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COMBAT MODELING IN THE RAAF

By

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About the Author

Wing Commander Greg Donaldson is currently on staff at the Air Power Studies Centre. He graduated from the RAAF's Diploma Cadet Squadron in 1974 after completing engineering studies. He has undertaken a variety of staff and unit postings including Senior Engineering Officer posts in both 2SQN and 79sQN operating Canberra and Mirage aircraft respectively. Before arriving at the Air Power Studies Centre, Wing Commander Donaldson was involved in Logistics Policy development in Air Force Office.

He will complete a Master of Engineering Science at the end of 1993. During the course of this study, he developed a thesis on the use of systems dynamics modeling in an air power environment.

INTRODUCTION¹

Combat modeling has evolved considerably from the wargaming sand tables² and the analytical models or Lanchester models³ developed in the early part of this century. While these techniques had adequate functionality for the nature of war in those times, the complexity of modern warfare demands far more sophistication in terms of combat modeling. It was not until the advent of analogue and digital computers in the latter half of this century that the required sophistication became available. The advent of great power in desktop computing has provided memory and processing capabilities at reasonable cost and allowed the various forms of combat modeling to be cost-effective methods of modeling and simulating combat and military scenarios.⁴

Combat modeling can and should be used for the assessment and translation of high level strategic guidance down through operational concepts, published RAAF doctrine, concepts of operation, and air campaign plans. Combat modeling can also be used for modeling tactical level combat scenarios. However, it is evident that this practice – modeling tactical level combat scenarios – in the past, has attracted the major interest to the detriment of modeling higher level processes.

Combat modeling provides a lower cost and clearly more risk-averse method of rehearsing combat scenarios and undertaking campaign planning compared to learning lessons in actual combat. In a broader sense, it can be used to support six principal areas of activity: force structure planning, campaign planning, training, education, analysis, and research. Although all these areas are important to supporting the RAAF's mission, the RAAF possesses only a limited combat modeling capability. The dearth of RAAF combat modeling capability is compounded by a lack of ADF or RAAF combat modeling policy.

There has been a narrow focus within the RAAF in the past on 'wargaming', perhaps to the exclusion of a broader focus on combat modeling. Limitation of focus to wargaming has tended to deny the RAAF an understanding of other combat modeling techniques which may have greater utility for particular circumstance. It also has the potential to lead to a limited appreciation of the need to use and integrate combat modeling techniques across the broad range of activities from the development of force structure through to tactical level simulations. This paper provides a broad coverage of the subject of combat modeling and indicates potential uses of each combat modeling technique.

Finally, there is a propensity for combat modeling enthusiasts to become besotted with the technology of combat modeling to the exclusion of the substance of models

¹ Some of the issues raised in this paper have been raised previously in a paper by Gary Waters titled 'Combat History, Analysis and Modeling for an Air Force' published in Ross, Andrew (ed.), *Combat History and Analysis*, Australian Defence Studies Centre, Canberra, 1992, pp 31-46.

² A sand table was a tool which allowed combat modelers to create the topography of a battlefield on which toy soldiers and equipment would be placed and moved about to simulate military action.

³ Lanchester models are analytical models comprised of differential equations defining aspects of combat. The term 'Lanchester model' originates from an early analytical modeler, Frederick W. Lanchester, and is used to describe all analytical models constructed using differential equations.

⁴ It should be noted that the term 'combat modeling', through the use of the word 'combat' has connotations of only being applicable to combat scenarios. However, it has applicability to all fields of military endeavour.

and the broad conceptual framework necessary to support individual models. There is a need to stop ‘playing’ with models and to undertake a thorough analysis of the use and requirements of combat modeling across the ADF, not just within the RAAF.

This paper commences with a brief history of combat modeling in the RAAF then proceeds to a definitional baseline and to scope the techniques used. Some potential applications of combat modeling in a RAAF context are then discussed, followed by a strategy for developing the application of combat modeling.

BRIEF HISTORY OF RAAF COMBAT MODELING

The history of combat modeling in the RAAF goes back to its early days. The most notable examples of early combat modeling are recorded in the notes of Air Vice-Marshal H.N. Wrigley, an early Australian air power theorist, who used forms of influence diagrams to denote aspects of air strategy.⁵ In the early 1920s, he also used simple graphical models to depict the principles of concentrating air power in time and space in combat.

During World War II, the RAAF developed an operational analysis capability to undertake combat modeling. This formed the basis of post-war combat modeling capabilities within the Defence Science and Technology Organisation and the Central Studies Establishment within the Department of Defence. In more recent years, some combat modeling work in the air environment has been undertaken within Analytical Studies Unit in Force Development and Analysis Division of the Department of Defence. In the last decade, modeling work has also been carried out within Development Division in Headquarters Australian Defence Force.

Combat modeling in the form of military exercises has been carried out over the entire history of the RAAF. In recent times, the Kangaroo series of exercises have provided large amounts of potential data for air combat modeling.

An officer was appointed to undertake a Chief of the Air Staff Fellowship at the RAAF’s Air Power Studies Centre in 1991 to study wargaming in the RAAF.⁶ This study resulted in a report recommending, *inter alia*, that ‘wargaming must be endorsed as a valid, cost-effective tool for research, planning, education and training.’⁷ Subsequently, a position was established and manned at the Air Power Studies Centre to promote the use of ‘wargaming’ in the RAAF.⁸

⁵ Some of Wrigley’s notes are recorded in Stephens, Alan and O’Loughlin, Brendan (eds.), *The Decisive Factor*, AGPS, Canberra, 1990. His diaries are held at the RAAF Museum, Point Cook.

⁶ See McCarry, Squadron Leader Peter, *This is Not a Game, Wargaming for the Royal Australian Air Force*, RAAF Air Power Studies Centre, Canberra, 1991.

⁷ *Ibid.*, p 68.

⁸ The term wargaming often does not include the use of other forms of combat modeling as defined in this paper.

DEFINITION AND SCOPE OF COMBAT MODELING

Combat modeling can be defined as any structured activity which is undertaken to represent higher level strategic guidance, doctrine, operational concepts, concepts of operation and combat scenarios in terms of varying degrees of abstraction and reality. The scope of combat modeling spans influence diagramming, dynamic simulation, wargaming and conduct of military exercises as shown in Figure 1.⁹ It is important to note the trends in realism, degree of abstraction and convenience and accessibility from one end of the spectrum to the other. There is also a tendency towards higher cost associated with techniques at the right hand end of the spectrum compared with those at the left hand end.

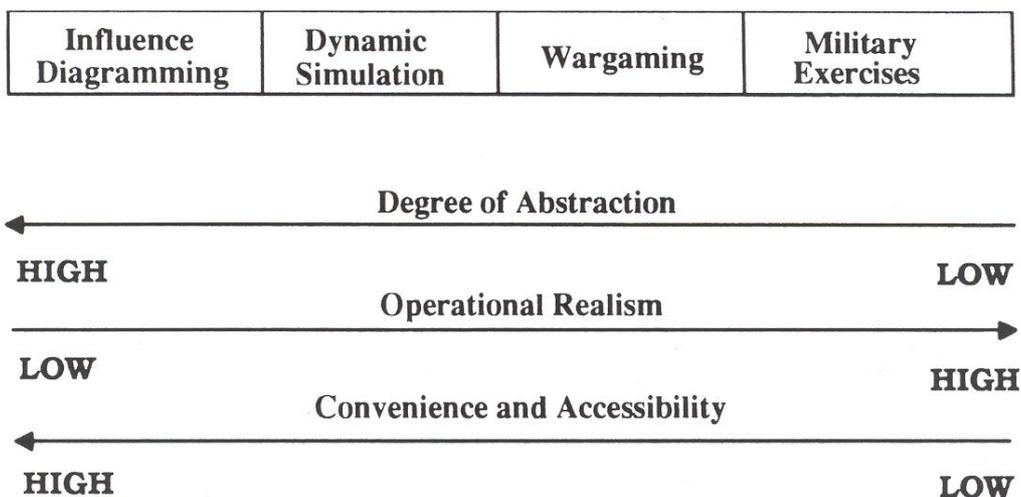


Figure 1 - Scope of Combat Modeling

It is interesting to Huber (1983) has identified three main analysis and modeling techniques in combat modeling, which broadly equate to the combat modeling techniques detailed in this paper.¹⁰ Huber's techniques are:

- a. Field experiments, (including manoeuvres, exercises and combat experiments),
- b. Interactive Simulations (including all formal models with man-in-the-loop such as manual and computer-assisted war games and player-assisted computer games), and
- c. Closed Simulations (including stochastic¹¹ and deterministic¹² simulation models as well as analytic models of combat).

⁹ This was developed from a diagram published in James G. Taylor, *Force-on-Force Attrition Modeling*, Operations Research Society of America, Arlington, VA, 1981.

¹⁰ Reiner K. Huber, 'On Current issues in Defence Systems Analysis and Combat Modeling', published in *Omega*, June 1985, pp 95-106.

¹¹ A stochastic model acknowledges and allows for different probabilities of occurrence of events and outcomes in the model.

Field experiments equate to military exercises in Figure 1, interactive simulations equate to wargaming, and closed simulations equate to influence diagramming (or causal loop diagramming) and dynamic simulation combined. This paper will address the combat modeling techniques in terms of Figure 1.

Influence Diagramming

Influence diagramming involves recording the relationships and influences between entities and elements within a system. An example of an influence diagram used in an air power context is shown at Annex A. The use of the technique of influence diagramming¹³ is normally a precursor to the development of dynamic simulation models but has significant utility in its own right for increasing understanding of key elements and relationships in a combat scenario. Principally, it is a qualitative technique which has significant application in the training and education environment where the dynamics of the scenario are of no or only secondary importance and where understanding the relationships between elements is of primary importance.

There are some previous examples of influence diagramming being used to model logistics systems within the RAAF, including repairable item pipelines. A similar technique was also used to undertake a comprehensive study of the RAAF logistics system in 1986.¹⁴ However, there are no known uses of the technique in modeling across a broader range of activities including air operations. There is no reason why the technique cannot be used to model any environment within the context of air power. However, the principal focus of most modeling effort in the RAAF will be to simulate the dynamics of a scenario and influence diagramming is an essentially static technique, with dynamics only being inferred. Therefore, the techniques of dynamic simulation, wargaming and military exercises will probably be at the core of most combat modeling activity in the RAAF.

Dynamic Simulation

Dynamic Simulation is a technique which is part of the system dynamics methodology. This methodology has been defined by Professor Geoffrey Coyle (1977) as 'a method of analysing problems in which time is an important factor, and which involves the study of how a system can be defended against, or made to benefit from, the shocks which fall upon it from the outside world'.¹⁵ A simulation, which can be undertaken using system dynamics techniques, has recently been defined by

¹² A deterministic model does not allow for different probabilities of occurrence of events and outcomes and essentially considers assumptions, variable values etc as predetermined – hence the term 'deterministic'.

¹³ For an article on the use of influence diagramming in a military context, see Coyle, R. Geoffrey, 'A Model in the Dynamics of the Third World War – An Exercise in Technology Transfer', published in the Journal of the Operational Research Society, Volume 32, 1981, pp 755-765. Coyle describes a combat scenario involving air and land forces.

¹⁴ See Watson, R. *et al*, *The RAAF Logistics Study*, Central Studies Establishment, Canberra, 1986. The actual technique used was 'soft-systems' modeling, which is a technique for analysing systems in which human (or 'soft') issues play a large part in the way that the system performs.

¹⁵ Coyle, R. Geoffrey, *Management System Dynamics*, Wiley, Chichester, 1977, p 2.

RAND as a 'special kind of model that represents at least some key internal elements of a system and describes how those elements interact over time'.¹⁶

System dynamics then is a method of simulating the dynamic outcome of systems. With the complexity of combat scenarios and modern force structures, this is normally done through the use of computers. Initially, the relationships between the elements of the systems are developed and depicted through a technique such as influence diagramming. Subsequently, algorithms are developed to define the mathematical relationships between elements. System dynamics facilitates the concept of 'systems thinking' which involves an understanding of the way that systems interact as a whole rather than as individual elements acting independently. This systems concept sits well with the RAAF's air power doctrinal principle of unity of command. The parallel relates to the fact that in accordance with the unity of command principle, the air commander is responsible for the management of the air power application system as a whole. The system is not managed as a number of 'penny packets'.

The role of the computer in dynamic simulation is to simulate the actions of opposing forces without interactive input from those forces. Dynamic simulation programs process the inputs to the computer in terms of the algorithms and assumptions embedded in program code. Computer programs actually model the responses of commanders to various scenarios based on code written by the program developers. This is the core of the difference between the operation of a dynamic simulation and a wargaming package.

A number of different programming languages have been developed specifically for the dynamic simulation environment, including Dynamo, and IThink™ in conjunction with a scheduling package for use in force structure planning.¹⁷ His paper strongly argues the case not only for the use of combat modeling techniques for this task but also argues for development of a structured suite of models which facilitate combat modeling and force structure (or air capabilities) modeling.

System dynamics is a methodology which has significant potential for assisting campaign planning. It would allow commanders and their staff to model different campaign options at the strategic, operational and tactical levels. This would facilitate the development of alternative approaches and allow the best course to be selected. The implications of a particular campaign approach, in terms of a wide range of issues such as consistency with national objectives, political influences, C³I and logistics can be modelled to varying degrees using system dynamics. Optimisation will ultimately assist in the development of detailed combat planning at all levels. On the basis of the output of these models, comprehensive campaign planning can then be undertaken.

¹⁶ Davis, Paul K., And Blumenthal, Donald, *The Base of Sand Problem: A White Paper on the State of Military Combat Modeling*, The RAND Corporation, Santa Monica, 1991, p 1.

¹⁷ See Thoms, Group Captain Gavin A., *Generation of Air Capabilities – Toward a Predictive Model*, Air Power Studies Centre Paper Number 1, Canberra, 1991.

Wargaming

Perla (1990) defines wargaming as ‘any type of warfare model or simulation, not involving actual military force, in which the flow of events is affected by decisions made during the course of those events by players representing opposing sides’.¹⁸

Wargaming provides an environment which facilitates the human interaction of participants representing opposing forces. It does not necessarily need to involve a computer to process the inputs as wargaming is often conducted in a manual environment or in environments that are only partially automated. The key feature of a wargame is its ability to allow two game participants to interact in real time.

Wargaming may involve actual operations at the strategic, operational and tactical levels or a combination of these. However, it is most common to have wargames involving actual operations at the operational and tactical levels. Wargames could involve the use of simulated inputs generated via non-interactive modeling techniques such as those discussed earlier in this paper.

Simulation at the tactical level of combat may involve the use of simulators for particular operational scenarios. Operational flight trainers or simulators which have the capability for interactive input by different operators could be classified as wargames and indeed may be used to provide data for input to the wargame at higher levels. Alternately, these simulators may provide a wargaming capability on their own which is purely limited to activities at the tactical level.

Military Exercises

Military exercises involve the comprehensive use of actual personnel and equipment for simulating the effects of combat. The degree of realism achieved depends on the extent to which inputs to the exercise are generated by simulation compared to those which are actual event-related inputs. Compared to the other combat modeling techniques, the conduct of military exercises is very expensive. However, they do have the potential to provide an experience that is as close as possible to actual combat. Ultimately, they have the disadvantage compared to wargaming and dynamic simulation techniques of relative inflexibility of approach once the exercise is underway. Once the event has occurred, for example an aircraft has been lost, the event cannot be restaged as it can be in a wargame or a dynamic simulation. It is generally not practicable to undertake many different approaches to the attainment of combat objectives in the course of a particular exercise, as military exercises are generally run according to a pre-determined scenario, and changes involve considerable expense.

¹⁸ Perla, P.P., *The Art of Wargaming*, Naval Institute Press, Maryland, 1990, p 11. Wargaming is discussed in more detail in an paper by Squadron Leader Mark Kelton titled ‘Establishing a RAAF Wargaming Capability’.

RAAF APPLICATIONS FOR COMBAT MODELING

Combat modeling can provide a basis for the way that the RAAF does or should operate. At the highest level it can assist in the development and verification of organisational doctrine. It can contribute to the development of force structure, and short and long-term plans. All successful organisations determine their goals and objectives and establish the most effective and efficient means of achieving those goals and objectives. Combat modeling potentially provides a means of identifying those areas in which effectiveness and efficiency are, or would be, lacking and also potentially a means for identifying goals and objectives, and developing short and long-term plans. In a properly structured modeling environment, all these factors should be integrated to minimise the duplication of effort and to ensure that there is adequate feedback between key elements of the model.

Management in a military environment, particularly a combat environment, is fraught with complexity and often involves severely compressed timescales. It requires military staff to have an intellectual and doctrinal basis for their profession gained through a strong educational system and comprehensive training, and also requires operational experience and specialist management skills. Indeed all these attributes are required for the development of useful combat models, but they can also flow from the greater understanding that combat modeling facilitates. Therefore, these attributes can be enhanced by the use of combat modeling through an iterative process.

The ability to model combat scenarios ahead of time allows military commanders and staff to better understand their combat objectives and means of achieving them prior to the event. Indeed the professional *deep* understanding gained through combat modeling involves the ability to understand how the combat force will operate as a 'system' as well as to understand the many ways that scenarios may unfold.

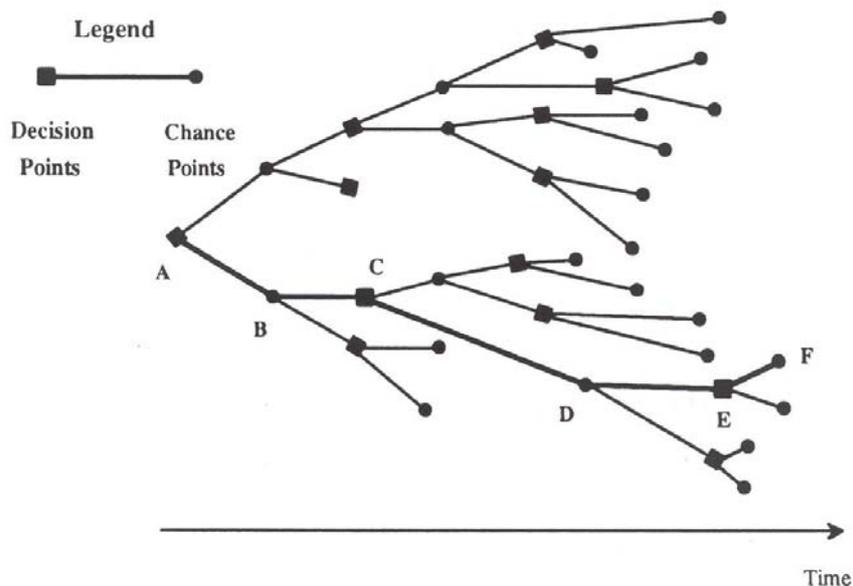


Figure 2 - Growth of Possible Decisions with Time

Figure 2 depicts the fact that combat scenarios involve a plethora of combinations of objectives, decisions and strategies. This diagram indicates that an objective determined say at the strategic level (represented at the left side of the diagram) will branch out into a much larger number of objectives and strategies at lower levels. Combat modeling allows greater understanding of what the implications may be of combat taking a certain course. Various decision/objective paths such as the one labelled ABCDEF in Figure 2 can be modelled to establish the best course of action in a particular scenario.

Combat modeling can be a powerful adjunct to campaign planning. It can be used to assist centre-of-gravity analyses, to develop combat objectives, to prepare war-winning strategies and to develop and refine campaign plans. However, the combat modeling techniques to be used for combat planning need to be carefully evaluated and selected. In this regard, it is interesting to note the view of Huber (1983) that:

‘It appears that closed simulation techniques in general and system dynamics in particular hold a powerful potential to cope with the tremendous variability associated with most long range planning problems in defence. It is this variability which makes the use (only) of the classical interactive techniques (wargames) and sometimes also of Monte Carlo-type simulation a somewhat vain exercise in support of, for example, force structure and contingency planning’.¹⁹

This latter statement indicates that the RAAF needs to analyse and manage the role that all techniques discussed in this paper will play in future RAAF activities. Techniques will need to be carefully matched to required modeling outcomes.

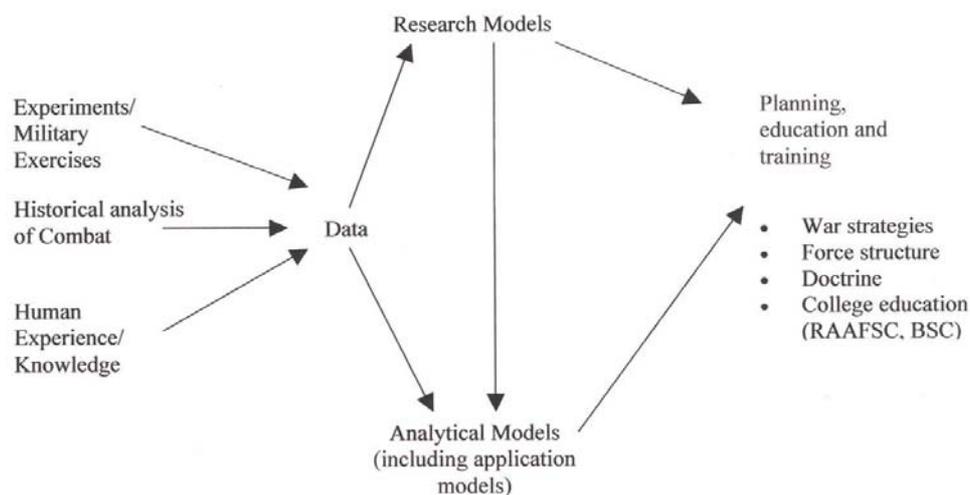


Figure 3 - Application of Combat Modeling

Despite the merits of acquiring a combat modeling capability, it does not come cheaply. A significant amount of expertise and effort is required in order to research

¹⁹ See Huber, Reiner K., *On Current Issues in Defence Systems Analysis and Combat Modeling*, p 97.

and analyse data for models as well as to develop the models themselves. For example the Army Wargaming Centre uses a simulation package called JANUS(T). A permanent staff of three civilian computer experts and two military staff are required to maintain JANUS(T).²⁰ additionally, up to one man-year of effort is required to fully populate the database prior to running a wargame. But ultimately the cost of combat modeling expertise needs to be balance against the benefits that accrue.

The principal areas in which combat modeling methodologies can assist RAAF goals and objectives are planning, training, education, research and analysis. Each of these areas will be discussed briefly in the following paragraphs. Figure 3 depicts the way that the different areas would fit together in a comprehensive approach to combat modeling.²¹

Planning

In his paper titled ‘Generation of Air Capabilities – Toward a Predictive Model’, Group Captain (Rtd.) Gavin Thoms has indicated the inadequacies and the cost penalties involved with the current planning process for the development of air power capabilities. He states:

‘Existing staff procedures allow preparation of approximate workable solutions which are developed in conjunction with relevant Service offices and functional commands. This process produces *inter alia*, estimated sustainment requirements but these usually do not fully reflect the internal dynamics of the sustainment and operational functions’.²²

Clearly, here is identification of an inadequate linking of the force structure development and planning process with lower level functions. As a solution, Thoms proposes a structured modeling environment (discussed later in this paper) utilising automated tools.

The lack of a structured suite of models within the RAAF, as suggested by Thoms, inhibits the ability to translate higher level strategic objectives into operational and tactical plans. That is, the lack of a formal modeling process ensures that not only is the force structure development process sub-optimal but so is the ability to develop campaign plans. It might also be highlighted that the limited formal doctrine, particularly at the operational level, inhibits the process of campaign planning.

²⁰ Davis, Paul and Blumenthal, Donald, in *The Base of Sand Problem: A White Paper on the State of Combat Modeling*, p 33, have identified the large costs of combat modeling. They refer to wargames such as JANUS, JESS and RSAS being ‘developed over periods of many years and costing tens of millions of dollars, ultimately’. JANUS(T) is a tri-environment interactive, near-real-time model developed to explore the relationships of combat and tactical processes. JESS (Joint Exercise Support System) is an automated CPX driver designed to aid in training Tactical Air Control Centre, corps, division and brigade staffs. RSAS (Rand Strategy Assessment System) provides a laboratory for the analysis of military strategy and operations in which alternative strategies and operations are evaluated in terms of the robustness of outcomes across the inherent range of uncertainty in scenarios, performance factors and rules of war. These model descriptions have been taken from *Catalog of Wargaming and Military Simulation Models*, 11th Edition, Defence Logistics Agency, Washington, 1989.

²¹ This diagram was developed from a diagram presented in Davis, Paul K., and Blumenthal, Donald, *The Base of Sand Problem: A White Paper on the State of Military Combat Modeling*, p 29.

²² Thoms, Group Captain Gavin A., *Generation of Air Capabilities – Toward a Predictive Model*, p 11.

The role of combat modeling in the campaign planning process is primarily to assist in the development of a structured campaign plan consistent with objectives at all levels of war. This consistency can only be achieved through the formal linking of the objectives with strategies and the resources required to implement those strategies. Modeling in the complex world of military combat can realistically only be achieved through the use of automated models, which allow an understanding of the dynamics of the system. This understanding of system dynamics should also allow for an understanding of the effect of trade-offs including those caused by the employment of different strategies and different resources, perhaps even the changing of campaign objectives.

Finally, there is a current interest within Force Development (Air) Branch of HQADF for a force development methodology.²³ That methodology would be well supported through the use of combat modeling techniques.

Research

Combat modeling in a research, and indeed in the analysis role discussed later, involves the development of doctrine and campaign strategies at all levels, but particularly at the operational and tactical levels. The use of all combat modeling techniques will facilitate the research function, but those at the lower end of the spectrum, particularly system dynamics, would be of greater utility. These modeling techniques allow greater flexibility and hence allow rapid change and assessment of the performance²⁴ of combat models during the development phase.

Research models are a knowledge base for combat modeling. They embody the characterisation of relationships, assumptions and the outcome of differing strategies developed during the research process. Research in combat modeling can be very expensive but is vitally necessary if appropriate models for the Australian environment are to be developed. Davis and Blumenthal have identified Research and Development in combat modeling as of prime importance (in this case for the US environment, but there would be similar applicability to the RAAF and ADF generally). Davis and Blumenthal state that in terms of combat modeling 'environment':

'The first requirement is to have the concept of research and development (R&D) be as strong with respect to combat modeling as it is in other aspects of DoD work. Such R&D funding needs to be steady and focused on the mid-term and long-term. We cannot over-emphasize how difficult a problem area this is'.²⁵

Associated with the research function is the collection of combat data for combat modeling. Unfortunately, there has been very little combat data obtained relating to the application of air power in the Australian environment. Data can be derived from actual combat but also from the conduct of military exercises and other forms of combat modeling. Huber (1983), reflecting a concern for the paucity of combat data in

²³ Elicited from discussions between DGFD (Air) and DAPSC in May/June 93.

²⁴ Note that this is not the same as validation. *Validation* of combat models is not possible due to the complexities and unknowns involved in military scenarios.

²⁵ Davis, Paul K., and Blumenthal, Donald, *The Base of Sand Problem: A White Paper on the state of Military Combat Modeling*, p 33.

the US and European environment, suggests that more effort must be made to collect data from the conduct of military exercises because of the paucity of combat data.²⁶ The lack of data ensures that combat modeling in the Australian environment will be problematic at least for the foreseeable future.

Analysis

Combat modeling in an analysis role involves the refinement of work undertaken in the research cycle. The distinction between the use of combat modeling for research as distinct from analysis is somewhat blurred. However, analysis primarily involves the development work required to transform data gathering and modeling effort undertaken during research into useable, realistic models.

As with the research function, the analysis function requires the application of significant resources and skills, but it is an essential part of having a combat modeling capability. The RAAF should be aware of the analysis implications when in future it considers its combat modeling needs.

Training and Education

Combat modeling can be used for training and education in a wide number of specific applications. However, the most important role is arguably in the training of junior and middle managers. Combat modeling used in an educational context provides educators and students with a structured methodology for demonstrating and understanding, for example, the application of air power in different combat scenarios. Furthermore, the potential impact of air power doctrine on the outcome of combat can be readily demonstrated.

The use of combat models for training and education allows instructors to assess the decision-making skills and command potential of the students as it provides a means of evaluating these military skills in a simulated combat environment. Combat modeling techniques have been used at RAAF Staff College in the past, but the principal model that was developed has now fallen into disuse.²⁷ Notwithstanding, there is a strong perceived need at Staff College for combat modeling to be enhanced in this environment.

A COMBAT MODELING STRATEGY FOR THE FUTURE

McCarry has made the strong recommendation that the RAAF must make use of wargaming as a 'tool for the development of doctrine, strategy, tactics, force structure and logistics support and in the education of officers in the principles of air power'.²⁸ This recommendation is correct but limiting, as the full range of combat modeling techniques must be used to ensure that modeling effort is cost effective.

²⁶ See Huber, Reiner K., *On Current Issues in Defence Systems Analysis and Combat Modeling*, p 97.

²⁷ A wargaming model called Prometheus was developed at RAAFSC some years ago. The model was eventually automated and used for a short period in this form. A new automated model is currently being developed.

²⁸ McCarry, Squadron Leader Peter, *This is Not a Game, Wargaming for the Royal Australian Air Force*, RAAF Air Power Studies Centre, Canberra, 1991, p 67.

As discussed earlier, Thoms has proposed an integrated suite of models which could form the basis of a combat modeling framework or architecture. The suite of models would be developed and constructed via a modular approach which has independent modules assigned to strategic, operational and tactical levels. Each of these modules may involve a range of combat modeling techniques. He argues the following advantages of this approach:

- a. Simulations at each level relate directly to the military objectives and force development concepts at that level. The same models may be used to support conceptual and doctrinal development, preparation of force development concepts, and operational employment of capabilities thereby ensuring consistency of approach and economy of modeling effort.
- b. Models are limited in complexity to representations at one level only; this constraint should result in reduced production, operation and maintenance costs. The results at a lower level of simulation are integrated and used as input to the next level. This serves to reduce the scope of the modeling task at each level, to reduce the range of input data required and hence minimises set up, running and maintenance costs.
- c. The Model which would be employed for control of the air power development process would consist of an integrated suite of each level of simulation, and
- d. Use of generic simulations at each level would reduce the number of models required and hence their development and maintenance cost'.²⁹

The modular approach to combat modeling suggested by Thoms has great merit from the point of view that the suite can be built gradually with highest priority being given to the areas of most need. Davis and Blumenthal also identify the wisdom of this approach in discussing the desirable attributes of models. They state that:

'New models should be modular to permit plug-in plug-out operations within an organisation and should be designed so that suitable models can be readily constructed for cross-organisation review and use (eg use in distributed wargaming)'.³⁰

The lack of combat modeling capability at the operational level for undertaking campaign planning would seem to be the area of greatest current combat modeling need. Effort placed into combat modeling at this level would assist the development of a core of combat modeling expertise within the RAAF as well as provide an improved capability for campaign planning.

There is some difficulty in this approach however, as inevitably combat modeling at the operational level involves joint Service considerations. Therefore, the joint role of the ADF Warfare Centre and RAAF agencies responsible for combat modeling needs to be clarified through the issue of appropriate policy on combat modeling. Unfortunately, there is currently no extant ADF or RAAF policy on combat modeling to prescribe combat modeling roles or standards to be observed. The problems that can be caused by the lack of control of combat modeling within military organisations

²⁹ Thoms, Group Captain Gavin A., *Generation of Air Capabilities – Toward a Predictive Model*, p 26.

³⁰ Davis, Paul K., and Blumenthal, Donald, *The Base of Sand Problem: A White Paper on the State of Military Combat Modeling*, p 32.

have been highlighted by Davis and Blumenthal.³¹ They highlight the wasted effort inherent in the way combat modeling is managed within the US military, where there is no central agency controlling the practice of combat modeling.

The report also highlights the problems caused by the lack of standardisation³² across the Services in combat modeling, for example in terminology, programming languages and symbology. These problems are likely to be exacerbated in the relatively small Australian defence structure. Ultimately combat modeling efforts in the individual Service environments and Defence organisations such as DSTO should be seamlessly integrated, as required, to produce appropriate joint combat models. There is therefore some urgency in the need for standardisation of combat modeling effort within the RAAF and more broadly, within the Department of Defence, including the ADF.

Notwithstanding the difficulty involved in the interface with combat modeling across the ADF, there seems to be justification, on the basis of the benefits to be gained from the use of combat modeling techniques, for the establishment of more extensive RAAF combat modeling expertise. The establishment of a centre of combat modeling expertise should be seen as a necessary asset for use in combat. In this regard, Waters has highlighted the importance of the use of C3ISIM in the Gulf War; C3ISIM being a ‘long-term study-oriented model that was taken into a near real-time operationally-oriented environment’.³³ He particularly highlights the importance of using analysts, trained and exercised in peacetime, and their models, being involved in combat planning:

Trained analysts with appropriate tools, exercising with operations staff in any transition to war, have tremendous potential to help manage attrition and more broadly, assist the commander in his planning.³⁴

The question of where the ‘centre of mass’ of RAAF combat modeling expertise should lie needs to be addressed. To some extent, the broad scope of the subject makes this somewhat difficult. However, there is no doubt that combat modeling should be focused to ensure that corporate expertise is developed in a professionally stimulating environment and to ensure that appropriate standards are met. Waters has highlighted the fact that the USAF is currently training *operational staff* in modeling techniques and integrating them through the air staff and various commands.³⁵ The strategy for the RAAF should be to have a suitable balance of operational *and* non-operational staff involved to promote comprehensiveness in modeling activities.

The RAAF currently has one principal focal point for combat modeling and that is the wargamer position at Air Power Studies Centre. However, the long term appropriateness of the location of this position needs to be reviewed. Certainly, the title ‘wargamer’ does not reflect the work that the position should be involved in. It

³¹ *ibid*, p 6-19.

³² *ibid*, p 16017.

³³ Gary Waters, ‘Combat History and Modeling for an Air Force’ in Andrew Ross (Editor), *Combat History and Analysis*, Australian Defence Studies Centre, Canberra, 1992, p 38.

³⁴ *ibid*, p32.

³⁵ *ibid*, p32.

should be clear from this paper that the position needs to embrace the broader range of combat modeling activities.

The Air Power Studies Centre to this point has undertaken research into combat modeling and has been involved in the drafting of a simulation policy for HQADF. It has a short to medium-term role in the further development of knowledge in this area and some residual role in the use of combat modeling for the development of doctrine. However the bulk of the future 'hands-on' work needs to be undertaken at HQADF (DGFD(Air)), Air Force Office, Air Headquarters and Logistics Command.

There are no RAAF personnel known to be qualified in combat modeling and this will severely inhibit its further development. The use of enthusiastic amateurs will only produce similar problems to those caused by the use of similar enthusiasts in the computing arena in the past.³⁶ There are apparently a number of universities in the US which are currently offering post-graduate studies in system dynamics, although not directly applied to the combat modeling environment. Given the need for more generic, abstract combat modeling and the advantages offered by the technique of dynamic simulation, it would seem appropriate that the RAAF further investigates the availability of this type of study with a view to placing a student into the program.

In the interests of improving the value extracted from a combat modeling program, there must be a greater emphasis on abstract modeling techniques which address the extended battlefield concept. Traditionally, combat modeling tends to focus at the tactical level of combat. However, RAAF doctrine emphasises the strategic nature of air power and it is therefore appropriate that models embrace the extended battlefield. The latter has been well defined by Warden in his five rings concept.³⁷ A higher degree of abstraction in modeling would allow for more rapid modeling of the strategic environment as defined by Warden (for example). A detailed approach to modeling, particularly for campaign planning will generally not be cost-effective. It is in meeting the need for greater abstraction that the technique of dynamic simulation, as identified by Huber,³⁸ is most promising.

CONCLUSIONS

All combat modeling techniques have great utility if applied appropriately. However, there has been too much emphasis in the past on the wargaming and military exercise end of the combat modeling spectrum. An emphasis on tactical wargaming has also diverted attention away from modeling strategic combat scenarios. There is a need to break away from this essential tactical combat modeling paradigm in order to more closely fit the role of air power as a largely strategic form of combat power. The most cost-effective way of modeling strategic environments is the more comprehensive employment of abstract forms of combat modeling such as dynamic simulation.

³⁶ There is no marking for Footnote 36 on this page however it reads – For further discussion on this point, *ibid*, p 43.

³⁷ Warden III, Colonel John A., 'Employing Air Power in the Twenty-first Century', in Schultz, Richard H. and Pfaltzgraff Jr, Robert L. (eds.), *The Future of Air Power in the Aftermath of the Gulf War*, Air University Press, 1992, p 64-65.

³⁸ Huber, Reiner K., *On Current Issues in Defence Systems Analysis and Combat Modeling*, p 97.

Before proceeding with the further development of combat modeling techniques in the RAAF, there needs to be a more comprehensive review undertaken of their utility. This review should be carried out in the near future so that meaningful policy on the employment of combat modeling can be carried out. There is evidence cited in this paper of the difficulties that have occurred in the combat modeling community in the US. The extent of the problems experienced in the US must be forestalled in Australia by the development of an appropriate policy framework and an implementation plan for a coordinated approach.

Implementation of combat modeling as a distinct form of RAAF expertise involves addressing a number of issues including the types and balance between the techniques to be used, the location of a centre of expertise and the architecture of any combat modeling suite. All these issues should be part of the more extensive review being proposed. In terms of implementation, clearly, there needs to be some consideration of the way that RAAF combat modeling fits with the activities being undertaken in HQADF and DSTO currently.

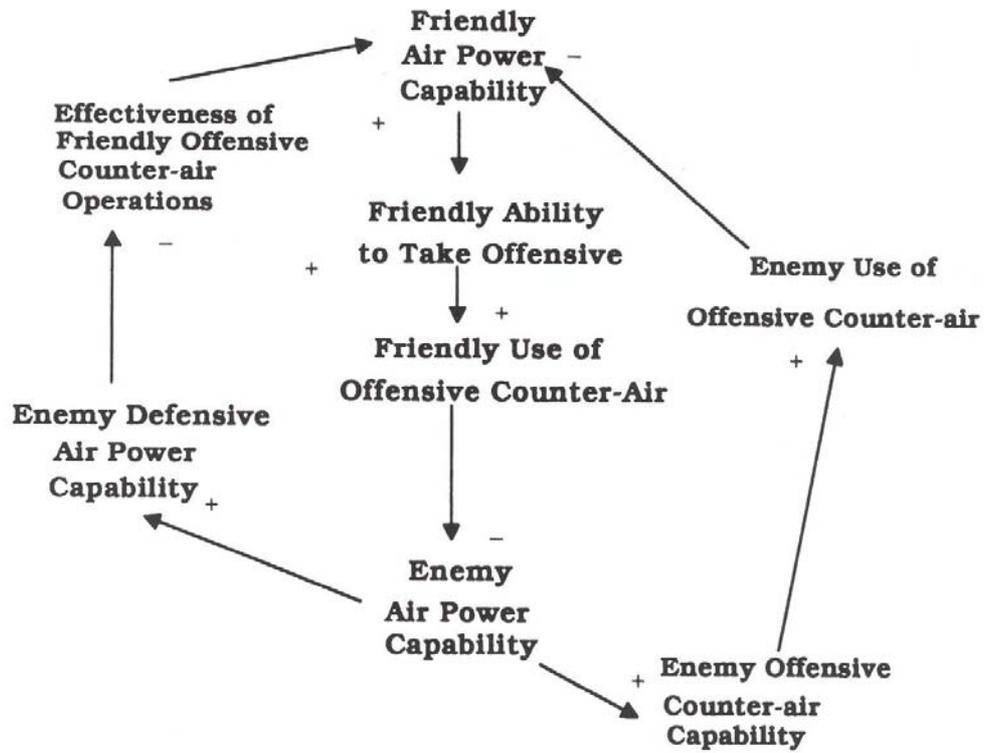
Finally, the appropriate focal point for future RAAF combat modeling needs to be established. As was evidenced by the Gulf War experience, there is both an application and a need for combat modeling techniques in the development of campaign planning. There is also a need for the development of a methodology for linking RAAF strategic objectives with force structure development. These would seem to be the most pressing areas in which combat modeling techniques could be used.

Annexes:

A. Influence Diagram

B. IThink Air Power Model

INFLUENCE DIAGRAM



Influence Diagram

ANNEX B

IThINK AIR POWER MODEL

