A Flexible Methodology for Simulating Wider Peacekeeping Campaigns (DIAMOND)

Andrew Caldwell

High Level Studies, Centre for Defence Analysis
The Defence Evaluation and Research Agency
Farnborough, Hampshire
United Kingdom
e-mail: adcaldwell@dera.gov.uk

Andrew Caldwell graduated from Surrey University, England, with an honours degree in Materials Engineering and worked for three years as an operational researcher at British Steel Plc. He then joined the Centre for Defence Analysis (CDA), Farnborough as an analyst to provide operational analysis (OA) support to the current Conventional Forces in Europe (CFE) negotiations and scenario development work for the United Kingdom Ministry of Defence (MoD). Recently, he has being involved in developing a suitable framework with which to model non-warfighting operations at the campaign level.

ABSTRACT

The Centre for Defence Analysis (CDA) supports the United Kingdom Ministry of Defence with a wide variety of operational research programmes. A proportion of those programmes address issues associated with policy and future force structures. Traditionally, combat modelling has provided the principal environment on which to base these programmes. However, increased emphasis on the commitment of UK forces to non-warfighting operations has highlighted a requirement to examine policy and force structures in a high level model environment that addresses the issues and difficulties associated with civil military interaction. As a result of this requirement CDA have developed a flexible methodology with which to examine high level non-warfighting scenarios and that methodology will be applied to a new model development entitled DIAMOND (Diplomatic And Military Operations in a Non-warfighting Domain).

INTRODUCTION

THE CENTRE FOR DEFENCE ANALYSIS

The Centre for Defence Analysis (CDA) was formed in 1995 by bringing together all the operational analysis units across the UK Ministry of Defence (MoD) and the three services. CDA employs 700 people and currently operates as a sector of the Defence Evaluation and Research Agency (DERA). CDA exists to provide authoritative and impartial analysis to

government departments across the full range of defence activities. The CDA is involved activities ranging from policy, procurement to operations. In particular CDA provides analytical support to:

a. Broad questions relating to defence policy and future force structures.

b. Needs and numbers studies for procurement decision support and related programmes.

c. Operations, tactics and doctrine for the three services' operational commands.

d. Balance of Investment studies.

e. Wargaming, simulation, field trials and data provision.

f. System definitions and advice.

It is fulfilling the first of these activities, (broad questions relating to defence policy and future force structures), that has necessitated CDA to develop a flexible methodology for simulating wider peacekeeping campaigns. This methodology is to be applied to a new model development, entitled DIAMOND (Diplomatic and Military Operations in a Non-warfighting Domain) to provide a suitable high level tool with which to examine civil-military interactions.

REQUIREMENT FOR METHODOLOGY

One of the principal areas of CDA's programme is to support the UK MoD by better understanding and answering broad questions relating to defence policy and future force structures. Traditionally, CDA has provided a proportion of this advice by using combat modelling to test current and future force structures against a wide variety of scenarios.

However, since the end of the Cold War the types of operations in which UK forces have become involved have had their emphasis increasingly biased towards non-warfighting[1], rather than warfighting operations. The existing suite of high level combat models at CDA does not provide complete coverage to answer all the issues that are related to non-warfighting operations such as peacekeeping, peace enforcement and humanitarian aid. Consequently, CDA has undertaken a study to develop a flexible methodology to provide a new high level model, DIAMOND, with which to examine policy and force structure issues in civil military, non-warfighting environments.

SCOPE

It was considered important to address the scope of the DIAMOND development at the earliest opportunity. Due to the limited number of existing models with which to examine

[1] Non-warfighting is the current UK MoD phrase to describe what has previously being referred to as Operations Other Than War (OOTW). As such non-warfighting includes operations such as peacekeeping, peace enforcement and humanitarian aid.

non-warfighting, there would always be the temptation to try and develop a methodology that dealt with all civil military interactions at all levels of aggregation. Such a development would have required considerable capital outlay and would have been extremely high risk.

The aggregation level for DIAMOND was guided, in part, by the Centre for Defence Analysis model hierarchy. The principal of the model hierarchy is that there are layers of models, conceptually arranged in a pyramid with tactical models forming the base, models at the operational level the middle layer and finally campaign level models at the apex. In moving up this pyramid, from layer to layer, outputs, behaviours, performance and effects are aggregated up from the lower layers to support the higher layers of the model hierarchy (Figure 1). The CDA model hierarchy is seen as an essential way to maximise the shelf life of models, reduce development costs and gain the maximum benefit from related models operating in the same domain.

When the DIAMOND development began there were already two other models due to enter service which fitted into the tactical and operational layers of the CDA model hierarchy. They were SIMBAT (SIMple BATtlegroup model) and the LFM (Land Formation Model). This left an obvious void in the CDA model hierarchy at the campaign level.

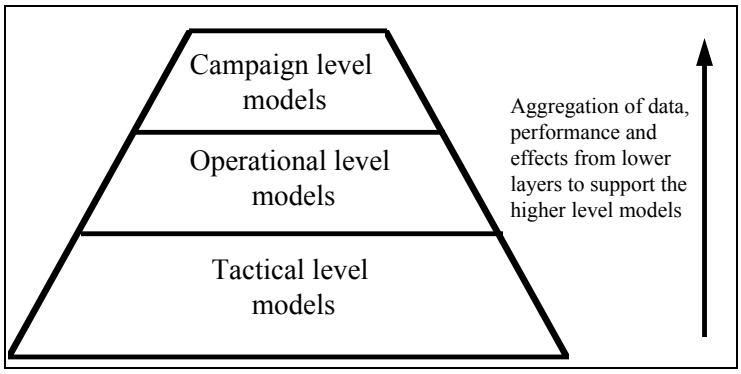

Figure 1: The Centre for Defence Analysis model hierarchy.

The other consideration that influenced the development team was that the majority of policy and force structure studies were carried out at high levels of aggregation. In combination with the model hierarchy factor it was decided that the DIAMOND development was best placed as a campaign level model. In making this decision the team accepted that low level events could often affect the nature of non-warfighting campaigns and that if it proved necessary to examine these areas then an event driven resolution of certain events may be required. The presence of two lower level models in the CDA model hierarchy encouraged the team to believe that, in most circumstances, these occasions could be investigated in SIMBAT or the LFM and the outcome of those events represented as simple algorithms or data in DIAMOND.

The second issue to resolve was which non-warfighting operations DIAMOND should address. A firm focus for the work would be important but so also would be maximising the utility of the development. To resolve these issues a series of workshops were convened to identify the tasks and activities that UK forces would undertake across the spectrum of non-warfighting operations. By mapping common activities and tasks onto one another it was determined that peacekeeping, peace enforcement and humanitarian aid would encompass the

majority of non-warfighting activities (Figure 2). A successful representation of these operations would provide the greatest utility with the benefits of a firm focus for the development (Caldwell, 1998).

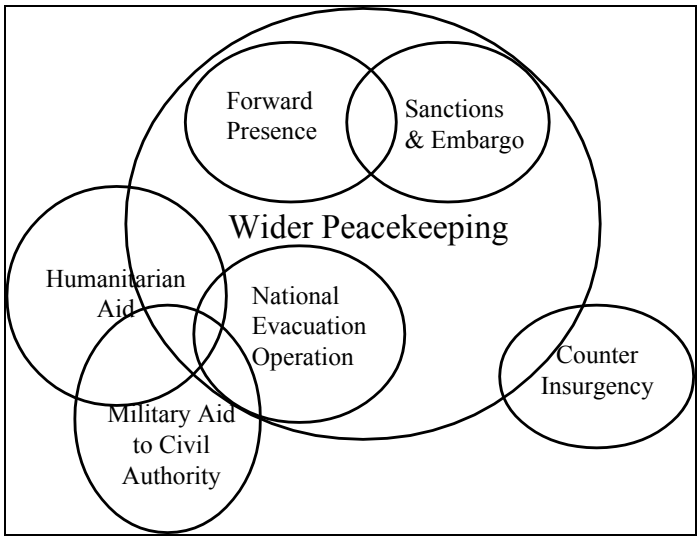

Figure 2: Overlap of activities between different types of non-warfighting operation.

GENERAL CONSIDERATIONS

FLEXIBILITY

One of the cornerstones of such a development is to ensure the methodology (and thus the model) provide a flexible framework suitable to accommodate future programmes. Since the end of the Cold War, model flexibility has been an essential requirement for CDA models, as the environment in which UK forces now operate is considerably more unpredictable than the Cold War period that proceeded it.

This unpredictability has necessitated a wide range of scenarios to be developed which are constantly being reviewed and updated to reflect representative environments and operations that UK armed forces may be deployed to in the future. This evolving scenario environment, in which CDA analysis is couched, seriously reduces the shelf life of models that cannot accommodate rapid changes to their architecture.

In answer to this challenge CDA's current model strategy (Wagstaff, 1997) advocates the use of:

a. A hierarchy of models ranging from the tactical to the campaign level.

b. Command and Control based architectures.

c. Data- driven (rather than hard-wired) models.

COMMAND AND CONTROL ARCHITECTURE

Traditional model architectures developed during the Cold War were dominated by conflict and attrition functions. This emphasis rendered the majority of these models inappropriate to examine military operations that fell short of general war. In modern military operations, especially those dealing with civil military interactions, the use of force is often an inappropriate way to achieve the aims of a campaign. However, information flow is common to both warfighting and non-warfighting environments and is therefore a suitable architecture with which to develop a common set of models to explore both types of operation.

This technique is known as Command and Control (C2)-led modelling. C2-led models allow the representation of the key decision makers and the links between them in a simulated environment. Command structures may be represented and objectives, instructions, decisions and intelligence may be passed across the communications network, from entity to entity. This is an especially powerful technique for modelling non-warfighting campaigns, especially when coupled with a mission-based system for allocating objectives to units or other entities represented in the model.

The principal strengths of Command and Control-led modelling are:

a. Allows representation of communication delays and shows the effect on force cohesion.

b. Effective mechanism to investigate the consequences of any difference between ground truth and an entity's recognised picture.

c. Allows entities to respond to their environment.

d. Reduced demand on the model operator to set up and run a scenario.

DATA-DRIVEN MODELS

During the 1980s it was common practice to have tactics and doctrine hard-wired into models. This was acceptable to the model designers of the time as the Cold War environment provided a stable two-sided scenario. In recent years, in response to the evolving operational environment it is not efficient, nor sensible to build into the model as hard-wired code the very concepts you may need to investigate. However, if data is separated out from the model it becomes possible to release the potential richness of the simulation, allowing for a more flexible, customisable and scenario independent model. The disadvantage is that it is sometimes hard to capture tactics or doctrine in an appropriate data format.

A further consideration for CDA to use data-driven modelling for the examination of non-warfighting operations is that it improves the visibility of data and assumptions and this, in turn, eases the validation process. For the output of any model to be useful, CDA must prove to the UK MoD that the data used comes from a sound and accepted source and that outputs from the model can be traced back by an audit trail to that data. The requirement for validation can constrain the techniques available to CDA for developing models, however, it ensures that model outputs and subsequent analysis can stand up to rigorous cross examination by stakeholders.

SPECIFIC CONSIDERATIONS

WHY A STOCHASTIC SIMULATION?

As modelling civil military interaction is still a new area there are benefits to be had from a number of broad approaches to the subject. System dynamics, object orientated and simple historical based models all have their strengths and weaknesses. CDA's approach has focused on an object orientated, command and control-led approach as this is the most appropriate framework for supporting our current study programmes.

In the choice of techniques on how best to realise an object orientated, command and control-led, approach for modelling civil-military interaction the principal contenders are simulation and wargaming. Due to the unpredictable nature of many such operations wargaming would, on the face of it appear the stronger contender. Wargaming allows the introduction of human decision-making which is often an essential part of such operations and has the ability to help players assess which factors in such operations are most important. However, wargaming is disadvantaged by requiring a significant number of participants, can be slow and is ill suited to demonstrating repeatability of results.

These disadvantages can be compensated for by simulation, which is faster, requires less manpower and is ideally suited to sensitivity analysis. The principal disadvantage of simulation, the lack of human-decision making as a scenario unfolds, can be compensated for by the command and control system.

The choice of a stochastic, as opposed to a deterministic, approach goes further to compensate for the disadvantages of simulation over wargaming. A stochastic approach is also likely to produce results that recognise there is never a perfect answer to such scenarios, only a distribution of solutions given certain assumptions and constraints.

Despite anticipated advantages of a stochastic simulation it is recognised that wargaming is still a very powerful technique. As such it is expected that CDA will scope scenarios that are to be modelled in DIAMOND with pol-mil gaming or other accepted techniques that allow the human-decision making elements to be investigated.

ENTITIES AND ENVIRONMENT

As the DIAMOND methodology has been developed to support analysis into future force structures it was important to represent an appropriate range of UK military units and assets. As the simulation will be data driven only a generic representation of these units is required in the model itself with the detail of each unit's capabilities being captured and described by data entered by the model operator. However, what was important to establish at this stage in the development was which additional types of units or entities would be required to model civil-military interactions. The minimum set of additional entities that would require modelling were assessed to be:

a. Groups of civilians and refugees.

b. Groups of evacuees.

c. Monitors.

d. Media teams.

e. Non-governmental aid teams.

f. Non-military engineering teams.

g. Non aligned traffic (cargo by road, rail, etc.).

h. Belligerent factions' combat units.

The environment in which these entities will operate can be described effectively by a node and arc system (Figure 3). A node and arc system allows the operator to describe points of strategic interest and the journeys between them. This is best represented graphically, as it allows the operator to inspect the entities during the simulation and interpret their interactions. Both nodes and arcs will be described by data that will represent the type of terrain and important elements of that terrain such as housing, facilities such as ports, airfields and food and water sources.

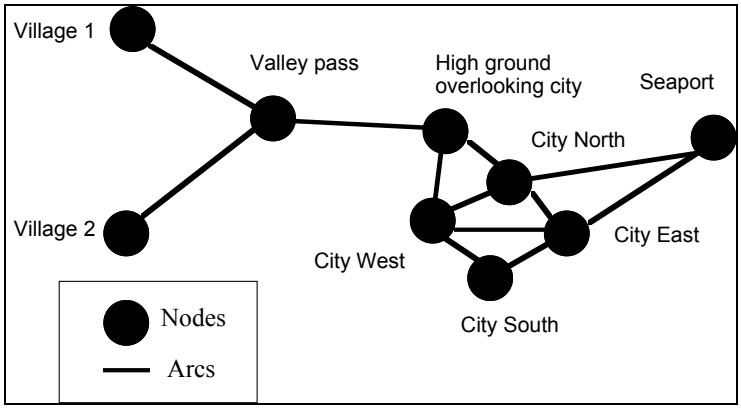

Figure 3: Node and arc representation of terrain.

RELATIONSHIPS IN MULTI-SIDED MODELS

In existing combat models it has been traditional to represent only two sides of any conflict. This is a suitable assumption for most conventional battles as, regardless of the number of participants, they tend to fall neatly into the categories of attacker or defender. In non-warfighting operations this assumption is not valid as there are often a large number of participants, none of which can be classified purely as hostile to each other. For example, in Bosnia there were three main armed factions, their respective civilian populations and the peacekeeping forces. In Somalia there were upwards of twenty-four warlords vying for control, the embattled civilians, the multi-national peacekeeping forces and United Nations

personnel, all of which were of strategic importance to the operation at one time or another. Very quickly it becomes obvious that any successful attempt to model non-warfighting operations requires a multi-sided approach. It was decided that each side in the simulation would be identified as a separate party and that the relationships between those parties would be used to describe their affiliations, rather than aggregating like minded parties into distinct sides.

In accepting that a multi-sided model is required it is necessary to identify the relationships that will be required to describe the affiliations of each party. Again, in traditional combat modelling only one type of relationship is modelled, that of hostility between parties. In non-warfighting models a greater range of relationships is required. Previous work in another CDA model, SIMBAT, saw the introduction of neutral and friendly relationships in addition to a hostile relationship. A further workshop was convened at CDA to examine this aspect of the work for a campaign level model and it became apparent that the minimum number of relationships required were five, they are:

a. Hostile.

b. Uncooperative.

c. Neutral.

d. Sympathetic.

e. Friendly

This minimum set of five relationships was considered to be sufficient to represent the key interactions between parties in a non-warfighting environment. It was further recognised that a relationship between a party does not have to be symmetrical. For example an NGO (Non Governmental Organisation) may consider its relationship with a belligerent faction as neutral whereas that faction may adopt an uncooperative or even hostile stance in return.

MISSION-BASED MODELLING

Having established an architecture that allows representation of a multi-sided non-warfighting conflict the next stage is to determine what activities those parties and entities will be undertaking in the simulation. Mission-based modelling allows the operator to assign objectives with defined end conditions to each party or to each entity if required at the beginning of a simulation run. This technique allows the operator to quickly set up a scenario without extensive scripting of the elements and their interactions in the simulation.

In determining the missions required the development team found it important to remain focused on the scope of the DIAMOND project. Earlier work had identified that the greatest utility for the development could be captured through examining peacekeeping, peace enforcement and humanitarian aid operations. In tackling the issue of which missions and activities were required the development team further analysed these operations from three perspectives. Those of:

a. The belligerent factions.

b. The peacekeeping / peace enforcement forces.
c. Non-aligned organisations and groups.

This approach produced a extensive set of missions, some of which were applicable to all parties and some of which were specific to one of the particular group perspectives identified above. Each mission was then subdivided into a series of possible courses of action (activities) that could be undertaken to satisfy that mission (Caldwell and Christley, 1998).

An example of this approach is given below and represents four missions identified for NGOs. Each mission is then further subdivided into possible activities.

a. Provide aid.

   i. Assess requirement for aid.
   ii. Distribute aid.
   iii. Provide medical services.

b. Withdraw.

   i. Move to a safer area.
   ii. Suspend operation.
   iii. Leave theatre.

c. Return.

   i. Return to a previously vacated area.
   ii. Resume a suspended operation.
   iii. Return to theatre.

d. Negotiate and liaise.

   i. Create link.
   ii. Make inquires (e.g. assess need).
   iii. Make requests / demands (e.g. passage and escort).
   iv. Bargain or stall.
   v. Reach agreement / Refuse agreement.
   vi. Break link.

The missions specified above would be allocated to an appropriate NGO organisation at the beginning of a simulation. Each entity from that party would then perform an appropriate action from the missions assigned to them, based upon their perceptions (their interpretation of intelligence received from their own and other parties, their own sensor reports and their relationships with those parties with which they are interacting). As circumstances change alternate activities may be triggered under each mission. This approach allows the data collected to support the DIAMOND development to be focused on addressing specific issues. Typical data collection requirements generated from the above four missions for NGOs may be:

a. How do NGOs assess need?

b. How do NGOs prioritise aid delivery?

c. Under what circumstances will NGOs withdraw from an area or an operation?

d. Under what circumstances would an NGO return to a previously vacated area or to a previously suspended operation?

e. Under what circumstances would an NGO request escort for aid delivery?

Once specific data requirements for the DIAMOND development have been identified and that data has been collected, it will be possible to calibrate that party's preferred activities for each mission against perceptions of key parameters (such as their own safety). This will then allow the party to interact with its environment with minimal guidance from the model operator.

PERCEPTIONS AND NEGOTIATION

As part of the development methodology it was recognised that effective mechanisms to represent the complex areas of perception and negotiation were required. At the Centre for Defence Analysis, the representation of human factors (e.g. the effects of fatigue and morale) are becoming increasingly important areas of research and DIAMOND is no exception to this trend.

An entity's perception will vary according to its circumstances and changes in its circumstances may have an impact on its behaviour. Perception is influenced by an entity's current status (e.g. availability of supplies, casualties and current activities), relationships between entities from different parties, sensor information, intelligence received from the entity's own party and intelligence received from other parties. Intelligence from other parties is likely to be weighted depending upon the relationship with that party and the type of information. This allows propaganda effects to be simulated.

During execution of a scenario entities will compare their current perceptions of key parameters (e.g. safety) against the data that defines which activities they would prefer to follow for each mission they are allocated. If an entity's perceptions indicate that another activity would be preferred at that stage in the simulation the entity will then alter its behaviour accordingly.

In tackling negotiation it was determined that a generic negotiation mechanism for all interactions was not feasible. Instead negotiation mechanisms in DIAMOND were based on the assumption that individual types of negotiation could be identified. Some examples are:

a. Resolution of a conflict between parties.

b. Request for support or protection from another party.

c. Request or demand right of passage.

These negotiation types can be considered to be additional missions that can be assigned to selected entities (i.e. the commanders) within a party. If a commander is required to enter into negotiation he will activate the 'negotiate and liaise' mission and proceed through the activities in line with their perceptions of the situation. Each party will adopt a negotiating position, again based on the type of negotiation being undertaken and the perception of that party. These positions are represented by a five point scale shown below:

a. Victory.

b. Demand concessions.

c. Compromise.

d. Cede concessions.

e. Surrender.

If both sides of the negotiation reach one of three natural pairings then the negotiation can be resolved. The natural pairings between two sides to resolve a negotiation are:

a. Victory / Surrender.

b. Demand concessions / Cede concessions.

c. Compromise / Compromise .

If a natural pairing does not occur then the negotiation will continue until the perceptions of one or both parties change (allowing a natural pairing) or until one party exhausts its patience and withdraws from the negotiation (possibly triggering other activities in the process). At all stages the time used to during negotiation will be figured into the activities of those entities.

FUTURE WORK

CONCEPT TESTING AND MODEL DESIGN

Throughout this project many new mechanisms, concepts and ideas have been generated on how best to model civil-military interactions in a non-warfighting environment. The next stage of the work is to take these concepts and test them with dummy data in workshops either on paper or through prototyping. This process should reduce the risk that the final DIAMOND model will be inadequate to tackle the campaign level issues associated with force development. The completion of the concept testing stage will allow CDA, in concert with an appropriate software company, to draw up a detailed design document to cover the architecture and software requirements for the DIAMOND model. It will then be possible to proceed to construction of the DIAMOND model itself.

DATA COLLECTION

For the reasons set out in paragraph 3.3 (data driven modelling and validation requirements) data collection is anticipated to be one of the major areas of research for the DIAMOND project. The DIAMOND methodology has been developed to provide an effective framework on which those data collection activities can be focused and this will take place in three phases.

The first phase will be the identification of suitable data sources to support the requirements of the model. The second phase will be a detailed break down of the specific data requirements generated by following the DIAMOND methodology. The mechanism for doing this has been alluded to briefly in paragraph 4.4.5. The third and final phase will be the collection of that data and its subsequent analysis, validation and assimilation into a model shell. Further data collection activities beyond this are anticipated to be scenario specific.

CONCLUSIONS

The application of the DIAMOND methodology has identified the key requirements for a campaign level model that is capable of representing peacekeeping, peace enforcement and humanitarian aid.

The DIAMOND methodology will provide a robust structure onto which data collection activities can be focused, allowing the outputs from the model to pass CDA and UK MoD validation requirements.

It is anticipated that the successful construction and data population of the DIAMOND model will enhance CDA's capability and provide a flexible, low maintenance tool with which to answer a variety of issues associated with force development.

REFERENCES

Wagstaff, K, 1997. CDA model strategy paper, unpublished DERA report.

Caldwell, A.D., 1998. Outline requirements for a high level operations other than war (OOTW) model, unpublished DERA report.

Caldwell, A.D. and J. Christley, 1998. User requirement document for the DIAMOND model — Phase 1, unpublished DERA report.

GLOSSARY

C2 Command and Control

_

CDA	Centre for Defence Analysis
CFE	Conventional Forces in Europe
DERA	Defence Evaluation Research Agency
DIAMOND	Diplomatic And Military Operations In a Non-warfighting Domain
HLS	High Level Studies
LFM	Land Formation Model
MoD	Ministry of Defence
OOTW	Operations Other Then War
SIMBAT	SIMple BATtlegroup model
UK	United Kingdom

PERMISSIONS