Analytical LEGO ®— Vignettes as the Building Bricks for Studies of Compliance and Peace Building Scenarios

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Ian Mitchell has worked in Operational Research (OR) since 1988, following a flirtation with accountancy. For the Centre for Operational Research and Defence Analysis (CORDA) he initially produced historical data compilations. Studies of the land battle followed until 1992. After two years as an independent OR consultant to the UK Department of Social Security and European Space Agency he joined the Defence Research Agency (DRA) at Fort Halstead in 1994. He managed the Battle Group War Game, and led infantry studies. He moved to Porton Down in 1998 managing OR studies until 2000 when he became the OR specialist for the Directorate of Equipment Capability, Nuclear Biological and Chemical (DEC (NBC)). Ian served on the Council of the UK OR Society from 1994 to 2000. He was commissioned into the Territorial Army in 1984 and was introduced to OR as part of a Business Studies degree during 1986.

ABSTRACT

The essence of analysis is abstraction of key variables. With increases in computing capacity this may be forgotten resulting in attempts to produce generic universal models of everything within a campaign. These have yet to succeed.

Breaking down the complex situations into bite size — manageable chunks is a key process. As Peace Support Operations are often more complex and lengthy than warfighting this subject is of particular relevance to studies of this area.

LEGO ® bricks are leading educational toys. Combinations of the range of plastic LEGO ® bricks can represent many different structures. The paper suggests LEGO ® bricks as a metaphor for the use of vignettes as building blocks for the analysis of scenarios.

Vignettes are discrete excerpts by time and space from the full sequence of events, which form an operational scenario. The paper draws upon past Cornwallis proceedings in considering key activities in Peace Support Operations. These suggest what should be the subject matter of vignettes to form a set of representative situations amenable to detailed representation and simulation.

INTRODUCTION

Peace Support Operations (PSOs) may be seen as interventions by one system to change the state of another system. Compliance with agreements and the process of peace building are aspects of these interventions.

The output of analysis is enhanced understanding to inform decisions with regard to preparation for, interventions, or their conduct, so there is an implied need for advice to recognise these as a whole and in parts.

The whole provides the level at which to gauge success or failure of the operation overall. This is necessary to test force structures and national contribution to coalition forces. To estimate the higher level capability requires a means to represent the lower level interactions generating measures of effectiveness from which an assessment of the outcome can be formed.

In order to keep the analysis relevant and feasible requires that a scenario be broken into smaller excerpts by time and space. Aggregating these vignettes into the high-level scenario treats them as analytical "LEGO ® "bricks, building different structures from the various designs of brick.

This paper considers the selection of which bricks should be used in the analysis of operations aimed at peace building and compliance with agreements. Establishment of a set of "bricks" of common interest to the broad range of stakeholders, both military and civilian, is sought. Cornwallis offers a unique venue to explore this question. It is hoped that a set of vignettes and the most important criteria by which they are judged may be identified.

ANALYSIS OUTPUT — UNDERSTANDING

Operational Research (OR), sometimes known in its military variant as Operational Analysis (OA) is about the development of understanding to inform decision-makers. The Cornwallis V proceedings (p. 333) recognised the importance of crisis management to peace support operations.

To make decisions without OR support, based purely on judgement is to risk schemes or technological solutions, which do not work in an operational context. The Operational Research method describes a seven-step process to produce understanding for decision-makers. The seven steps are:

- Understand the problem.
- Define the key variables.
- Formulate the variables.
- Solve the formula.
- Interpret the results.

- Validate the formula.
- Implement the findings.

Although presented as a mathematically centred linear sequence the method has implied iteration present with much qualitative input. The last three steps of interpretation, validation and implementation define stages of advice provision. The penultimate step, validation, invites further runs through the sequence as understanding of the problem is increased. Issues of understanding and validation bring in qualitative perspectives. Much day to day business of OR practice is in the formulation and solution stages.

As PSOs are interventions by one system into the function of another the supporting OR needs to provide tools to aid in understanding their effects. PSOs tend to be longer lasting than warfighting operations with some key incidents within them. The military capability acts as an enabling system of systems to a larger system of intervention. It has also been apparent that small-scale actions have significance at the strategic level.

To deal with such a range of operations may suggest that a generic universal model of everything is required. Developments in computing capacity and the implications of Moore's Law suggest that science fiction concepts of *Holodeck* and *The Matrix* may become real options for analysts. This is deceptive. Large complicated models are both awkward to manage and opaque in nature. The greater the detail the more variables there are. Chains of cause and effect are difficult to trace through clouds of variables. The essence of analysis is to abstract reality into something analysable. Structuring the subject matter is the first step to addressing this.

STRUCTURE OF ANALYSES

The triangle diagram of OA describing studies of defence against Nuclear Biological and Chemical (NBC) threats introduced by Trethewey and developed in subsequent NBC OA strategy papers is shown below (Figure 1).

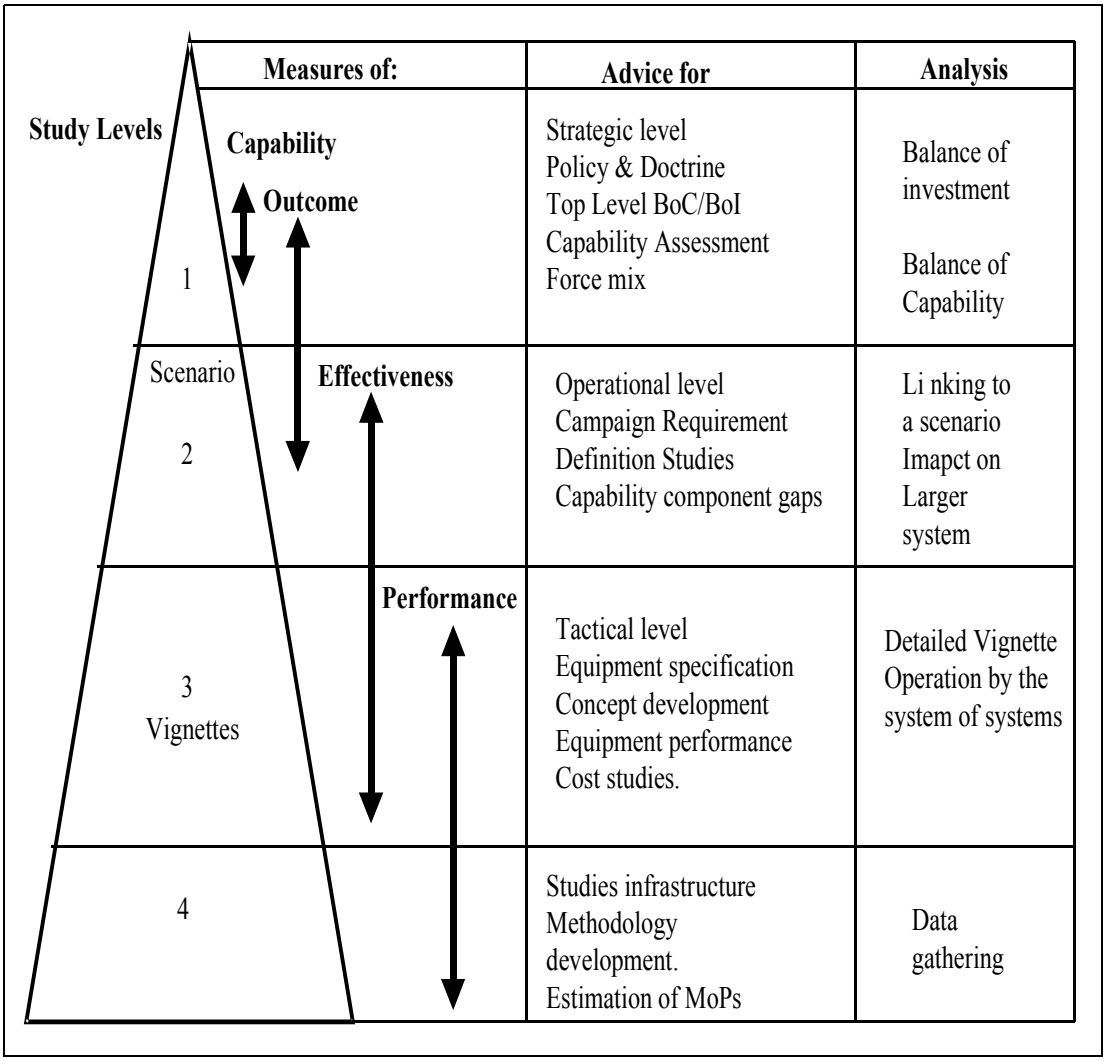

Figure 1: Structure for Operational Research (OR) studies.

NBC defensive capabilities act as an enabling system of systems to the larger system of a deployed military force. Similarly for PSOs military forces are often enablers for the achievement of the intervention by one state system into another. Level 3 (Figure 1) describes vignettes. These are smaller parts of the overall scenario of a manageable scope.

VALIDITY OF REPRESENTATIONS

What is a valid representation depends entirely on the question being addressed. Within the triangle there are many different models with varied representational approaches. Two examples are the DERA/Dstl computer simulation DIAMOND (briefed to Cornwallis on previous occasions) and the board game CRY FREETOWN.

Figure 2: Cry Freetown .

CRY FREETOWN, shown at the 18th International Symposium of Military Operational Research (18 ISMOR), is a manual game allowing exploration of the operational level. A board shows an area of West Africa and players control each of the factions, such as the RUF, the UN and mercenary forces. The players seek to win the game by scoring points awarded for achieving objectives. CRY FREETOWN has a simple (i.e. highly aggregated output) representation of processes governing economics, control of areas and conflict between factions. It is operating at Level 2 allowing a level 1 view to be taken of the relative merit of the strategies adopted by the players. Most of its inputs are at Level 3.

Both models require input data on performance to operate. Neither creates this within its processing. For example combat effectiveness of forces in CRY FREETOWN is determined by a dice roll with simple modifiers, such as a +2 for the use of terror. This represents the effect of terror as being a +34% chance to succeed in combat. The processes of terror such as amputations as described by Shawcross are not represented.

The key issue in design of representation is the balance of process and effect. A process representing model allows the means by which how an intermediate output is created. In contrast an effect representing model takes such output as its input to consider the impact on a higher level of the system.

Work by NATO Panel 3 Working Group 4, on the modelling of small arms effectiveness, was supported by a scheme of levels of representation proposed by M. Manders. This recognised the representation of the functioning of a firearm as discreetly different from its operational use.

A detailed model of infantry combat requires as input data a weapon's performance in terms of ballistics (Figure 3). A higher level model may be interested only in casualty rates and sustainability of these effects from a force equipped with a class of weapon. Neither model is interested in the processes of working of an individual firearm. Representation of the processes of the weapon cycling such as how a cartridge case interacts with the extractor claw or the bullet with the rifling of the barrel.

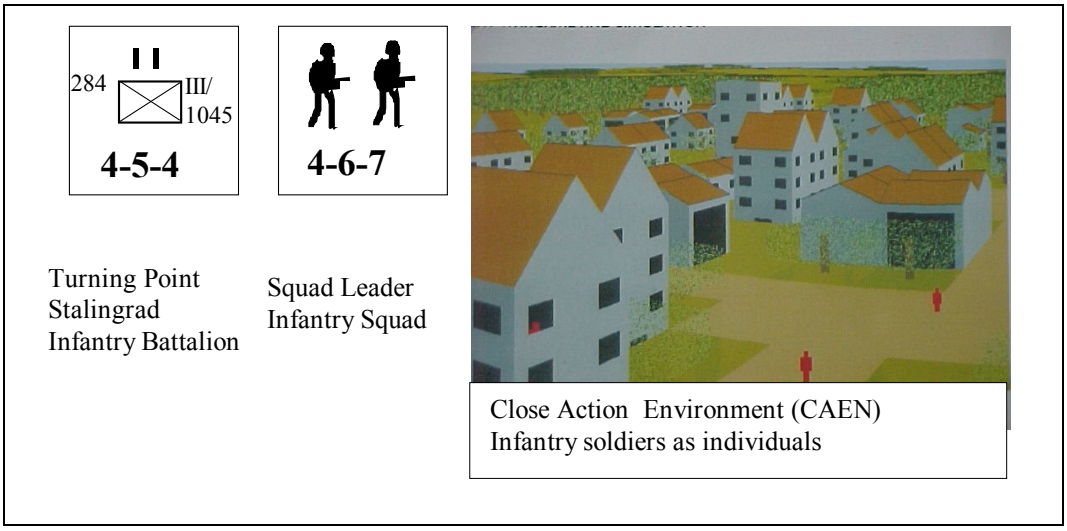

Figure 3: Levels of representation.

This performance data may be created with a model of a weapon operating in laboratory conditions or indeed from empirical data. Alternatively a set of effects or output data may be assumed as a means to provide input. Such assumptions can also be used as sensitivity analysis to decide whether an area merits detailed representation or data gathering efforts.

The difference between the levels lies in what the model represents as a process rather than an output. Hierarchies or chains of models may allow the levels to be connected with the input of one being provided as the output of another. Similarly the development of vignette hierarchies can be developed with a group of vignettes forming a single larger entity. The next issue to consider is what the models should be representing. P R Anderson closed his 1997 paper to Cornwallis II with the question "What are the equivalent basic building blocks for PSO?"

"ANALYTICAL LEGO ®"

LEGO ® bricks are well-established educational toys. A range of plastic interlocking bricks has provided a means to build models of many different things since the late 1950s. The range has grown with many specialised pieces. Ironically these have less general utility than some of the earlier basic shapes.

Vignettes are subsets of a campaign scenario. Within the triangle structure described earlier, they are in Level 3. They have details of location, environment and an operational context. They are the tactical level building blocks, the LEGO ® bricks for analysis. Boxes of LEGO ® bricks contain pieces and a book indicating how to put them together to produce

particular structures. Users can produce anything else if they can work out what shapes are needed and how to build valid structures from these. Some bricks have much broader applications than others. Designing the building bricks and the design for putting them together to produce a valid representation of a peace building scenario is a major undertaking.

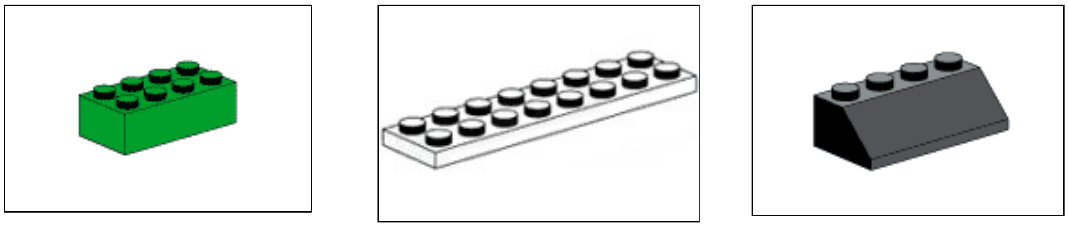

Figure 4: LEGO ® bricks.

VIGNETTE COMPOSITION

Vignettes are excerpts from the campaign sequence of events. They are subsets by constraints in time space and the numbers of participants. Cornwallis has seen a number of studies such as Anderson and Johnson in 1997 and Chouinard and Davis in 1998. Both classify activities within PSOs as tasks. Johnson identified the most commonly occurring ones from a database covering 29 operations out of a list of 400. 'Observing and Reporting: On Developments' was the only task appearing in all operations as shown in a table providing percentage of peace operations where each task was found relevant.

A further step would be the estimation of the number of times the task was carried out and in what circumstances. The latter details are effectively the design of the vignettes. Choice of vignettes is based on the importance of the vignette and the frequency with which it is encountered or may be anticipated. Following on from this is the method of aggregating the vignettes to provide a higher level view to be formed. Risk Analysis as taught by UK Joint Services Publication (JSP) 375 is driven by two factors: Probability of occurrence and consequence of occurrence. A similar approach may be used to identify the key building bricks.

Importance of the vignette (Impact of going wrong or going right) and frequency of occurrence are the two scales. The technique is commonly used in risk assessments to identify what contingencies merit management attention. It uses two four-point scales to describe impact and probability. The product of the scores is used to guide management attention to where it has greatest potential for improving a situation. For PSO vignette classification the schema shown in Table 1 is suggested.

The characteristic of frequency could be based on percentage of force time spent on or in anticipation of a type of vignette. The characteristic of importance is based on the potential of the outcome of the vignette to affect the issues valued by the stakeholders. From a western perspective such issues include:

- Casualties incurred.
- Casualties caused .

- Expense of efforts incurred.

- Achievement of mission aims.

Importance	No effect	Minor	Medium	Major	Extreme
	0	1	2	3	4
Frequency of occurrence – or duration of possible occurrence					
0 Never	0	0	0	0	0
1 Few	0	1	2	3	4
2 Some	0	2	4	6	8
3 Many	0	3	6	9	12
4 All the time	0	4	8	12	16

Product	Risk assessment	Vignette importance
0	-	No occurrence
1,2	Control adequate	Low
3,4	Act if necessary	Medium
6,8	Action to control risk to be taken	Material
9 12 16	Urgent action Required	Essential

Table 1: A suggested schema for PSO vignette classification.

Selection of vignettes can appear to be like financial auditing based on the identification of transactions material in their own right (the "key" items) and then sampling from the remainder. Having identified those vignettes which in themselves can generate operational success and failure, the key vignettes, identifying a set of other vignettes of the forces main operations provides the basis for forming a view of the force's capability. Description of vignettes may be via the framework proposed by Starr to the first Cornwallis Group. Although aimed at the development of scenarios to support C3I analysis it has potential for broader application. Starr used four categories, with subordinate factors:

- *Operational Environment:* Geography Climate Infrastructure.

- *Friendly Forces:* Numbers composition equipment tactics.

- *Adversary Forces:* Numbers composition equipment tactics.

- *Mission Context:* Levels of conflict Initial conditions other participants.

AGGREGATION OF VIGNETTES

Aggregation towards the campaign level has been explored by such as Frankis and Bailey. This used tasking rules of thumb to identify the number of aircraft needed in-theatre to do the missions identified and so estimate the overall requirement.

The use of defined operational scenarios, outlines of sequences of events at the level of national contribution, is an implied requirement for the use of vignettes in this way. Without such scenarios there is no context for the vignettes. Categorisation of historical experience, recorded in unit logs, can suggest simple structures such as daily patrols by 10 person groups for 83 days with 10 shooting incidents, 1 Road Traffic Accident involving civilian car and a riot involving 2000 people and a whole company squadron group.

Such Scenario Occurrence Analysis allows coarse estimates. Treating the highest level of representation as the systems of the interveners and those intervened may suggest system dynamic representation. Cobb uses this approach implemented via STELLA™ software. Cobb also recognises the need for sources of greater detailed information: "All that is needed is good data over a sufficiently long span of time so that the regression methods can generate estimates with a reasonable degree of accuracy."

It is to the good data that vignettes commend themselves as a framework for estimation or collation of historic data.

CONCLUSION

The study of PSOs is a complex area. Analysis has the potential to contribute to this area by abstracting the key drivers from the complexity and providing guidance on implications of policy decisions may be for a given set of assumptions.

Breaking down the scenarios of interest to a country, in terms of the vignettes allied to a scheme of aggregation provides a method of study on a systematic basis.

What the vignettes should be is driven by the view of what is important to the various decision-makers. The views of members of the Cornwallis Group provide a useful perspective on what these factors should be thereby establishing attributes to be sought from vignettes as LEGO ® bricks for analysis.

ACNOWLEDGEMENTS

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- CAEN, the Close Action ENvironment, is the low-level infantry close combat wargame and simulation developed by DRA, DERA and Dstl.

- CRY FREETOWN was designed by Michael J Young.

- SQUAD LEADER® is a trademark of The Avalon Hill Game Company.

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- DIAMOND is the PSO model developed by DERA and Dstl.

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