The Application of Influence Diagrams for the Development of Military Experiments

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Abstract

The use of qualitative, diagrammatic, modelling is a growing trend in system dynamics with a well-developed literature, designed to deal with problems with a multitude of 'soft' variables, strong influences from human actors, and profound effects from political forces. An application area is the design of defence experiments to assess the effects of contemplated military investments on the ability to meet national goals. The difficulty lies in the design of experiments to test the system under a range of reasonably realistic, but sufficiently different, contexts to provide a comprehensive understanding of the issues. The paper will describe a hypothetical instance of tensions between nations and develop an influence diagram that inter-relates the political factors with the military factors. Study of the feedback loops connecting the political and military factors show how distinctly different experiments can be designed to test the totality of national crisis management capabilities.

Key words: Influence diagram, defence, design of experiments, strategic planning, scenarios.

1. Introduction

1.1 Background

Our future global security environment is characterised by uncertainty. Such an environment presents many challenges for strategic planners considering emerging social, political, military and technological trends and the events they may lead to. A goal of military strategic planning is to understand where these trends may lead and prepare for the potential eventualities. This paper will explore the technique of qualitative, diagrammatic modelling for analysing such eventualities to inform military capability development.

Military strategic planning begins with understanding the key factors and characteristics of the range of potential future environments and the likely areas of friction. Actions taken by nations to affect key factors can be classified into four domains: diplomatic, information, military, and economic (Australian Department of Defence 2002, 11). Action in any one, or a number of the domains is intended to either reduce the tension within the environment or to create conditions favourable to a nation. The adversarial nature of some of the national actors produces a situation where the environment can be characterised by a number of key factors and variables that are in constant transition within a complex coercive system (Flood and Jackson 1991, 32; Groom 2002, 4). The difficulty that arises in examining such environments for the purposes of military capability development is that many of the variables are soft and the influences they have on each other are dynamic, multifaceted and cross domain. Hence a challenge of military capability development is the representation and analysis of complex coercive systems so as to model potential future environments as collections of dynamic, interdependent variables from all domains. Such problem messes require a hierarchy of modelling techniques, initially to define the problem, and then more traditional operations analysis approaches providing deeper investigation into specific areas.

The capabilities of the military domain can be relatively slow to respond to changes in strategic circumstance, particularly when the acquisition of new equipment or changes to force structure and doctrine are desired, compared to the diplomatic domain which does not require lengthy acquisition cycles. The identification of what capabilities are required to effectively combat the range of possible future scenarios is a process of balancing the uncertainty of the future with the realities of an economic framework that necessitates choice between eventualities (Davis 2002, 1). The considerations of these problems go beyond that of an equipment solution to the full range of capabilities available in the military domain and the integration of these capabilities with actions from the other three domains. Often the strategic planning process can provide guidance on possible future conflicts and illustrative planning scenarios, however the development of the best mix of military capabilities to meet the challenges within these scenarios is a complex exercise, particularly when diplomatic, information and economic influences are alternative avenues and not always complementary in

achieving resolution of an issue. For example the Iraq crisis of 2003 demonstrated how diplomatic negotiations continued with Iraq toward a peaceful resolution on the issue of weapons of mass destruction but the need to preposition military forces for a possible military eventuality undermined the sincerity of such diplomatic efforts with the threat of force.

1.2 Methodology

A method for dealing with the complexities of translating strategic guidance into capability guidance is military experimentation. Analytically, the term military experimentation describes a multimethodology that brings together a range of hard and soft operations analysis techniques within an experimentation campaign that investigates the problem from many perspectives through a series of experiments and scenarios (Alberts and Hayes 2002, 43; Curtis and Bowley 2000, 3; Davis 2002, 12). A desired product from military experimentation for force development is the set of capabilities that perform robustly in both the range of likely scenarios, and the probable contingencies that arise within those scenarios because of the adversary's strategy. It is equally important to be cognisant of the situations in which the set of capabilities are insufficient since these represent potential vulnerabilities of the military response that need to be mitigated through coordination with the other three domains.

An aim of scenario-based analysis for capability development is to identify the critical missions that are common across a range of scenarios, and the capabilities required to perform these missions robustly. The context for the analysis is stimulated through the conduct of war games that involve not only military players, but also participation from diplomatic and government officials. A range of scenarios are used in the war games that illustrate potential future environments, the associated political contexts, and a variety of stressful military missions. The types of war games used are a simple seminar style where a small number of participants divide into two or more teams and take turns in plotting moves on a game board which is then adjudicated by an independent facilitator.

Qualitative diagrammatic modelling, in the form of influence diagrams (ID), are used as an analysis tool to capture the relationships between key variables for each scenario gamed. The IDs are used in the subsequent design of experiments to test the important subsystems, defined by military missions and described by capabilities, under a range of reasonably realistic, but sufficiently different, contexts from those used in the war game. Figure 1 shows the problem definition process which is aimed at narrowing the scope of the problem space to be investigated before applying higher fidelity, often more costly, analytical techniques, such as modelling and simulation, hard operations analysis or even further war gaming to investigate specific issues. Once the problem definition process has been applied to a range of scenarios a number of focussed experiments are conducted, the results of which, in the form of a capability set, are interpreted back up into the context of the illustrative planning scenarios to demonstrate their significance or otherwise.

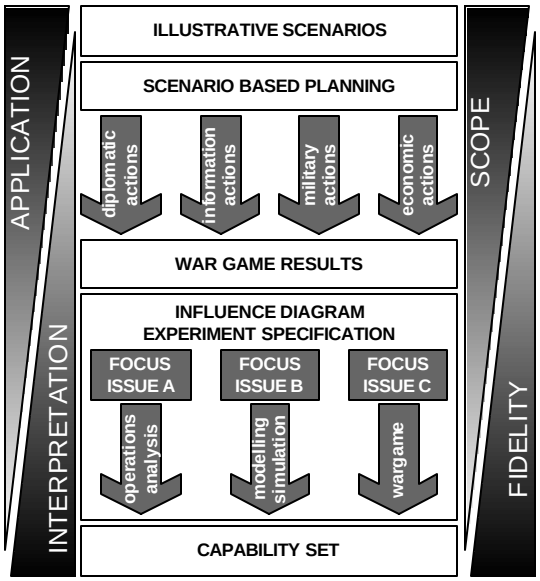

Figure 1: Problem definition process

The application of IDs to military experimentation is similar to their traditional use as a lead in step for defining equations and relationships for quantitative system dynamics models in that they are used to generate conditions for the design of focussed studies (Coyle *et al* 2000, 310; Coyle 1992, 311; Coyle 1983, 885; Coyle 1981, 755). The focussed study could take the form of a system dynamics model but more than likely in a military experimentation campaign it would be just one analytical tool from a broad range used to investigate different aspects of the system. In a military experimentation campaign the ID is a capstone tool capturing the overall system representation that is then used to specify the conditions for focussed studies using other models. The ID is then used to situate and relate their results in the broader context of the system and other related scenarios with similar system structure and elements as shown in Figure 2 (Wolstenholme 1988, 10).

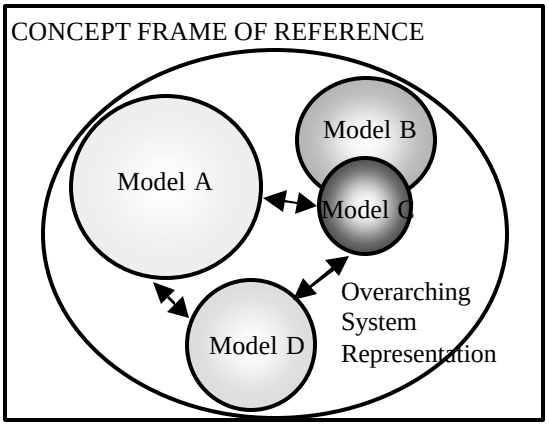

Figure 2: Overarching system representation linked to focussed studies

The remainder of the paper will use a hypothetical scenario to demonstrate the method used for developing the ID. The tensions in the scenario might require the active use of military force to a greater or lesser extent or it might be possible to deter the potential 'aggressor'. An ID of the situation is presented which inter-relates the political factors, such as national and multinational support, with the military tasks, such as offensive and defensive actions. Study of the feedback loops connecting the political and military factors show how distinctly different politico-military experiments can be designed to test the totality of national crisis management capabilities.

2. Hypothetical Political and Military Context

The broad scenario description is used to provide participants in the war games a context for their actions. The scenario described below is representative of a small-scale regional conflict that, for simplicity, has geo-political constraints limiting the number of actors. The set of military capabilities in the war game can be constrained to a particular set to evaluate their performance, or unconstrained to explore potential opportunities of emerging technology and methods of employment.

The scenario is set in the near future where over recent years, despite imminent election to the United Nations Security Council (UNSC) and the appearance of being a good international citizen comprehensively engaged within the region, Redland (R) has stepped up its claims to Northern Mainland of Orangeland (O). These claims have been supported by a sophisticated information operations campaign aimed at shaping world opinion on the issue, gaining regional acceptance of Redland's emerging military pre-eminence, and orchestrating a clandestine de-stabilisation program across all levels of Government in Orangeland.

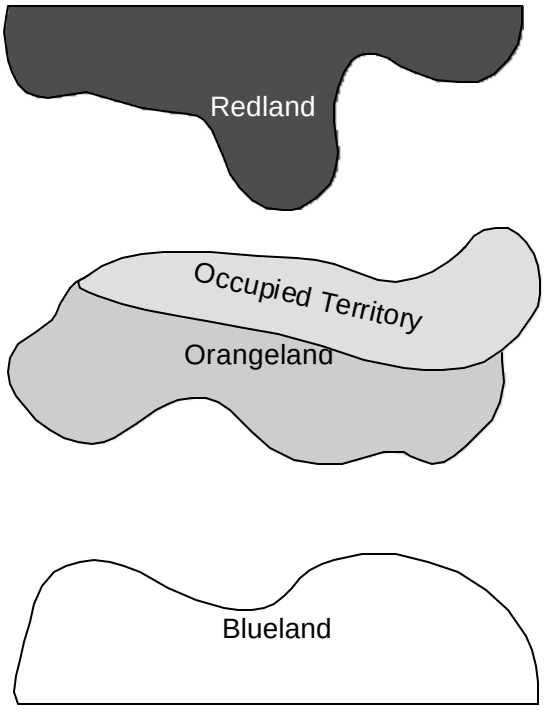

Figure 3: Redland occupies the northern area of Orangeland and Blueland comes to the aid of Orangeland

The devastation wrought by a recent humanitarian disaster on the north coast of Orangeland has allowed Redland to initiate its campaign to annex the Northern Mainland of Orangeland under the guise of humanitarian relief as shown in Figure 3. At the request of the Government of Orangeland, Blueland (B) will initiate joint military planning to firstly prevent further lodgement of Redland's forces in Orangeland whilst trying to persuade Redland to withdraw its existing forces through diplomatic, information and economic actions, and secondly to employ military force to expel them should they refuse. As membership of Redland's allies on the UNSC is likely to prevent UN involvement in a regional conflict, and as the allies of Blueland are committed elsewhere, the mission will essentially be a unilateral, rather than a multilateral, operation. This assumption is made to simplify the dynamics of the system for illustrative purposes only.

Blueland's military strategic plan has been developed as the military dimension of a 'Whole of Government' approach designed to re-establish a stable regional security environment whilst forestalling direct military threat to Blueland and its interests. Although framed by the basic tenet of 'Strategic Denial' which is aimed at coercing Redland to pull back form Orangeland, the immediate focus is on deterring further Redland expansion into Orangeland, forcing the withdrawal of Redland's military forces, and restoring Orangeland's sovereignty through the use of a coordinated air, maritime and land campaign. Blueland's military strategic plan has been divided into

the three phases of deter, defeat and develop. Complete military defeat of Redland remains the option of last resort because of the relatively even match of military capabilities. Blueland's military planners have been directed by the government to conduct planning for the military operation to restore Orangeland's sovereignty in accordance with the three military strategic phases.

1. Deter. Operations to deter further Redland expansion into Orangeland will focus on demonstrations of Blueland's forces and an increased military presence in Orangeland in parallel with ongoing diplomatic, information and economic pressure.
2. Defeat. This phase is likely to be initiated by a breakdown in diplomatic negotiations and begin with evacuation operations of approved foreign nationals from Orangeland. This opportunity will also be used to secure an appropriate operating base in Orangeland's unoccupied territory in order to facilitate subsequent operations. The concept of manoeuvre for defeating Redland's lodgement in Orangeland is based on three flexible response options – Isolate, Strike, and Expel – which can be employed either separately or in combination in order to force the withdrawal of Redland.
   - The 'Isolate' option focuses primarily on early air and naval blockade and interdiction operations between Redland and Orangeland.
   - The 'Strike' option emphasises coordinated combined strike operations by air, maritime and special operations elements.
   - The 'Expel' option is based on land operations with air, maritime and special operations to shape the battlespace, and provide support, as required.

   The key to defeating any of Redland expansion in Orangeland will be the speed and effectiveness with which Blueland's forces can contain the initial lodgement, and curtail any subsequent force build-up. The lodgement must be quickly isolated and, if necessary, reduced in strength to achieve a force overmatch before ground forces launch the decisive response.
3. Develop. Operations to develop positive post-conflict relations with Orangeland and Redland are based on engagement through military assistance with reconstruction and nation-building tasks, together with increased exercising and training commitments.

3. Development of the Influence Diagram

IDs show the causal mechanisms known or believed to operate in a given system, in this case the politico-military system of the scenario. They serve several purposes:

1. Putting onto one piece of paper a shared view of a complex problem.

2. The causal influences combine into feedback loops. These may be either 'positive' (reinforcing) loops, or 'negative' (limiting or goal-seeking) loops. Study of the loops can provide qualitative insight into the dynamics of the system.

3. The diagram can show the context for other analytical or modelling work.

4. Where necessary and feasible, the diagram is the basis from which a fully-fledged dynamic simulation model can be developed.

The techniques for developing IDs of a system have been described elsewhere within the context of military problems (Coyle 1992, 311; Coyle 1983, 885; Coyle 1981, 755). An ID for a given problem can usually be drawn in several versions, showing greater or lesser degrees of detail but retaining conceptual consistency. This section will focus on how war gaming and the associated processes of military planning can be used to generate the ID.

The identification of the key variables, and their dependencies, is the starting point for the development of an ID using scenario-based analysis. Before bringing together military participants to conduct the planning and war game it is useful to parse the documentation that describes the political and military context of the scenario. A number of candidate factors for the diagram and their relationships to events will be described in those documents. At this stage it is best to develop lists of these factors, or use other diagrammatic techniques such as rich pictures or impact wheels, to begin to form conceptual views of how the factors could be related (Coyle 2003).

Figure 4 shows a possible concept of operations that could be generated by parsing the guidance given to the commander of Blueland's military forces for the defeat phase of the plan. The key element is how Blueland might conduct an operation that would create a dilemma for Redland to stay or withdraw from Orangeland. The intent of the concept of operations is not to achieve success through attritions of Redland's forces but to present Redland's commander with a dilemma of either, risking the forces in Orangeland being isolated from their mainland and thus rendered less capable, or withdrawing the forces.

The dilemma in the mind of Redland's commander is developed through which line of operation, represented by the arrows labelled 1, 2 or 3 in Figure 4, Blueland will manoeuvre and thus how Redland should distribute its forces to combat the possible lines of operation. Blueland's tactic is to keep its forces distributed to develop uncertainty in the mind of Redland's commander as to what their objective is. However if Blueland becomes too aggressive in its disposition towards Redland by massing its forces at any one location in a concentrated attack, then there is potential for Blueland to be seen as the aggressor and lose the moral authority to act and thus reduce international support for their operation, after all Redland is in Orangeland under the guise of humanitarian relief. If Blueland decides to commit forces it must decisively counteract Redland's reaction while using a diplomatic campaign to balance the political implications of using military force in order to maintain the moral authority to act. Blueland's own dilemma is to balance the amount of force necessary to threaten Orangeland sufficiently to force withdraw of Redland, an operational victory, while not

using excessive force which would reduce Blueland's moral authority and potential lead to a strategic defeat because of negative world opinion. Thus by simply parsing the background material an idealised conceptual view of how the campaign events may play out can be developed as a basis for development of the ID.

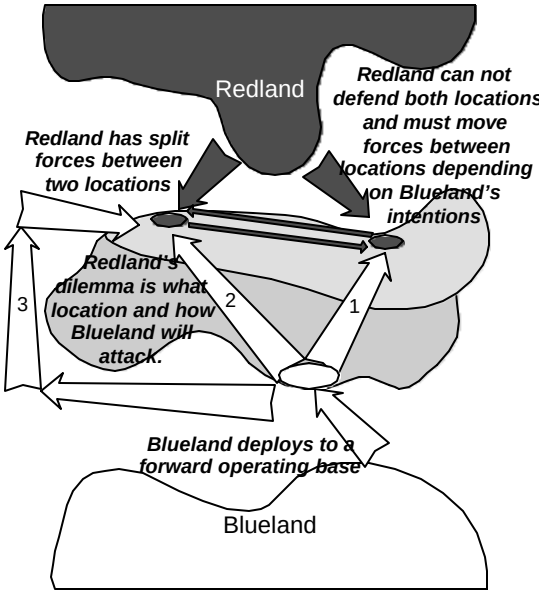

Figure 4: Possible concept of operations for the defeat phase of the campaign

At this stage the variables of the ID have not been developed, although the conceptual elements they relate to and the general factors they will describe have been identified, as in Figure 4. The next stage is to identify the variables through the observation of the planning process used by the participants prior to the war game. The planning process takes participants through a structured series of deductive and inductive reasoning to derive the best course of action to take in a situation by analysing factors that relate to their perception of the situation. It breaks down analysis of the situation into the following stages:

a. Study the existing situation
b. Decide the aim to be achieved
c. Consider all pertinent factors and draw deductions
d. Consider possible ways of attaining the aim, and
e. Decide the preferred course of action to achieve the aim.

Courses of action (COA) are produced by the participants prior to the war game using the planning process. Each COA is described as the series of actions required to achieve the aim of the campaign and the possible contingency actions that may be required to counter the likely reaction of the adversary. The COA is a specific instantiation of the concept of operations represented in Figure 4 described as a series of preferred actions and possible contingencies.

The inclusion of contingency actions, based on the likely reaction of the adversary, is an important element in exploring the complexity of the scenario. Without contingencies the system would be relatively simple and deterministic with each side following a series of actions irrespective of the adversary actions. Thus the exploration of contingencies is an element of the planning. For example COA 1 may be Blueland's preferred course but because Redland detected Blueland's early movements Redland decides to reinforce Blueland's objective with forces from its other base. The detection of massed forces at the first course's objective would prompt Blueland's commander to take a contingency action that would be to switch to COA 2. The desired effect would be to place a "wedge" between Redland's two major concentrations thus effectively isolating them from each other in the hope that Redland would then withdraw rather than face piecemeal destruction. Figure 5 represents such a contingency.

The combination of Blueland's relative flexibility to change between COAs compared to Redland's flexibility in reinforcing either position, and an ability to detect, or better still anticipate, Redland's decision to reinforce are the critical factors in Blueland achieving success at the campaign level. Both of these factors are time dependant and determined by the capabilities that make up the forces. In going from the representation of the campaign in Figure 4 to that in Figure 5 the temporal and adversary dimensions have been added to the conceptual model of the campaign. However a further dimension of the information from the planning process is required before the ID can be produced.

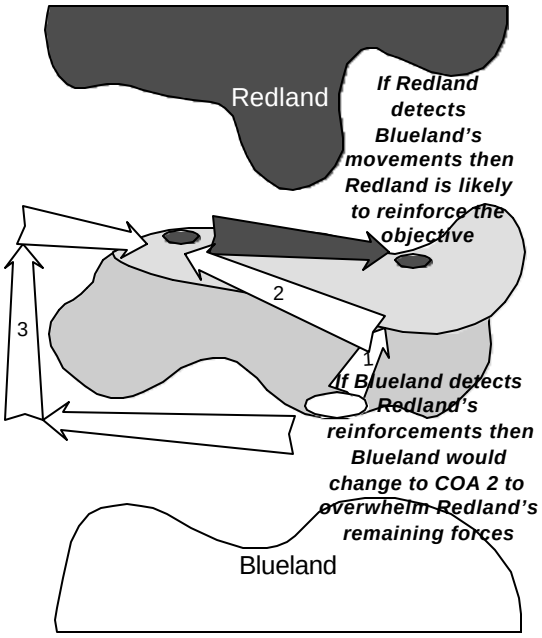

Figure 5: Course of action showing branch point from COA 1 to COA 2

The final stage in developing the ID is to synthesise the conceptual, temporal and adversarial aspects of the campaign through the war gaming process. It is through war gaming that the concept of operations is tested and the relationships between key variables in the COA established. War gaming can be as simple as moving counters on a board or as complex at using multiple linked simulations. The essential elements are representations of friendly forces, a capable and intelligent adversary and representation of the environment (Perla 1990, 15; Curtis and Bowley 2000, 9).

The influences between variables are a combination of those factors identified during development of the concept of operations and the decision criteria used by the participants in the war game. For example Blueland's moral authority, highlighted in the concept of operations, will have a reinforcing influence on the successful conduct of Blueland's offensive operations against Redland because it would increase international support for Blueland's operations leading to greater range of feasible COA. The opposite is also true, for example, the planned "Northern Front" in the Iraq crisis of 2003 was limited because of the lack of international support from Turkey and Syria. The flexibility of Blueland to change between COA compared to Redland's flexibility to reinforce either position will also have an impact on Blueland's offensive success. Thus it is useful to define a variable called Blueland's operational flexibility which is the combination of the number of feasible COA and the ability to transition effectively between the different COA. The ability to transition between COA is influenced positively by Blueland's military capability elements such as suitability of equipment and training levels for offensive operations and negatively by the level Redland's military capabilities for defensive operations.

Questioning of the war game participants and direct observation of the war game events is used to capture the relationships of the variables in the ID. The refinement of the ID is conducted through presenting the diagram back to the participants and obtaining their feedback on its structure and content. There is of course not always consensus amongst participants, particularly when considering the situation from the perspectives of Redland and Blueland in this example, so multiple IDs are accommodated in the methodology as different Weltanschauung[1], or world views, as they are described in Checkland's Soft Systems Methodology (Checkland 1984, 166).

3.1 Conventions and notation of the Influence Diagram

IDs can be a little confusing at first sight but, with practice, they can usually be read as easily as text. The standard conventions of IDs are:

[1] The German expression for worldview. This worldview, or perspective, makes the transformation process occurring in the influence diagram meaningful. An example of Blueland's Weltanschauung would be *the sovereignty of nation Orangeland has been threatened and Blueland, as an ally of nation Orangeland, will take reasonable action to restore that sovereignty.*

- All variables and parameters must be defined so that they could, in principle, be measured unambiguously. For example, International perception of Blueland's ability to restore Orangeland's sovereignty would be unsatisfactory as it is ambiguous, whereas International support for Blueland's ability to restore Orangeland's sovereignty is clear. The definition does not imply that the international community has support for Blueland. Were there is no support the variable would be low and if there were support it would be high. Redefining that variable as International disapproval for Blueland's ability to restore Orangeland's sovereignty would simply change the signs discussed below.

- A signed arrow pointing from variable X to variable Y asserts that X has a causal influence on Y.

- A plus sign states that, if X increases (decreases), then Y will also increase (decrease). In other words, Y changes in the same direction as X. A minus sign has the converse meaning. Two or more variables can influence Y, and Y can affect two or more other variables, as required by the problem.

- The sign is placed as close as possible to the head of the arrow and as unambiguously as possible where two or more arrows converge.

- A large D denotes a significant time delay in a link. If there are two or more Ds in a diagram it is not implied that they are of identical magnitude and subscripts can be used if necessary.

- Care is taken to minimise the number of arrows crossing one another, but it is usually inevitable.

- Greater care is taken to avoid double-counting the same cause or result.

The special conventions for this example are as follows:

- Solid lines are causal influences within the military context of the campaign. Finely dashed lines are the political and social milieu of the scenario.

- Variables that can change as time passes in the game are shown in ordinary Arial type, for example Blueland moral authority[2].

- Three 'output' variables are emphasised: **International support for Blueland to restore Orangeland's sovereignty, Success of Blueland's offensive operations against Redland** and **Degree of isolation of Redland's forces.** These seem to be the primary military phases and political aims of the campaign.

[2] The changes in typeface correspond to those in the diagram.

- Aspects such as ***Blueland's degree of freedom provided by rules of engagement*** and ***Suitability of Blueland's capability for COA*** (top of diagram) are so-called 'pressure points' (PP), or aspects of the problem where investment, changes in training and doctrine, or political choice, would have an impact on the dynamic behaviour. Strictly speaking, a pressure point is exogenous to the dynamics of the system, as is the case with, say, ***Redland's level of capability for defence*** or ***Length of time Redland has had to prepare defences***. In Figure 6, however, two of the PPs, ***Degree of freedom provided by rules of engagement*** and ***Suitability of Blueland's capability for COA*** are partially endogenous in that they are influenced by **International support for Blueland's operations**.

- Finally, one novel convention is the sign *+/0/-* (bottom of diagram) to suggest that Success of Blueland's offensive operations against Redland might increase the Degree of perceived hardship of Orangeland's population in the region occupied by Redland, have no effect, or decrease it.

The diagram may seem too broad-brush but that is largely due to the attempt to get a representation of the whole of the campaign onto one page, not to represent all the information from the planning process and war gaming onto a single diagram, as there are well established products from the planning process that do this. It could be disaggregated to show more detail in, for example, Suitability of Blueland's capability for COA. That would inevitably add greatly to its complexity and it may be better to disaggregate segments of the diagram into separate diagrams. For example, Suitability of Blueland's capability for COA could be shown as having subordinate pressure points such as suppression of enemy air defence, battle damage assessment, air task planning capabilities, and so on. The general rule is that, in a given diagram, the pressure points should be shown in comparable levels of detail.

For the purposes of the experiment specification process in Figure 1, the degree of resolution in Figure 6 may be suitable. The use of more detailed levels is discussed below for the generation of contexts for focus issue studies.

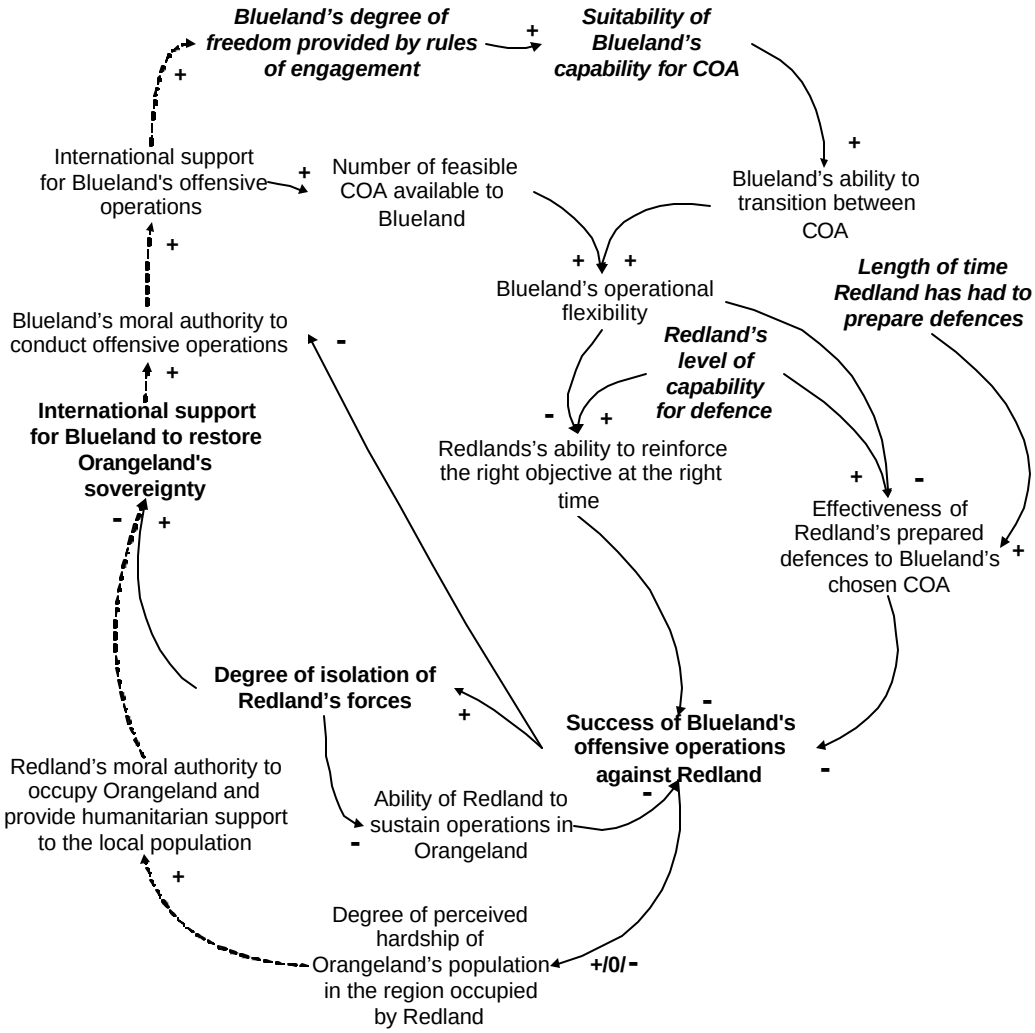

Figure 6: Influence diagram

4. Generating Experiments

The diagram can support the generation of conditions for subordinate analyses in two ways: via it's the feedback loops and pressure points.

4.1 Loop Analysis

A feedback loop exists if, starting from any variable and following the arrows, one can return to the starting point without having passed through any other variable more than once. It is still a loop if one link crosses over another, so a loop can be small and

obvious or very complex and convoluted. A given variable can feature in several loops, as can a given link (arrow).

From inspection, Figure 6 contains numerous feedback loops, all of which will not be discussed. For illustrative purposes, two are shown in Figure 7, emphasised by thicker arrows and identified by descrip tive names.

Both of these loops relate the purely military parts of Figure 7 with the political milieu, which may well be true for all the loops in the diagram. For these two illustrative loops, the inner *"HEAVY HANDED BIG BROTHER"* loop is negative, or restricting, and has the effect that **Success of Blueland's offensive operations against Redland** is reduced due to the weakening of Blueland's moral authority to conduct offensive operations. The international community, while approving the efforts by Blueland to restore Orangeland's sovereignty, as represented by the outer positive reinforcing loop labelled *"LIBERATION OF A SOVEREIGN TERRITORY"*, have an aversion to military offensive action. The toll the operations have on the local population produces a corresponding negative influence on Blueland's moral authority to conduct offensive operations as represented by the negative influence from **Success of Blueland's offensive operations against Redland**[3].

The relevance of these loops to the specification of experiments is that they offer two external conditions within which the military must function. In one case, the inner loop dominates, Blueland's moral authority to conduct offensive operations is diminished, there will be little International support for Blueland's operations and Number of feasible COA available to Blueland will be limited thus reducing Blueland's operational flexibility. If the outer loop dominates, the opposite will apply. Subordinate experiments should not attempt to predict which of these conditions dominates, but simply treat them as two experimental variants, or hypothesis, used to investigate a set of capabilities.

An interesting variation of this lies in the link to Degree of perceived hardship of Orangeland's population in the region occupied by Redland and the sign of **+/0/-**, labelled *"THE CNN EFFECT"* in Figure 7. If **Success of Blueland's offensive operations against Redland** is increasing the plus sign corresponds to a perceived adverse impact on the local population through the media because their hardship is increasing resulting in possibly less local support to Blueland, the 0 means that there is no perceived impact on the local population, in which case the loop would not exist, and the minus sign amounts to Blueland's actions reducing the perceived hardship of the local population through the favourable coverage of Blueland's actions and possible greater local cooperation for Blueland's forces. Three more political contexts based on local population support are generated through the **+/0/-** facility, and no doubt more could be identified in the other loops.

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[3] There are two reinforcing loops in Figure 7 but concentrate on the innermost through Redland's ability to reinforce the right objective at the right time. There are, of course, other reinforcing loops with parallel paths.

The relevance of the political milieu is clearly stated in the political and military context earlier in the paper and this preliminary loop analysis has linked those considerations very clearly to the dynamics of the military actions through the facilities of the ID.

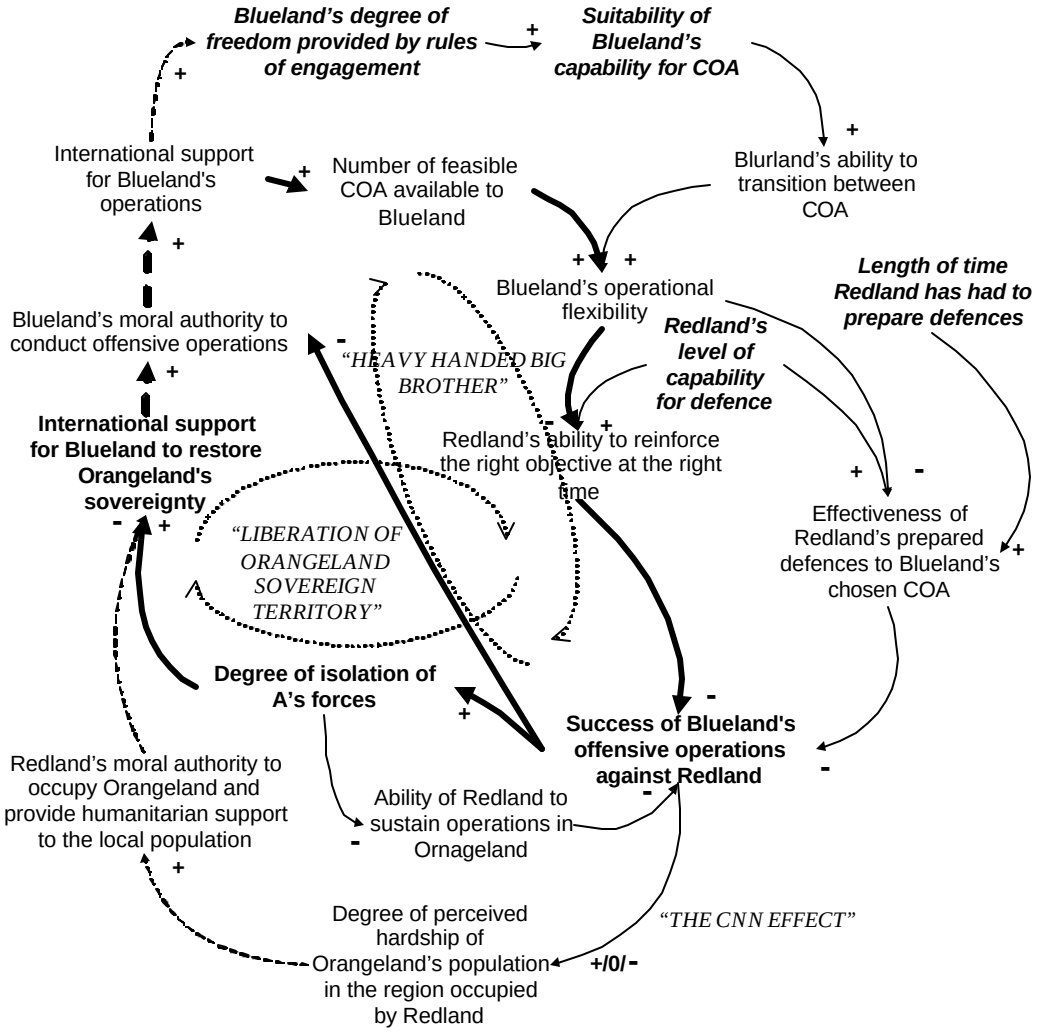

Figure 7: Influence diagram with feedback loops highlighted

4.2 Pressure Point Analysis

The pressure points (leverage points is an alternative term) in Figure 6 have been expressed in broad terms both for clarity of the diagram and to simplify the specification of experiments. In the latter sense the notion is to measure, for example, ***Suitability of Blueland's capability for COA*** as Blueland's capability for offence relative to that of Redland's for defence. The relative capability generation idea embraces not only

technologies, per se, such as avionics and missile performance, but also the doctrinal, training and organisational aspects across the full range of capability. Each pressure point offers another variable to define the experiment variants.

4.3 Specifying Experiments

The loops and pressure points allow the specification of a mission and associated conditions such as military and political constraints and freedoms of action for focussed studies, as in Table 1. The underlying principle is to specify experiments in which it is not clear what the outcome would be so as to investigate the areas of uncertainty by not having the campaign clearly weighted to any one side. Employing the principle of capability parity between the sides will ensure the experiments are informative rather than being a 'fait accompli'.

The specification of experiments also supports hypothesis generation with subsequent focussed studies providing tests of these hypotheses. The hypotheses are based on propositions that selected loops dominate system behaviour. Each focussed study of a hypothesis builds confidence in, or identifies changes to, the overarching campaign ID. Thus the problem definition process is iterative, with the results of focussed studies being reflected in an updated campaign ID.

It could be predicted that for Experiment One in Table 1, Blueland might be able to do little more than deter Redland's expansion in Orangeland and make a show of force in the region while being unable to take decisive action because of international pressures. In such a case Blueland would not have the moral authority to proceed past the Deter phase of the campaign. In Experiment Two, Blueland should be able to restore Orangeland's sovereignty through the Isolate, Strike and Expel actions of the Defeat phase of the campaign. The war game indicated that only in favourable political circumstance could such action be possible.

This approach for specifying experiments has several advantages, not least its simplicity, clarity, and flexibility. Its many combinations offer a great variety of experiments may be a mixed blessing. The variety is implicit in the concept of strategic planning, but the table makes it explicit. As with all experimentation, therefore, careful design will be needed to ensure that the experiments are sufficiently different to be interesting yet not so different that the results cannot be compared. It is also important to be mindful of whether one is using a constrained set of capabilities, in which case some experiments will clearly not be feasible and not require further effort, or allowing new capabilities to be explored to meet the challenges presented in a range or experiments. Thus the technique can be used for evaluation of a set of capabilities in various missions and tasks or the exploration of a new set of capabilities.

Its disadvantage may lie in the capability generation idea, which may seem a little too broad, as shown in Table 1. An issue is developing the most suitable level of aggregation so as not getting lost in a welter of detail when specifying experiments. The

disadvantage of the ID technique for experiment specification are the polar requirements of a high degree of detail for clarifying how the capabilities are generated and the requirement to remain abstracted away from the detail to make the diagrams of use as a representation of the entire campaign. To disaggregate the IDs into the fine detail of capability risks the user getting lost in complexity when specifying experiments. To avoid this problem a hierarchy of diagrams are used, the most aggregated, such as those in this paper, represent the entire campaign and the broad issues for focussed studies, and more disaggregated diagrams are used to support investigations into specific issues.

Table 1: Specifying experiments

	Experiment One	**Experiment Two**

Blueland's Mission	o Deter Redland's further build-up in Orangeland
	  o Demonstrate capability
	  o Increase military presence in Orangeland
		o Defeat Redland's forces from Orangeland
		  o Deploy and sustain forces
		  o Conduct strikes against Redland's deployed forces
		  o Expel Redland's land forces from Orangeland

Political Environment	o Inner restrictive loop dominates – Blueland has little moral authority for offensive action. o Orangeland's local population is not supportive since they see offensive action reducing the ability of Redland to provide humanitarian assistance.	o Outer reinforcing loop dominates – strong support for Blueland. o Redland remains defiant. o Orangeland's local population is supportive of Blueland because of humanitarian assistance being provided by Blueland.
Operational Consequences	o Rules of engagement very restrictive (e.g. self defence and interception only of clearly identified	o ROE more relaxed (e.g. self-defence, interception of any traffic to Orangeland, unrestricted action

	Redland military traffic). o Number of COA available to Blueland reduced to indirect action.	against Redland's assets in and around Orangeland). o Broad range of COA available including strikes on Redland's homeland.
Postulated military Capabilities (or experimental conditions from pressure points).	o Blueland's offensive capability is able to overcome Redland's defensive capability if 1) not reinforced or 2) Redland has been in place for less that 1 month. o If one condition is met then there is parity amongst forces, if both conditions are not met Redland has an overmatch on Blueland.	o Redland has a capability overmatch in the land component but Blueland has a capability overmatch in maritime and air. o Redland has built significant defences with the aide and support of the local population.

It must be remembered that Table 1 is based on consideration of only two loops in Figure 7, and those loops were so prominently visible as to be obvious. Figure 7 contains an as yet unknown number of additional loops (it might be as many as 10) so it is certain that other experimental milieus can be identified and it is very possible that one or more of those might specify much more valuable experiments.

In addition careful consideration should be given to the issue of whether and, if so, to what extent, the capability pressure points should be disaggregated into their components. By keeping the capabilities aggregated the experiment can explore the requirements for the capability in general terms rather than specifying the platforms, structure and doctrine that make up the capability. If the capabilities are disaggregated into specific platforms, structure and doctrine then the performance of that capability will be evaluated. The degree of aggregation is determined on the intent of the experimentation, either exploration or evaluation of capability.

4.4 Contexts For Other Studies

One of the uses of IDs is to define contexts in which other focussed studies can be carried out and to show the relationships between such investigations. Figure 7 offers many examples, the first could be a detailed model of the effectiveness of Redland's

defences to certain COA used by Blueland, with the environment, platform capabilities and Redland's ability to reinforce treated in some detail, and using, perhaps, Success of Blueland's offensive operations against Redland as an outcome measure. Such a study could be conducted under the conditions of Experiment One or Two in Table 1 resulting in different test conditions. For example under the conditions of Experiment One, a meeting engagement between Redland and Blueland would prove of interest because of Blueland's restrictive rules of engagement (ROE) and the tactics that would be employed to combat this. Under the conditions of Experiment 2 the deliberate battle may result in a very different outcome because of the impact of more relaxed ROE for Blueland balanced with better prepared defences for Redland.

The study might be done by any one of a number of techniques, such as constructive simulation or system dynamics modelling. The diagram then places the outcome measure in relation to other elements of the campaign. Figure 6 indicates that **Success of Blueland's offensive operations against Redland** has a positive influence on **Degree of isolation of Redland's forces**. Thus the results of the focussed study would provide the conditions under which Blueland's ability to isolate Redland's forces is improved or degraded. Through further qualitative analysis of the diagram the impact the conditions have on the entire campaign can be identified and thus provide an indication of their value not just in the area of isolation of Redland's forces but in the campaign overall. The limitation is that only the direction of change of the variables is shown through analysis of the ID not the magnitude or potential nonlinearities in the response that would form areas of investment. Due to the unquantifiable nature of many of the variables in the political milieu, the development of a comprehensive system dynamics model of the entire system is infeasible. However qualitative analysis of the entire ID coupled with quantitative analysis of critical sub-systems yields defensible and auditable insights for military experimentation with an economy of effort.

5. Conclusion

The ID in Figure 6 has captured the whole of the campaign on a single sheet. To do so required an element of aggregation and that, in turn, involved some broad-brush treatment of capabilities. The result has proven to be useful as a one-page portrayal of complexity and that may be helpful in its own right when presenting the results of military experimentation to inform capability development. The analysis of loops and pressure points has suggested a concept for the design of experiments to investigate a range of suitably different politico-military conditions under which to explore or evaluate the implications for military and national capabilities.

The aims of Figure 6 were fourfold:

1. The primary aim is to capture key elements of the campaign in one diagram. In addition, the overtly military aspects, such as impact of offensive action, are embedded in the milieu of the political aspects, such as moral authority.

2. Putting this complex problem onto one piece of paper has potential as an aide-memoire for both analysts and participants in the war gaming process. With suitable explanation, the diagram is a useful quick reference for the extensive briefing documents that accompany such studies.
3. The diagram can be used to generate conditions and assumptions for detailed studies using other analytical techniques.
4. The diagram can be used to qualitatively situate and relate the results of the detailed studies into the broader context of the diagram.

IDs offer an interface between the high level strategic guidance provided in illustrative planning scenarios and the detailed operations analysis trade-off studies of military capability development. All to often the results of latter are left without relevance because their purpose and motivation is not clearly linked through to strategic guidance. In addition, established operations analysis techniques find it difficult to deal with the unquantifiable nature of political influences that are dealt with qualitatively in IDs. The main development vehicle of IDs in this application is war gaming and the associated military planning process but the diagrams are equally well suited to a business environment where scenario based analysis is also popular.

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