Proceedings of the 1999 Winter Simulation Conference
P. A. Farrington, H. B. Nembhard, D. T. Sturrock, and G. W. Evans, eds.

MODELLING MILITARY REQUIREMENTS FOR NON-WARFIGHTING OPERATIONS

David Frankis
Noel Corrigan
Robert Bailey

CORDA Ltd.
Apex Tower, 7 High Street
New Malden, Surrey, KT3 4LH
UNITED KINGDOM

ABSTRACT

This paper describes work undertaken for national force development and planning staff, and NATO scientific staff, developing methods and models to assist military planners in identifying the military requirements for non-warfighting operations, typically peace support, humanitarian aid and disaster relief. Such models, when fully developed, give the military planner the ability to assess rapidly, the force requirements as circumstances change.

This paper describes the framework within which these tools have been developed. It then describes how it is possible to codify the capabilities required for such operations and the amount of capability required. The ensuing modelling is empirically-based, deriving from military doctrine, historical examples, and Commanders' personal experience. This is generalised and represented as 'rules of thumb'. The rules can then be used to derive the types and sizes of defined forces needed to fulfil a given mission in the light of the scenario or planning situation.

We describe how these rules can be formalised and combined to represent particular operational models and how the models can be represented in software to provide decision aids.

Further development of these methods and models is discussed.

1 BACKGROUND

In the nineties, the use of forces in small scale contingencies or non-warfighting operations has become a widely studied form of military operation. Analytical support to the planning of such operations presents different problems to those encountered in planning for combat, and new tools and techniques are required to solve them.

A number of nations, as well as NATO, have recognised this and are providing their planners with new tools that will help them plan and react to changing circumstances better. Such tools are conceptually different from the "typical" combat simulation. Whereas the typical simulation is predictive – it estimates the outcome of combat as a function of the forces assigned, the new tools are inductive – they assist the planner in estimating the force suitable for an operation.

2 WHY NEW METHODS ARE REQUIRED FOR PLANNING NON-WARFIGHTING MISSIONS

Two forms of operational analysis have traditionally been used to aid the planning of military operations:

a) Use of large *simulations*, requiring man years of effort to code and similar levels to supply with data and run;
b) Use of *simple models*, typically in a spreadsheet, that can be created and used rapidly but are limited in scope.

The simulation of military operations is normally predictive: for a given set of inputs, including a given force, they attempt to calculate (or forecast) potential outcomes: many simulations therefore start with the force package as an input. This paper is concerned with models and tools that generate the force package as the output: simulations can be (and are) used in this way by trying different force packages systematically but the process is cumbersome.

When planning contingencies, the luxury of time may be available, but during "hot" planning, time becomes a resource too precious to waste on effort intensive or slow-to-process simulations.

Simple models, on the other hand, are useful for assessing the forces required for one small part of an operation, but they do not capture the complex interrelations of a joint force fulfilling multiple objectives.

Furthermore, the creation of a model of either kind should be based on some understanding of the underlying theory of the phenomena being simulated. There is currently no generally accepted theory of the conduct of peace support or non-warfighting operations, though there is plenty of anecdotal, and some empirical, evidence about their execution. Simulations, and the accompanying theory, are being developed, but it is likely to be some years before they are mature enough to be trusted for planning actual forces.

The lack of such a theory arises from a variety of reasons, including the definitions of "success" and "threat", and interactions with civil agencies such as the lead UN representatives and major NGO (Non Governmental Organisations). The multinational aspect of many such operations is a further complicating factor, though obviously not unique. Another difficulty with PSO is that supporting units have a much more prominent role than in war. It is not sufficient to calculate the combat requirement based on the size of the threat, and then add in enough support units.

For all these reasons, the analytical support available to combat planners is not available to PSO planners. Thus neither type of tool on its own is adequate for generating credible force packages or required force structures, and a different approach was taken.

The approach adopted for the development of PSO planning tools was therefore to go back to the first principles of the planning process as laid out in NATO guidelines and apply what military doctrine and experience currently exist. The fundamental principles are to identify discrete missions to be carried out, match them to known capabilities, and then quantify the requirement taking account of support, sustainability, and the sequencing of missions.

Figure 1 attempts to illustrate the planner's problem, which is to get the clear focus of the formation requirement from the fuzzy picture of the planning situation. Additional factors that add to the fuzziness include the phasing of the operation, the readiness of the forces available, the location of the deployed units, and the rotation of the units.

3 THE PLACE OF TOOLS IN PLANNING

To determine the requirement for forces in a Planning Situation (PS), the planner will:

a) Analyse the PSO *mission* to be carried out, and decompose it into a list of tasks, and if appropriate, subtasks.
b) Assess the *force elements* that are required to successfully execute each task (as intimated above, these include elements that would in combat be regarded as supporting).
c) Characterise the PS in terms of the *Situational Factors* (which identify the rules to be applied) and *Critical Factors* (which form the inputs to the rules) (see below).
d) Apply Rules of Thumb (RoT), which use the values of the critical factors to derive required numbers of units for each task. The units may be generic or specific.
e) Sum the numbers of unit types and group into militarily sensible formations taking account of the sequencing and concurrency of missions.

The above synthesis is not a strictly linear process as indicated here. The planner will undertake iterations as more information defining the situation becomes available and his understanding of the mission comes into focus. Any tool needs to be structured to support this.

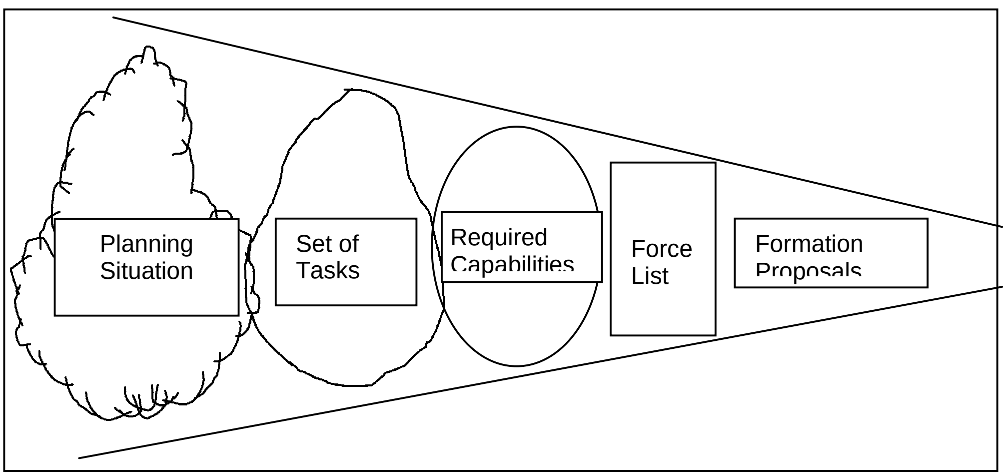

Figure 1: The Planner's Problem

The 'situational factors' are logical switches that help to identify the appropriate type of force element for a given situation. The critical factors determine the quantity of a given type of force element that is required to undertake a task. For example, a situational factor may state the operation is to be conducted at night. If so, night capable equipment is essential; a critical factor might be the size of area of responsibility, leading to the number of troops with a night observing capability.

Computer aids are able to assist all of these steps. The mission analysis into tasks and subtasks, once done, can be codified and stored in electronic form, and be re-used, because different operations will be analysed into the same relatively small set of tasks. The matching of force elements to tasks can be formalised in an empirical manner in terms of a table showing which force elements are relevant to which tasks under what conditions.

In deriving the Force packaging solutions it is essential to be able to consider "what if" courses of action within the planning situation. A key difference between combat operations and non-warfighting operations is in the use of supporting forces, such as Engineer and logistic units. In a conventional combat operation, the primary task is engaging the opposition, so the combat arms are planned first and the necessary support is generally calculated on a more or less pro rata basis; for example three combat battalions might require one support battalion for maintenance and re-supply. In PSO, the primary tasks will be less combat oriented, and the required support forces become more task oriented.

The identification of the situational factors and critical factors – essentially scenario analysis – is a task requiring military and, indeed, political judgement.

The application of the rules themselves then lends itself very well to the use of computer tools, as does the succeeding summation process. The remainder of this paper describes specific paper and computer planning tools.

4 CODIFYING THE FORCE PACKAGING PROCESS

The tools are designed to make the force planning more coherent (for example for the same set of input criteria the same output choice is generated); more complete (for example by making it difficult to overlook factors); to provide an audit trail; and to allow known planning situations to be revisited and updated quickly.

The desired system has many similarities with an expert system, as it endeavours to create rules and put those rules into some domain context, but it does not require any self-representation or learning ability, and so may be more accurately described as a problem-structuring tool. Even so, such a system is best constructed after considerable empirical study.

The force planning tools are attempting to capture and place the military expertise that the planner uses in doing this job, within a quantitative analytical framework. All the tasks require specific capabilities to undertake them, and all forces possess inherent capabilities. The planner's job is to match the right units to the right tasks in such a way as to minimise the overall force requirement whilst still ensuring overall mission success. This is achieved using his knowledge of military doctrine, personal experience and historical precedence. The challenge to the analyst is to represent this process and expertise in a software tool.

4.1 Initial Capability Assessment

The key to a successful force packaging and planning tool is to characterise the linkage between tasks and force elements in an elegant yet robust manner.

Since capability is the wherewithal to do something, a straightforward approach is to match the units directly to the tasks that they are capable of undertaking, given the restrictions imposed by the relevant situational factors. This produces a matrix to record tasks and subtasks against force elements or units. Table 1 shows a very small extract from such a matrix.

Table 1: Initial Capability Assessment Matrix

	Force Elements					
Tasks	Air Traffic Control Unit	Casualty Transport Ship	Ambulance (Armoured)	Air Ambulance Unit	Corps Hospital	Aerial Port Operational Support
Traffic control	X					X
Route control	X					X
Port operation control	X					X
Medical evacuation			X	X		
Medical treatment		X			X	

Note that some units have the capability to contribute to more than one task, and that some tasks may be undertaken by more than one unit.

A more sophisticated approach is to define the "capabilities" explicitly. This requires that, for each task, the capabilities required to undertake it are defined, and that the capabilities of each unit type are also defined using similar measures. Such an approach is inherently more flexible as new tasks and units can be created and added to the data set. The matrix approach requires the impact of any new task or unit to be fully evaluated off line first before being added to the data set. Although more elegant, the actual creation of coherent and complete capability definitions is a complex business.

4.2 Incorporation of Statistical Factors

The matrix at Table 1 can be further refined to include the situational factors, so that the type of unit that is capable in the desired conditions is narrowed down further still. We are currently working on the expansion of such a matrix. Table 2 shows an example, illustrating how refinements can be introduced to assist the planner.

The example shown illustrates a peace enforcement task of defending a land area. There are three situational factors shown, the threat, whether air superiority has been established and the terrain type. The higher the score in the box the more able is that unit to cope with that factor. A red flag indicates that the unit has no capability in that condition and cannot be selected. An example situation of High Threat, Air superiority, and Terrain type 3 suggests that the Armoured Battalion would be the favoured option in those circumstances. A different situation might favour a different unit.

This process of capturing military doctrine and experience is resource intensive, but assuming that the tasks and essential parameters have been well defined, it should be a one off exercise.

This development process is necessarily prototype by nature. It is not easy to observe a real military planning cycle whist it is being conducted, so it is not a straightforward task to capture exactly what and how it is done. However, by using retired military planners and running planning exercises it is possible to get some feel for the basic mechanics of the process.

There is usually more than one way to undertake a task, however, so it remains the planner's decision as to which type of unit to select for a given task.

Having qualified the unit types that are task-capable, the planner must then calculate how many of the units are necessary. This is achieved by the use of further simple rules of thumb.

4.3 Defining the Rules of Thumb

A 'rule of thumb' expresses the capability requirement for a given task as a static mathematical relationship. They provide adequate first-order approximations. These should be visible to the planner using the tool, to provide confidence in the numbers being generated, and have the benefit of allowing the planner to easily check the planner to easily check the critical factors driving the requirement for numbers of units.

As we have seen, the matching of units to tasks is a two-part process. The qualitative part has been described in the previous section. Here we discuss the quantitative part.

This consists of parameters and algorithms. The situational factors, such as terrain and weather, describe the aspects of the environment that will drive the choice of unit and the appropriate rule to apply. The critical parameters are the numerical inputs for the algorithms. These algorithms are generally simple linear relations between the various parameters influencing the conduct of the task and the number of units required.

Table 2: Consideration of Situational Factors

Units or Force Elements				
Task Situational Factors	Value	Armoured Bn	Inf Bn	Airmobile Bn
Threat	High	3	⚐	2
	Med	3	1	3
	Low	3	2	3
Air superiority	Yes	3	2	3
	No	2	1	1
Terrain	Type 1	1	2	3
	Type 2	3	2	3
	Type 3	1	3	1
Situation: High Threat; Ai superiority; Terrain type 3		7	⚐	6

An example drawn from an air PSO task (Frankis et al. 1998) is shown below

$$N = (A/F) * P * C * D/(R*T)$$

Where

N is number of aircraft required to maintain a CAP (Combat Air Patrol)
A is area patrolled
F is area of one fighter area of operation
P is number of combat air patrols per fighter area
C is number of aircraft per combat air patrol
D is required hours of patrol per day
R is daily sortie rate
T is time on station

This algorithm can sit inside a nested series of IF-THEN- ELSE statements that capture the qualitative aspects of the rule. These statements are then easily coded as rules in the planning and force packaging tools. The ensuing models are thus empirically-based, deriving from military doctrine, historical examples and from personal military experience.

4.4 Force Packaging

Having calculated the numbers of units necessary to undertake the various tasks in isolation, the next step is to constitute the elements into a coherent force, adding in any additional force elements that may be required, eg communications, command and control. There may be some tasks that are implied by the analysis conducted, but not explicitly stated. This will usually result in additional support units being identified.

At this stage the planner may have a long list of units in no particular order and with no specific command structure. If these raw units are used as the force requirement, the total force requirement will be greatly over-estimated, due to the large degree of overlap among the tasks. The next step therefore is to derive a sensible military grouping of all the identified units. This includes identifying role overlap, where a unit can double task either in time or location, removing redundant units, etc. This can be quite a complex optimisation process.

5 THE TOOL

We have described how rules can be formulated, formalised and combined to represent particular operational models. We now go on to describe how we have implemented some of these ideas in a software tool that the planner can use with a minimum of preparation and a rapid outturn of results.

Our prototype force packaging tool has been designed around the essential task of force planning and so can reasonably be described as a prototype of a carefully conceived support tool. Not all of the functionality that is envisaged has been implemented yet. The value of the incremental development approach that has been adopted is that it reveals conceptual and technical issues en route, whose solution may not be straightforward (and hence would defy a preconceived notion of a solution).

The current demonstrator is made up of three separate database components corresponding to the organisation and maintenance of Force Packaging information.

These components are defined as follows by three separate databases:

1. System Data Database. This contains information about force composition and organisation, threat, terrain and weather definitions, mission task templates, etc, judged to change relatively infrequently. There is no user functionality associated with this part of the system, which is linked to the other two components;
2. System Maintenance Database. Maintenance of this stored information is handled by a maintenance database which allows the planner to update the stored tabular information. This database allows the 'system maintainer' to define specific mappings between Capabilities, Forces and Tasks, and to create new, separate mission databases;
3. Mission Database. Mission specific information changes with each new mission and as planning proceeds within a mission, and must be kept with the mission itself. Separate mission databases are used to store specific mission information such as task start and end dates, and allow the planner to choose and compile a force packages for each.

This tool contains data sets defining available force units in terms of their equipment holdings and capabilities, and tasks and their associated capability requirements. These data sets are contained in a maintenance database, separate from the front end database that the planner accesses. Separate mission data sets can be created and stored to allow "what if" considerations to be rapidly considered.

The benefits of the tool that we are developing include the following:

a) transparency to the planner or analyst who can readily understand why the generated force is structured as proposed by the tool;

b) provision of a full audit trail so that each component of the final force can be tracked back to a task requirement;
c) encapsulation of previous military experience and judgement, exceeding that otherwise available;
d) help to avoid oversights in the force packaging process; and
e) enabling a fast response to planning information or support.

The tool will provide added confidence to the planner in recommending feasible and robust force package options to the Commander for decision.

6 THE FUTURE

Future developments may de discussed under two headings: incremental developments in hand; and longer term research proposals.

Current or near-term developments include:

a) Development of extensive checklists, designed to anticipate the users' needs and to help refine the proposed force package.
b) The ability to explore the capabilities of actual forces, through a form of force static measures. This would allow the user to examine and compare the merits of particular force packages in given tasks.
c) Linkage to a database of historical data on past operations - an important source of reference if available at the level of individual capabilities. Such a database already exists and can readily be linked.
d) Archiving facilities, so a user can switch in and out of a 'case file' to review it or to develop it further.

Proposals for longer term research include:

a) Scheduling of forces, by availability, to the various tasks of a mandate, examining the impact of different force scheduling options.
b) An extension to this, to calculate the overall force requirement for multiple concurrent operations, taking account of the chronological phases of each, and allowing robustness with respect to different relative timing of crises.
c) Addition of encyclopaedic data, e.g. covering geography or demographics of a country. This would mean that many of the inputs to the tool would be to hand for the user.

REFERENCES

Frankis, D, Dick, I, Powell, D, Mountain, J, and Griffin, S; Methodology for PSO Air Requirements, June 1998, CORDA report to Nato C3 Agency.

AUTHOR BIOGRAPHIES

NOEL CORRIGAN has over 20 years military operations research experience, encompassing mainly land and joint force studies. He has a wide variety of model development experience, ranging from simple spreadsheet models through training tools and wargames to battle simulations. He began his career with armour studies, working for a UK Ministry of Defence research establishment. He joined CORDA in 1985 and has held a variety of technical and managerial positions. Key assignments include his work on definitions of Generic Land units (inventories and capabilities) for use in NATO’s bi-annual Defense Requirements Review, and his work on the team developing the NATO Force Identification System (FIDS), relating force capabilities to tasks in given conditions.

DAVID FRANKIS has 20 years experience in military operations research, working (via CORDA) for all the main MoD OA customers as well as NC3A and the armed services. David was responsible for the development of a methodology for defining the requirement for aircraft for Peace Support Operations (PSO), in support of NATO’s Defence Requirements Review (DRR). He led a team of scientific and military analysts developing rules of thumb for the use of airpower. David also recently initiated a survey of novel concepts for PSO, to explore the possibility that PSO require a range of capabilities additional to those needed for high intensity conflict. He co-ordinated a workshop of CORDA, UK Centre for Defence Analysis and British Aerospace consultants to elicit new concepts. This work was carried out for BAe. He applied a ‘troops-to-task’ type of methodology in the workshop context to structure the discussion of what capabilities might be needed.

ROBERT BAILEY has worked in operational analysis for 26 years, both in the Civil Service and the commercial sector. During this time he has first led, and then directed or managed many projects including both conventional and soft OA, and historical analysis. He has recently facilitated the development and marketing of a Force Packaging Project and Tool for NATO and National Governments. He was also responsible for contracts with NATO C3 Agency for new work to define Force Requirements for PSO in support of NATO's bi-annual Defence Requirements Review. Jointly presented on the topic to 12th ISMOR (International Symposium on Military Operations Research) at RMCS, Shrivenham in 1995.