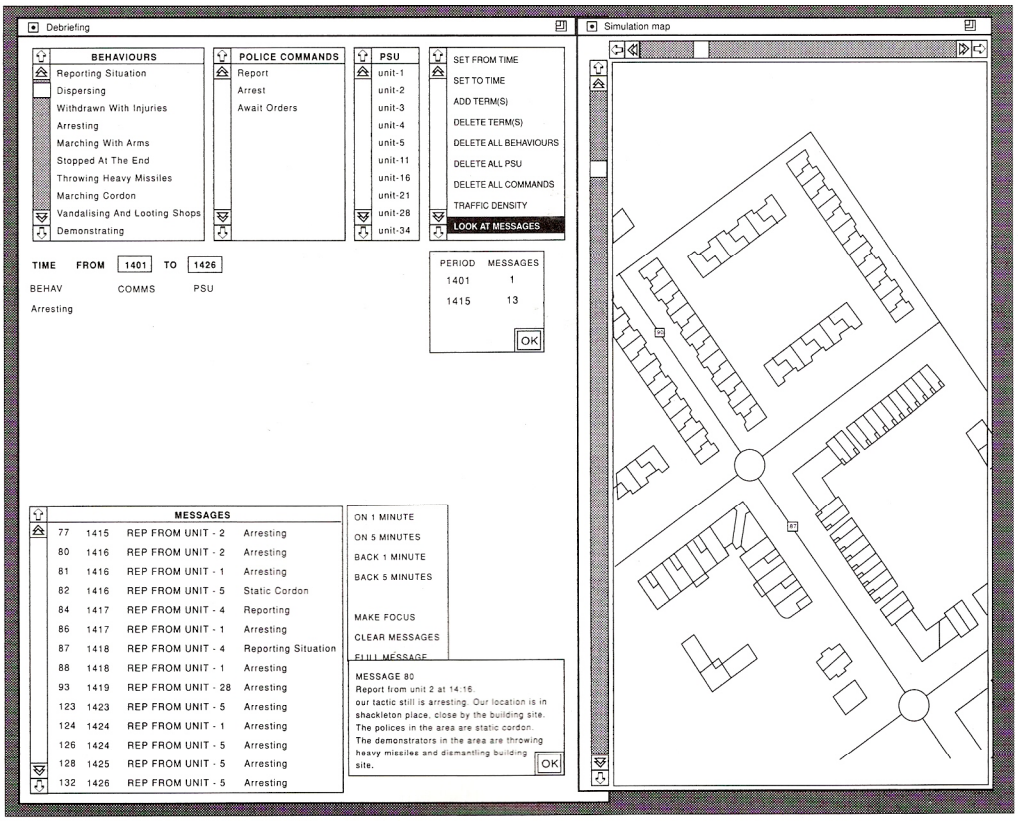


Figure 7: A Debriefing Screen

Any time period of interest can be set (see figure 7), and this automatically focuses the communications synopsis for this time - which can be moved on or back at one minute, five minute or longer intervals. Since the total number of messages occupying the time interval is displayed, the density of communication traffic (and activity) is easily shown. For closer inspection and discussion, more precise focusing conditions relating to the crowd behaviours, locations, police tactics and/or the units involved can be given (see the top-left panels in figure 7). The effect of these conditions (which are displayed beneath the time counters) on the number of messages is shown, and the communications record is automatically filtered so that only messages meeting these conditions are displayed. Hence, the trainer and trainee can concentrate on the management of incidents set in a locality and/or involving particular units, or specific types of events and tactics. Note that the debriefing program (which is fully integrated within the simulation) makes no judgments. However, through a summarising and filtering of the interactions recorded in the communication log, it quickly enables an overview of the trainee's management of the simulation, allows concentration on particular incidents or events or unit activities, and permits a fast re-creation of the *World*-state (as seen by the trainee) at any time.

As an example, in figure 7, after an overview of the communication messages, the trainer and trainee have concentrated on the time interval 14.01-14.26, and those reports which have noted the tactic 'arresting'. Fourteen messages fulfil this criterion in the time interval, but thirteen occur in the last eleven minutes. A synopsis of these is shown in the report log, and the trainee has printed message 80 (from unit 2) in full, and is in the process of posting this and other messages to the map (eg message 81 from unit 1) so that the situation can be more closely appraised. Following this, the trainee adds the other condition of unit 1 so that the deployment of this unit during the time interval can also be discussed.

7. The Role of the Trainer

It should be clear from this report that the project has not only produced programs for improving planning and decision making skills related to the maintenance of Public Order, but developed a software system that can be customised to meet the particular requirements and objectives of trainers and which can adapt to the experience and background of trainees.

This scope and flexibility arise from knowledge based techniques that are capable of generating events, behaviour reactions and communication records, rather than being limited by retrieving pre-stored materials operating under some specified calendar of events. Thus in CACTUS:

(i) A digitised OS map is used (with its associated database) and this can be located, without the risk of copyright infringement, in any district for which such mapping has been completed.

(ii) Different scenarios can be set; for example, the current demonstrator uses a large demonstration march as a context, but picketing confrontations, or hooligan groups following a football match dispersion or, on a small scale, group/gang fracas can be accommodated. These circumstances can be used to suit local training conditions.

(iii) The complexity of the training exercise can be controlled by the trainer, for example by regulating the route with its 'significant locations', by altering the number and type of crowd groups, and the number and specialisms of police resources. The range and probabilities of behaviours can also be altered or attuned so that crowd groups are more 'heated' or more likely to display particular types of actions. Such variations might result in interesting comparisons between simulation outcomes.

(iv) The simulations can also be managed by the trainer in various ways. For example, the trainee at the workstation may take the simulation exercises individually: here the objectives focus on the skills of decision making and contingency planning. Alternatively, the exercise may be managed by a small group of trainees with perhaps one trainee at a time making the decisions for a limited time period, and the trainer occasionally halting the simulation as a preface to group discussion or a debrief. In this situation, the comments and the learning will probably concentrate on general issues of management and meta-planning, and will discuss differing viewpoints. The debriefing mode might be used to focus and evaluate such comments. A further option is for the incident/event manager to receive audio-messages and to concentrate on the strategic decision making, with a communications assistant clicking in and transmitting the tactical actions. This mode will also focus attention on dealing with messages as they are delivered, and widen the simulation to include communications objectives.

Similar options with individuals or groups can be used with pre-event planning. Also, if the simulation is customised to a particular region, video clips taken by helicopter, for example, could be incorporated to give a three-dimensional illustration of the map and, under control of the simulation, provide a richer navigation when discussing the type and disposition of the police resources.

As well as acting as a training aid, CACTUS could also be adapted and used to assist the planning and management of actual incidents. For example, the map (and its database) could enable the route to be set, buildings and hazards noted, and particular locations of police units specified. A march could then be simulated to try out strategies/tactics and what-if scenarios (eg a larger crowd size or more active groups) run to provide more stringent tests for the police resources and contingency plans. (Note: In the current version of CACTUS the strategy/tactic decision making is not clearly separated; for training 'Silver' management, the strategy level would need to be specified and passed down to the 'Bronze' level which will automatically dispense the police tactics. Methods of doing this are being considered.)

In summary, we believe the software is general purpose and could be useful for training and management wherever there is decision making in response to actions, and where resources are finite so that meta- and contingency planning are involved.

8. EVALUATION AND DISSEMINATION

8.1 Formative Evaluation

The conceptualisation and design of CACTUS were based on and formed by discussion with our partners at the Metropolitan Public Order Training Centre, by observing their training methods and also attending selected large demonstration events. These experiences clarified the objectives of the project and greatly assisted the design of the *World*-model, the behaviour patterns of crowd groups and the strategic/tactical actions of Police Units. There was much trialling of the software components as they evolved, concentrating on checking that groups followed the probabilistic rules (eg by 'marching' groups past 'sensed' objects and noting behaviour changes) and that these rules, through the network, gave plausible patterns of behaviour escalation and de-escalation. Since there is no algorithmic model of crowd behaviour, the criteria had to be the judgement of experienced police officers. (A selection of the behaviour 'rules' for the crowd units is shown in the Appendix.)

Other judgements had to be made to regulate the interactions between the crowd behaviours and police tactics, and to specify the rulings of the referee. It is clearly important that inappropriate police decision making eg delay in taking action, or using too 'light' or too 'heavy' a police presence, should (probabilistically) result in appropriate consequences. For example, a 'heavy' police tactic may deter serious disturbance but stimulate more minor reaction and aggravation from the crowd. Checking of such sequences during the evaluation of the software was carefully and consistently carried out; although time consuming the process was accelerated when the user-interface was completed so that inputs and changes could be made easily.

The complete system has been put under trial. It is implemented using Garnet/Common Lisp on a SUN Workstation using XII/Motif and incorporating text-to-speech equipment produced by APTECH. These trials encompass the pre-event planning where police officers not only set up the route, allocate and position resources and justify these decisions, but have trainers comment on the training scenarios they would use in this organisation/planning exercise. Similar trialling procedures were followed in using the simulator for the management of events. Police officers provided comments on their decision making as actions and reaction took place, and the debriefing mode was used to ensure that such event sequences could be easily located and used to illustrate features and further focus on the decision. Following this experience, trainers were invited to comment on how they would use the system within their own centres, and we are grateful to the West Yorkshire Police Training School at Wakefield for their participation.

The results and the comments of the Police Officers/trainers give positive data on the value of the software. The system itself was easily used once the trainee had some familiarity with mouse handling and the windowing procedures. The simulation is robust, and able to operate in real time, the actions/consequences are plausible, and there is sufficient information and functions to accomplish all the objectives. The exercises engage the trainees' interest and abilities, and their reports indicate they felt the experience to be of value and the system to be a useful adjunct for training.

Some deficiencies, however, must be acknowledged. The windows contain a great deal of information and, during high action periods, the communication-log has a large number of messages from which the trainee has to pick out the most important for his critical attention. The actual content of such messages (which are generated by the system from text-templates) has been reduced and summarised in the current version, and the trainee is able to highlight messages for particular units - perhaps this visual marking should be extended to the more serious crowd behaviours. A further lack has already been noted, namely that strategic-tactical actions are not sharply demarcated. Ways in which strategies can be registered to control tactical actions at the high command level are being considered.

The flexibility of the software system has been discussed previously, but it is an important contribution that arises directly from the knowledge based design. A manual has been produced for users of the system, and trainers without technical knowledge will be able to alter the complexity of incidents and features of the location in which the simulation scenarios are set. Similarly, the probabilities used in the behavioural rules can be easily edited but it is necessary to check the effects of these amendments on the behaviour patterns of the various groups of agents who are governed by these rules. (A copy of the trainer/user manual is available on request.)

8.2 Dissemination

The work of the project has been presented at seminars within the University of Leeds, and also at a seminar on *Simulation Techniques for Learning* organised by the Institute of Electrical Engineers at their headquarters in London. The most comprehensive and important meeting took place at Shrivenham in November 1991: this was presented by the Department of Employment. A video illustrating the three related Command and Control projects supported by the Department was prepared and shown, and hands-on demonstrations allowed close and interested discussion of the techniques and their value to training. Further discussions on the ways the software can be more fully exploited in the Police Service are continuing with our collaborators.

Summary

Maintaining public order, for instance as large crowds exercise their legitimate right to demonstrate, is complex, and if things go wrong it can be expensive and adversely affect public attitudes and confidence. Training is clearly important but Operation Room large map simulations are difficult to organise and administer; also, recording information and actions for post-event debriefing is a significant problem. Hence, the objective of this project was to design computer based simulations that would improve planning and decision-making skills, and would complement and consolidate learning from the large-scale training exercises. Further, the computer based programs should be adaptive and able to be customised to suit particular training requirements.

The learning contexts span the logistics of pre-demonstration planning, the management of events required meta- and contingency decision making, and post-event debriefing. The simulation program uses Ordnance Survey digitised maps, with roads and buildings, on which dynamic objects (eg demonstrator groups and police units) can be placed. These have localised methods which determine probabilistically how their behaviours change in relation to the other objects which they sense. This *world*-model operates in real time with updating decisions taken at fixed (approximately 20 second) intervals; a referee module provides any necessary arbitration.

The trainee can use these facilities to pre-plan the policing of demonstrations and the placing of resources. When managing the event he will see the map display with the police unit locations, but will only receive information of events arising in the *World*-model via incident reports shown in a communication window. The trainee can request information from the police units and in response give them strategic/tactical instructions. The computer system can also provide some memory aids (on locations, status and events). A complete communication record is maintained, all the data is stored and can be filtered and organised in various ways. Hence, debriefing discussions can focus globally on events and decision making across the map or through time at particular locations.

The simulation system (which is implemented using Garnet/Common Lisp on a SUN Workstation using XII/Motif) can have audio-output and, in principle, be linked to visual-displays. The system has been trialled, and was presented at a National Workshop on Command and Control Training (organised by the Department of Employment). A final section of the report indicates how the techniques and software can be more generally exploited in training, and in the planning and management of actual incidents and demonstrations.

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Further information can be obtained from:
Computer Based Learning Unit
University of Leeds
Leeds LS2 9JT
Tel: 0532 334626
Fax: 0532 334635

APPENDICES

1. Examples of Rules governing Crowd Agent Behaviour

2. CACTUS User Manual - *available on request to CBL Unit.*

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Fax: 0532 334635

APPENDIX

Examples of Rules governing Crowd Agent Behaviour

```
(Def-Transition "Marching" "Demonstrating"
      '((GROUP-DEMONSTRATING-P 0.05)
        (|VULNERABLE PREMISES-P| 0.1)
        ((AND GROUP-DEMONSTRATING-P |VULNERABLE PREMISES-P|) 0.1)
                    (SAME-BEHAVIOUR-FIVE-MINS-P 5. OF-4)))

(Def-Transition "Marching" "Vandalising And Looting Shops"
    '(((AND SHOP-P
            POLICE-NOT-NEAR-P
            |RESERVE UNIT-NOT-NEAR-P|
            |SHIELD RESERVE UNIT-NOT-NEAR-P|
            |TAIL UNIT-NOT-NEAR-P|
            |FRONT UNIT-NOT-NEAR-P|
            |MOUNTED UNIT-NOT-NEAR-P| 0.01)
     ((AND |GROUP-VANDALISING AND LOOTING SHOPS-P| SHOP-P) 0.05)))

(Def-Transition "Demonstrating" "Dismantling Building Site"
    '(((AND SAME-BEHAVIOUR-FIVE-MINS-P
            |BUILDING SITE-P|) 0.1)
      ((AND SAME-BEHAVIOUR-FIVE-MINS-P
        |GROUP-DISMANTLING BUILDING SITE-P|
        |BUILDING SITE-P|) 0.2)))

(Def-Transition "Demonstrating" :Marching Angrily"
      '((SAME-BEHAVIOUR-FIVE-MINS-P 0.1)
      ((AND SAME-BEHAVIOUR-FIVE-MINS-P |GROUP-MARCHING
        ANGRILY-P|) 0.1)
       (GROUP-ARRESTING-P 0.3)))

(Def-Transition "Dismantling Building Site" "Throwing Heavy Missiles"
    '(((AND SAME-BEHAVIOUR-FIVE-MINS-P
             POLICE-NEAR-P) 0.4)
      ((AND SAME-BEHAVIOUR-FIVE-MINS-P
            |RESERVE UNIT-NEAR-P|) 0.4)
      ((AND SAME-BEHAVIOUR-FIVE-MINS-P
            |FRONT UNIT-NEAR-P|) 0.4)
      ((AND SAME-BEHAVIOUR-FIVE-MINS-P
            |TAIL UNIT-NEAR-P|) 0.4)
      ((AND SAME-BEHAVIOUR-FIVE-MINS-P
            |MOUNTED UNIT-NEAR-P|) 0.4)
      ((AND SAME-BEHAVIOUR-FIVE-MINS-P
            |SHIELD RESERVE UNIT-NEAR-P|) 0.5)
       (GROUP-ARRESTING-P 0.3)))
```