The DIAMOND Peace Support Operations Model – Lessons from an Iraq Scenario

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ABSTRACT

The DIAMOND model is a high level simulation model, designed to examine multi-party peace support operations scenarios at the campaign level, with various different relationships and rules of engagement between the parties. Originally designed to look at operations in Bosnia, new and emerging conflicts such as the current operations in Iraq pose additional challenges for the DIAMOND model.

A scenario based on the ongoing operations in Iraq has been implemented and analysed in DIAMOND to assess the capability of the model to represent insurgency campaigns within a peacekeeping scenario. DIAMOND can also be used to shape data collection from Operations Other Than War (OOTW), by providing an indication of what data should be collected and why.

A Data Quality Scoring System has been developed which can help structure and assess the value of the data gathered for analysis use. The future development of DIAMOND will build upon lessons already learnt and aim to incorporate more of the difficult civilian and cross-party tension aspects of peace support operations.

INTRODUCTION

Policy and Capability Studies (PCS) Department sits within the UK MoD's Defence Science and Technology Laboratory (Dstl). Much of the work of PCS relies on Operational Analysis (OA) techniques to analyse the relative merits of various policy and capability options. To this end, a variety of modelling tools are maintained by the department, one of these being the DIAMOND model, the primary PCS high level tool for the analysis of peace support operations.

THE DIAMOND MODEL

WHAT IS DIAMOND AND HOW DOES IT WORK?

DIAMOND stands for **DI**plomatic **A**nd **M**ilitary **O**perations in a **N**on-warfighting **D**omain (Caldwell, 1999; Caldwell, 2001). It is a high level model which can be used to study Peace Support Operations and Operations Other Than War. This includes peacekeeping, peace enforcement, evacuation scenarios and provision of humanitarian aid. It is part of the stabilisation methodology that has been developed by PCS under the Stabilisation Study (Parkman, Body and Pearson, 2005). It complements the High Level Stabilisation Model developed within this study, operating in a greater level of detail.

DIAMOND is based on a node-arc network that represents the physical infrastructure of the scenario, and data-driven entity templates that represent the entities or "actors" within the scenario. Nodes represent towns, areas or important road junctions and the infrastructure present. Arcs represent transport routes or other infrastructure such as essential services, water, oil or electricity transmission routes.

The entities within DIAMOND are arranged into any number of parties, and this multi-sided approach is one of DIAMOND's great strengths in comparison with other high level campaign models. The parties can represent coalition or individual country peacekeeping forces, indigenous security forces, insurgents, factions, various civilian parties, Non-Government Organisations (NGOs), contractors and any other actors which are deemed significant to the scenario. The entities within the parties may include military or non-military units, civilians, military and non-military commanders or leaders. The level of resolution of DIAMOND means it is normal to represent entities at the company level, although smaller entities can be represented if necessary for the coherence of the scenario. The size of scenario represented is most often between a brigade and division sized area of responsibility. Additional capabilities such as engineering capability and transport capacity can be specified for each entity.

Entities act within the scenario according to the missions they are allocated. An entity can be tasked with a mission in several different ways. Default missions allow a unit to carry out an ongoing task, for example, guarding a base or patrolling an area. Although units may in reality rotate through tasks, for simplicity in DIAMOND, the representation would be of one unit constantly guarding, one patrolling and one in reserve, for example. These default missions can be overridden by a scripted mission, in which an entity will be tasked at a predetermined time to, for example, transport certain logistic supplies or move to an area. This in turn can be overridden by a delegated mission from a commander.

Entities in DIAMOND may sit within a military-style command chain, where the higher level commander will allocate plans depending on the concept of operations. These missions may be triggered by scenario time, the success or failure of other missions, detection of an entity from another party in a particular area, or events which may have a particular pre-determined response, e.g. "Explosion in area A". The missions represented explicitly in DIAMOND are defend, deny movement, engineering, escort, evacuate, intelligence, movement, presence, reserve, secure, strike and transport. This list demonstrates the

combination of more traditionally military tasks such as secure and defend with "softer" tasks such as escort, evacuate and engineering.

Each party has a relationship to each of the other parties which can vary on a five point scale from friendly, through cooperative, neutral and uncooperative to hostile. This can be changed during the scenario, if it is assessed through analysis that a relationship would have improved or degraded at a certain point in the scenario (Mee and Marshall, 2004). A relationship may not necessarily be symmetric between two parties.

Rules of engagement define who or what can be targeted, for example, military or civilian entities or infrastructure, to what level it may be destroyed, whether a party may respond on behalf of third party or facilities, for example to defend civilians or infrastructure, and the level of detail and credibility of intelligence that is required to engage. Engagement is also dependent on the relationship between the parties involved. Each party and indeed each mission which is undertaken can be given a specific set of rules of engagement.

Entities in the various parties will interact with other entities depending on their missions, relationships between the parties, their rules of engagement (ROEs) and the force ratios between the entities in that node or arc.

DIAMOND contains stochastic elements, which include the delay and outcome of negotiations to gain access through a roadblock, the level at which an entity considers itself defeated, and the probability of component loss when carrying out a strike mission. This stochastic element ensures that realistic uncertainties are imposed into the results analysed for a scenario, and allows a range of scenario outcomes to be considered and any outliers to be investigated.

WHAT CAN WE USE DIAMOND FOR?

PCS department conducts analysis of the capability of various force structures, both current and future, to meet the requirements of a range of different types of operation, including peace support operations and other operations. It is possible by using a range of parametric variations, to assess some of the impact of varying the force mix (for example replacing some heavy forces with additional engineers), force size and tasking of the forces in theatre. It is possible to look at the utilisation of different elements of the force within a scenario. The impact of NGOs not being able to operate due to insufficient security can also be investigated.

By gathering the data and examining scenarios in the detail required to produce a credible plan in DIAMOND the analyst is forced to think about features and influences within the scenario which may have otherwise not been examined. This in turn may lead to a greater understanding of peace support operations by the analytical community, which may be passed on to higher decision makers.

DIAMOND can be an aid to structuring data collection within theatres of operation, and the DIAMOND team have been working with some members of the department's Support to Operations group who have deployed to Basrah. This has enabled the DIAMOND team to understand the data which is available, and the restrictions on data-gathering in theatre.

DIAMOND AND DATA

WHAT IS REQUIRED TO RUN DIAMOND?

DIAMOND is a data-driven model of peace-support operations. Data is required from a range of sources, including military planning data, historical data and analysis, open sources for data regarding civilian and NGO activities, and expert advice. Expert advice can come from the military, people with experience of working with NGOs or social scientists thinking about the interactions between civilians and the different parties involved in a scenario.

THE DATA QUALITY SCORING SYSTEM

It has been recognised for some time that any (OA) model is only as good as the data that supports it. In fact, in some cases (or, it could be argued, many cases), the quality of the data may be more important than the model that is supported. However, there has not been a simple metric that gives an indication of the overall quality of a data set. This has made it difficult to assess the increasing maturity of those data sets as they are developed. It has also meant that it has been difficult, if not impossible, to compare the quality of the data sets developed in support of different models.

As a part of a DIAMOND data recording task, a metric, which has been termed the Data Quality Score (DQS), has been developed (Bailey, 2003). This metric takes account of not only the perceived quality of each individual data item in a set but also its potential importance (in terms of the number of times that the data item is defined and whether it has an impact across a range of scenarios). The metric itself is defined as a percentage, which indicates how close the current data set is to an 'ideal' data set. In this way it takes account of the possibility that some of the data items may always be subjective and open to argument.

Sub-Section	Variable	Dimension	Scope	Quantity	Quality	Max Qlty
Relationships	Mean Access Negotiation Delay	Hrs	D	2	B	D
	Mean Support Provision Delay	Hrs	D	2	A	D
	Initial Relationships	Option	D	2	B	D
	Access Negotiation Decision Probabilities					
	- Time	Secs	D	2	B	D
	- Probability	0 - 1	D	2	B	D
Planning and Reporting	Planning Time					
	- Basic	Hrs	I	2	N/A	N/A
	- Increment per Component	Hrs	I	2	N/A	N/A
	Reporting Time					
	- Basic	Hrs	I	2	B	D
	- Increment per Component	Hrs	I	2	B	D

Figure 1: Example from DQS table. The Iraq scenario has a current DQS of 66% using the weighting system described above.

A data table records information about data in DIAMOND that includes the dimension, scope (scenario independent, scenario dependent), quantity (defined once, a few times, many times), quality, maximum quality attainable and the source. Figure 1 shows an example of the

structure of the table, with some information on the data regarding relationships and planning and reporting times.

The Quality and Maximum Quality scores are based on the 4 point scale below, with the addition of a "Not Applicable" category for data items such as names.

A: Assessment achieved by means of subjective judgement only.

B: Assessment achieved by means of subjective judgement informed by objective evidence. (Objective evidence can include OA, experimental results and historical evidence).

C: Assessment achieved by means of judgmental interpretation of existing objective evidence.

D: Assessment drawn directly from objective evidence.

Initial weighting values

1, 1 for scope (i.e. no differentiation made between scenario independent and dependent)
1, 2, 3 for quantity
0, 1, 2, 3, 4 for quality (equating to N/A, A, B, C, D)

were developed for simplicity and to test the approach. The actual values used are less important than the consistency across the attributes (scope, quantity, quality, and maximum quality). Consistency is required to ensure that no one attribute takes precedence over any of the others. The initial weighting scores are slightly skewed due to the maximum score of 3 for quantity and 4 for quality. An enhancement would be to score out of 12 to give greater consistency.

The percentage score for the data set is calculated using the following formula:

$$\frac{\sum_i scope_i \times quantity_i \times quality_i}{\sum_i scope_i \times quantity_i \times max\_quality_i}$$

where *i* ranges over all data items.

The DQS has the potential to allow us to track how the model data sets are maturing, assess the relative cost and benefits of targeted data collection exercises and assess the potential implications of model improvements on the overall data quality. For example, if data in an area of the model which has been shown to be particularly significant in sensitivity analysis and contains many instances of data use is improved, this will have a greater impact and be more cost beneficial than focusing in an area where the data only used rarely and has minimal impact. It may be possible, by using consistent scoring systems, to compare the relative qualities of the data sets for various models.

DIAMOND IRAQ SCENARIO

AIMS AND BACKGROUND OF SCENARIO

DIAMOND was originally conceived to examine scenarios such as the operations in Bosnia and the capability of the model to examine counter-insurgency operations such as the one currently ongoing in Iraq had not previously been assessed. The amount of open-source material available concerning the operation made it an ideal candidate for an unclassified demonstration scenario. This enabled new users to gain understanding and experience of building a scenario and thinking about the ways in which real events could be modelled in an abstract manner. Testing the capability of DIAMOND to represent counter-insurgency operations has added to the validation portfolio and enabled us to recognise strengths and weaknesses, and therefore identify areas where additional data is required and model areas which could benefit from potential enhancements.

The PCS Historical Analysis team provided a scenario background, primarily from news reports. This was supplemented with information from the Support to Operations group with their recent operational experience. This scenario background describes the situation in the period leading up to the modelled scenario (from November 2003). It should be remembered that this is a possible future, not a recreation of real events, and does not model every aspect of the situation – DIAMOND is intended to be a high-level simulation.

The background provided lists the desired end states, missions and objectives for several significant parties. However, not all of these are suitable for modelling due to either their detailed level of resolution or their overly political nature.

The scenario implemented represents the whole of Iraq, with a high level of aggregation (typically battalion level). A recent update has focused on the smaller area of the Multi-National Division South East (MND SE), in which units are represented down to the company level. This lower level seems to be a more useful and appropriate level of detail for looking at counter-insurgency type operations in DIAMOND.

PARTIES REPRESENTED IN THE SCENARIO

The following parties and their missions were chosen as a simplified representation of the real situation:

- Coalition.
- Iraqi Security Forces.
- Engineering Contractors.
- Civilian Infrastructure Degradation.
- Insurgents.
- “Civilian Threat.”
- Civilians.

There are many other ways in which the parties could have been chosen to represent the real situation but as the aim was to produce a demonstration scenario to test the model capabilities and build experience and knowledge in the user base, this simplified set was used. Were the work to be repeated by the same analysts there are some aspects which, having the knowledge of the operation and model we now do, could usefully have been implemented differently. This process of development is continuous and adds to the knowledge and user base for the model.

The physical infrastructure of the country is represented by nodes and arcs, with each node representing one of the 18 governorates in Iraq. Figure 2 shows the representation of the physical infrastructure and facilities within DIAMOND.

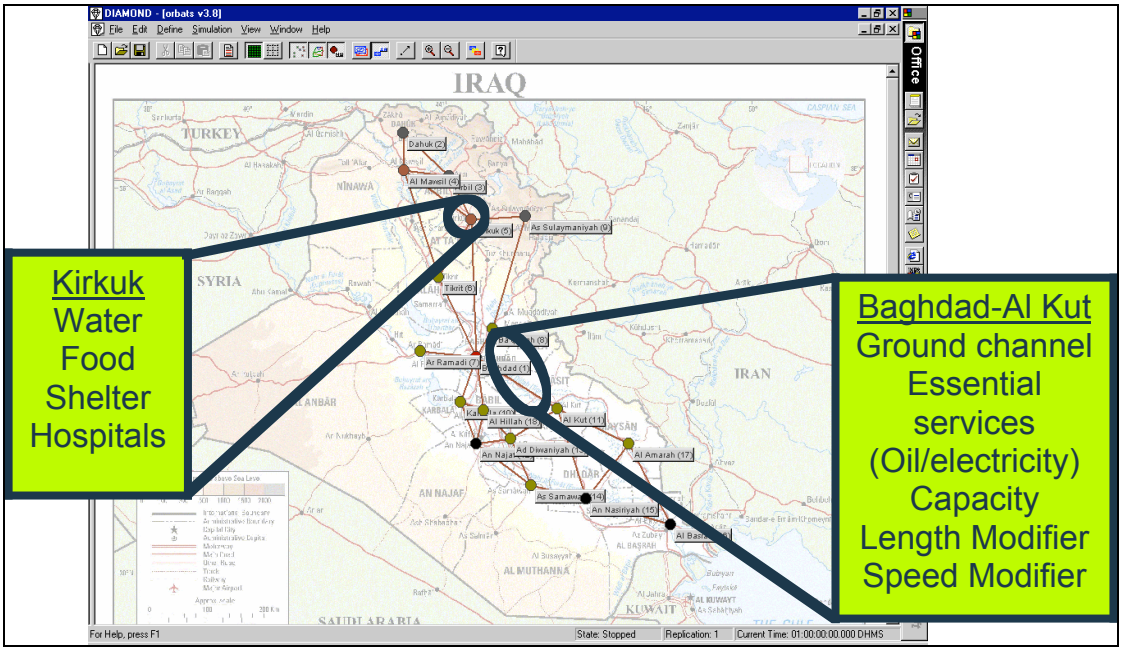

Figure 2: Screenshot from DIAMOND Iraq scenario.

The coalition forces have rules of engagement requiring them to defend facilities and civilians if they come under attack. They have patrolling, intelligence gathering and guarding missions. They also provide some capability to repair infrastructure at nodes, for example, shelter, hospitals and water.

The Iraqi Security Forces (ISF) are represented by a party. The ISF undertake similar missions to the coalition forces. The ISF party gains recruits over time, with a stronger force able to provide more security towards the end of the scenario.

An engineering contractor party represents the use of civilian contractors to provide an engineering capability to repair infrastructure based along arcs, for example, the roads and essential services such as oil pipelines and electricity transmission lines.

The "Civilian Nodal Degradation" and "Civilian Arc Degradation" parties represent looters and troublemakers within the civilian population who provide a continuous gradual destruction of infrastructure thus representing lawlessness. Examples include taking a pick-axe to a pipeline to get access to oil or water, or stealing copper from electricity pylons to sell for profit.

Insurgent groups carry out attacks against coalition forces and civilians. In reality the Iraqi security forces are also a prime target and representing the influence of these attacks on the future direction of the scenario and the relationships between the parties including support for the coalition is a major area of interest for future DIAMOND development. The insurgents operate from "dummy" nodes, representing their ability to hide within the local population.

A "Civilian Threat" party is included in the scenario which represents some impact on civilians of the threat provided by insurgent attacks. A "virtual" entity which does not attack civilians but is perceived as hostile by them provides a "threat level" against civilians. Its presence coincides with insurgent attacks to represent a possible impact of terrorism. If the threat is great enough in proportion to the size of the civilian group, small breakaway groups may move away to a different area. However, movement of civilians is an area which is poorly understood and difficult to predict. It is an area which is currently the subject of further study within PCS (Thomas, 2005).

Three civilian groups are represented, coinciding with the major religious and ethnic breakdown in Iraq of Sunni Muslims, Shia Muslims and Kurds. These groups can have independent relationships to the other parties. Civilian entities within DIAMOND move due to a lack of food or water in the area or a perceived threat (as stated above, civilian movement is poorly understood). They die if they do not receive food for a certain period of time or if they come under fire. There is also a representation of collateral damage. Currently death due to lack of water is not modelled due to the complexities surrounding this issue such as sanitation and disease.

MEASURES OF EFFECTIVENESS (MOEs)

MOEs WITHIN DIAMOND

Measures of effectiveness to be used for analysis of peace keeping operations, whether in real life or in simulations, need careful consideration. They may vary depending on the purpose of the analysis and the type of scenario being examined. Examples which could be collected from DIAMOND include (Howard, 2005):

- Number and type of attacks on friendly forces.
- Availability of services (e.g. water, electricity).
- Amount of territory controlled by different parties.
- Success or failure of each parties objectives.
- Level of attrition (military and civilian including collateral damage).

For analysis to be used in studies, criteria and thresholds for success should also be defined where possible. The thresholds should be determined by reference to historical analysis, analytical and subject matter expert advice, similar country comparison or the pre-conflict situation. As some of the analysis is subjective it may also be useful to provide analysis of the relative success or failure of different options within the campaign, for example, different force structures or sizes.

MOES IN THE IRAQ SCENARIO

As the scenario was designed as a model capability test rather than for study use we did not set clear thresholds for success or failure. Instead we were interested in the relative success in different runs of the scenario with different force strengths and structures.

The MOEs presented here are:

- Capacity, repair implemented and damage caused to facilities and infrastructure
- Coalition and civilian attrition.

EXAMPLE DIAMOND RESULTS FROM IRAQ SCENARIO

Multiple sets of results were run to take account of the absence or presence of a peacekeeping force and the size of that force. The forces were taken from a baseline of 100% strength (the forces in theatre in November 2003), increased in 25% increments to 150%, decreased in 25% increments to 50%, and run with the troublemakers and insurgents more "determined" and therefore less likely to withdraw from an area due to security force presence. The key for the charts in Figures 4-6 is given in Figure 3.

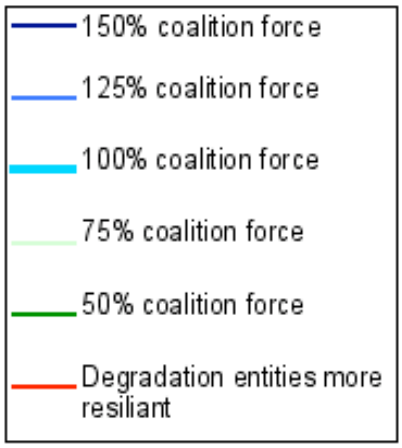

Figure 3: Key for Figures 4 to 6.

The capacity of facilities at each node can be examined throughout the scenario. The capacity changes due to damage caused by nodal and arc degradation entities and due to repair by coalition or contractor engineer entities. The initial level of capacity of each facility was taken to be 50% of the size of the population at the node.

The charts in Figures 4 to 6 display the combined capacity of hospitals, shelter and water at Baghdad and Basrah in percentage terms of the maximum potential capacity. This was taken to be the amount sufficient to support the population in the area. It can be seen that due to the minimal amount of disruption in Basrah area in the modelled scenario, even a greatly reduced force manages to implement a small improvement to the level of services. However, at Baghdad where more disruption occurs, a smaller force is unable to deter the

troublemakers or provide enough repair capability to reverse the damage caused. The line crossing the others represents the more "determined" troublemakers.

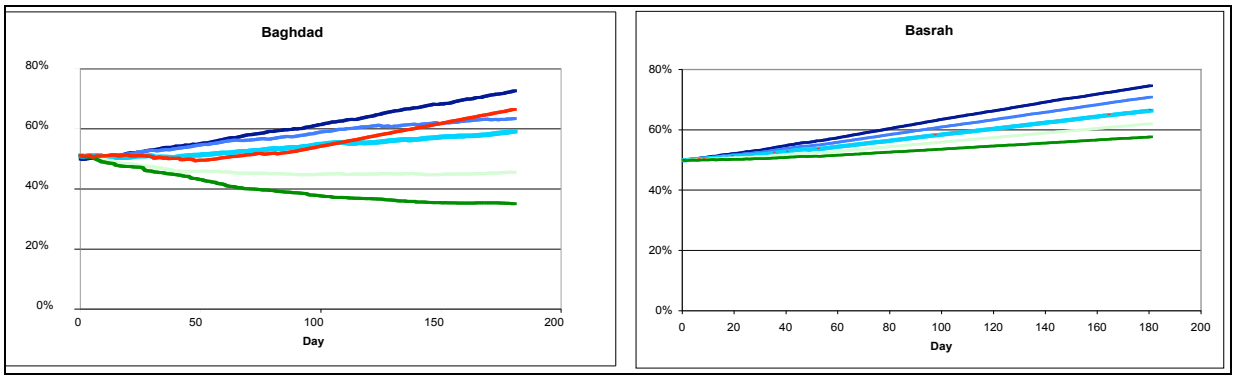

Figure 4: The combined capacity of hospitals, shelter and water at Baghdad and Basrah in percentage terms of the maximum potential capacity

One of the limitations encountered within DIAMOND whilst developing the Iraq scenario was the representation of engineering missions. The first version repaired facilities in a preset order up to 100% capacity before moving on to provide any other engineering capability elsewhere or towards a different facility. In Figure 5 it can be seen that whilst the capacity of hospitals has improved by the end of the scenario, the provision of water has in many cases decreased.

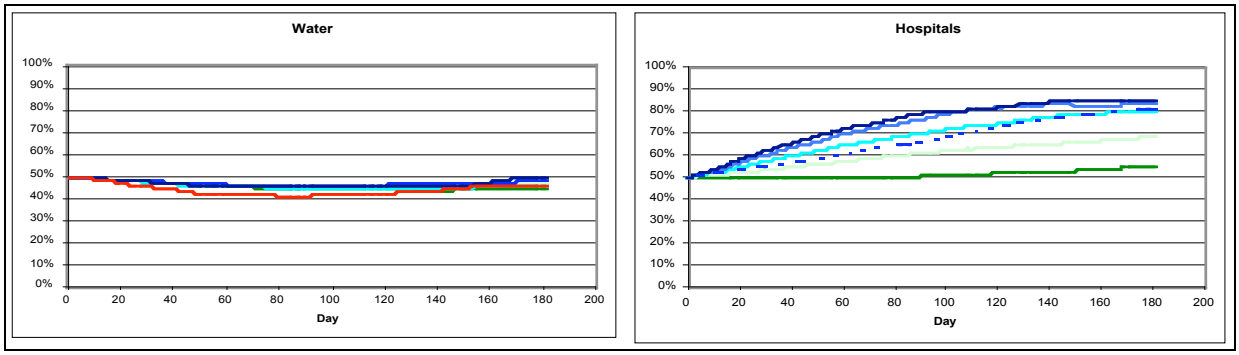

Figure 5: Capacity of all nodes across country to provide hospitals and water in previous DIAMOND version.

The later version with enhanced functionality allows thresholds to be set with a weighting of effort over different capabilities. This allows priority facilities to be specified, and all areas given some repair if required rather than concentrating all effort on a small area small area. This is displayed in Figure 6 where the repair of hospitals and water is at a more even rate (shown for force strengths of 50%, 100% and 150%).

The attrition due to attacks by insurgent forces on coalition forces (Figure 7) shows a low level of attrition with peaks and troughs. The total percentage force losses are small in comparison to the whole force, but may be concentrated in certain units. As we have seen, the impact of a "small" number of losses may be far greater in a peacekeeping scenario than in a more combat focused operation, in part due to political pressure, media attention and expectations. Capturing these impacts within DIAMOND is difficult and is currently carried out using offline analysis and discussion.

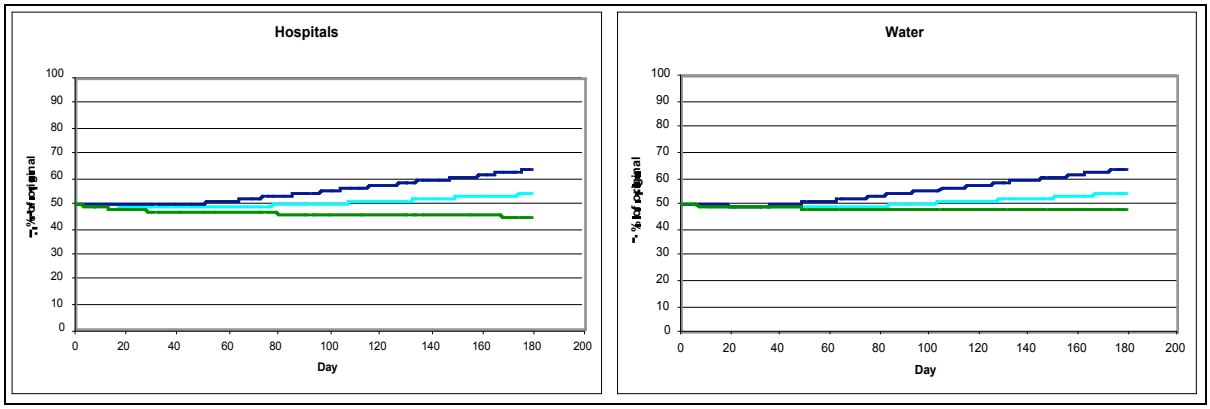

Figure 6: Capacity of all nodes across country to provide hospitals and water in enhanced DIAMOND version.

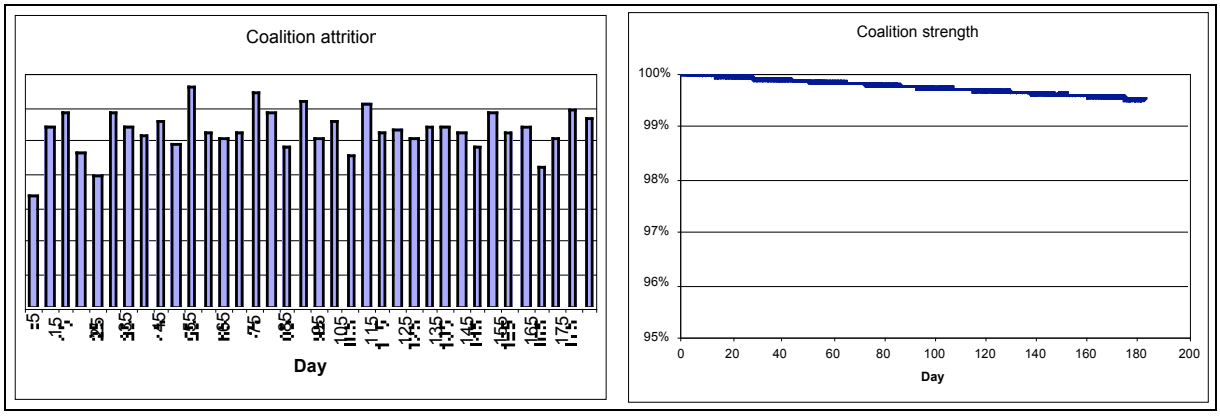

Figure 7: Coalition attrition (5 day sum totals and cumulative) due to insurgent attacks (baseline 100% force strength).

It was demonstrated that DIAMOND has the capability to represent the recruitment of indigenous forces throughout a scenario (Figure 8). It was decided that step changes representing the graduation of training courses would be most appropriate. The rates of recruitment and retention of these forces and the impact of other aspects of the scenario are not fully understood and any further work on this will be incorporated in future DIAMOND scenarios.

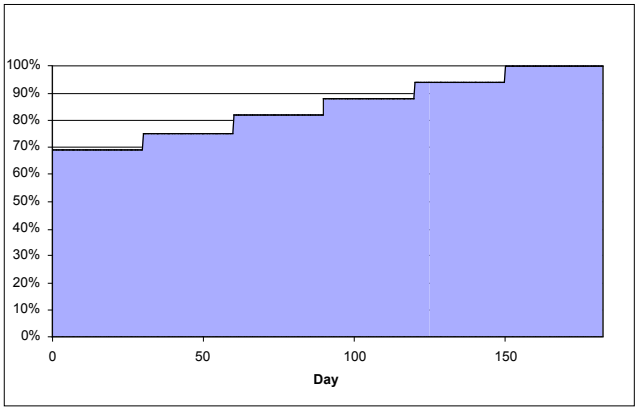

Figure 8: Iraqi Security forces strength increasing over time up to their maximum potential of 100%.

WHAT HAVE WE LEARNED FROM THIS DIAMOND IRAQ SCENARIO?

ACHIEVEMENTS

Representation of the infrastructure of an area was fairly effective, although accurate data on current and expected levels of service is difficult to obtain. It is also possible to represent elements such as electricity and oil pipelines in an abstract way.

It is fairly simple to populate the scenario and node-arc structure with a representation of the physical features of a scenario, and the coalition forces and civilians. However, there are several important areas in which data and understanding to support modelling within DIAMOND are currently limited. It is hoped that continuing demand for this data and understanding of relationships will prompt further study.

The potential to represent positive interactions between parties, for example, the coalition and indigenous forces, and the engineering contractors, was demonstrated. Friendly parties cooperate on certain missions such as to provide engineering capability for an area.

DIAMOND has the ability to represent the recruitment of indigenous forces as explained above.

A comparison of varying coalition force levels was demonstrated, and the non-linear impact of this, depending on the actions of other entities in the model. Continued military and subject matter expert involvement in the development of DIAMOND will further enhance the credibility of these impacts.

Some representation of a potential civilian reaction to threat is possible with the civilians moving away from a perceived threat. However, study of refugee movement to date has identified that prediction of civilian movement is very difficult and highly scenario dependant (Thomas, 2005). Study on the factors that may trigger movement will be incorporated into future developments where possible.

LIMITATIONS

As the understanding of peacekeeping operations is still limited, and there is a limited understanding of the factors influencing success, these limitations are reflected within DIAMOND. However, hopefully projects such as DIAMOND and the Stabilisation Study will encourage further investigation and understanding, and as this is gained it can be incorporated into the model capabilities.

The representation of insurgency and opportunistic attacks is difficult (but possible) within DIAMOND, which was designed with operations such as Bosnia in mind. Recent developments have improved the situation, although there are still many additional factors to consider. The representation of non-traditional opposition forces is an area of interest that will be focused on in the near future. Historical analysis has also shown that there are many

other factors besides force ratio which affect the effectiveness of security forces to maintain a secure environment and therefore achieve success in a peacekeeping operation (Morley, 2004). Outputs from this work and the High Level Stabilisation Model will feed into DIAMOND development to ensure it becomes more dynamic and reactive to other triggers besides direct military force.

Limitations to the representation of engineering missions are discussed above, and recent enhancements have improved the representation, although data is still limited in this area.

The interactions involving civilians and military forces are currently poorly understood. In the previous version of DIAMOND, it was not possible for civilians to feel any protective impact from the presence of a peacekeeping force; they would simply feel threatened by any hostile force in their vicinity. The functionality to express the impact of a protective force is now available, however, data and understanding to support this is currently limited and relies on scenario specific subject matter expert advice. The influence which civilians may have on military operations is also an area which is poorly understood.

DIAMOND relies on the relationships between parties to trigger certain behaviours. It is thought that certain events or combinations of events, such as continued lack of security or improvements to services falling behind expectations will lead to changes in the relationship between the parties involved. Similarly, if improvements to the situation exceed expectations, relationships may improve. It is hoped that the outputs from the High Level Stabilisation Model will feed into DIAMOND relationships by equating levels of co-operation and consent to certain relationships. Work in other areas of PCS will also contribute to a better understanding of this area.

RECENT DIAMOND DEVELOPMENTS

It is now possible to pause and edit the scenario to gain a better understanding of the interactions occurring and the important triggers within the scenario. This will also improve the ease of use of the model. It allows changes to be made based on the occurrences in the scenario such as the relationships between parties as mentioned above.

Engineering missions have been enhanced to provide a more appropriate representation of reality, so that it is possible to repair different facility types in parallel with prioritisation of effort. It is now possible for entities to start the scenario with a strength lower than their maximum potential strength, which improves the capability to represent the recruitment of indigenous forces and avoids previously necessary modelling “workarounds”.

There is now the potential for the number and relationship of civilians to military or insurgent forces to impact upon the likelihood of the forces to undertake a mission or to withdraw from an area. Data to support this is now required to supplement military advice.

DIAMOND now has the capability to represent the impact of peacekeeping forces on civilians and their propensity to move from an area where they perceive themselves as being under threat. It is hoped that work being carried out within PCS will support this functionality.

It is possible to represent generic events and a reaction to these, such as a Quick Reaction Force (QRF) being deployed to a disturbance in a certain area. This decreases scenario development time and improves the representation of force utilisation within DIAMOND.

Initial analysis using these changes has been encouraging, and there is now more opportunity to represent the interactions between the various parties and civilians.

THE FUTURE FOR DIAMOND

Modelling of Peace Support Operations is a continuously developing area, and as understanding of the most important factors grows, our modelling capability will be enhanced.

Some of the priorities for development are an improved representation of insurgent activity, and an enhanced dataset, in particular for non-military data. A better understanding of the interactions of civilians with the other parties involved, and the tensions which arise between parties, will allow DIAMOND to be more flexible and dynamic in representing Peace Support Operations.

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GLOSSARY

DIAMOND	DIplomatic and Military Operations in a Non-warfighting Domain
Dstl	Defence Science and Technology Laboratory
HLSM	High Level Stabilisation Model
HMSO	Her Majesty's Stationary Office
ISF	Iraqi Security Forces
MoD	Ministry of Defence
MOE	Measure of Effectiveness
MND SE	Multi National Division South East
NGO	Non-Government Organisation
OA	Operational Analysis
OOTW	Operations Other Than War
PCS	Policy and Capability Studies
PSO	Peace Support Operations
QRF	Quick Reaction Force
ROE	Rules of Engagement

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PERMISSION