Defence Preparedness and Economic Rationalists
A System Dynamics Framework for Resource Allocation

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Abstract

In 1996 the Australian National Audit Office (ANAO) reported critically on the Defence Department's force capability and preparedness methodology: preparedness objectives did not adequately address interactions between Army, Navy and Air Force; competing resource implications were not adequately understood; performance management information systems for preparedness planning were inadequate. The ANAO directed the Department to develop management systems, which address the interaction between defence budgets and the operational, logistical, and training dimensions of defence preparedness.

This paper presents the system dynamics framework, developed at the Australian Defence Force Academy (ADFA), which is seen by senior defence executives as the basis for responding to the ANAO requirements. ADFA has recently reported on the feasibility of using system dynamics modelling to achieve these goals.

Full implementation of the project would involve integration of the suite of models into the Australian Defence Headquarters command and control system. The paper outlines the development of a 'virtual' management learning laboratory, a joint research project between ADFA and Computer Science Corporation (Aust), which aims to explore the use of these modelling tools in building shared understanding of complex problems.

KEYWORDS: Defence preparedness; system dynamics; learning laboratory; Lotus Notes™; Powersim™.

Background on ADFA Modelling of Defence Preparedness

A System Dynamics stream was introduced in undergraduate and postgraduate teaching programs at ADFA in 1989. In 1993 the Directorate of Army Research and Analysis requested the system dynamics group to explore the use of system dynamics modelling for Army preparedness planning. Subsequently, formal presentations by ADFA were made to the Deputy Chief of the General Staff, the Chief of the Air Staff and key corporate planning staff. In 1994 the Directorate recommended greater use system dynamic modelling tools to assist management understanding of complex 'feedback' areas such as preparedness and mobilisation planning.

In 1997, the Preparedness and Mobilisation Directorate of Australian Defence HQ contracted the ADFA system dynamics group to advise on the development of a system dynamics based 'Defence Preparedness Resource Model (DPRM). DPRM was to be that element of the Defence's Command & Control System which addressed the linkages between specified levels of preparedness and the resources required to achieve them, including:

a) identification of resources required to achieve and maintain defined levels of preparedness;

b) identification of the resources required to change between levels of preparedness;

c) the potential impact on ADF preparedness of changes in resource allocation; and

d) development of advice for Government on the resource implications of change in levels of preparedness.

Prototype models were developed (Submarine Squadron, Army Aviation units and some small combat elements) and a report was presented addressing the project scope, modelling methodology, project management and risk management. Formal presentations on the proposed concept, including a general overview system dynamics, have been made to top defence executives. The project has now moved to a detailed scoping phase.

Feedback and Delay in Defence Planning

Feedback and time dynamics are ubiquitous in defence operations. The functioning of any military unit is influenced by complex interactions between international politics, national policy, major capital acquisition and general resourcing decisions, personnel management, logistics management, training doctrine etc.

For example, individual and collective skill levels decay over time if they are not being exercised, necessitating retraining. (This is most obvious for pilots, where a given number of flying hours per month is required by law to maintain currency.) But increasing training activity 'uses up' equipment life, diverting resources to maintenance and acquisition, and thereby removing resources from operations which are the very purpose of

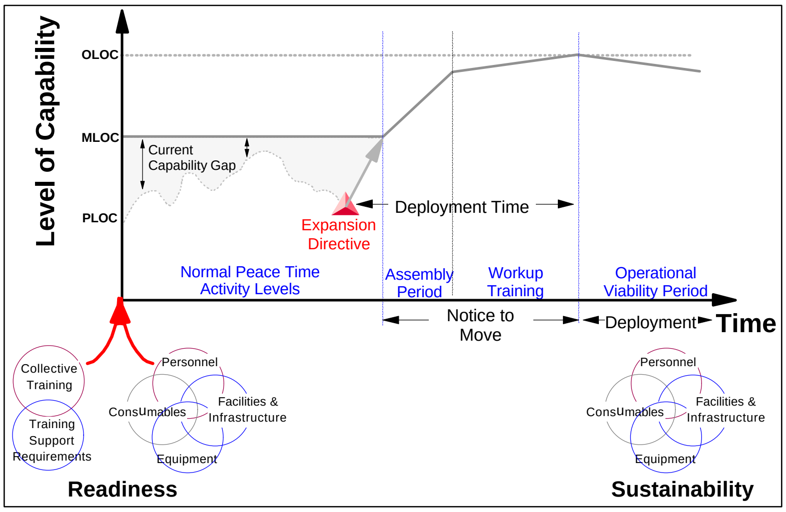

Figure 1: Conceptual preparedness concepts

the training. Compounding the difficulties for management planning are the lengthy delays, often 10 years or more, that accompany major capital re-equipment decisions.

The Defence Organisation's conceptual preparedness model contains two dimensions, illustrated in Figure 1. The vertical axis is a relationship of required *Capability* over time. E.g., the peacetime level of capability (PLOC) is set at the minimum value consistent with the ability to move (through re-equipment, recruiting and training) to the target operational level of capability (OLOC) within the policy driven scenario time frame.

The horizontal axis contains two components, *Readiness* and S*ustainability*, that are the net result of complex interactions between personnel, equipment, facilities and consumables with individual and collective training. Much of the difficulty in developing resource preparedness strategies lies in any rigorous quantified understanding of how the components of preparedness combine to create a position on the capability axis. The complex interactions between the components of readiness can be described through the use of influence diagrams, illustrated in Figure 2, where the 'dashed' arrows represent some of the interactions between the different components.

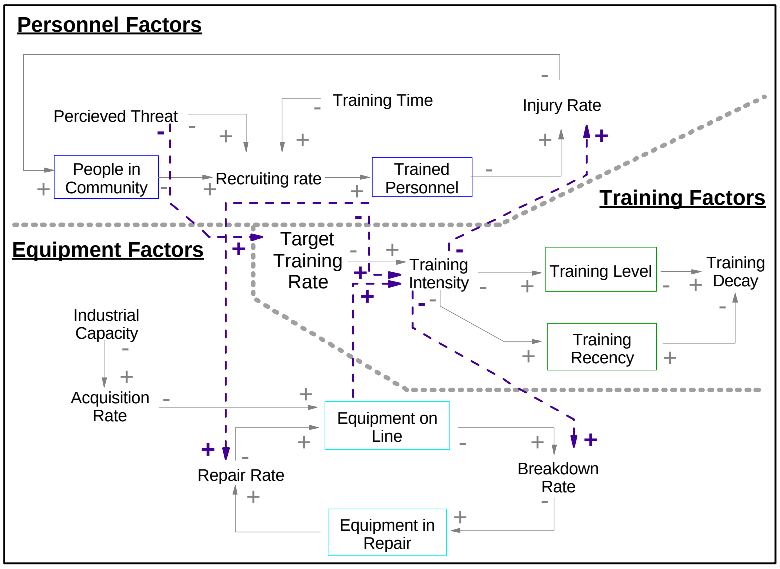

Figure 2: Interactions among preparedness sub-systems

These relationships are all time dependant, and interact with varying delays. It is the ability to represent these that is the strength of systems simulation modelling, and which can not be addressed in traditional resource management tools such as databases.

Force readiness, however, has a much more significant and more complex dimension of relation-ships. Figure 2, in a sense, represents the 'vertical' relationships. That is, the interrelationships within any given organisational strand from top budgetary and command directives, through doctrine, staffing and training decisions to day-to-day operating decisions. The prototype modelling at ADFA has concentrated on developing 'templates' for this 'vertical' dimension of several force elements, for example with the Army Aviation Regiment:

- Top level resourcing decisions impact on available flying hours and the availability of spare parts.
- Personnel decisions impact on the availability of skilled pilots for tasking and training.
- Personnel decisions also impact on demand for training flying hours as distinct from operational support hours.
- Maintenance decisions impact on the number of aircraft available, and hence on their intensity of use.
- Doctrinal, tasking and local management decisions complete the environmental complexity.

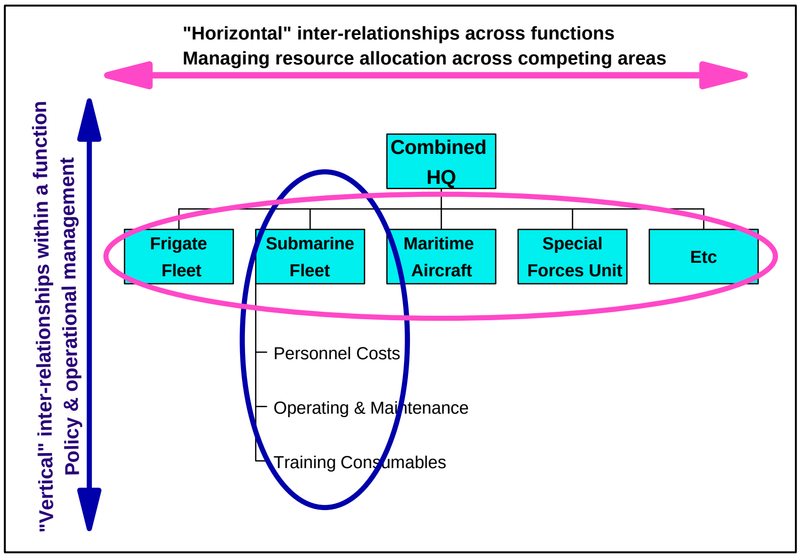

Figure 3: Two dimensions of systemic relationships

However, few military units operate in isolation. There are 'horizontal' interdependencies *between* force elements. Thus the submarine fleet must train with other surface and air elements to reach full operational capability. These 'vertical' and 'horizontal' dimensions of systemic inter-relationships are depicted in Figure 3.

Model Aggregation

A critical aspect of this modelling is setting the appropriate level of aggregation. It is be futile to try to model the interrelationships between all personnel, training and equipment categories. A critical step in modelling is identifying organisation features that are surrogates for broad classes. For example, if pilot numbers are broadly proportional to other aviation staff (observers, maintainers etc) modelling the relationships between pilot training and capability may suffice.

The DPRM is an ambitious project, which is pushing the limits of the technology. There are no "off the shelf" solutions. Whilst the ADFA research gives grounds for optimism, a multi-phase development process was advised with clear risk management protocols. Objectives for the initial stage of development included:

- provide a robust 'vertical' model of a key force element from each of the Armed Services
- evaluate the different systemic features in modelling capital intensive versus person intensive units, multi-role versus limited role force elements and short lead time versus long lead time mobilisation units
- analyse the systemic interdependencies between logistics and operational functions
- demonstrate feasibility to address 'horizontal' interrelationships between force elements that must operate in conjunction with each other

Simulation Games and System Dynamics Models and Management Learning Laboratory

An important dimension of the ADFA systems modelling involves building client confidence in the work … in addition to 'technical' validation. The graphical interfaces for system dynamics modelling packages such as Powersim™ make it relatively easy to communicate the logic of a model to subject area experts who provide the initial input and who must validate the model output. Senior executives, certainly, want 'technical' confidence in the model, but they are fundamentally concerned with its use as a tool to develop a shared understanding of options and consequences. From extensive interactions within a relatively sceptical environment, our work suggests that, in building a simulation model, careful attention must be given to the following areas:

- the outcome to be tested – *existing organisational performance indicators are often an inappropriate focus*
- who are the champions – *where simulations challenge corporate policy or where the issues cross organisational boundaries, top executive participation is critical*
- which business rules should be 'hard wired' into the model and which should be left to the players
- what are the characteristics of the 'learners' (e.g. their motivation, decision making style, learning style etc).

As demonstrated in the work of Sterman, Senge and others, addressing systemic problems must go beyond individual learning to the development of a shared understanding. The concept of the management learning laboratory is important to this end. A *learning laboratory* is a 'training' workshop where managers experiment with organisational interrelationships, by cycling back and forth between 'war gaming' and debriefing sessions. The aim is collectively, to understand why the system behaves the way it does, and how they might modify their behaviour accordingly. The simulation gaming capability of Powersim™ allows the combining of the system dynamics simulation model with the learning laboratory.

In business and government, specialisation results in 'walls' or 'stovepipes' that separate different functions into independent and often warring fiefdoms. A learning laboratory offers the possibility, in a non-threatening environment, for the respective managers to understand how their performance (on which *they* are judged) is impacted by the activities of other units. It enables managers to learn about the impact of delayed feedback relationships. It challenges the validity of performance indicators and helps find better ones.

Towards a Virtual Learning Laboratory

A shortcoming of traditional workshop learning approaches is the artificiality of the environment. Managers tend to be on their best co-operative rational behaviour, away from the distractions of telephones, meetings, deadlines and all the other distractions that characterise their normal decision environment. ADFA, in conjunction with Computer Science Corporation, is developing a 'Virtual Learning Laboratory', where the simulation game can be played in a distributed environment, via Lotus Notes groupware.

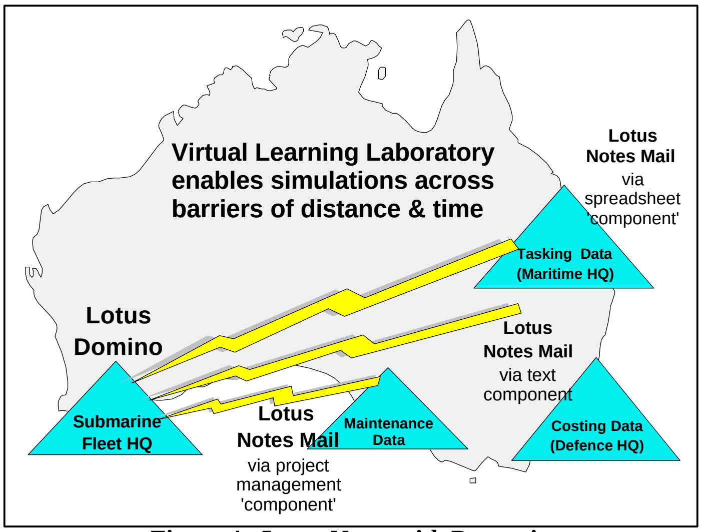

Figure 4: Lotus Notes with Powersim
A virtual learning laboratory in normal work environments

Lotus Notes provides the backbone of Australia's Defence HQ top level Command and Control system. It is also widely used within the Army, Navy and Air Force. By integrating Powersim™ simulation models with Lotus Notes, game players can participate in the midst of the everyday chaos of their normal work environment. Feedback information from the model simulation to the respective managers can be provided in familiar corporate report feedback, and managerial responses can be fed into the model also in standard corporate format. Figure 4 illustrates the communications structure of a prototype simulation game for the Australian submarine fleet.

Lessons from research thusfar

The flight simulator concept has attracted strong support from Defence top management. The process of development has highlighted a number of invaluable lessons including:

- it is important to involve users in the development and validation of the simulation
- seemingly rigorous data sets are not always what they seem to be – the data may in fact be of limited value because of lack of clear definition, quality control or both.
- every system has implicit, and often very critical, assumptions based only on 'professional judgement and experience', which are so part of the culture that they are never challenged.
- the design of input and feedback formats is important and should, as far as possible, replicate the formats used by the players in their normal jobs.

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