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Behavioural Situation Awareness Measures and the Use of Decision Support Tools in Exercise Prowling Pegasus

Monique Kardos

DSTO-TR-1521

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Land Operations Division
Systems Sciences Laboratory

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ABSTRACT

Exercise Prowling Pegasus was held during May 19th to the 22nd, 2001, at DSTO Edinburgh. The aim of the exercise was to support ARH doctrine and TTP development, and the development of joint Land Air Systems concepts. A human factors behavioural observation approach was taken in order to assess the behavioural indicators of situation awareness (SA) and the effect of SA enhancing tools on the performance of military participants. Results on the levels of behaviour, the outcomes of wargames, and the relations of the two are discussed. Future work aims to clarify the relationship between behavioural observations and wargame outcomes.

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Behavioural Situation Awareness Measures and the Use of Decision Support Tools in Exercise Prowling Pegasus

Executive Summary

Exercise Prowling Pegasus was held during the 19th to the 22nd May, 2001, at the Land Operations Division (LOD) of DSTO Edinburgh. The aim of the exercise was to support Armd Reconnaissance Helicopter doctrine and Tactics, Techniques and Proceduress development, and the development of joint Land Air Systems concepts. A human factors behavioural observation approach was taken in order to assess the behavioural indicators of situation awareness (SA) and the effect of SA enhancing tools on the performance of military participants. Participants were military staff from a variety of locations within Australia, as well as military staff from within LOD itself.

Results on the levels of behaviour, the outcomes of wargames, and the relations of the two are discussed in terms of levels of behaviour, correlations with other behaviours and a basic outcome measure (the kill/loss ratio in this instance). Trends of behaviour level and outcome results are shown graphically and discussed. There are no significant relationships obvious between the behaviour and outcome measures taken during this study, although the trends observed tend to be indicative of associations between these measures which may be elucidated using differently structured experments. Certain expected trends were observed, as in the increase in levels of information handling behaviours during or immediately following the occurrence of critical events. These observations also show that the rises in behaviour occur most prominently in the critical area of the moment (eg. when an event makes the airborne component of the Land Air System vital, the changes to behaviour levels are most obvious in the Aviation Regimental Headquarters). Clear preferences for the use of radios as communication tools are still observed in two of the four locations, indicating a preference for voice contact when passing information to other staff. The introduced SA tool was the preferred tool for briefings, particularly in the Brigade Headquarters. These results can be expected given the relatively unfamiliar nature of the SA tool, making it less efficient than voice communications for the transmission of information at this stage.

Future work stemming from the current project aims to clarify the relationship between behavioural observations and wargame outcomes, in addition to employing a more in-depth approach to the representation of relevant behaviours. This approach — known as the "behaviour systems" methodology — structures the observed and expected behaviours in a way that triggers feedback loops, and the consequences of changes to the environment can be pinpointed. This would enable remedial steps to be taken in a situation where introduced technology or changes in processes have resulted in disruption of the performance levels of subjects. Clearly, the value here is the ability to analyse the source of problems and to take steps to remedy the implementation of tools and technologies in order to avoid such occurrences in the future and ensure that such tools enhance the functioning of the military as a team.

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Glossary

ARH	Armed Reconnaissance Helicopter
Avn Regimental HQ	Aviation Regimental Headquarters
Bde HQ	Brigade headquarters
BG	Battle Group
C2	Command and Control
Cmdr	Commander
COA	course of action
DIS	Distributed Interactive Simulation
EW	Electronic Warfare
FA-18s	fixed wing strike aircraft
FAC	Forward Air Controllers
GBAD	Ground-Based Air Defence
Helo	Helicopter
HQ	Headquarters
JOSCC	Joint Offensive Support Coordination Cell
LoCon	Lower Control
LSAS	Land Situation Awareness System
M (+ number)	Mission
MAP	military appreciation process
MoDSAF	Modular Semi-Automated Forces
NCW	Network Centric Warfare
SCD	System Concept demonstrator
SE	Synthetic Environment
SoS	System of Systems
STAGE	Scenario Toolkit And Generation Environment
TTPs	Tactics, Techniques and Procedures
TUAV	Tactical Unmanned Aerial Vehicle

1. Introduction

As part of the ongoing work within the Land Operations Division (LOD)[1] on enhancing Situation Awareness (SA), data collection for a Human Factors assessment of shared SA and the use of technologically advanced SA tools was carried out during Exercise Prowling Pegasus (conducted at DSTO Edinburgh, 19th to 23rd March 2001). This report presents the results of the Human Factors analysis of behavioural indicators of SA and examines their relationship with incidents occurring during the exercise, the achievement of the commander's intent, and the use of tools during the missions.

Recent years have seen the continuation of work conducted in the area of enhanced SA in LOD: three key foci within this comprehensive area are the generation of knowledge from information, the Information Management and Dissemination Architecture (IMDA) to support SA for various decision-makers, and a methodology for developing System of Systems (SoS)[2] emergent behaviour and measuring the impact on force effectiveness (Seymour, Grisogono, Unewisse, Johnson, Krieg, and Haub, 2000). In the midst of the development of such tools, and their introduction to the Land Force as potential methods of shortening the decision cycle (in order to work within the enemy's OODA[3] loop), there are additional aspects to be considered. Evaluating the effects of these tools on the performance of the force(s), and the usability and design of the tools themselves, for example, are areas where the Human Factors contribution can be valuable.

When the performance of tools within the team context — as the Military can be termed — refers to the overall performance of the human-machine system, assessments can be conducted on the behaviours performed by the team members in order to carry out particular important functions (eg. developing and maintaining SA). That is, behaviours displayed by team members that are designed to develop and maintain SA can be examined, and compared with those displayed when new technologies are added to the system. To be effective, such technologies should enhance the speed at which SA is developed and how fluidly it is maintained, and/or the quality of the SA shared by commanders and staff. In addition these tools should allow commanders and staff to produce the necessary SA within a shorter time frame than previously observed.

Recently, the focus of such research has become the question 'what tools, functionalities and combinations of functionalities will be of maximum benefit to distributed teams or teams of teams (ToT)?' When commanders need to maintain their overall understanding of a situation and their battlespace awareness, and they are working with combined forces [which may include land, sea and air troops], what are the requirements for effectively

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1 DSTO Edinburgh, South Australia.

2 Here, the SoS is one involving multiple information sources – such as Intelligence, Surveillance and Reconnaissance (ISR) - and tools for accessing, processing and acting on information (known as C4 technologies: Command, Control, Communications and Computers). Refer to Seymour *et al* (2000) for further detail.

3 Observe, Orient, Decide, Act.

maintaining this awareness? In this case, the Human Factors researcher might ask 'what aspects of behaviour are essential to effective SA maintenance, and how can the functioning of these be enhanced via the systematic introduction of technology?' In order to answer these questions, it is necessary to delineate the types of behaviour carried out, at what levels these behaviours occur, how they may relate to critical incidents during the battle, and what relationship the tools provided may have with these behaviours (ie. is there an interaction, and if so, is it effective).

1.1 Behavioural SA indicators

The data collection instruments used for the exercise consisted of a checksheet containing a list of behaviours relating to aspects of SA development and maintenance, and a checksheet consisting of a log of tool use by the participants. These are described more fully in section 2.3.

The behaviour list was initially developed from one constructed by Muniz, Stout, Bowers, and Salas (1998) for use in the SALIANT methodology for measuring team SA. The behaviours (shown in Table 1) are theoretically based indicators of SA, and thus a list of physically observable behaviours needed to be extrapolated from these. This was carried out using experience from previous observations to interpret and expand on the list put forward by Muniz *et al* (1998), as well as behaviours observed in three or more instances as outlined in Prince and Salas (1999) [reviewing research by the U.S. Army Aviation Centre (1992) and Prince and Salas (1993)]. These behaviours are outlined in Table 2. The resulting list of behaviours developed for the purposes of this evaluation methodology was placed into a checksheet format for systematic use by the observation team. The frequency of occurrence of these behaviours would be observed in order to ascertain whether there may be a relationship between the levels of behaviour, specific types of incidents occurring during mission conduct (and their outcomes), and the potential for automated tools to contribute to the efficiency of these behavioural processes.

As the list is a 'first cut', it will need to be refined and tuned to make it optimally useful in terms of evaluating SA levels and relating these to outcomes (eg. such as success of mission, achievement of commander's intent). The list is shown in Table 3. Additional consideration will need to be given to the potential differences between laboratory controlled simulation experiments/exercises, and field training exercises. The individual behaviours have been placed into slightly more general categories (shown in the left-hand column) to facilitate ease and consistency of observations by the observers.

As part of the tuning process, behaviours that tend to show constant levels across different missions or experimental scenarios will be omitted, as observations of a constantly occurring behaviour will not inform the researcher about the relationship of the behaviour to the mission (or other) outcomes. The behaviour should not be completely disregarded, however it may remain a crucial component of the process of developing and maintaining SA. It is simply not observed on a frequency basis as the other behaviours are.

Table 1: Behavioural indicators of team situational awareness (from Table 1 in Muniz et al, 1998:p. 11-4).

Demonstrated awareness of surrounding environment
Monitored environment for changes, trends, abnormal conditions
Demonstrated awareness of where he/she was
Recognised problems
Reported problems
Located potential sources of problems
Demonstrated knowledge of problem consequences
Resolved discrepancies
Anticipated a need for action
Recognised a need for action
Anticipated consequences of actions and decisions
Informed others of actions taken
Monitored others (self & others)
Demonstrated knowledge of tasks
Demonstrated knowledge of tasks
Exhibited skilled time sharing attention among tasks
Monitored workload (self & others)
Shared workload within workstation
Answered questions promptly
Demonstrated awareness of information
Communicated important information
Confirmed information when possible
Challenged information when doubtful
Re-checked old information
Provided information in advance
Obtained information on what is happening
Demonstrated understanding of complex relationships
Brief status frequently

Table 2: Specific behaviours for rating team situation awareness (adapted from Prince & Salas, 1999: p. 204).

Mission Situational Awareness (U.S. Army Aviation Centre, 1992)	**Situation Awareness (Prince & Salas, 1993)**
1. Routinely update one another on mission status and SA elements' status	1. Demonstrates ongoing awareness of mission status
2. Anticipate the SA needs of others	2. Provides information in advance
3. Verbalise and acknowledge changes in elements of SA	3. Comments on deviations
4. Is aware of physical and mental state of others	4. Demonstrates awareness of task performance of self and others
5. Alert others to personal problems	5. Identifies problems/potential problems
6. Alert one another to the presence of obstacles	6. Verbalises a course of action
7. Request needed information	

Table 3: First cut behaviour list for developing and maintaining shared SA in and between teams.

Checksheet Behaviour Category	Behaviours included under the category
Monitor environment/battle	• Monitor environment • Monitor visualisation screens
Monitor others	• Watch others at work
State location	• State location of self or others
Request information	• Request information on current situation, status, location, weather, friendly, enemy, civilian, etc
Receive information	• Receive information on current situation, status, location, etc
Send information	• Send information via computer terminals • Send information manually (paper) • Send information via radio
Indicate information on map	• Mark known routes/locations of entities • Mark anticipated routes/locations • Mark other information on map
Explain information	• Explain information to others
Confirm information	• Confirm new information • Recheck old information • Challenge information
Anticipate need for information	• Provide information prior to request • Provide advice/instructions/explanation prior to request
Brief status	• Brief team members on current status, locations, etc
Discuss task knowledge	• Discuss task(s) • State understanding of complex relationships
Identify discrepancies/deviations from plan	• Identify and discuss deviations or discrepancies from plan
Record deviations from plan	• Record deviations from original plan
Report problems	• Report problems to others • Discuss consequences of problems • Indicate sources of problems
Discuss actions	• State/discuss need for action • Discuss possible outcomes of actions
Inform others of decision/actions	• State decision/ action information to others
Implement remedial action	• Implement action(s) to deal with problems • Implement change of plan/ action
Reallocate workload	• Reassign work to team members

As Tables 1, 2 and 3 show, the majority of behaviours crucial to SA involve communication and the handling of information. Information is, it has been argued, the critical component of military HQ operations. In particular, information regarding *identity, location, status,* and *intent* with regard to (i) own forces, (ii) enemy forces, and (iii) neutral forces, as well as the *topography* and the *weather* are the basis of the Commander's Critical

Information Requirements (CCIR) (Rees and Bowden, in process). These appear to be common to all military headquarters (HQs), and are vital to the understanding and interpretation of the battlespace. Thus, these information categories essentially define the data required to obtain situation awareness in the battlespace (Rees and Bowden, in process).

Given the reliance of HQs on obtaining, interpreting, and applying battlespace information, any attempt to design and introduce automated tools to this arena should take these information needs into consideration. This then begs the question of the ability of the introduced tools to facilitate the transfer, handling, and interpretation/ understanding of these pieces of information by the commander and his staff.

Developing a series of accurate and consistent behavioural indicators of performance may be crucial to the understanding of the impact of tools and technologies on the performance of the military; in addition, the use of tools and technologically enhanced systems may produce specific training needs. These can potentially be identified and understood within the framework of a behavioural foundation. Using a 'behaviour systems' type approach — pioneered by Timberlake (1983; see also 1993, and Timberlake and Silva, 1995) in the field of animal behaviour, yet equally applicable to human behaviour — it may be possible to develop a picture of the activities that military subjects perform and the possible effects of changes to their environment (including the tools available for their use). This stems from the use of the systems perspective in the study of human behaviour and outcomes.

The expression of behaviours and activities from a systems perspective is elegant and relatively straightforward. An example of an animal behaviour system and a simple military example can be found in Appendix A. Essentially, behaviour systems express behaviour in terms of several levels or groupings of behaviour types, that is, the *system* the organism (in this case, a human) is functioning within. In terms of animal behaviour, this could be something such as feeding. For military purposes, it could be something such as 'planning'. The individual components of a *system* are functional units that represent typical combinations of determinants and categories of outcome. The four levels of control hierarchy outlined in this paragraph — and their components —select and coordinate individual responses (termed action patterns). The *system* level accounts for the tendency of behaviour to be organised around important functions. Below this is a *subsystem*, which indicates the sub-category into which the behaviour group fits. An example here might be 'mission planning' or 'Strategic planning', for example. *Subsystems* refer to combinations of stimulus sensitivities, motivational states, and response components that constitute strategies for meeting the needs of any *system*. The activity of a *subsystem*, then, should increase a subject's sensitivity to certain stimuli and therefore increase the probability that the relevant *modes* and *modules* will be expressed as coherent sets of *action patterns*.

Within these *subsystems*, there are other more specific groupings called '*modes*', which denote motivational substates that relate to the sequential and temporal organisation of *action patterns*. Within planning, for example, these may include 'Mission Analysis',

'Course of Action (COA) Development', COA Analysis', and 'Decision and Execution'[4]. *Perceptual-motor modules* (hereafter termed 'modules') are the next level down, and these indicate the predisposition to respond to certain stimuli with particular response components. The perceptual aspects include sensory filters that modify incoming stimulus properties and assist in organising and combining different stimuli. Motor organisation refers to motor programs or their assembly. *Action patterns* (hereafter referred to as '*actions*') are coherent sets of behavioural responses.

Clearly, the animal and human behaviour systems are action oriented (that is, actions are performed to achieve the higher goals of the system), however the human system tends more towards the handling and utilisation of information.

According to the systems perspective, humans are a reliable 'stand alone' system, and the commission of errors in the work setting (for example) tend to arise when humans are interacting with technological systems. Serig (2002) states that these errors can be triggered by technology and its environment, as a result of the way these factors interact and challenge human limitations. Here, we can see that there is a worthwhile avenue of research that may benefit both the military and the organisations attempting to provide technologies to enhance the performance of the military. It has been observed that there is ample opportunity for errors to occur during the operation of new or relatively unfamiliar technology in most settings, and clearly if this is occurring in the military operational setting, the results could be disastrous. Benefit can be seen, then, in conducting training exercises and experiments in order to discover the potential areas for error before they become an operational issue. This will be further explored in future studies.

1.2 The observational data collection methodology

In order to generate the type of data necessary for this type of behavioural evaluation and relation of behaviours to events, outcomes and tool performance, the observational data collection methodology (ODCM) was implemented. This is briefly described below.

Observational data collection functions as an objective and unobtrusive way of recording events/behaviours, which can then be used for evaluating team performance in, eg. an HQ. It is unobtrusive because it does not involve interrupting the workings of the team in any way, and objective because it does not involve recording opinions or interpretations of what is occurring, simply the behaviour(s) observed at any given time.

This method is excellent for use in situations where interference with participants is not feasible (ie. would cause possible danger to the participants) or where it would affect the outcomes of the experiment such that the resulting data would not be meaningful. Is possibly more reliable than subjective data in some ways, because there is no 'after-the-fact' bias or tainted recall of events or actions.

[4] In keeping with the military appreciation process (MAP) structure.

Initially, a taxonomy of behaviour should be designed via:

(i) working from the literature in the area (previous experimental observations, field trial observations, SOPs and manuals, pamphlets, etc)

(ii) preliminary observations (continuous, with note taking where this is possible well prior to experimental observations), and — in some cases —

(iii) interviews with military staff

This enables the researcher to build a holistic picture of the behaviours occurring within the chosen context, and should provide an overall view of the range of behaviours performed. Within this behaviour range, there may be a behavioural subset that will be useful in terms of evaluating the effects of introduced tools or techniques on specific team functioning. This will be determined following *problem definition.*

Problem definition is vital to good data collection. It allows researchers to focus their observations and collect only the data necessary to answer the question at hand. It is impossible to observe *everything* that occurs, and observers should not attempt this if they want to record accurate and meaningful data. Thus, a project should have a well-defined aim and set of objectives, and the data gathered should attempt to address these. For example, a researcher may be concerned with how the Int cell of a HQ performs, and what effect introducing a new communication medium will have on this performance. Here, an overall picture of Int cell functioning should be developed first, and then observations taken again once the new communication medium is introduced. These observations can be compared with those during baseline functioning in order to provide an assessment of effect.

In order to do this systematically, the variables being examined should also be determined beforehand. These variables will also emerge from definition of the problem. That is, there are *independent* and *dependent* variables that must be outlined prior to beginning data collection. *Independent* variables are also known as factors — in the case of the above example, these would be the new communication medium. The *dependent* variables are the 'measurables' (ie. those whose levels are affected by the factors, and which can be observed or measured in some way). Dependent variables can therefore provide an indication of the affects of independent variables on the performance of a team. So in the case of the Int cell example, the independent variable would be the new communication medium, with the dependent variables being the team performance attributes (such as communication, cognitive and physical workloads, and frustration).[5]

[5] Refer to the technical report (DSTO-TR-1034) on research methodology by Mills and Stothard (2000) for a more detailed explanation.

1.3 The relationship between behavioural SA indicators and measures of performance

Behavioural indicators of SA alone are not enough to perform an evaluation of team performance. They must be tied in closely with outcomes provided by such measures as (for example):

a) how well the commander's intent was met
b) the number of enemy destroyed
c) the timeliness of actions by various parts of the overall human-machine system
d) the ratio of enemy kills to friendly losses
e) the length of time blue assets were vulnerable to enemy weaponry

This will produce an evaluation method with much more utility than a behavioural assessment alone.

The aims of this paper are as follows:

- to illustrate the operation of an HQ through observing the behaviour of staff, and
- to attempt to relate behavioural and outcome measures to provide a meaningful evaluation of team performance, with particular reference to SA (this is important, as SA is an enabler for the effective functioning of the forces in the battlespace).

Additional benefits of designing a behaviour taxonomy should emerge as the tools are put in place and used by HQ staff. That is, such a taxonomy of behaviour should provide a reference for the effects of adding automated tools into the human-machine system. That is, questions need to be answered with respect to:

- how these tools affect team performance overall
- where the initial effect(s) occur (ie. is there a specific point in the behavioural repertoire which has been altered)

This type of analysis should assist in providing guidance for tool redesign and training needs analyses if the performance of the team is adversely affected by the addition of the new tools[6].

2. Data Collection

2.1 Exercise Prowling Pegasus

Prowling Pegasus was run from March 19th to 22nd, 2001 at DSTO Edinburgh, with a connection to AOD at DSTO Melbourne. The main aim of this exercise was to support ARH doctrine and TTP development, as well as the development of Joint Land Air Systems concepts.

6 Following an adequate training and familiarisation period, that is. Initial adverse effects may simply be due to the unfamiliarity with tools and technology, and may be mitigated by training.

Relating to this aim were a number of objectives including:

- Examining the impact of the new battlespace visualisation and management tools on procedures
- Determination of joint Land Air System teams effectiveness in meeting the commander's intent
- Examining the behaviours associated with the use of the new situation awareness tools

The experiment involved several key aspects: (1) a large number of military and DSTO civilian research personnel; (2) a large number of technical staff responsible for the connectivity of the variety of systems and tools being utilised in the experiment, as well as video and sound recording of the experimental proceedings; (3) a multitude of hardware and software systems on site at DSTO Edinburgh; and (4) a connection to AOD in Melbourne for video conferencing, input into the AARs[7], and Fast Air input into the scenarios.

2.1.1 Experimental structure

There were four days of experimentation, during which a single scenario was run multiple times under different conditions. That is, each scenario was a repeat of the previous one but utilising different combinations of assets to examine the effectiveness of teaming (or the effect of various force mixes on the outcomes of missions).

The first day was designed to familiarise the military participants with both the operation of the Land Situation Awareness System (LSAS) in terms of its capabilities and the manner in which functions would be carried out, and with the background to each of the four missions.

Day two saw the first mission (M1) as a practice mission, with last minute glitches and system unfamiliarities being attended to prior to the three experimental runs of the scenario. It also gave the military staff an opportunity to familiarise themselves with the LSAS terminal operators they would be working with for the next three missions.

Missions two to four (M2 to M4) were those during which the observers collected the bulk of their data, and these lasted approximately 1.5 hours to 2 hours each. Each of the missions involved the same scenario, however the configuration of assets varied according to the list below.

> *Mission 1*: The two ARHs conducting search and destroy missions. The helos were networked to each other as well as to the ground-based HQ.

7 After Action Reviews. These were designed as scientific debriefs rather than formal military AARs in order to supplement the data collected during the missions themselves.

Mission 2: As for M1, but with the two ARHs coordinating with (a) Special forces conducting close reconnaissance and target designation; (b) GBAD for airspace control; and (c) UAV for reconnaissance.

Mission 3: As for M2, but with fixed wing added and the ARHs acting as forward air controllers.

Mission 4: As for M3, but with the ARHs also carrying out an attack function.

The scenario developed to explore the potential of these teaming arrangements revolved around the Land Air System (LAS) assisting a conventional mechanised Brigade (Bde) in an operation to expel enemy forces from a town (in this case, the town of Katherine in the Northern Territory, Australia). Priority enemy targets were to be destroyed outside the town limits. The missions relied on the operation of a synthetic environment (SE), described in Seymour, Sands, Grisogono, Unewisse, Vaughan and Baumgart (2001: 8) and paraphrased in section 2.1.2.

2.1.2 The Synthetic Environment

The System Concept Demonstrator (SCD) of the Land-Air battle group (BG) interacted with constructive simulations of the enemy force and the remainder of the friendly forces. Additional Land components were simulated using ModSAF, while the extra Air input was provided by the STAGE simulation. Models of radar surveillance were also included, and the entire SE was linked using DIS protocols. The information coming from the constructive simulations included the position and status of all the blue and red elements (where the red element information was determined by the available surveillance assets). Where surveillance assets were modelling in ModSAF, automatic feeds of information went into the information space (infospace). Where humans detected and identified a virtual entity through their view into the virtual world, the information was manually entered into the infospace via the LSAS interface (and an experienced operator). The movements of the blue entities were carried out by human operators (Locon) who received voice or LSAS carried commands from the HQ (often a combination of these two). A DSTO staff member chosen to represent the enemy commander controlled the red forces.

2.2 Subjects

The subject of observations were the military participants in the Prowling Pegasus exercise, specifically those staffing the Bde HQ, JOSCC, Avn Regimental HQ and Locon. This was a maximum of 15 people at any given time during the observation periods.

2.3 Observation Methods

2.3.1 The observation method for Ex Prowling Pegasus

Of a team of four observers, one individual was located at each of the main HQ areas (Bde HQ, JOSCC, Regimental HQ, and Locon) in order to observe the behaviours of the participants relating to situation awareness development and maintenance and use of the Land SA and other tools for the duration of each mission. The observers were equipped with SA checksheets, Tool Use checksheets, folders, notebooks for opportunistic observations and general notes, and pencils.

The checksheets for SA and Tool Use are shown in Appendix B.

Observations were taken using both the continuous sampling method (ie. observers record each instance of the listed behaviours in the box corresponding to the appropriate time interval) and the instantaneous scan sample (ie. a scan of the team is done at the end of each time interval and the behaviour occurring at the time is recorded). Thus, the SA checksheet provides a frequency of behaviour over time, while the Tool Use checksheet provides a representation of the overall average level of tool use.

3. Results

Note that results for mission 1 are not presented, as the data collected were too unreliable due to the 'practice' type nature of this initial scenario run. Thus, all results will refer to Missions 2, 3 and 4.

3.1 The SA–related behaviour list

Table 4 presents the behaviours recorded by observers in each location during Ex Prowling Pegasus by mission. Behaviours or categories which were not observed six or more times out of a possible ten observations (that is, in three main locations across the three main missions, and also in Locon during mission 4) will be considered for omission from the active behaviour list. These behaviour categories include:

(1) Monitor others
(2) State location
(3) Reallocate workload

The lack of observation of some of these behaviours can be explained by some of the circumstances of the experiment. *Monitor others* was not observed in the Bde HQ or the Avn Regimental HQ, possibly due to the fact that both of these locations contained only two staff members. The JOSCC and Locon both observed the *monitor others* behaviour

category at relatively high levels, and the number of people in each of these locations was generally a minimum of four.

Table 4: Missions in which situation awareness related behaviours were not observed for each location are indicated by a cross in the table below. Note that LoCon is omitted here because all categories of behaviour were observed in that location. Ratio O:N indicates the ratio of locations in which the behaviour was observed versus not observed.

Location>>	**Bde HQ**			**JOSCC**			**Avn Reg HQ**			**Ratio (O:N)**
Mission>>>	**M2**	**M3**	**M4**	**M2**	**M3**	**M4**	**M2**	**M3**	**M4**	
Behaviour:										
Monitor others	X	X	X				X	X	X	3:6
State location	X	X	X	X	X	X				3:6
Explain info									X	8:1
Anticipate need for info	X	X	X	X	X	X		X	X	1:8
Indicate info on map							X	X	X	6:3
Identify deviations from plan	X		X		X	X			X	4:5
Record deviations from plan	X	X	X	X					X	4:5
Report problems	X	X	X		X		X			4:5
Inform others of action/ decision		X		X	X					6:3
Implement remedial actions	X	X	X	X					X	4:5
Re -allocate workload	X	X	X	X	X		X	X	X	1:8

Thus, referring to Table 4, there are a number of behaviours that will potentially be excluded from the observational checksheet in future data collection for various reasons, including:

- Lack of applicability to the situation under observation
- Constancy of the level of the behaviour across situations
- The behaviour not being recorded by observers during the course of the experiment

In addition, there are issues in terms of the overall levels at which behaviours were observed during the exercise. That is, there are clear differences in the levels at which certain behaviours were seen to occur during the 225 minutes of mission time (for missions 2, 3 and 4 as analysed in this report). Some behaviours occur at very low levels, and it is unlikely that these will have a large impact on overall performance. It may be that the behaviours are not carried out overtly: that is, there may be unspoken or automatic tendencies to do certain tasks which make them difficult to observe. Table 5 shows the overall levels of behaviour across the three missions and all locations.

Table 5: The total occurrences of behaviour during missions 2,3 and 4 across locations

Behaviour	Total Occurrences
Request information	159
Receive information	345
Send information	325
Indicate information on map	200
Explain information	120
Confirm information	76
Anticipate information needs of others	13
Brief status	201
Identify deviations from plan	*6*
Record deviations from plan	*28*
Report problems	*14*
Discuss actions/decisions	485
Inform others of actions/decisions	128
Implement remedial actions	*14*
Reallocate workload	*2*
Total Observation Time: 225 mins	

Clearly, behaviours such as *identify deviations from plan, record deviations from plan, implement remedial actions, report problems,* and *reallocate workload* occur at very low levels. In addition, *anticipate information needs of others* also occurs at a low level here, but this must be interpreted with care. Previous observations of teams with higher levels of experience working together indicate that the level of this behaviour can be expected to rise as the team members become more familiar with each other. During observations conducted at the Headline 2000 experiment, the Bde HQ team showed higher levels of this type of pre-empting behaviour than the BG HQ team (Mills, Huf and Kardos, 2001). In this scenario, the Bde HQ team members had worked together on more occasions than the BG HQ team, leading to greater familiarity. In all cases, the artificiality of the experimental setup — particularly in terms of team structure and size — must be considered before conclusions are drawn too hastily.

Thus, although there is no doubt that the behaviour list will need to be modified; the reasons for the omission of certain behaviours during the exercise must be considered carefully. It is vital that some important aspect of team interaction or team member behaviour which contributes to SA development and maintenance is not prematurely omitted on the basis of limited evidence. Some of the potential reasons for particular behaviours not being observed in this situation may include:

- Moderate to low fidelity compared with real HQ staffing setups (very few staff imitating the functions usually carried out by far more individuals, and lack of an S2 in the Bde HQ)
- The lack of familiarity of the military with their assigned team members
- Lack of experience of the observers leading to inability to identify, or inconsistency in identifying the behaviours in question

- Lack of equipment to enable the behaviour to occur (eg. Avn Regimental HQ were given the ModSAF view only during mission 4)

It is also possible that the low level behaviours themselves may need to be altered to better reflect what is going on in the HQs.

3.2 Levels of behaviour

For ease of presentation of the results, the behaviours are divided into categories relating to their functions. The first category is *Information Handling*, and involves behaviours that move information to, from, and between staff within the various HQs, as well as to the units in the field. The levels of behaviour relating to *Information Handling* during mission two for each location are shown in Figures 1 to 3. The behaviour levels are presented as percentage contributions to the total in each location, with time intervals indicating five minutes each.

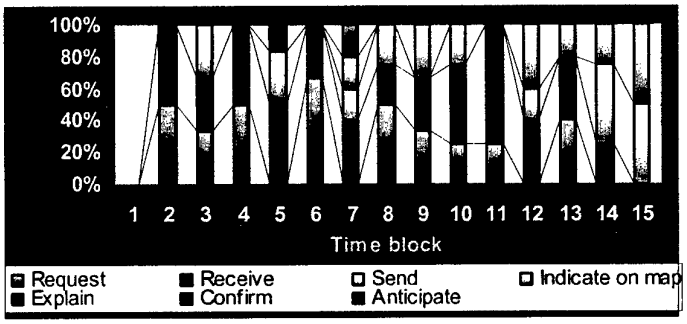

Figure 1: Bde HQ information-related SA behaviour during mission 2

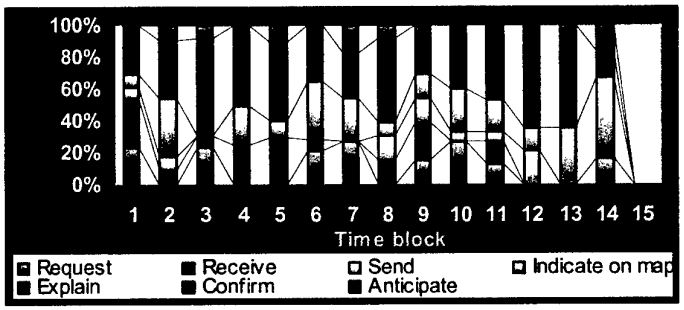

Figure 2: JOSCC information-related SA behaviour during mission 2

Clearly, the Bde HQ in Figure 1 shows a high tendency towards *requesting* and *receiving information*, with an increased tendency towards *indicating information on maps* near the end of the mission. The JOSCC shown in Figure 2, by contrast, shows moderate levels of both *requesting* and *receiving information*, with much higher levels of *explaining information* obvious throughout the mission. In Figure 3, the high levels of the behaviours *receive* and *send information*, along with sporadically moderate levels of both *request* and *confirm information* supports the fact that the Avn Reg HQ tended to depend more on the radio

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communications than the SA tool (computer screen) for its SA updates. The Avn Reg HQ staff also show a level of *anticipatory* behaviour not encountered in the other locations. This may be due to the ability of a smaller number of staff to acclimatise to the needs of their fewer co-workers more quickly (cf a large group).

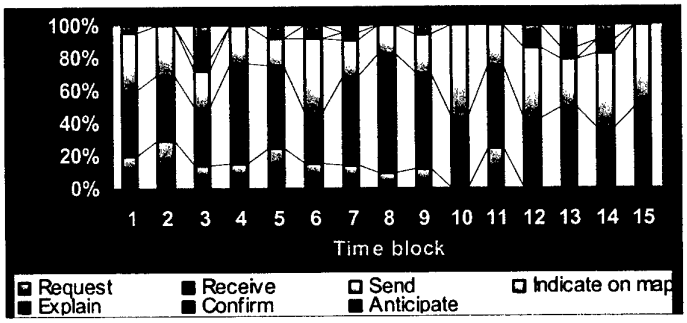

Figure 3: Avn Reg HQ information-related SA behaviour during mission 2

When the critical events list is examined, it is apparent that there are peaks in particular behaviours during or adjacent to time intervals containing critical events. During time interval 5, for instance, Bde HQ issued orders to the elements engaging the T-80s to the effect that these elements were to withdraw and allow the tanks to be engaged by the helicopters instead. Figure 1 shows that this coincides with high levels of *receiving* and *explaining information*, and *indicating information on the map*. In the JOSCC, however, this time interval coincides with a high level of *explain information*, concurrent with moderate levels of *receive information*, and low levels of *confirm information* and *indicate information on map*. During this period, the Avn Reg HQ demonstrates very high levels *receive information*, with moderate levels of *request*, *send* and *anticipate information* and moderate levels of *request* and *send information* apparent. These levels of behaviour indicate that something of importance was occurring during this time interval, and that it was of particular importance for the Avn component of the blue force. The higher levels of *send information* occurring in the following time interval indicates that the information received by (and processed in) the Avn Reg HQ was then imparted to other locations (Bde HQ, for example) in order to maintain the SA of the team members.

The second category of behaviour used here is the *Status/Action* category. The average levels of behaviour relating to commander's perception of the current situation and necessary actions (during mission 2) are shown in Figures 4 to 6. Again, the time intervals shown indicate five minutes each.

When Figures 4, 5 and 6 are compared with the table of critical events for mission 2 (Table 6), it is clear that during time interval 5 the Bde HQ focus is on *briefing the status* of the mission to the staff, while the JOSCC shows no behaviour during that period (which relates to the staff attending to the Bde HQ briefing). The Avn Reg HQ shows high levels of *brief status* and *discuss actions/decisions*, with a moderate level of *inform others of actions/decisions* during this interval.

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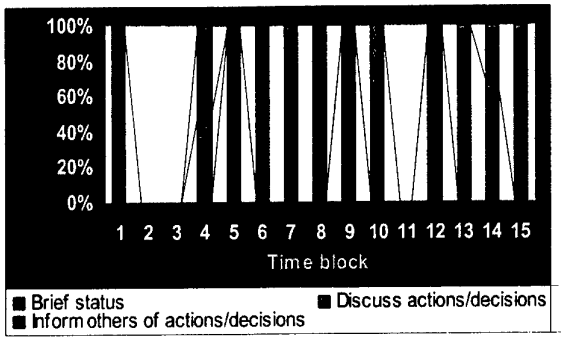

Figure 4: Status and action-related behaviour levels in the Bde HQ during mission 2

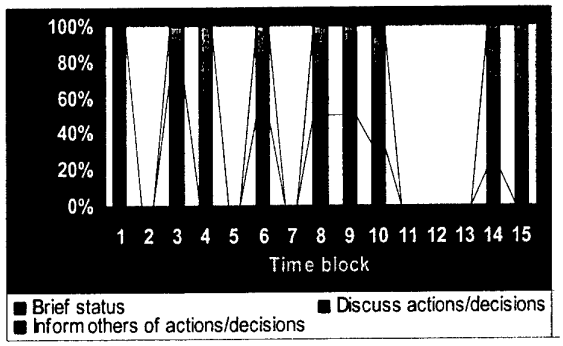

Figure 5: Status and action-related behaviour in the JOSCC during mission 2

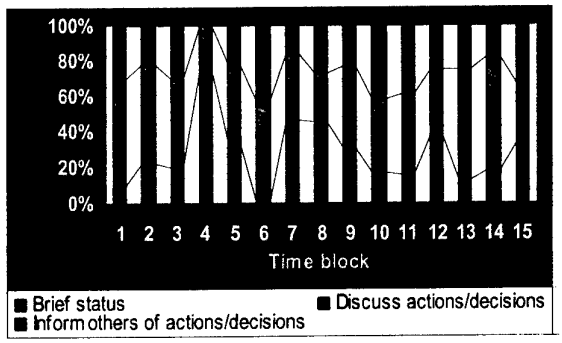

Figure 6: Status and action-related behaviour levels in the Avn Reg HQ during mission 2

This supports the assumption that the workings of the airborne component of the force are of importance at this point in time. This is further supported by the rise in *discussing actions/decisions* and *informing others of actions/decisions* in the following time interval, as the Avn Reg HQ is ensuring that the rest of the team are aware of events and the status of air assets.

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Table 6: Events occurring during each time block for mission 2

Time interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Event		Helo 1 crashed	Helo 2 landing for replen waitout	ManPad destroyed; Helo 2 back up	Order from Bde HQ wrt elements engaging T-80s to withdraw, helos to engage instead	Helos engaged and destroyed T-80s; order from Bde HQ to BG Locust re: movement		Weevil reports 3 x BTRs destroyed; Bde request confirm en target destroyed		Helos engage enemy near burnt out carriers; en at objective 4 engage blue forces	Identified Coy of T-80s between GS 0796 - 0799	Helo 2 shot down	BGs Sabre & Mitre secure Knots Crossing; Manbulloo reported secured		

Figures 7, 8 and 9 show the proportions of information related behaviour occurring in each location during mission 3. It is clear that the Avn Reg HQ shows a much higher level of *confirmatory* behaviour than either the Bde HQ or JOSCC throughout the mission. Bde HQ seems to show the highest incidence of *requesting information*, with the JOSCC initially showing a higher level of *receiving information*, which then turns to higher levels of *indicating information on maps* (at time interval 5) and *sending information* (at time interval 9). Comparing the levels of behaviour in the figures above with the events listed in Table 6, it is apparent that there is a relationship between critical occurrences and increases in the levels of particular behaviours in the different locations. This will be further discussed in section 3.2.1, however some of the patterns will be discussed here.

Table 7 indicates that during time interval 7, the bluefor mechanised infantry were engaged with enemy T-80s, and that the helicopters were tasked to provide offensive fire support. When Figures 8, 9 and 10 are examined, it is clear that the Bde HQ shows a high level of *sending information* during this time interval, with moderate levels of behaviours such as *request*, *receive* and *indicate information on maps*. The JOSCC, by comparison, shows higher levels of *indicate information on maps*, with moderate levels of behaviour such as *request*, *receive* and *confirm information*. The Avn Reg HQ shows very high levels of *receive information*, with moderate levels of *request*, *send* and *confirm information* shown in Figure 9.

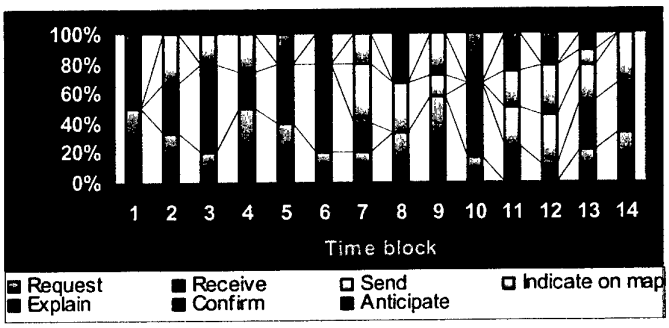

Figure 7: Bde HQ proportions of information related behaviours during mission 3

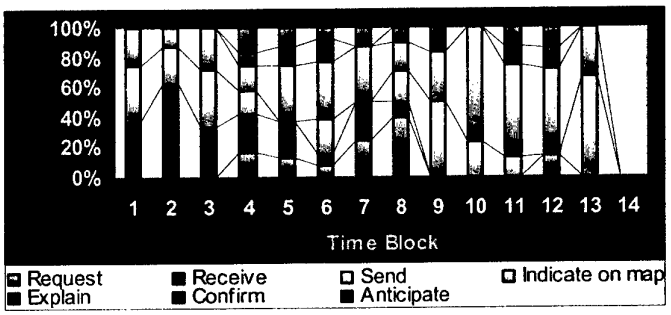

Figure 8: JOSCC proportions of information related behaviours during mission 3

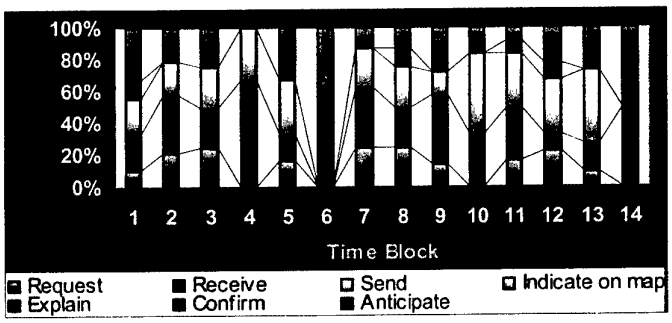

Figure 9: Avn Reg HQ proportions of information related behaviours during mission 3

Figures 10, 11 and 12 indicate the proportions of behaviours relating to the commander's perception of the current situation and necessary actions during this mission. When these figures are examined, it is apparent that while Bde HQ has such a high concentration on *sending, requesting, receiving* and *indicating information on maps* behaviours, there is no time spent on *briefing status, discussing actions/decisions,* or *informing others of action/decisions.* The JOSCC, however, shows extremely high levels of *discussing actions/decisions,* coupled with moderate levels of the behaviour *brief status.* As the JOSCC has incoming information from both the mechanised units and the aviation components of the force, it is the hub of

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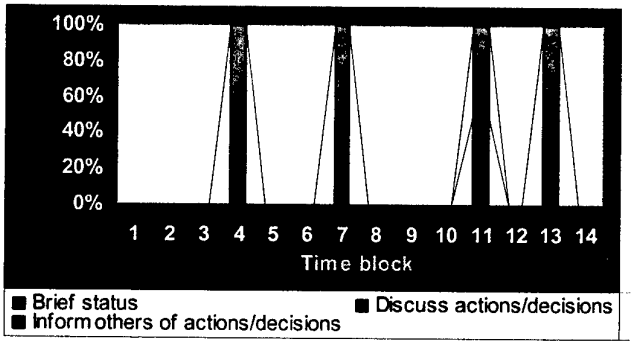
incoming updates from these force areas, and thus is functioning at a high level during periods of action such as these. The Avn Reg HQ shows a very high level of *inform others of action / decisions*, which follows from the HQs function of coordinating and following the actions of the helicopter contingent in the blue force. That is, information received from the helos themselves is digested and disseminated to the JOSCC staff as the battle progresses.

Table 7: Critical events during each time interval in mission 3

Time interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Event	GBAD has already shot down TUAV; ground units not visible on SA tool	Laser designation capability down	CAIRS done; ZSUs & SA16s destroyed; Locust holding squad of BMPS	Falcon contacts BMP	Grasshopper sees dust trails but no en	T-80s identified; indirect fire permission given; BTR80s observed	Mech infantry engaged with T80s;ARH provide offensive fire spt	En withdraw to north; Falcon contact tank troop	En C2 being engaged; Falcon cleared lines Sydney to Melbourne	Falcon destroyed T80s; Weevil destroyed BTR80s		Falcon in contact with unknown en assets	Falcon: en cmdr discussing surrender. All to hold fire	En surrender official



Figures 10: Levels of behaviour relating to status and actions in the Bde HQ during mission 3

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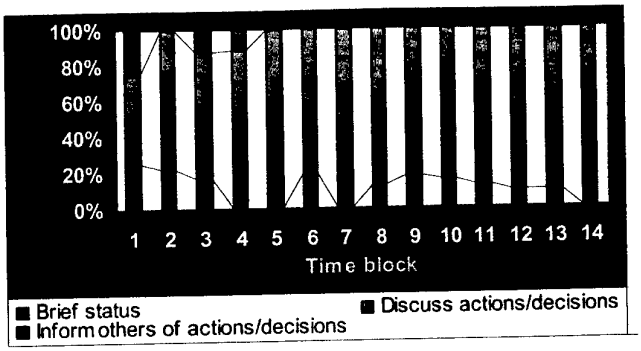
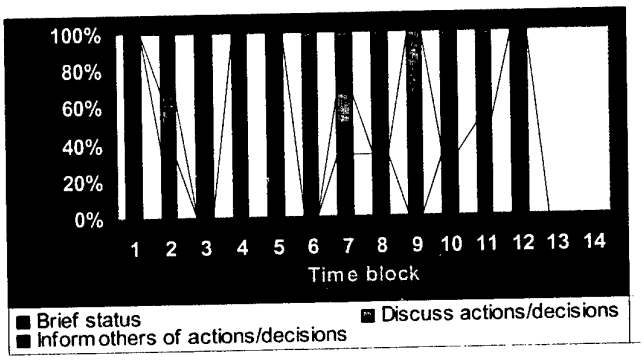


Figure 11: Levels of behaviour relating to status and actions in the JOSCC during mission 3



Figures 12: Levels of behaviour relating to status and actions in the Avn Reg HQ during mission 3

Figures 13 to 16 show the levels of information-related behaviour occurring during mission 4, while figures 17 to 20 show the levels of behaviour relating to the commander's perception of the situation and necessary actions during this mission. These figures should be viewed in conjunction with Table 8 for the list of critical events. It can be seen that initially, the Bde HQ has high levels of *receive information* (during intervals 1 – 8), which becomes high levels of *request information* during intervals 9 and 11. These are accompanied by very high levels of the behaviours *indicate information on map, send information* and *confirm information.* The JOSCC shows its highest levels in the *indicate information on map* and *send information* categories, with additional high levels observed in the *request* and *confirm information* categories. The Avn Reg HQ displays high levels of *send* and *receive information* across all time intervals, with particularly high levels occurring at intervals 1, and 6 and 7 respectively. *Confirming* and *requesting information* also show relatively high levels across the majority of time intervals. Locon shows more moderate levels of behaviour across time intervals (that is, *request information, send information, indicate information on map, and anticipate information needs*), with the exception of *receive information,* which occurs at a high level throughout and peaks during intervals 5, 6, 13 and 14.

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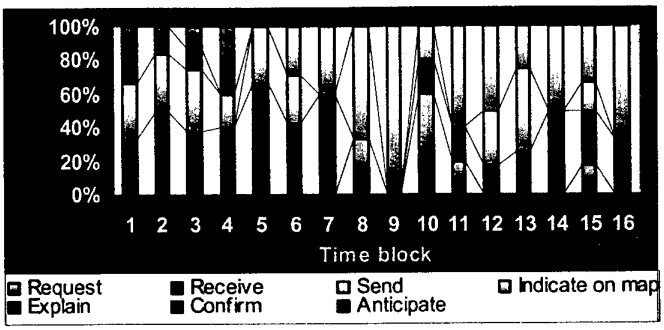

Figure 13: Levels of information handling behaviour in the Bde HQ during mission 4

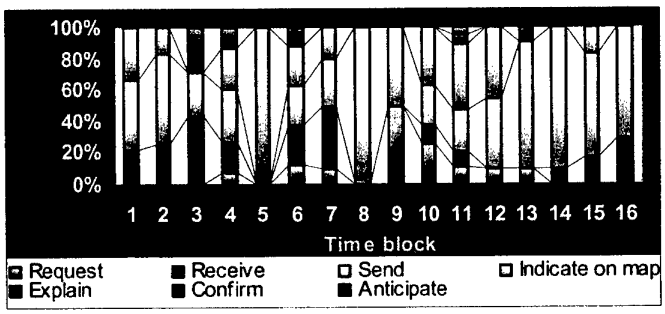

Figure 14: Levels of information handling behaviour in the JOSCC during mission 4

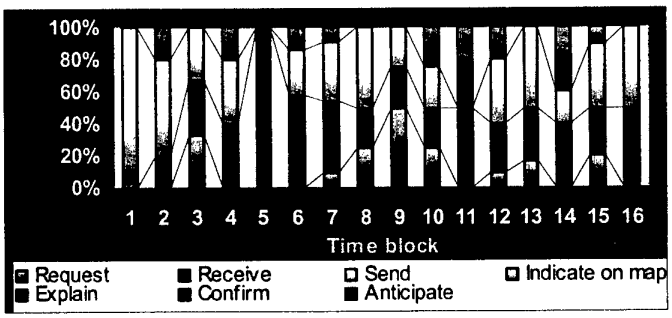

Figure 15: Levels of information handling behaviour in the Avn Reg HQ during mission 4

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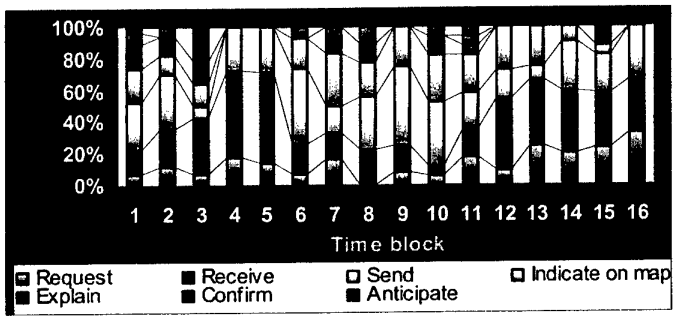

Figure 16: Levels of information handling behaviour in the Locon during mission 4

It is interesting to note that the most frequent occurrences of anticipatory behaviour were found in Locon. This supports the previous assertion that anticipatory behaviours (ie. *anticipate information needs of others,* in this instance) will tend to increase in frequency as the team members become more familiar with each other, as Locon was populated with Military staff local to DSTO who had worked together[8] previously.

Table 8:Critical events table for mission 4

Time interval	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Event	Troop en BMPs contacted	Prepare for handover to FA18s	Weevil attempting to withdraw & break en contact	Falcon sth & central CSs in contact with en T-80s: must picket & wait for helo spt	Confusion over grid squares and clear ground for Falcon	Weevil to laser designate for helos	Falcon hit by T-80s & needs spt; helos id targets in TAI3, request permission to engage	Orders to Sabre & Mitre re: next targets & advances	Avn Reg cmdr orders concentration of timed fire; Arty & fast air splash TAI2	T-80s in minefield and fast air targets destroyed; Obj 1 & Manbulloo secured	Weevil to send BDA re: BTR80s & en C2 node status			En vehicles detected withdrawing to NW of river; Knots Crossing secured; no comms to fast air	Detect hostile jets, air raid warning; BTR80 Trp contacted	En surrender accepted

[8] Including training together at PT and participating in the social activities of the DSTO Division to which they were assigned.

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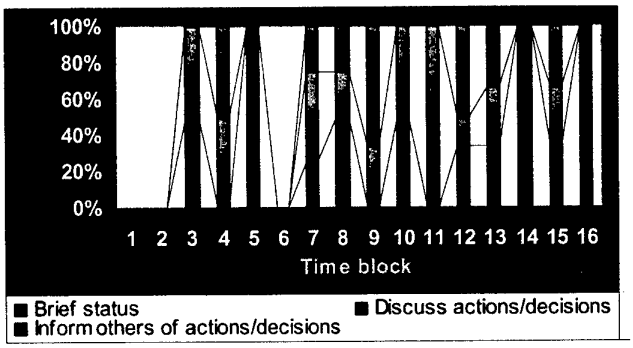

Figure 17: Levels of status and action-related behaviour in the Bde HQ during mission 4

In terms of the Status/Action category of behaviours (ie. relating to the commander's perception of the situation), the Bde HQ (Figure 18) shows a mixture of behaviour levels across time intervals, with high levels of all three behaviours overall, and peaks at different times. *Brief status* peaks during intervals 5 and 16, while *inform others of actions/ decisions* peaks during intervals 9 and 12, and *discuss actions/decisions* peaks during intervals 4, 7, 10 and 11. The JOSCC, by contrast, shows very high levels of *discuss actions/ decisions* throughout the mission, accompanied by low levels of *brief status* (Figure 19). Avn Reg HQ (Figure 20) shows high levels of *inform others of actions / decisions* and *discuss actions / decisions* during intervals 2, 6 and 12. Peaks in these behaviours occur during intervals 13 and 14, and 3, 10 and 15 respectively. The *brief status* behaviour only occurs during interval 9, but does occur at a very high level at this time. Locon (Figure 21), by contrast with the other locations, shows a moderate level of all three behaviours across all time intervals.[9]

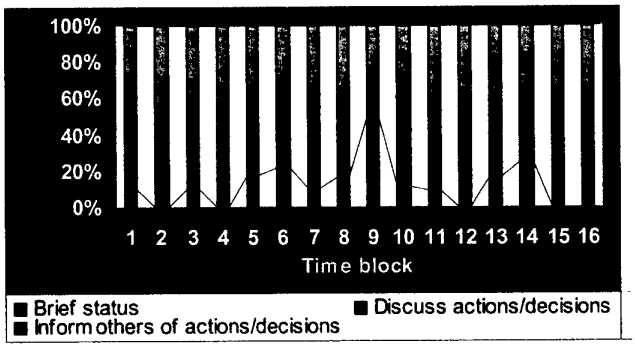

Figure 18: Levels of status and action-related behaviour in the JOSCC during mission 4

[9] This possibly reflects the fact that the Locon staff were simulating the roles of multiple Battle Groups (BGs) and Combat Teams (CTs) throughout the missions.

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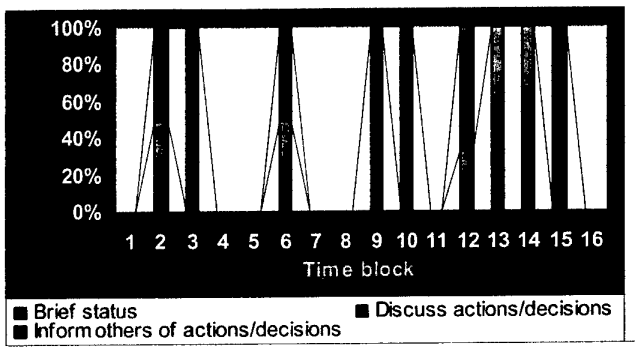

Figure 19: Levels of status and action-related behaviour in the Avn Reg HQ during mission 4

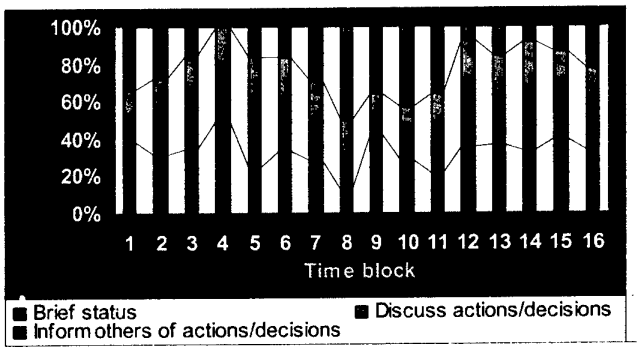

Figure 20: Levels of status and action-related behaviour in Locon during mission 4

It appears that there is a general trend towards the prevalence of particular behaviours during (or immediately prior to or following) events occurring during the battle. The trends were expected to be stronger given that the behaviours observed related to the handling and treatment of *information* – which is at a premium during battle and particularly during high tempo operations.

Unfortunately, there are no clear, strong and consistent patterns emerging from this study which can be said to inform researchers of the possible effects of new technology on the performance of the subject team. This lack may relate to several causes, including:

- The artificiality of the situation
- New and unfamiliar tools being provided to the subjects, with time constraints on training and familiarisation
- The disruptions caused by system breakdowns in the wargame
- The unfamiliarity of the subjects with their team mates

In addition, it may be that the behavioural measures, while suitable for use in the field environment during exercises or actual operations, may not be suited to the laboratory environment in their current form.

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3.2.1 Correlations between team behaviours

Table 9 shows the significant correlations between behaviours in each location across missions during Exercise Prowling Pegasus. There are several highly significant correlations evident in the table, and correct interpretation of these may require returning to the raw data to clarify the relationships elicited from within the data. For example, the very high significant negative correlation (r = -0.838) between *critical event* and *receiving information* in Locon (bold in Table 9) is not intuitive until the raw data is examined. It can be seen then that this negative relationship simply indicates that there is a time lag between the critical events occurring and the receipt of information by Locon, which means that the two zero scores for the critical events correlate with the highest levels of receipt of information.

Moderately high correlations between *critical events* and the *requesting* and *sending* of information, as well as the *informing others of actions and decisions* taken at the Bde HQ level can be expected, as there is an obvious need for the passage of troop information to and from the command level. The commander's SA must be maintained and updated as the situation changes with the progress of battle.

There are interesting trends apparent in this Bde group, however. It is clear that there was an increasing tendency across missions for Bde HQ staff to *indicate information* on the battlemap (located on the large Smartboard screen). In addition, the JOSCC staff showed an increasing tendency to *send information* to other locations as well as to *discuss information* with other staff in their location, while the level of *explain information* behaviour showed a strong tendency to decrease over missions. This is possibly due to the increased familiarity of the staff with the Smartboard technology, therefore leading to their increased ability to pinpoint desired information of their own accord.

Table 9: Pearson correlation coefficients for behaviours across missions 2, 3 and 4 in each location

Behaviour 1	**Behaviour 2**	**Pearson Correlation Coefficient (*r*)**	**Probability (*p*)**
Bde HQ			
Critical event[10]	Request information	0.315	P < 0.05
	Send information	0.316	P < 0.05
	Inform others of actions	-0.434	P < 0.01
Request information	Indicate information on map	0.316	P < 0.05
	Brief status	-0.306	P < 0.05
Mission number	Indicate information on map	0.406	P < 0.01
JOSCC			
Mission number	Send information	0.591	P < 0.01
	Explain information	-0.752	P < 0.01
	Discuss actions/decisions	0.657	P < 0.01

[10] NB: 'Critical event' is not a behaviour, rather it is a variable in the database indicating that an event or events took place during a given time interval.

Behaviour 1	Behaviour 2	Pearson Correlation Coefficient (*r*)	Probability (*p*)
Request information	Send information	-0.316	P < 0.05
Receive information	Brief status	0.351	P < 0.05
	Inform others of actions	0.424	P < 0.01
Send information	Explain information	-0.400	P < 0.01
	Confirm information	-0.349	P < 0.05
	Brief status	0.314	P < 0.05
	Discuss actions/decisions	0.435	P < 0.01
Explain information	Discuss actions/decisions	-0.648	P < 0.01
Brief status	Discuss actions/decisions	0.328	P < 0.05
	Inform others of actions	0.808	P < 0.01
Avn Reg HQ			
Request information	Receive information	0.419	P < 0.01
	Confirm information	0.308	P < 0.05
	Brief status	0.352	P < 0.05
Receive information	Send information	0.473	P < 0.01
	Brief status	0.569	P < 0.05
Send information	Inform others of actions	0.420	P < 0.01
	Discuss actions/decisions	0.618	P < 0.05
Explain information	Brief status	0.469	P < 0.01
Discuss actions	Inform others	0.672	P < 0.01
Critical event	**Receive information**	**-0.838**	**P < 0.01**
Receive information	Discuss actions/decisions	0.647	P < 0.01
Send information	Indicate information	0.628	P < 0.01
	Inform others of actions	0.682	P < 0.01
Indicate information on map	Explain information	0.561	P < 0.05
	Confirm information	0.581	P < 0.05
	Inform others of actions	0.732	P < 0.01
Explain information	Confirm information	0.611	P < 0.05
	Anticipate information needs	0.518	P < 0.05
	Inform others of actions	0.616	P < 0.05
Brief status	Discuss actions/decisions	0.667	P < 0.01

3.2.2 Correlations between information handling behaviour and a basic performance measure

The basic performance measure used in this report is the kill/loss ratio, which gives an indication of the level of concomitant red and blue losses. The total losses to both sides over time are illustrated in Figures 21 and 22.

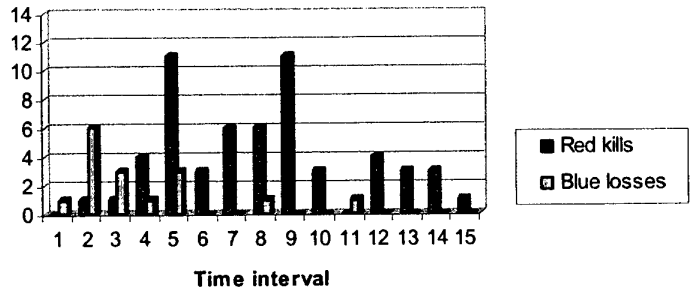

Figure 22: Red kills and blue losses during mission 2

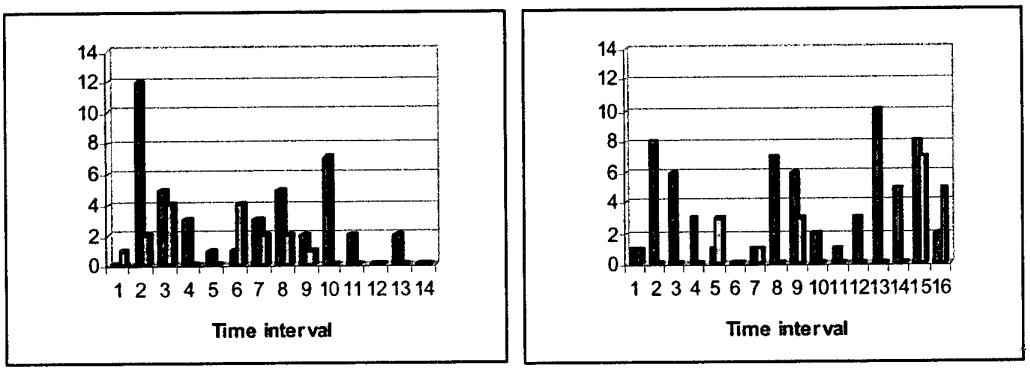

Figure 23: Reds kills and blue losses during missions 3 (left) and 4 (right)

The correlations between the behaviours observed in the staff at the various locations and the number of red kills and blue losses are shown in Tables 10a and 10b. It is apparent that there are few clear relations between these variables, with the exception of moderate positive relationships between information traffic in all locations (requesting and receiving information) during missions 2 and 3. The Avn Reg HQ results in Table 10b indicate that the strongest tendencies for discussion, receipt and briefing of information lay with the staff in this location, possibly because they were isolated from the Bde HQ and JOSCC tents, which were located adjacent to one another in the atrium and therefore allowed more simultaneous communal observation of information by staff. In addition, the Avn Reg HQ's role of communicating with the ARH pilots and tasking the helos would mean that they had a more direct role to play in this type of information handling when critical events occurred during missions.

Overall, then, the correlations between behaviour and the numbers of red kills and blue losses illustrated in Table 10 simply support the notion that information is the most important commodity in the headquarters locations. It remains for future work — preferably in a field setting — to investigate whether there are in fact consistent observable relationships between these behavioural factors and the performance outcomes of the battles fought.

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Table 10: Significant correlations between behaviours/events and numbers of red kills/blue losses

a) During each mission (across all locations)

Item 1	Behaviour	Pearson Correlation Coefficient (*r*)	Probability (*p*)
Mission 2			
Reds destroyed	Request information	0.217	$P < 0.05$
Mission 3			
Blue Losses	Request information	0.264	$P < 0.05$
Reds destroyed	Request information	0.396	$P < 0.05$
Reds destroyed	Receive information	0.347	$P < 0.05$

b) In each location (across all missions)

Item 1	Behaviour	Pearson Correlation Coefficient (*r*)	Probability (*p*)
Avn Reg HQ			
Reds destroyed	Discuss actions/ decisions	0.302	$P < 0.05$
Reds destroyed	Receive information	0.576	$P < 0.05$
	Brief status	0.667	$P < 0.01$

3.3 Tool use

Tool use in each of the different locations is shown in Figures 24 to 26. Mission codes relevant to the figures below are stated in Table 11. It can be seen that the use of SA tools and radios occurs at a relatively high level across missions for the Bde HQ, the JOSCC, and the Avn Reg HQ (shown in Figures 24, 25 and 26 respectively). The highest reliance appears to be on the use of the SA tool (in this instance, the LandScape software) in the JOSCC and Avn Reg HQ, with the Bde HQ showing similar levels of use for both the SA tool and the radios. SA tool use dropped away quite sharply during mission 4 in the Avn Reg HQ, and this was later found to be a product of the low level of staffing in that location[11] rather than any preference for other modes of information handling.

Table 11: Mission codes used in Figures 24 to 29

Codes	Mission Numbers
1	2
2	3
3	4

11 Pers comm. CW4 R Huffman.

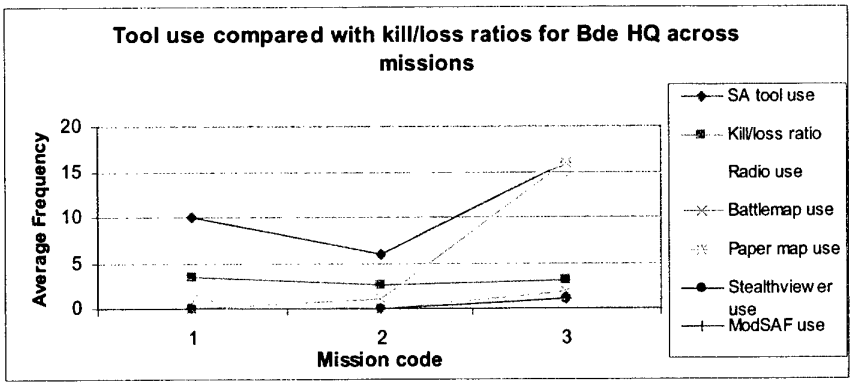

Figure 24: Tool use and kill/loss ratios in the Bde HQ

It is apparent that there is a strong correlational relationship between the use of certain tools (such as the SA tool and radio) and the kill loss ratio shown in Figures 24 to 26. The values of these correlations are shown in table 12. Significant moderate positive relationships between the performance measure (ie. the kill/loss ratio) and the use of the SA tool, paper maps and radios are seen in the Bde HQ, indicating that improvements in performance are associated with higher levels of use of this equipment by staff. The JOSCC, by contrast, shows a significant negative correlation between the kill/loss ratio and the use of the SA tool and Stealthviewer. The cause for this is unclear, particularly given the results obtained for the Bde HQ, but it may be an artefact of the artificiality of the experimental command location setups.

The Avn Reg HQ shows highly significant, strong negative correlations between the kill/loss ratio performance measure and battlemap and Stealthviewer use, indicating that improved performance was associated with lower levels of use of these tools. Radio communications at this location, on the other hand, showed a significant strong positive relationship with performance, indicating that there is still a strong reliance of the pilots and those in base command posts on voice communications for the updating of individual (and group) SA.

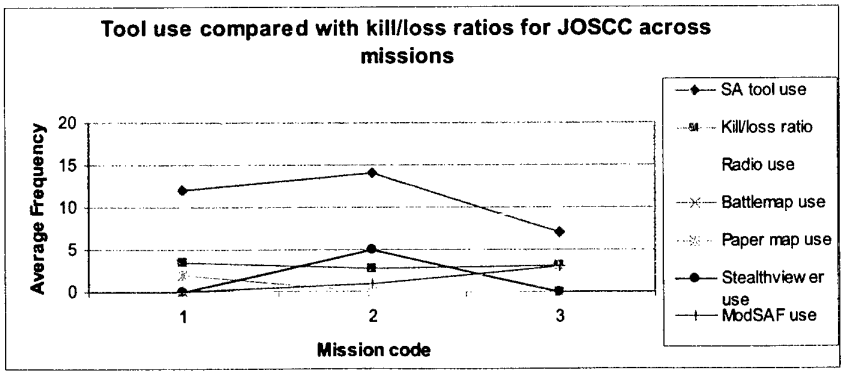

Figure 25: Tool use and kill/loss ratios in the JOSCC

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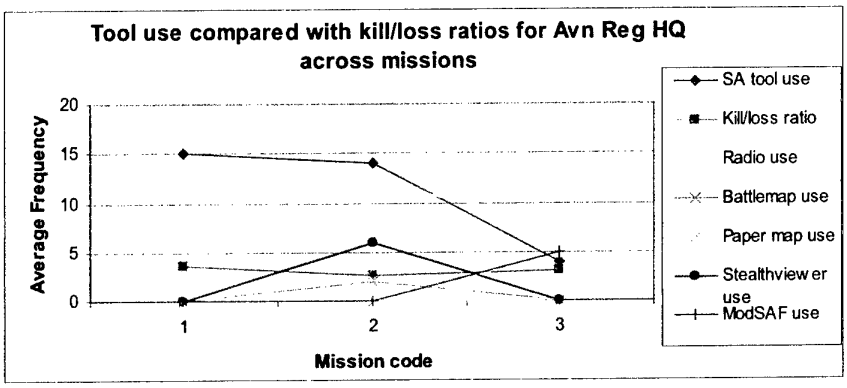

Figure 26: Tool use and kill/loss ratios in the Avn Reg HQ

Table 12: Correlation coefficients for the relationships between tool use and kill/loss ratios in each location across missions

Item 1	Item 2	Pearson's *r* Correlation Coefficient	Probability (*p*)
Bde HQ			
Kill/Loss ratio	SA tool use	0.486	$P < 0.05$
	Radio use	0.583	$P < 0.05$
	Paper map use	0.583	$P < 0.05$
JOSCC			
Kill/Loss ratio	SA tool use	-0.372	$P < 0.05$
	Radio use	0.911	$P < 0.01$
	Paper map use	0.812	$P < 0.01$
	Stealthviewer use	-0.912	$P < 0.01$
Avn Reg HQ			
Kill/Loss ratio	Radio use	0.911	$P < 0.01$
	Battlemap use	-0.910	$P < 0.01$
	Stealthviewer use	-0.911	$P < 0.01$

3.3.1 Tool use and team behaviour

Figures 27 to 29 illustrate the significant relationships between behaviours and tool use that are listed in Table 13 below. Clearly, the SA tool in the Bde HQ was of use to staff when briefs of events, or asset status or locations were occurring. It is also apparent that the Stealthviewer (images fed to the Bde HQ from the TUAV) was sought after for confirmation of reported information, and that the MoDSAF screen was used as a back up for the SA tool in terms of asset information.

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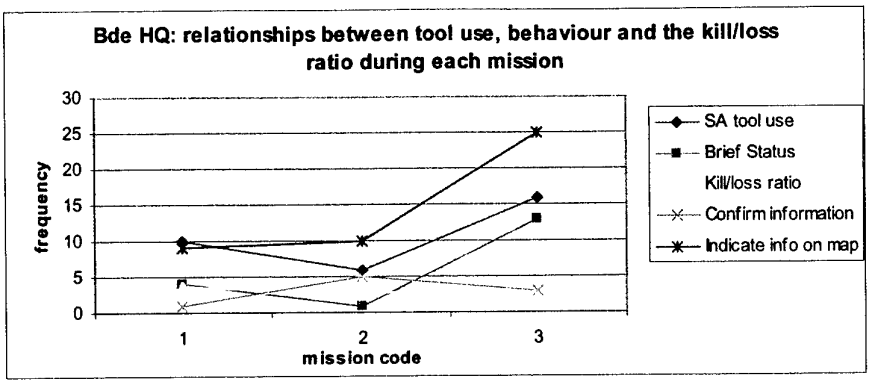

Figure 27: Significant correlational relationships between tool use and behaviour in the Bde HQ

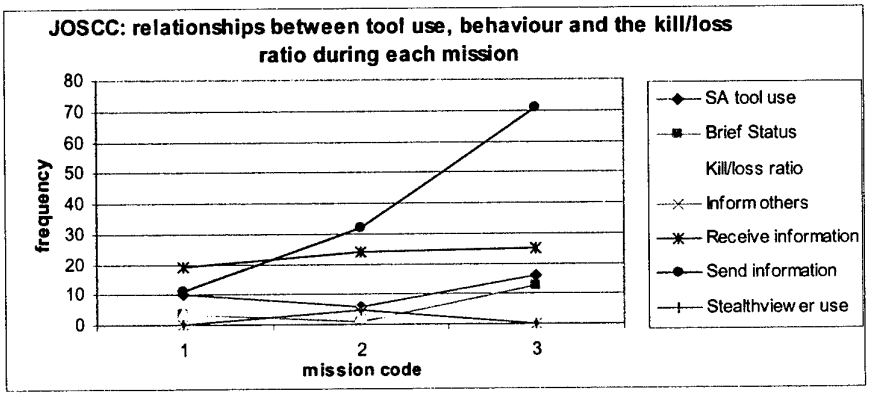

Figure 28: Significant correlational relationships between tool use and behaviour in the JOSCC

Figure 28 shows that in the JOSCC, the battlemap was often used concomitant with the Stealthviewer during mission 2, and its use was also commonly associated with behaviours such as *receiving information, brief status,* and *inform others of actions/decisions.* The use of MoDSAF was frequently observed concomitant with *sending information,* indicating that staff tended to check or obtain information from the MoDSAF screen prior to sharing this information with staff in other locations.

Figure 29 shows that the use of the SA tool was often backed up with the use of paper maps in the Avn Reg HQ. This appears to indicate that the staff are still unsure in the use of the SA tool (due to minimal training and lack of experience with the tool at this stage) or that (as previously stated in the case of the Avn Reg HQ) the lack of staff numbers — possibly combined with the lack of experience — make the use of this tool inefficient and relatively unreliable compared with the well known pen and paper method. Use of the battlemap and paper maps are often concomitant with the use of the radio, however behaviours such as *explaining information* and *brief status* showed a negative correlation with radio use, indicating that the tendency is to deal with staff *in situ* and that the radio was therefore not needed. The negative relationships between these two behaviours – in

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addition to the use of both battlemap and paper maps – indicates that the tendency is for the staff member carrying out the briefing or explanation to acquire the necessary pieces of information prior to beginning the brief/explanation, and then to carry these out without the use of prompts.

Table 13: Significant correlations between tool use and team behaviour across missions in each location

Tool Used	Behaviour/Tool used	Pearson Correlation Coefficient (*r*)	Probability (*p*)
Bde HQ			
SA tool	Brief status	0.346	P < 0.05
Stealthviewer	Confirm information	0.308	P < 0.05
ModSAF	Indicate information on map	0.395	P < 0.01
JOSCC			
Battlemap	Stealthviewer	0.550	P < 0.01
	Receive information	0.353	P < 0.05
	Brief status	0.600	P < 0.01
	Inform others of actions	0.846	P < 0.01
ModSAF	Send information	0.465	P < 0.01
Avn Reg HQ			
SA tool	Paper map	0.354	P < 0.05
Radio	Battlemap	0.427	P < 0.01
	Paper map	0.500	P < 0.01
	Explain information	-0.347	P < 0.05
	Brief status	-0.305	P < 0.05
Battlemap	Brief status	-0.335	P < 0.05
Paper map	Explain information	-0.303	P < 0.05
	Brief status	-0.457	P < 0.01
Locon			
Paper map	Explain information	0.681	P < 0.01
	Confirm information	0.507	P < 0.05
	Anticipate information needs	0.717	P < 0.01
ModSAF	Explain information	0.691	P < 0.01
	Confirm information	0.808	P < 0.01
	Paper map	0.683	P < 0.01

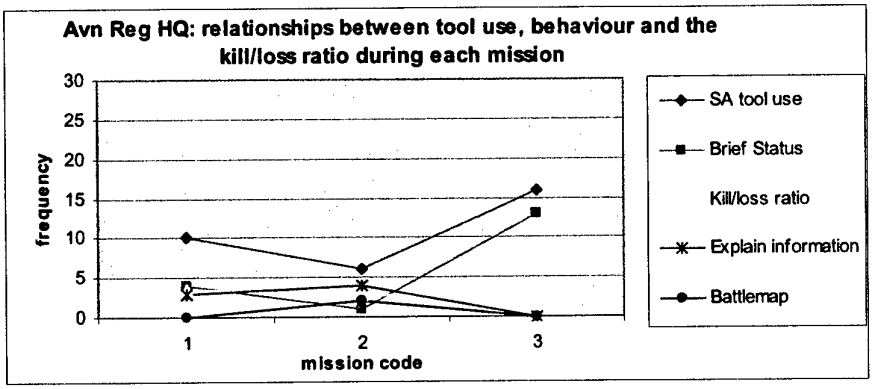

Figure 29: Significant correlational relationships between tool use and behaviour in the Avn Reg HQ

Locon is not represented graphically, as observations were only carried out on this location during mission 4, and therefore no pattern can be illustrated across missions. Clearly, though, there are very strong positive relationships between the use of the paper maps and both *explain information* and *confirm information* behaviours, as well as *anticipating information needs.* The use of MoDSAF also correlates very strongly with *explaining information* and *confirming information,* as well as the use of the paper map. The population of Locon with the LOD military (ie. local DSTO-assigned military staff) may have contributed to the higher incidence of anticipatory behaviour recorded here, as these staff have had more prior experience working with each other than the majority of the military staff brought in from the various base locations. In addition, they are more familiar with the workings of MoDSAF than 'outsiders', and have developed a level of familiarity with the functions provided by these technologies.

3.4 Performance measures and perceptions of achieved intent

During the AARs held following missions 2, 3 and 4, staff from the different locations were asked to outline several important items of information and comment on the effectiveness of their mission(s) and the achievement of intent. These areas included:

- The mission
- The task(s)
- The endstate achieved
- The tactics used
- The weapons and/or sensors used
- The effectiveness of the mission
- The achievement of intent

Summarised versions of the AAR outcomes can be found in Appendix C.

The overarching intent for all missions followed the guideline:

'ITF is to capture Katherine in order to dislodge MAF elements and force them to the North West in order to set the preconditions for their destruction in detail.'

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This was the guidance that determined the planning conducted by the sub-unit commanders, and the methods to be used for the operational phases of the missions. The crucial element of the mission outlined above is that the enemy was to be dislodged from within Katherine and destroyed in detail in the open areas to the Northwest. One of the intentions here was to minimise the civilian casualties in the town itself. That is, it was not adequate to simply destroy the enemy, it was intended for this to occur in a carefully controlled area. Once this type of issue is considered, it becomes abundantly clear that a single simple measure of effectiveness (such as the kill/loss ratio used earlier, for example) is not adequate to judge the quality of the outcomes achieved. There should be a combination of measures used which take into account all the important aspects of the battle.

Thus, the perception of achieved intent can work interestingly with the actual outcomes in terms of the number of red kills and blue losses, and/or the kill/loss ratio examined in conjunction with the location of the enemy assets that were destroyed.

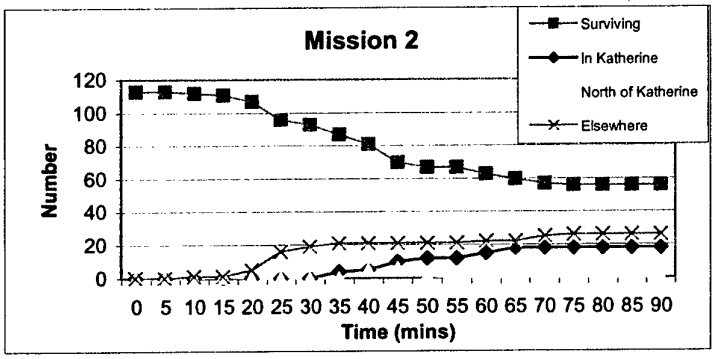

Figure 30: Reds surviving and reds destroyed (and where) during mission 2

A figure such as 30 breaks down the actual destruction of red assets and the locations of the red kills, which can give a clearer indication of the actual achievement of intent in its most precise form. It can be seen that the number of reds destroyed in Katherine is initially relatively low, and that those destroyed elsewhere is quite high. The number actually destroyed within the designated zone is very low. Comparing this with Figures 31 and 32 (below), it is clear that only at the end of mission 4 is the intent to destroy the enemy in the area North West of Katherine met to any great degree. The number of reds destroyed in this area rises sharply during the third-last time block, however there is still a high level of red destruction occurring in the 'elsewhere' category and also within Katherine itself.

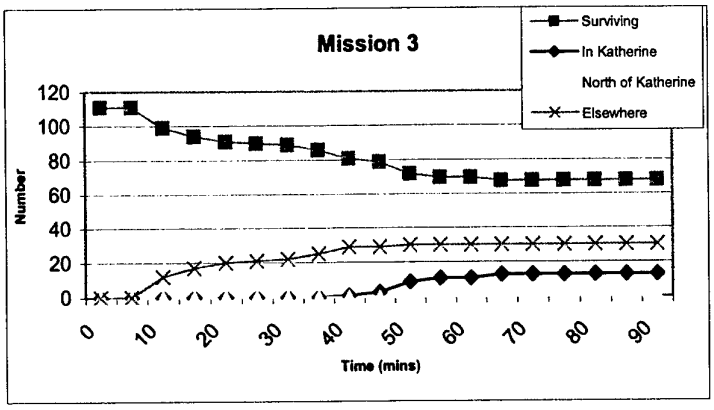

Figure 31: Reds surviving and reds destroyed (and where) during mission 3

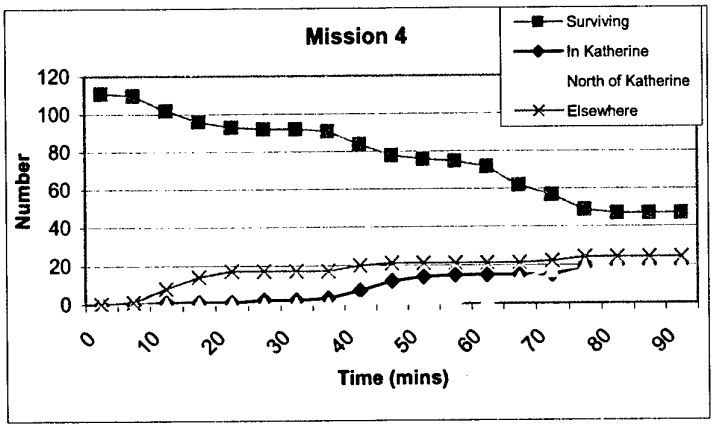

Figure 32: Reds surviving and reds destroyed (and where) during mission 4

Although there should be a relatively clear relationship between the outcomes of the wargames and the perception of achieved intent, more work needs to be conducted in terms of relating the measures of performance chosen to the outcomes of the wargames themselves to elucidate this relationship. As can be seen from the figures above and the comment available in the AAR summary in Appendix C, perceptions of successfully achieved missions and the meeting of intent incorporate factors other than simple comparisons between what happened and the way the original commander's intent was stated. In order to successfully make statements regarding these relationships, an understanding has to be sought from the military staff involved. This in itself may not be simple, in that different commanders tend to have individual styles of command and possibly perceptions of what constitutes acceptable adherence to the commander's intent in conjunction with the achievement of aims. This will be addressed in future work.

3.5 Higher level measures and behaviour

In terms of the system of systems analysis desired by researchers at DSTO, the outcomes of the behavioural observation have not proved to be good indicators of the outcomes produced in the artificial laboratory environment. A list of possible causes for this is outlined in section 3.2. It is intended, however, that future work will attempt to delineate a relationship between performance measures at all levels, wargame outcomes, and behavioural indicators in a variety of settings – including field exercises and (potentially) operational settings.

In addition, future work will attempt to investigate relations between the higher level outcome measures and the measures of behaviour utilised here. There are several types of higher level measures suggested for use in this type of experiment. They are outlined in brief below, and follow a list of potential measures outlined during the planning process for the Prowling Pegasus experiment.

Measures of Force Effectiveness (MOFEs)
These are a series of measures designed to elucidate the level of effectiveness of the force under certain conditions. They include:

MOFE1: the total time taken to expel all enemy from Katherine
MOFE2: a time integral of the enemy's capability in town (which requires a graph of the enemy capability in the town over time). Enemy capability can be taken as equivalent to the number of enemy to a first approximation.
MOFE3: the number of enemy destroyed outside the town. Aspects of this measure include (a) the number of enemy escaping, (b) the number of enemy destroyed inside the town.

Measures of Force Cost (MOFCs)
MOFC1: the overall cost of the force in terms of assets and equipment (a list of numbers and types of assets is necessary for this. Eg. 500 infantry, 40 SF, 30 LAVs, etc)
MOFC2: the number of losses to the blue forces (numbers and types of assets, as well as troops)
MOFC3: the number of civilian losses

Measures of Effectiveness (MOEs)
MOE1: includes items such as

- The number of targets destroyed by the LAS
- The number of targets assigned to the LAS but not destroyed by it

MOE2: includes items such as

- The rate of targeting (ie. a graph of the numbers targeted for and by the LAS as a function of time)
- The number of elements of the LAS remaining and untargeted

Measures of Cost (MOCs)
MOC1: includes such items as

- The capital value of the LAS (a list of numbers and types of assets and troops within the LAS)
- LAS losses
- Fratricide due to the LAS (both own force and civilian)
- Collateral damage caused by the LAS

MOC2: includes such items as

- Vulnerability
- The total time elements are within the range of enemy weapons

Measures of Performance (MOPs)
These are measures of the times taken to complete the phases of the procedures implemented and hence, they will change if different procedures are used. These should be converted to rates (ie. the inverse of time)

MOP1:
Tasking time (this includes brigade level planning, preparation of orders to the BG, communication and receipt of intent and orders). It is the start time to the finish time (when the orders reached the Regimental HQ).

Mission planning time. This is from the receipt of orders to the actuality of having the plan in the helicopter and other LAS elements. This can be further broken down into planning times for each element of the BG.

Time to target area. This is from the time the plan is received to actually reaching the NAI. This should involve separate measures for each of the elements involved.

Search time for the LAS element doing the target acquisition. This is from the time of reaching the NAI to the time of target location.

Engagement time. The time from locating the target to weapon engagement, including the handover time for third party targeting.

Retasking time. The time from weapon engagement on one target to the receipt of retasking orders.

Costs at this level include:

- The ratio of numbers of threats known to the total number of threats
- The acceptable risk factor (in the experimental situation, this would be a subjective assessment by the SME, rated on a scale of one to ten).

MOP2:
The contribution of various system components to the MOP1s needs to be measured, and then system decomposition and influences are required. A series of comparative baseline experiments are necessary so that effects of system components can be assessed, and the MOP1s should be used here to assess the impact of these system component aspects. The system synergism issues should be taken into account, which means that the true impact of the technological enhancements can only be made apparent if procedures designed to harness their potential are implemented alongside the system components themselves.

It is suggested that the measures can either measure the performance of the tools in terms of their provision is SA to the subjects, or assume that SA is directly related to the ability to perform tasks and therefore measure task performance.

Tasking time. This is influenced by the time taken to acquire the SA which leads to the decision to task the LAS, and the LSAS should have an impact here. It should also impact on other contributing aspects, including the Brigade's planning process, the issuing of orders, and the receipt of intent.

Mission planning. The LSAS will impact on the acquisition of the SA (including red, blue, and the environment in general) and the understanding of their interactions. In addition, the mechanics of plan production and communication will also be impacted.

Time to target area. This will depend on aspects of platform mobility, but also the SA related to the platforms' navigation and threat avoidance.

Search time to target acquisition. This will depend on sensor capabilities and surveillance procedures (such as search patterns and cooperative surveillance), and should be impacted by the LSAS.

Engagement time. The LSAS can assist the handover from target acquisition to the weapon or response system.

Retasking time. The LSAS can provide the ability for collaborative tasking, and so can assist retasking 'on the move'.

Costs. The LSAS can reduce the vulnerability of blue assets by providing displays of known and potential threats, including their engagement ranges. Mission planning can be conducted using the LSAS to utilise terrain features in order to avoid these threats.

The list of higher level performance and cost measures above constitute a preliminary attempt to define effective and meaningful measures which will allow researchers to give some significant feedback to the military participants as well as supplying valuable insights into the workings of the military and their interaction with technology in a variety of situations.

4. Conclusions

Overall then, when the results are examined, some patterns and general observations can be made.

The observed ties between behaviours and events in the different locations were different, however this may not be especially meaningful in light of the fact that subjects in each location differed on several dimensions. That is, each location had different numbers of subjects, they had different levels of experience functioning as a team with other members, and there were differing levels of experience in their assigned roles.

Overall across missions 2, 3 and 4, the subjects tended to display higher levels of *sending, requesting, explaining information,* as well as *indicating information on map* in temporal proximity to the occurrence of critical events. This should be expected as the team members would have been sharing and analysing important information, both for its content and for the consequences to their force. In the Avn Reg HQ, however, this was eclipsed by *receiving information* (although *sending* and *requesting information* remained high) as they tended to act as a conduit between the Bde HQ and JOSCC, and the helicopters.

In keeping with expectations as the increasing levels of familiarity and experience the participants gained during the exercise, the levels of anticipatory behaviour showed a concomitance in all locations.

In terms of observed behaviour and its correlations with the basic performance measure (ie. the kill/loss ratio) across the locations, there was little in the way of an overt trend, since the correlations were relatively weak and did not indicate a strong relationship.

Tool use levels showed that there was a difference in tool preference between the locations, with the Bde HQ consistently preferring radios to other tools, while the Avn Reg HQ and JOSCC both clearly preferred the SA tool during missions 2 and 3, reverting to a radio preference during mission 4.

The preferential use of particular tools for specific jobs (ie. the SA tool for the briefings conducted in the Bde HQ) were noted, and the popular characteristics of the tools noted for inclusion in future design specifications.

The achievement of intent and mission success measure require refinement and adjustment, as there are no clear guidelines at this stage to indicate during this scenario what constituted acceptable blue losses, and what level of enemy destruction was acceptable within the Katherine town limits (given the original intent). More specific data needs to be sought during the scientific AARs in order to clarify these points and allow more accurate assessment of the outcomes of the experiment.

In summary, further work needs to be conducted on the relations of behaviour and performance in these settings. As the relations under these experimental conditions are relatively tenuous, more rigid controls may be needed in order to strictly test the outcomes of adding technological enhancement to military teams performing under battle stress. It is here that the input of the behaviour systems/systems perspective approach will be valuable in determining precise points of error and the origins of problematic outcomes (which can occur when staff are unfamiliar with new technologies). These issues will be addressed in future studies in this area.

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Appendix A: Simple behaviour systems models

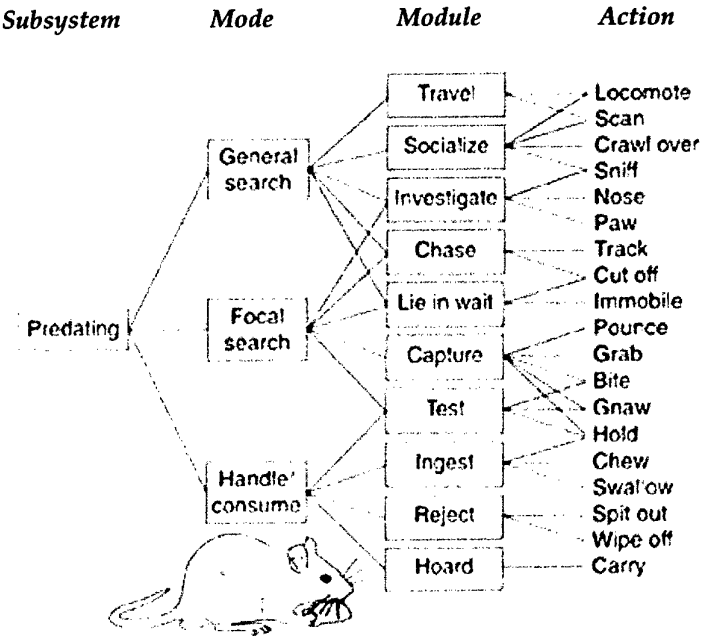

Figure A1: Part of the Feeding behaviour system of the rat.(Figure 3.14 from Shettleworth)

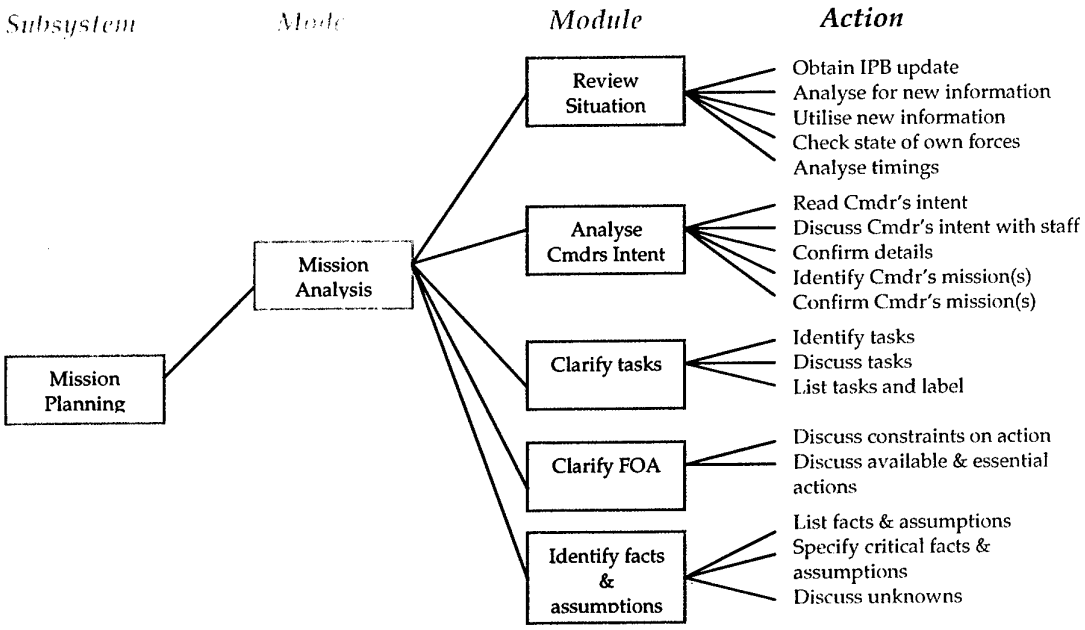

Figure A2: A section of the Planning behaviour system for military staff.

Appendix B: Checksheets

B.1. Situation Awareness checksheet

Situation Awareness: Date: _____ Time: _____ Observer: _____ Day & Session: _____

Subject of Observations: (team) (no. of team members)

[NOTE: Record all instances of each behaviour by marking the box in the appropriate time slot]

Time Block (mins) / Action/Behaviour	5	10	15	20	25	30	Total
Monitor environment / battle							
Monitor others							
State location							
Request information							
Receive information							
Send information							
Indicate information on map							
Explain information							
Confirm information							
Anticipate need for information							
Brief status							
Identify deviations / discrepancies from plan							
Record deviations / discrepancies from plan							
Report problems							
Discuss actions							
Inform others of decisions / actions							
Implement remedial action(s)							
Reallocate workload							

B.2. Tool Use checksheet

Place a mark in the box at the end of each interval to indicate tool use, operator resting, or operator absence.

Time Block (mins)	SA tool (BS/LSAP)	Radio	Radio Log	Duty log	Whiteboard	Battlemap	Other (specify)	Operator resting (not actively working)	Operator absent
5									
10									
15									
20									
25									
30									
35									
40									
45									
50									
55									
60									
Total:									

Other:

- Stealth view
- Phoenix
- Paper and pens

Appendix C: After Action Reviews: summary of results

C.1. AAR 1: Missions 2 Tuesday 20/03/01

ARH

What was the mission? (Information from each level)

- Route for the helicopters
- Primary task – clear route to Manbuloo
- Security for force troops on the ground

End state

Landing Zone (LZ) at Manbuloo secured to continue operations

Tactics

- Both to clear route N/NE
- Performed normal techniques within limits of sensors and visual range

Weapons/Sensors

- Combination of all sensors
- Air to ground missiles (3000m range)
- Cannon for ranges less than this

Effectiveness

- Covered the lack of reality
- Unrealistic weapons choice (eg hellfire used on manpads)
- Not as effective against single enemy targets

Was the Commanders intent covered? Yes, via specific orders.
Feedback from ARH to Commander (COMD) helped COMD know about updates.
Was there sufficient freedom of action? Yes. Plenty of freedom to conduct the mission.

SQN HQ (NORTH)

What was the mission?

- Destroy the enemy (en) C2 node/s
- Preliminary operation: clear NAI2 (GBAD) in conjunction with SF
- Phase 1: destroy C2 at TAI (West of Katherine)
- Locate and destroy en reserve(res)

End state

GBAD, NAI2 destroyed/neutralised
En C2 nodes/HQ destroyed
Res destroyed

Tactics

- Maximum standoff range
- Ground based laser designation for 1st two targets
- Res combination, recon and standoff range

Weapons/Sensors

- Mainly hellfire and ground based designation (SF)

Were any sensors vital? Yes, optics.

Effectiveness

Achieved end states and was effective.

Why destroy GBAD? CAIRS not available and destroying GBAD allowed freedom to do the required tasks.

SQN HQ (SOUTH)

What was the mission?

- Air assault security
- Secure assault elements
- Security for ground forces

Weapons/Sensors

- Hellfire and cannon
- UAV's (couldn't tell where the target was from it)

Effectiveness

- fair

Impact of Situation Awareness (SA) tools

Good. Would be good if the control display could have control graphics added and linked to the pilots display. (eg) attack by fire line on the display.
Control Graphics would help with the coordination (eg) Bn HQ to Bde could have plan with continuos graphics and linked tot eh ARH off the one script so everyone is working to the same plan.
UAV info great, but the link wasn't so good. Is there a way for UAV info to appear in ARH as a tool?
With respect to targets on SA display – 3 Tiers of target:

- **Detection**
- **Recognition**
- **Identification**

IFF (ID Friend or FOE systems may help with this)
These 3 tiers are essential for SA. Can entities be identified in this way in Battlescape? Once en is confirmed, it should be entered though this process to recognition and ID and then entered into the system.

Pilot doesn't want details (ie what, where, how fast etc) – wants simple symbol on screen for en.

One Option to this.....
Pilot wants to get info with respect to where contact is, doesn't want to work it out from grid refs etc. Should be able to lase via link.
A menu system – one button- to enter what it is and be able to enter quick descriptor is necessary, and then lase info back in burst or via link. Detail can even be via short .wav burst. Allows them to get on with job. Can do active or passive system lasing.

One solution of many – minimum disturbance of what aircrew is doing.

Comparisons with current operational helicopter simulators etc. show that the capability for this is out there. (I can elaborate on this if you like)

UAVs
What was the mission?
Locate en in Manbuloo and the res force

Tasks
- Locate en in Manbuloo
- Prepare to lase targets for ARH
- Find res

End state
Secure airmobile operation and identify res

Tactics
- Descend through to area move/ascend to ensure out of weapons range then continue to next position
- Had to unrealistically descend to get good resolution
- Were able to fly by Manbuloo and to reserve
- If still able, would have stayed with airmobile area until retasked
- Lack of control of UAV. Is there a technical glitch here?
- Actual plan didn't happen

JOSCC and Bde HQ need to be able to control the UAV loc.

UAV is a good cuing device. Preplanned route was flown. Operator has control of view not the flight path – can correct this with another ModSAF box.

BDE HQ
What was the mission?
- Capture Katherine and dislodge en, destroy defence and en reserve to N of Katherine

Task

- Establish strong SF and Armd recon screen
- Secure Manbuloo
- Destroy GBAD
- Destroy en C2 and res
- Attack Katherine – dislodge en –attack NW Kath and destroy en.

End state

Successfully capture Katherine with minimum damage to infrastructure. Destroy/capture en NW of Katherine.

Tactics

- Establish strong SF/Armd screen early
- Conduct preliminary operation –airmobile to Manbuloo
- Destruction of GBAD
- Destruction of C2/res
- 2 phase attack
- phase 1- Katherine
- phase 2 – area NW of Katherine

Weapons/Sensors

- SF, ARH, Helos, Armd Recon, UAV, Mechanised and Motorised Infantry, guns, artillery

Information on the high bridge being out came via EW data.
Passed control of assets around during battle to ensure tasks completed for both big and local pictures.

Effectiveness

- Very effective battle group
- Very effective ARH, SF and Armd Recon
- UAV not as effective as hoped
- Control of UAV – JOSCC
- Was almost too effective- didn't rout en in Katherine –instead corralled them there.
- Perhaps should have been less aggressive to west of river.
- Current scenario would not have minimised the impact of destruction.

Tools

Smart board and Battlescape good.
How it would transition to reality is still a question.
Improvements: there is too much symbology and it needs to be easier to manipulate.
Still a huge improvement on pins and maps.

Gave superb SA with respect to movement about the battlefield. Mastering the symbology would make it more effective. SA has definitely sped up the whole process (allowed multi rolling to be used)

Analysis Function not being performed in Bde HQ. Data would be turned into useful info by S2 and that sent to pilots. Need the S2 role to be more real so analysed, contextual data sent.

Able to do more with SA and therefore some mission objectives failed and too much was done without the plan. S2 would be able to control and slow down info flow when necessary and advise on way to proceed.

Pilots

Tools

- In reality both pilots are SA aware
- Front pilot can't give info to back pilot
- Limitation of current system

Information Sharing between helicopters? This is normal through radio comms.

There is no capability to designate en and 'pass off'. If it could, it will appear on everyone's screen (if using a data link would be realistic) or would normally be sent verbally.

Pilot broadcasts when he decides - but Bde can request info.

Continuos update in position not realistic.
BDE HQ doesn't want to know where every entity is. Just Company HQ for eg.

Back brief from Battle map on Screen

BDE HQ

- Airmobile went particularly well, consisted as planned
- ARH very successful in bottom LOCUST part
- North preliminary operation worked well
- Tick and Flea worked well and able to use 2CAV – which was unplanned but very effective
- CAIRS not available and PGM artillery also not available
- Distracted ARH from NTH to clear en GBAD NAI2 –well supported by SF
- Caught out when ARH came down and took out en C2 very quickly and were unprepared.
- Way ahead from Manbuloo not secure yet
- That's when the corralling of en started
- Locating the en Tank company on the W side of the river was a surprise which required redirected effort (eg) ARH effort
- Should have used artillery on them

- Speed of the ARH was the trigger to bring forward H hr
- Effort of ARH's focussed on C2 and destruction of the reserve.
- Fear of a pause in the battle for en to regroup and destroy crossings – the Bridge already being out was a surprise – had to adjust groups MITRE and SABRE so that MITRE had to go around and cross at Knots Crossing instead.
- A gridline limit was imposed on MITRE until sure that Phase 1 was complete

JOSCC

- ARH to clear area – expected to be there and they were
- Stopped short about 1km of Manbuloo and had two simulated battles to get inside en decision cycle and ensure he fights 2 battles
- GBAD and C2 destruction were event driven
- Concerned that intent was not relaying across system and resulted in loss of 2 ARH's
- Used pincer movement to destroy T80's
- Need graphics to support voice comms
- Didn't want the ARH's to engage that close
- Analysis question for future: can you pass intent down a radio – or do you need graphics (SA) also?
- Pilots are often given eastings and northings to stay clear of – such as here. That intent can be passed by radio. It was the method of execution that changed not the meaning of the intent.
- Are these methods sufficient given SA tools?
- SQN HQ can designate no fly area – can depend on the skill of the pilot.
- Pilot needs discretion to accept or reject a digital update eg re: EW threats. As soon as a restriction update (eg no fly zone) is added, then it can't be rejected as it's a control measure. Receipt has to be acknowledged (ACK)
- Machine to machine ACK is not sufficient like Human to Human ACK.
- If control measure is in then it needs to be accepted.
- Pilot must ACK that he understands
- Info via digital ok, but need the verbal comm of ACK of new control measure
- Helo's internal net needs button to represent 'ACK' and stop verbal 'Roger Sir'
- Was interesting to see what the helo's would do once they crossed the no fly line
- Effectively, some human needs to say that I got hat and that I understand it.
- Confirmed that the 'ack' button needs to be added.

SQN HQ(NORTH)

- All conducted in accordance with RGT COMD orders, was modified only after res destruction
- New mission, close support for battle Group on Line of Departure and find and engage T80's E of Katherine
- Only significant change was the quick execution of GBAD in NAI2

Because it was so quick and effective, was any thought given to dwelling until airmobile ready? No. Was a deviation in the plan. Airmobile didn't impact on mission. May have

caused synchronisation issues at Bde – may have wanted him to delay - S2 might have provided that info.

SQN HQ(SOUTH)

- Only deviation was en route to cut off res force needed to route to destroy 3 T80's.
- Then flexed right and targets of opportunity and continued to Katherine and lost 2 Air.
- Did the SA screen show targets to ARH's? targets didn't come up , saw no en

Aviation will not always have a reserve and Avn COMD adapted accordingly.
Trigger for launching 2 res ARH's – T80's – high value targets
Red entities always appear on screen in Bde HQ even when dead and made confusing. Planned to change dead entities to black.

Helicopters

- Route recon and airmobile
- Target not identified by UAV so general sweep performed
- Proceeded according to plan
- 2 res ARH to move up and act as screen but didn't arrive, so stayed in position acting as screen
- Direction to engage targets of opportunity to Katherine
- Took a 'bull in a china shop' approach to Katherine which led to death – unsure how died, didn't see.
- Encountered some technical difficulties

Situation Awareness

ARHs

Source of SA
Passed between other ARH and ID of en on screen ie SA display. Cross-referenced between them.
How maintained SA?
Same way
How was the data fused?
Friendly, en info correlated with SA to what Intel on TV and FOV.
Was this achievable or was the info too much? Fairly realistic for flight info.
Sharing information/SA?
Unless laser designation used, then by conventional radio comms
Did you share with any other units? No. Just helo and HQ. Not aware of any other friendly units in vicinity.

At 1150 H2 found en Manpad and engaged. H1 flew between them. H1 were you aware of your loc and H2 were you aware of H1s locn?

H2 told H1 on radio – but too busy getting rid of manpad to get him out of way.

H1 not aware of his loc.

When Helo finds target, can't make it appear on screen. Have to lase and communicate manually to other helo. Need a menu to add this as mentioned before.

Currently can't keep track of all targets that appear.

Tp COMD

Source of SA
Recon source SA. Sensors overlap. Confirmed route clear. Used SA tools, especially for other air loc and for most sensor info.
The less and more impt info that can be displayed on screen for pilot the less the hazard.
As a planning tool for given routes the area covered information would be good, but not as a real time display.
How maintained SA?
Looking at moving map display and sensors
When in Close proximity to other air, do you intuitively know who's who? No, have to look at symbology.
How was the data fused?
TADS system a priority (targets and who's trying to kill me)
Then mission info then radio
Sharing information/SA?
Other helo – voice, map display
Didn't do this with designation – maybe should have (b/w helo)
Ergonomic issue: back pilot needs to twist to look at sensors info – not readily available.

SQN HQ

Source of SA
What's on map, using their FOV sensors, radio in background for SITREPS
No direct feed from UAV – would have liked.
North HQ didn't see his air on the screen. Using LOCON ModSAF to determine what was supposed to be displayed.
How maintained SA?
Monitoring source
How was the data fused?
Intuitively. Understand what the battle plan is and visualise what it is. Didn't have to look at screen that much to gain SA.
Rehearsal, planning, Synch matrix, bulk of tools for SA.
Sharing information/SA?
Info primarily shared with Regt COMD with Exception of SF (but that was mostly LOCON). Verbally over radio.
Even if Regt COMD has moving map, still needs verbal comms ie SITREPS to confirm the picture in his mind.
Replay – very quick and stopped early. Info if required available.

ID Targets 3 Tiers: Detection, recognition and identification
Helos, was this played out today? Detection of en in LZ initially - ? of en and friendly wearing same cam. No real answer here.
Technical and Future Concepts
Any extra comments can be added in books.

HUD's (Head up Displays) to simulate HUD for helos' here? A good idea? Yes. Also, contrast colour for info on screen eg black strip on bottom with white text.
Want a hot mike system for between pilots in same helo and a footswitch system for comms b/w helos.
Augmented reality concept has tremendous application and will be available for next expt.

End of AAR 1.

C.2. AAR 2: Mission 3 Wednesday 20/3/01

Manoeuvre COMD brief
No real change to plan. Synchronised with battle command. Attacking concentrated in the northern area. Launched and went right with timing through to SNAPPER where GRASHOPPER couldn't designate for FA/18. Were able to get it going though and GBAD was successfully destroyed. C2 then destroyed inadvertently and through 'bull in china shop' pushed enemy (en) out of town. Had to do a weapons hold to control a little and monitor reserves (res).

More coordination with fast air and artillery needed – but is coming along well.
Used impromptu fire lines and control measures. Were effective and intent was realised with hold fire.

Mission was quite effective and was achieved today as opposed to yesterday.

BDE COMD brief
No real change to yesterday. Synchronisation issues with CAIRS and when GRASSHOPPER lost laser designation.

Significant change was when ARH at BASS, chose not to engage res when found. Was trying to avoid the corralling of yesterday (opportunity for them to get out). Did engage later.

Speed and effectiveness of ARH caused changes to synchronisation and how things were worked.

SQN COMD (NORTH) brief
No real change, primary task the same. Difference was not to actually destroy the GBAD – CAIRS. Coordination with Grasshopper was significant – then laser designation went down. In battle position and prepared to engage, but necessarily prepared to be able to designate for CAIRS. Not particularly good SA at Sqn HQ at that time, worked off the synch. Matrix. Timings were early – no SA graphics gave indication.

C2 nodes, WEEVIL had effective designation and ARH Tp removed.
Not receiving SA of all call signs.
Order to locate and destroy reserve. Some confusion with pilots when told TAI4 when it was TAI2 and TAI2 had been mixed up with objective 4. Sorted out by SQN CMD and successful.
Full achievement of mission not completed by weapons hold.
Effectiveness was okay and there were gaps in the SA.

How did you work around the SA loss? Used the radio, but at times, bits were lots with other messages cutting over the top.
Need some toll indicating what targets are engaged by ARH to be 100% sure.
Is it a danger with the tools to micromanage the pilots? Yes. Easy to get too involved – but you're not the man on the ground.
SA of environment – should be used to synchronise at the command levels – not micromanage.

SQN COMD (SOUTH) brief
Involved some hasty attack operations as well as the usual.
Battlescape needs a notional reports issue eg when the landing Zone (LZ) was clear of threats.
Synchronisation coordination was via the Regt as was flow of info. Can't do spot reports in this system as you can do in the field.

ARH COMD brief
2 air from Tindal. Confusing as to which aircraft were following which helo.
Destroy GBAD at TUNA and then C2 at Katherine. Monitor and destroy res NW. en route to 1st task didn't see GBAD, 1st target was armoured (Armd) vehicle. 'Bull in china shop' issue – didn't exactly stick to plan. Didn't see any C2. Armd vehicles and res only targets seen. Location resulted in SA breakdown ie SA screen showed further Sth than actual location. Didn't relate laser point to where were on map.

Synchronisation issues b/w helos, gnd tps, HQ? Communications between and inter helo were good. No problems.
Issue: targets grid form – map didn't have northing/eastings easily seen and sot he screen had to be manipulated which made things difficult.

WEEVIL informed Bde HQ that the C2 was destroyed, but he helo's didn't realise they had been taken out.

Sqn HQ didn't think they would see the nodes. WEEVIL had eyes on the target and designated for it and were the confirmation. Sqn HQ aware of C2 taken out.

Mission was effective.

ACE brief
1st problem was the lack of a link to AOD. Therefore jets modelled in ModSAF. TAOC passed to ACE who passed to FAC for strike. Pilots seemed happy. Directive had been given earlier. Ground based laser designation issue (GRASSHOPPER). Held off. Then rectified and they came in and successfully destroyed GBAD. FAC passed back to ACE who then passed back to TAOC.

Artillery (arty) coordination and grids and terminology - had some issues, but an SME assisted.

SA Tools used? None really. Used SA from radio and those around.
Not happy with the JOSCC SA tools provided to know arty, guns, firing, tracks, airmobile etc for coordination and control. Eg don't want to send airmobile through an engagement area. Would allow things to happen quicker and with more confidence.

LOCON brief
GRASSHOPPER laser designation issue in NAI2. Still don't know what caused it.
BDA's were received okay.
WEEVIL designation effective. Resulted in ~50%hit success with laser designation and further hits to target.
WEEVIL contacted and so had to break designation on C2 nodes.
LOCUST successfully took out Manbuloo.
FALCON was effective in taking out T80's with ARH support.

UAV brief
Focussed on N instead of S this time. Got to locations eventually.
Clash with airspace issue with air force
Had to then go too low to clear out and got shot down.

2nd UAV – issues with controls and unrealistic feel (as per yesterdays AAR)
was able to ID some targets and confirm the high level bridge was out – but that came late.

Useful tool with a mixed bag of success. Hasn't had to search for targets. Would use standard helo tactics for search.

En brief
No comment.

FA/18 Bombing Activity
Capt. Thomas with input form others. Coupled with a battle map.
At H-80 left to move to SNAPPER, until H-60 when CAIRS supposed to join. CAIRS had been called in earlier and he was not aware of this. They then thought they had to designate for CAIRS when ground based designation didn't work. Wouldn't have made it in time if the designation wasn't fixed. Trip to SNAPPER was a lot quicker than expected. Able to get everything to work in the end.

What would have been needed if the ARH's did have to do the laser designation? SF grids and it would have taken longer to acquire the targets. Location info would have assisted in the grid points. Time to detect the anti-air asset would have delayed. Moving into the threat envelope would have increased the risk to the asset. Laser code for designation would have been transferred.

Any use of threat domes? No. But the information there is still invaluable and is planned to be used later. Simpler if ARH using weapons to attack to hold off and use craft over max height.

SA TOOLS
Going around the room to collect any additional information.

Problem: ModSAF operator killing targets, but they reappear and so lost confidence in the system. This has been fixed.

Problem: clearing display from tracks, then cleared areas of interest and therefore lost SA and couldn't get them back – too busy to work it out.
When SA lost used comms, higher command and remembering.

More control measures need to be in place (introduced from planning phase) for when SA is lost.

Conflict over thoughts for reality now and reality 10 yrs from now.

SA is still a great and tremendous improvement. Looked at concepts of battle tracking and attrition tables. As en killed be able to cross off to know how many of theirs are left etc. for decision making. Gives a battle history as you go. Used OPORD overlays.

Still can't do grid refs. Have more faith in the SA tool screen than on the old map boards and pins and radio transmission and someone can always write something down wrong and transfer that info thru the chain.

Possibility of using control graphics in real time-no opportunity today as would take too long. At the moment it's quicker to do by radio. Should be able to construct graphic on

screen and upload to ARH. Mouse or smart board would make this easy with out dialogue boxes etc. Has to be quick.

Reading Grids issue. If using GPS be prepared for confusion. Confirmed that lat/long cords can be converted to grids.

Cockpit workloads were at a max when chatter was at a max. This was also when needed to focus on SA display (look for grids) and therefore lost some capability.

Need better tools, to cut out some radio chatter and presentation of info to be clear and intuitive. Eg own symbol centred always on screen.
Wrong grid reference came out of this – 400m difference – enough to kill. (118035 instead of 118039)

Confusion with SA display showing wrong location of helos to pilots.

3rd party designation. Did you have any knowledge that missile would be in footprint? No. Programmed in missile. Just point and shoot. No control.

Points from MONDAY 19/3/01

Bde HQ orders given using smartboard but besides that wasn't much different to a WWII HQ. Could be better with the tools available.

Eg program in plan and watch it unfold as an orders tool and adjust accordingly. Ie wargame and order at same time – allows rehearsal and adjustment.

Currently underway, should be ready for next expt.
LTCOL Chris Burns did not participate in WWII.

Agreed that there is so much scope and that only about 10% of capability was used.

Good to see from last year that things are developing in a simple way and 'back to basics'. Simplicity is the key: need an area a job and the resources to do it.

Need to get away from cluttered screens – too complicated to clear – only simple techniques. The aggregation of icons would be good.

EW Discussion

Sensors were used for en info – how can you be sure that en hasn't interrogated sensors so you see info? How do you know if a ref (grid) of en target is true? Eg creating a false entity?

Air used a lot of visual ID – but if relying on sensors then that's another story.

Reliant on correct designation and en not doing it to us. (with codes etc chances are very low)
No confirmation in answer to question.

For Gnd Comd unless Intel has sensor picking up emission then usually forces make contact and fight.

Need to get phantoms into system for experience and training and allow practice with reprioritising and chaos.
Allow a process for confidence and validity to be introduced. Outside scope of task but still beneficial.

EW part of the bigger package.

Idea of working and using EW is to be prepared and trained for it so when confronted with it can deal with it.

DSTO Comments

EW issues for bigger exptl picture – outside scope of task, but can value add – need stakeholder acceptance.

SA display comments have been thought of and are under development – trying to incorporate for next expt.

Asked military to think about what issues might be learned about training? Initial responses: practice with target designation by ground and more visual flying in sim.

Were the systems reasonable intuitive? Sim was fine, screens ok. Just takes some adjusting in what is seen and correlating to mission. Would be good to fly some training sorties on the battlefield for orientation.

Would a facility for training similar to this be good? Yes. UK are currently using a sim for Comanche training successfully.

Comment: pilots flew good mission today in SERF allowing for short time using them

Impact of Tools and Land Air Systems on CAIRS:

Changes in procedure resulted from SA.
Jets were held at contact while laser restart could redirect designation.

Could SA speed up traditional current CAIRS mission? Yes, if you have a backup plan. Need lots of flexibility for evolving tactical plans. CAIRS missions need 5 layers of redundancy, so need flexible systems and tools.

When laser was down, gave small insight into the changes needed to flexible plans. Good FAC would have contingencies already planned.

Mission 4 will have ARH close to C2. In real ops, whether ARH in close or jets used depends on the weapon required. Only use CAIRS if need that weapon.

Effect of weapon system/platform on battlefield used to achieve an effect – not just because it's there.

End of AAR 2.

C.3. AAR 3: Mission 4 Thursday 22/03/01

ARH

What was the mission?

- Route for the helicopters
- Primary task – clear route to Manbuloo
- Security for force troops on the ground

End state

Landing Zone (LZ) at Manbuloo secured to continue operations

Tactics

- Both to clear route N/NE
- Performed normal techniques within limits of sensors and visual range

Weapons/Sensors

- Combination of all sensors
- Air to ground missiles (3000m range)
- Cannon for ranges less than this

Effectiveness

- Covered the lack of reality
- Unrealistic weapons choice (eg hellfire used on manpads)
- Not as effective against single enemy targets

SQN HQ (NORTH)

What was the mission?

- Destroy the enemy (en) C2 node/s
- Preliminary operation: clear NAI2 (GBAD) in conjunction with SF
- Phase 1: destroy C2 at TAI (West of Katherine)
- Locate and destroy en reserve(res)

End state
GBAD, NAI2 destroyed/neutralised
En C2 nodes/HQ destroyed
Res destroyed

Tactics
- Maximum standoff range
- Ground based laser designation for 1st two targets
- Res combination, recon and standoff range

Weapons/Sensors
- Mainly hellfire and ground based designation (SF)

Effectiveness
Achieved end states and was effective.

SQN HQ (SOUTH)
What was the mission?
- Air assault security
- Secure assault elements
- Security for ground forces

Weapons/Sensors
- Hellfire and cannon
- UAV's (couldn't tell where the target was from it)

Effectiveness
- Fair

UAVs
What was the mission?
Locate en in Manbuloo and the res force

Tasks
- Locate en in Manbuloo
- Prepare to lase targets for ARH
- Find res

End state
Secure airmobile operation and identify res

Tactics
- Descend through to area move/ascend to ensure out of weapons range then continue to next position
- Had to unrealistically descend to get good resolution

- Were able to fly by Manbuloo and to reserve
- If still able, would have stayed with airmobile area until retasked
- Lack of control of UAV. Is there a technical glitch here?
- Actual plan didn't happen

BDE HQ

What was the mission?

- Capture Katherine and dislodge en, destroy defence and en reserve to N of Katherine

Task

- Establish strong SF and Armd recon screen
- Secure Manbuloo
- Destroy GBAD
- Destroy en C2 and res
- Attack Katherine – dislodge en –attack NW Kath and destroy en.

End state

Successfully capture Katherine with minimum damage to infrastructure. Destroy/capture en NW of Katherine.

Tactics

- Establish strong SF/Armd screen early
- Conduct preliminary operation –airmobile to Manbuloo
- Destruction of GBAD
- Destruction of C2/res
- 2 phase attack
- phase 1- Katherine
- phase 2 – area NW of Katherine

Weapons/Sensors

- SF, ARH, Helos, Armd Recon, UAV, Mechanised and Motorised Infantry, guns, artillery

Effectiveness

- Very effective battle group
- Very effective ARH, SF and Armd Recon
- UAV not as effective as hoped
- Control of UAV – JOSCC
- Was almost too effective- didn't rout en in Katherine –instead corralled them there.
- Perhaps should have been less aggressive to west of river.
- Current scenario would not have minimised the impact of destruction.

Tools

Smart board and Battlescape good.
How it would transition to reality is still a question.

Improvements: there is too much symbology and it needs to be easier to manipulate. Still a huge improvement on pins and maps.

End of AAR 3

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Behavioural Situation Awareness Measures and the Use of Decision Support Tools in Exercise Prowling Pegasus

Monique Kardos

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19. ABSTRACT

Exercise Prowling Pegasus was held during May 19th to the 22nd, 2001, at DSTO Edinburgh. The aim of the exercise was to support ARH doctrine and TTP development, and the development of joint Land Air Systems concepts. A human factors behavioural observation approach was taken in order to assess the behavioural indicators of situation awareness (SA) and the effect of SA enhancing tools on the performance of military participants. Results on the levels of behaviour, the outcomes of wargames, and the relations of the two are discussed. Future work aims to clarify the relationship between behavioural observations and wargame outcomes.