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REPRESENTATION OF HISTORICAL EVENTS IN A MILITARY CAMPAIGN SIMULATION MODEL

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ABSTRACT

Dstl has sponsored the development and use of several campaign level models of military operations. The models are required to provide insight into force assessment, procurement decisions of future concepts and for investigations into potential doctrinal developments. COMAND is a theatre level representation of the naval-air (maritime) campaign. COMAND also contains a simple representation of the joint force influence on the land campaign. COMAND is a stochastic model, and runs on a desktop PC under Windows NT. The key to COMAND is the representation of command and control aspects of the campaign, with representation of sensor and communication systems, information flows, command decision making, combat and perception of the battlefield. As part of the process to establish the validation status of COMAND, an attempt was made to replicate the 1982 Falkland Islands Campaign. This attempt was largely successful, and provided much information on the strengths and weaknesses of the model.

1 INTRODUCTION

COMAND (the C3-Oriented Model of the Air and Naval Domains) is a campaign level model of joint and combined operations of high intensity warfighting, and was designed for use on studies by the UK Ministry of Defence. It is currently operated by the Defence Science and Technology Laboratory (Dstl), with support from CORDA Ltd. Specifically, COMAND is designed to be used to:

- study a campaign over time;
- inform studies on the balance of investment between systems;
- compare the theatre level implications of new doctrines, force structures or technologies;
- assess coalition operations;
- examine the effects of variations in capabilities;
- examine the sensitivity of outcomes to variations in scenario data.

The model has a flexible command and control (C2) architecture that allows the representation of any force structure with any doctrine in any location.

The effects of deliberate planning ("top down" high level command) and rapid planning ("bottom up" reactions to local events) are captured in COMAND by:

- a mission based structure, applicable at all levels of the command process;
- an ability to create or evaluate high level joint plans and change these allocations as the model runs.

2 DEVELOPMENT OF COMAND

COMAND is a constructive simulation which has been designed according to object oriented principles. Rational Rose is the chosen CASE tool for carrying out the Analysis and Design stage . The model has been implemented in MS Visual C++ and runs under Windows NT.

Development of COMAND started in 1998 with the writing of a specification by a joint team of designers, analysts and military staff. The first operational version (v1.2) was delivered in March 2001. Several UK MOD studies are currently using COMAND, and development currently stands at release 1.4.

2.1 Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)

COMAND is an event driven simulation that has been designed with particular attention to the following features:

- representation of the command structure, communications and associated delays;

- maintenance and sharing of discrete intelligence pictures by command entities;
- ability to allocate resources and initiate missions on the basis of the commanders plan;
- a representation of C4ISR;
- a stochastic representation of weapons and sensors.

3 VALIDATION

3.1 Scope

As with any military simulation model, COMAND's ability to represent military operations and interactions with fidelity must be established (i.e. the model must undergo a validation process). One of the mechanisms proposed in order to achieve this was a historical comparison with the 1982 Falkland Islands Conflict (hereafter referred to as FI82).

As a first step, it was important to gain a detailed knowledge of the historical conflict to a level that permitted the generation of data. The main areas considered were:

- equipment (gathered through extensive research);
- the objectives of both sides;
- campaign phases;
- missions of ship groups;
- air campaign details;
- weapon performance data.

The exercise was conducted by comparing key results from the model with those from the historical campaign. It was felt that the following key results would provide sufficient evidence to determine the suitability of the functionality of COMAND for modelling maritime and air operations:

- Ship losses;
- Aircraft losses;
- Submarine losses;
- Distribution of losses amongst equipment types, and their cause.

Runs of 160 replications were used to carry out this analysis.

It is important to note, of course, that the FI82 campaign might have been unusual for various reasons. Any difference between the model and "reality" did not necessarily result from problems with the model, but was used to provoke further research in order to determine why the differences occurred.

There are some aspects of the actual conflict that it was not desirable to represent and others that it was not possible to represent. This was either because of a lack of detail in historical documents, because of a lack of functionality in the model or because efforts were made to simplify the scenario. Generally, areas that were left out of the COMAND representation were unrelated to the key combat operations undertaken. For example, it would theoretically have been possible to represent the movement of tankers, salvage tugs and supply ships to the replenishment area and back to Ascension, but it would have been time-consuming and would have added little to the representation.

The following sub-sections discuss in some detail the problems and issues encountered in representing the messy details of historical reality within a simulation model.

3.2 Geography and Weather

In COMAND, naval units may come into contact with land if any part of their patrol box overlaps with land - there is no automatic avoidance algorithm. If a ship should come into contact with land, it ignores any future missions it might have. The problem can be avoided by ensuring that patrol boxes do not overlap with land or by specifying waypoints for the patrol route of the ship so that the land is avoided. Neither approach is very flexible especially for the representation of operations in the littoral domain. The problem is exacerbated by the automatic evade facility. If the commander of a group chooses to evade a threat he retreats directly away from the enemy and may go outside of his patrol box. In cases where the ship is close to a coast, this can mean that the ship retreats into the land. This can be resolved partially by reducing the distance a ship retreats when evading, but this solution is unsatisfactory.

In FI82, Argentine air operations were limited by bad weather (cloud, heavy rain, fog). This could not be explicitly represented in COMAND, as bad weather does not prevent air operations - aircraft still fly but the probability of hit for weapons that are affected by weather conditions (laser guided bombs, for example) can be reduced to reflect the degradation of their effectiveness. In the model, the turnaround times for Argentine aircraft were increased so that over the course of the campaign the correct numbers of sorties were flown.

It was not possible to represent a night transit by a day-only aircraft followed by a dawn attack, or to represent a situation in which a night-capable aircraft is leading a group of day-only aircraft. This is because, in COMAND, aircraft not specified as being able to conduct night operations will not fly if any part of their mission would occur at night.

In the historical campaign high sea states frequently prevented aircraft being launched from the deck and degraded the performance both of sensors and weapons. In COMAND, sea state is represented by four broad categories of actual sea state, called "sea condition". The only impact of different sea conditions in the model is on the speed of ship movement; hence the negative impact of high sea states could not be fully represented (although a lack of historical data on the effects of high sea states would also have hindered any representation).

The weather/night representation capability provided by COMAND is sufficient for analysis of most important scenarios, other than in the representation of the effects of bad weather on air operations. Some types of modern aircraft may be unable to take off from carriers or airbases in some weather conditions and it is important that this can be represented.

3.3 Entities and Groups

The representation of entities and groups within COMAND was generally sufficient to meet the requirements of this historical comparison. However, should the ships that make up the main body (the ships at the centre) of a group be sunk, then any future missions involving that group will not proceed - i.e. missions are reliant on the existence of the main body. To negate this problem, additional default behaviour for ships that are in a screen around a main body that has been destroyed is required, but this results in an unnecessarily complex mission structure.

It was not possible to represent ships in screens performing dual roles: if, for example, a ship was assigned to an ASW barrier it would not fire its area surface to air missiles (SAMs) at incoming aircraft. This could be important in the analysis of future scenarios, where one high-capability ship may be tasked with both roles.

3.4 Command and Control

Entity/group missions are the building blocks of the scenario and the key to COMAND's representation of command and control. Broadly it was possible to represent all types of mission; including, for example, the retreat of the Argentine navy to port once one of their ships had been sunk, the merging of the various ships into a single amphibious landing force and the subsequent move of that landing force to San Carlos.

It proved difficult to represent the Naval Fire Support (NFS) missions that the UK conducted in FI82 within COMAND. Whilst the missions themselves could be represented, the continual reconfiguration of groups caused by the departure and return of NFS ships would have resulted in a complex mission structure. Further thought will be given to the procedure for governing ships leaving and rejoining groups. In practice, as the missions usually occurred at night, when the Argentine air force did not operate, it was felt that not including them in order to simplify the scenario was a valid action, especially since the majority of the missions were conducted against strategic targets rather than being in support of the land battle.

The mission triggers (i.e. those events which have to happen before a group takes a specified action) proved very flexible within the model, but two important areas were identified for improvement. The first is that mission triggers based on losses cannot check for individual ships. Thus a mission intended to simulate what would happen in the event of the loss of a particular high-value unit, such as the UK aircraft carrier Hermes, could not be represented. The second is that the user must specify which actual ship (e.g. HMS Sheffield) fits into a mission template rather than being able to specify a class of ship (e.g. Type 42 destroyer). For a patrol mission, for example, the user must specify which exact ships are to participate. If these ships are sunk, then the mission does not go ahead. If the class of ship could be specified then an alternative ship of the same class could perform the mission instead.

It is not currently possible for the model to have different rules of engagement (RoE) in different areas of the battlespace. In FI82, hostilities began on 25th April at South Georgia when the Argentine submarine Santa Fe was sunk. When RoE are changed in COMAND to allow this they are applied over the whole geographical area of the scenario. The result is that hostilities commence around the Falklands themselves slightly earlier than in reality. One solution would be to have a number of RoE 'zones', which could be user specified.

3.5 ICS / ISTAR

The model's representation of ICS/ISTAR was sufficient to meet the requirements of the study. On the Argentine side, the primary sensors were MPA (Maritime Patrol Aircraft), the Narwal (an intelligence trawler), and various assets located on the islands - all of which were represented. On the UK side the primary sensors were the ship-based radars and CESM (Communications Electronic Support Measures) - both of which were represented.

One example of ISTAR and ICS working as designed was that the Argentine sortie rate showed a significant increase following the move of UK ships into San Carlos. Argentine sensors were then able to detect the ships and pass this information back to the mainland, where it was used to plan air strikes.

In reality, the sensor performance of the UK escort ships in San Carlos was degraded by the cliffs around the sound itself, and also by the hills of West Falkland. Within COMAND it is possible to set up 'physical barriers'. They can have a height and an 'opacity' which degrades the performance of sensors trying to see through them. This was not used in the comparison study reported here because, in order to follow closely the terrain, the map would have to be zoomed in beyond its currently limits.

3.6 Combat

On the whole, it was felt that COMAND was able to represent the key combat interactions that occurred within FI82 extremely well. However, an even better representation would have been made possible with more time and effort available to construct the scenario and generate effective-

ness data. This sub-section discusses these issues, along with areas where the representation would benefit from some minor modifications to the model's functionality.

Although COMAND is capable of representing aircraft cannons and ship anti-aircraft artillery, these were not represented in the model due to a lack of effective performance data. There is, therefore, no explicit representation of either Sea Harrier cannon or the 20 and 40mm guns that the ships used for self-defence. For the ships, the kill probability of the Sea Cat system was increased to represent the capability provided by the anti-aircraft guns (as Sea Cat was the most common SAM on UK ships). For the Sea Harrier, the probability of engagement was increased slightly to represent the additional capability that the cannon provided. Greater availability of data for weapons in future scenario should mean that explicit representation would be possible.

In COMAND, aircraft can launch strike missions at areas of empty ocean (based on the assumption that the target ship maintains the course and heading it had when detected). As most UK ships were on patrol missions within a defined area in FI82, and thus frequently changing course, a number of Argentinean sorties in the model runs miss their targets. The problem is particularly apparent when UK ships are in San Carlos, with a very limited area of movement. COMAND does have the ability to specify a radius of effect for a weapon (a high level method for representing either the search capability of the weapon or the radar on the host platform), but this was not used for this historical comparison.

Aircraft in the model currently fly the shortest route from their bases to the predicted location of their target ships (in the case of maritime attack sorties) or their designated patrol areas (in the case of recce and maritime patrol sorties). They do not use a different route if this course crosses UK combat air patrol (CAP) boxes or missile engagement zones. This initially resulted in an artificially high rate of losses of Argentine MPA which were flying through UK CAP boxes and consequently being shot down. In the model this was fixed by creating a new 'dummy' air base for MPA from which the shortest course would avoid UK CAP boxes.

During FI82 a number of British ships were hit and damaged to an extent that compromised their effectiveness but could not be considered an operational kill. The representation of degrees of damage within COMAND was considered during the development of Release 1.0 and deemed not appropriate. This was primarily because of the difficulty, time and effort that would be required to acquire appropriate lower level data relating to ship damage inflicted by different weapons.

In FI82 a number of Argentine aircraft sorties did not reach their target areas, returning instead to their bases following to technical problems. Equipment failure is, however, not represented in COMAND. An implicit representation was possible by setting the aircraft turnaround time to a level such that the right number of sorties reached the target area. This was not a satisfactory solution.

In FI82 engagement by UK CAP aircraft often caused Argentine aircraft to abort their mission through (for example) being forced to jettison their weapons or use too much fuel. COMAND has a 'CAP engagement abort' probability that represents this. There were also occasions when Argentine aircraft detected a CAP aircraft and aborted their missions before engagement occurred. This cannot be represented in COMAND.

COMAND is not currently capable of representing support helicopters. This is because there is no non-combat role for aircraft within the model. In the historical comparison, this meant it was difficult to compare the aircraft losses occurring in FI82 with those that occurred in COMAND. Later releases of COMAND do, however, have the ability to assign aircraft to non-combat roles.

Although representation of small arms and MANPAD SAM is possible in COMAND, they were not represented in this historical comparison due to a lack of data.

3.7 Logistics

In FI82, UK ships were able to replace fuel and weapon stocks by RASing (replenishing at sea). In the version of COMAND used for the comparison. it was not possible to represent this. Fuel replenishment can be implicitly represented by specifying higher ranges for UK ships. SAM replenishment similarly can be implicitly represented by allocating a considerable reserve of missiles to each ship. However, this means that ships are not limited by magazine capacity in how many missiles could be fired. This leads to an unrealistically high number of SAM firings, with a corresponding increase in aircraft losses. In reality, a series of intense raids over a short space of time could lead to a ship exhausting its missile stocks.

In the real FI82 campaign, aircraft weapons were located on each aircraft carrier and also at each airbase. In COMAND, allocating weapons to ships and airbases is not possible; rather each side has a total number of aircraft weapons from which ships and airbases can draw. This means, for example, that if a RFA carrying Sidewinders is sunk, the total number of Sidewinders available does not change. COMAND needs to be able to represent weapon stocks aboard individual ships, and ensure that if the ship sinks the weapons on board are not available to other assets.

3.8 Code Faults

One of the key benefits to be gained from generating any new and different scenario within a model is the identification of coding faults within the model. Different scenarios can utilise different parts of a model to the test scenarios and identify coding flaws which otherwise may not have come to light. Numerous code faults were identified and rectified as a result of the validation exercise.

4 OVERALL RESULTS

Despite the significant differences between COMAND and reality listed above, the model has been shown to be able to reproduce key events from the FI82 conflict. The key areas for comparison were the platform losses incurred by both sides, which were in good agreement. Figures 1 and 2 illustrate the comparison between reality and the results from the model for the number of UK ships lost and the number of Argentinian aircraft lost respectively, where the solid line shows the model results and the broken line shows reality.

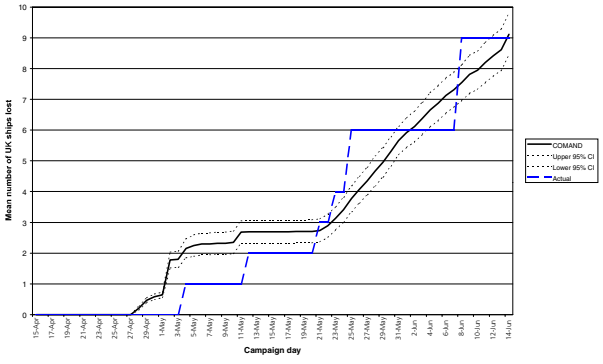

Figure 1: UK Aircraft Lost in FI82

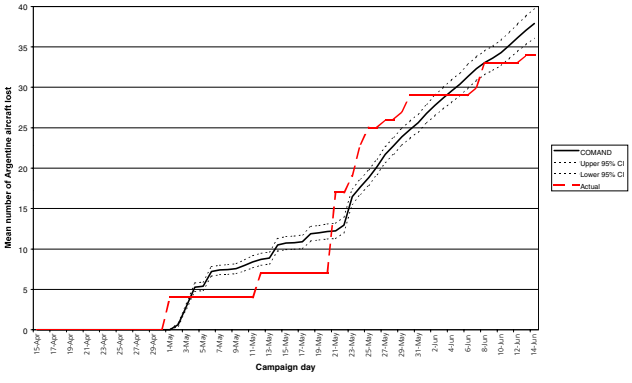

Figure 2: Argentinean Aircraft Lost in FI82

Identifying the reasons behind any differences between reality and the results derived from the model has provided significant information on the model's functionality. This information has been used not only to feed into the validation process, but has also provided a basis for the ongoing model improvement process.

FI82 was limited as a maritime and air campaign, both in terms of the total number of entities present and the range of military activities taking place. Whilst this exercise has demonstrated that the majority of entities and interactions could successfully be modelled in COMAND, it is important to supplement this validation with larger, more varied conflicts.

5 CONCLUSIONS

The results produced by COMAND are, on the whole, similar to the results of FI82. Where they are not it is for a good reason. Although some aspects of the conflict were not represented, this was usually due to a deliberate decision to exclude them. In many cases these excluded elements could have been represented - patrol boats, for example - but for reasons of simplicity in setting up the scenario, and of keeping the run time reasonably low, they were omitted.

The FI82 historical comparison work, along with other validation activity, has led to an acceptance of COMAND as a model valid for particular types of study, and with certain caveats. The model is currently in use within UK MOD on a range of studies. Further development work is currently under way to address many of the issues raised by the work reported here.

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