2002 Command and Control Research and Technology Symposium

C2 Transformation Through Experimentation

June 11 – 13, 2002

Naval Postgraduate School, Monterey, CA.

Modelling & Simulation Track

Optimising the Design of Land Force C2 Architectures

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Abstract:

Two different configurations of the Australian Army Brigade HQ have been investigated using a Systems Engineering simulation tool known as CORE. A Military Appreciation Process (MAP) has been utilised as a common operational planning procedure for both configurations. The two configurations analysed were a Future Land Force (FLF) where the Brigade HQ is divided into two different locations with separate functions, and the other is a Current Land Force (CLF) structure. The model included the Battlegroup (BG) planning process for both the FLF and CLF architectures. It has been shown that on average, the FLF design achieves the total Brigade-BG planning cycle 30% more quickly than the CLF configuration. This provides more time either to carry out further operational planning (and therefore achieve a higher quality plan within the allotted time), or to accelerate the Brigade commander's OODA loop to move within the enemy commander's decision–action cycle.

1. INTRODUCTION:

The design and structure of the Australian Army Land Forces can either enhance or restrict its level of functionality and performance. A HQ design that speeds information flow, a Land Command and Control (C2) system that emphasises function rather than procedure, and a planning paradigm that is streamlined towards achieving the Commander's Intent rather than simply implementing outdated traditional methodologies, can each optimise HQ efficacy. Making changes to existing military systems and procedures in order to expedite the accomplishment of operational goals is an ongoing research objective.

A Comparison of Land Force Architectures

At DSTO Land Operations Division (LOD), an investigation is being carried out into the effectiveness of the design of a Current Land Force Brigade HQ compared with a proposed architecture for a Future Land Force Brigade HQ. Figure 1 depicts a simplified outline of the C2 structure showing one generic battle group – which represents the five manoeuvre elements in the FLF design with four subordinate Rifle Companies (the W, X, Y and Z are data bandwidths). The Chief of Army's vision for a Future Land Force is "a modern, flexible, highly mobile force, capable of independent, widely dispersed operations within a joint and coalition or combined framework". One of the key features of the FLF design is that it has a divided Brigade HQ, consisting of a Command Support Element (CSE) and a Deployed Forward Brigade HQ (DFBHQ). The CSE is concerned mainly with planning future operations and controlling current operations; while the DFBHQ is concerned primarily with the execution of the current operation. In the current design of a CLF Brigade HQ, the CSE component is combined within the DFBHQ. In both cases, the Coalition HQ (CHQ) would be located on a ship or on friendly territory. The Brigade may be commanded by the Deployable Joint Force HQ (DJFHQ) if it is solely an Australian operation.

Developing an Operational Plan

War seldom unfolds as planned. Moltke the Elder noted, "No plan for battle survives the first encounter with the enemy". Disorder in battle increases with each encounter with the enemy, forcing a series of improvisations that have little resemblance to the original plan. For Napoleon, "the battlefield is a scene of constant chaos; the winner will be the one who best controls the enemy". In order to achieve their desired outcomes, it will be necessary for commanders to appreciate and understand warfare's enduring features and the need for the exertion of fighting power to overcome the resulting chaos. The Land Warfare Doctrine of the Australian Army states: "The command and control of war is best achieved by applying a framework to influence the flow of action, rather than seeking to control each event." In order to maximise friendly influence over the flow of action, the structure of the Brigade HQ is being analysed in order to optimise HQ processes, such as developing high quality operational plans.

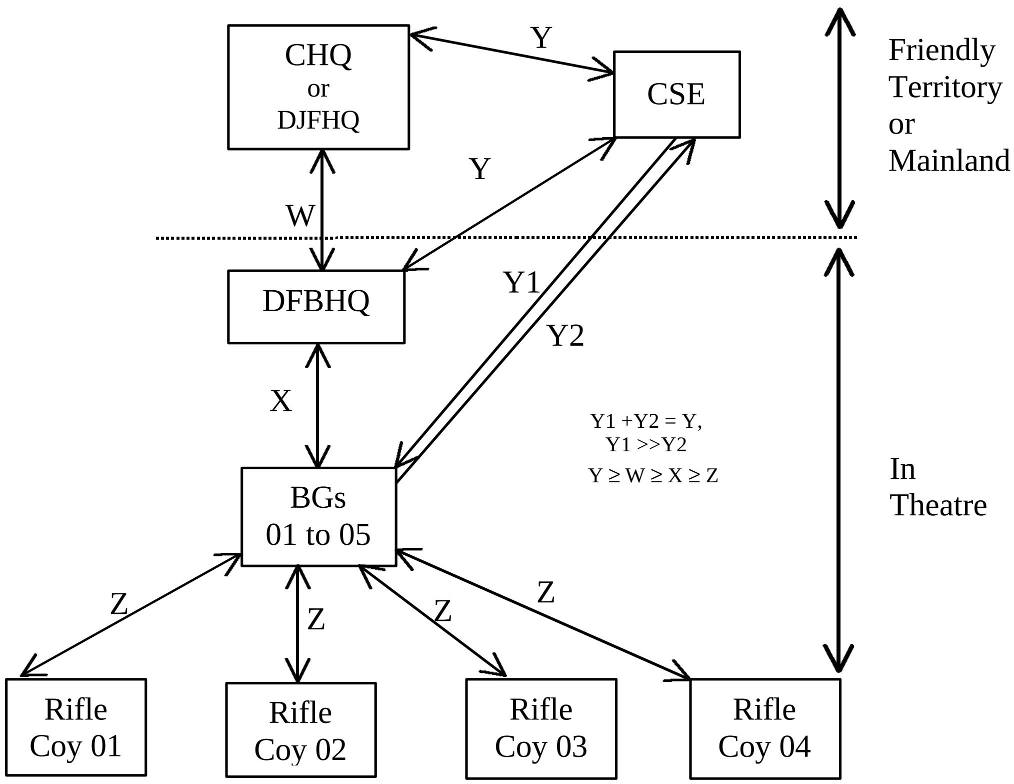

Figure 1 A simplified diagram of a Future Land Force for the Australian Army

Decision Superiority

Decision superiority is the ability to make and implement more informed and more accurate decisions faster than the enemy. Commanders will make effective and timely decisions, while the quality of the enemy's decision–making is eroded due to his increasingly incomplete or incorrect information. It is hoped that if high quality plans can be developed sooner (via a FLF design implementation, for example), that this would facilitate the development of decision superiority.

The implementation of Network Enabled Warfare

Within the context of operations in 15 years time, it is assumed that Network Enabled Warfare (NEW) will be implemented within the Australian military to enable communication between all relevant levels. (Network Centric Warfare is not implemented fully in the Australian context, as not all levels need to communicate to all levels directly.) Therefore the architecture and simulation for a FLF is based on an NEW paradigm. Some of these benefits which increase combat power are delineated below:

Physical Domain: For a FLF, most elements of the force will be robustly networked achieving secure and relatively seamless connectivity.

Information Domain: In combat operations, the sharing, access, and protection of information improves survivability, lethality, speed, timeliness, and responsiveness.

Cognitive Domain: Development and sharing of both high quality situational awareness and knowledge of the commander's intent will increase the ability to self-synchronise operations[1].

2. ADVANTAGES OF A SIMULATION TOOL:

Various analysis options are available, whereby the two HQ configurations can be tested relative to each other. Live experimentation is one avenue, where military staff carry out planning activities under combat-like stresses both for a CLF Brigade HQ and a FLF Brigade HQ configuration. These human based military experiments (open simulation) are very complex and it is difficult to isolate the many parameters involved, especially the variability in human performance over a staff of 10 to 12 military officers (a full Brigade HQ would have up to 50 staff officers). Current progress in this work is reported on elsewhere in these proceedings[2]. These human based military experiments can provide multi-dimensional data and hence a broader range of insights[3].

In order to complement human based experimentation and to accommodate its complexity, another avenue of investigation was sought where a more controlled environment could be achieved. This was not to overlook the human dependence of the functions of the Brigade HQ, but it was anticipated that inexperience, lack of staff training or lack of team coherence could affect the results of a Brigade HQ experiment. A closed simulation environment was chosen in order to normalise aberrant human influences. Within a simulation environment, the influence of delimiting factors can be averaged out, and an overall measure of effectiveness obtained. This provides an avenue for unbiased assessment. For example, in a Command Post Exercise, if an experienced friendly commander was pitted against a novice enemy commander, the friendly commander may prevail in an operation regardless of the Brigade HQ configuration employed, thus biasing the investigation.

Learning Effects:

Another advantage of choosing a closed simulation environment, is the ability to carry out a comparison of the two HQ configurations without the learning effects a human HQ staff would encounter. Ideally, to investigate the architecture of a Brigade HQ, the same friendly commander and staff would need to operate in each Brigade HQ configuration against the same enemy within the same scenario, and develop the same plans in each case. The difference in operational result would be reflected by the greater efficacy of one of the Brigade HQ configurations. This is clearly an untenable experimental goal because of learning effects; as the Brigade staff and commander would perform better the second time through the same scenario. Hence the value of the simulation of a Brigade HQ within a certain battlespace and scenario, where the same theoretical enemy can be addressed in each case with a theoretical staff that has no learning bias from previous operations.

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[1] Arthur L. Money, Assistant Secretary of Defense (C3I), "*Report on Network Centric Warfare, Sense of the Report*" Submitted to the Congress in partial fulfillment of Section 934 of the Defense Authorization Act for FY01 (Public Law 106-398) March 2001.

[2] Bob Seymour *et al.* This proceedings of 2002 CCRTS, Monterey, CA USA, June 11-13 2002.

[3] Yi Yue, Robert Seymour, Wayne Johnson, Jon Vaughan, and Nikoleta Tomecko, *Evaluating Future Australian Army Command and Control Concept with Iterative Experimentations*, 2002 CCRTS, Monterey, CA USA, June 11-13 2002.

Quality of Plan:
The quality of plan developed by a Brigade HQ staff depends upon a variety of factors, some of which are: understanding of the enemy picture, awareness of enemy doctrine and ability to anticipate enemy response options; knowledge of the political, cultural and battlespace environments; and the level of friendly situation awareness, viz cognition of the friendly picture, estimated morale and warfighting capability. Given these factors are constant, the quality of the plan will increase with time available for planning.

Assessment of the quality of an Operational Plan is made by executing the plan (usually after contact with the enemy), and by considering the losses incurred, the number of unanticipated enemy responses, who won the battle, and whether the Commander's Intent was achieved. Winning the battle is not a sole indicator plan quality, viz the success of the plan to retreat from the shores of Gallipoli on Jan 8th 1916 where not a man was lost.

Therefore, the quality of an Operational Plan can be judged by the degree to which the Commander's Intent was achieved. This can be used as a useful summary for estimating the level of quality of an operational plan. (The commander's intent is a formal statement of purpose, method and endstate; usually in the concept of operations or general outline of orders, and provides clear direction on the commander's intentions.)

Measure of Effectiveness (MOE)
Command and Control is an essential component of any military organisation. C2 is discussed, defined, and practiced in every military force in the world and yet its definition can be surrounded by debate. Therefore, there can be a perceived difficulty in establishing measures to demonstrate the level of effectiveness of C2. To clarify this, the MOE of the C2 system under analysis here needs to be defined.[4]

An MOE refers to the effectiveness of a solution, and is independent of any particular solution, i.e. a property that a potential solution must possess in order to meet a need. A Measure Of Performance (MOP) refers to the actual performance of an entity, i.e. what something is capable of doing even if not required by the end users. An MOE is a measure against which we judge how well we achieved what we intended or wanted to achieve.[4]

In the Brigade HQ simulation, it is assumed that on average, the quality of plan produced by a theoretical HQ staff will increase as time provided increases from about 6 hours to 5 days. This may not be true in some cases, but it is the basic premise of this paper that on average it will be true. (In some cases a high quality plan could be achieved in a short time and conversely a poor plan could still result after much planning.) The rate of increase in plan quality will vary throughout this time period, but is not quantified in this work. Consequently the assumption is that on average, given an experienced, capable planning staff, if they are provided more time, they will produce higher quality plans. If six hours is the lower limit in which a useful MAP can be carried out, it is in this regime in which the saving of a short period of time can return a high benefit in planning quality. A time less than 6 hours may be too short for a staff to perform a MAP, and longer than 5 days may well not return any improvement in quality. Hence the (6 hours, 5 days) is a proposed time interval over which the Operational Plan quality will improve – but is not strictly limited to these boundaries.

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[4] *A Systems Approach To Establishing Effectiveness For Command And Control,* N. Sproles, ICCRTS, Canberra, Australia, October 2000.

3. OVERVIEW OF A MILITARY APPRECIATION PROCESS (MAP)

The focus of any planning process should be to develop a timely, flexible, tactically sound, integrated and synchronised plan that increases the likelihood of mission success with the fewest casualties possible. A MAP is a detailed, thorough and time-intensive process used when adequate planning time and sufficient support staff are available to thoroughly examine numerous friendly and enemy Courses Of Action (COA).

Military Appreciation Process Steps

Each of the four steps of the process begins with input derived from the previous step, Figure 2. Each step, in turn, has its own output that drives the remaining steps. These inputs and outputs can be either physical products or levels of conceptual understanding. A MAP commences with the receipt of an Operations Order (OPORD), Fragmentary Order (FRAGO), Warning Order (WNGO) or guidance from higher headquarters. The warning order can be confirmed or refined at the end of mission analysis, and again on completion of a MAP while the final plan is being produced.

Intelligence Preparation of the Battlespace (IPB)

The IPB is a systematic, dynamic process for analysing the enemy and the environment. It is a processing medium through which intelligence staff provide an ongoing assessment of environmental effects on operations and an estimate of enemy capabilities, intent, COAs, centre of gravity (COG) and critical vulnerabilities (CV). The IPB continues throughout the MAP, providing updates at each step[9].

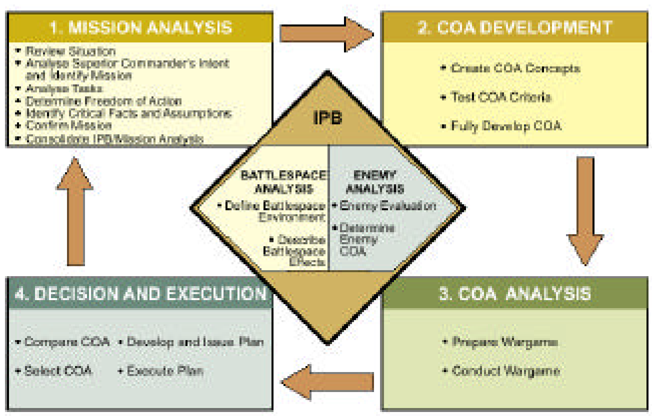

Figure 2: The Military Appreciation Process

Step One: Mission Analysis

The first step of the MAP, mission analysis, is the principal decision-making tool that promotes the application of mission command. It is here that the tasks necessary to fulfil the mission are extracted and deduced from a superior's orders. It places in context what effect has to be achieved in the overall design for operations and enables the commander to assess his assigned tasks and purpose.

Step Two: Course of Action Development

The COA development stage refines the commander's guidance and the broad COA concepts into developed COAs that provide the commander with a range of workable options from which to choose a plan. These are tested against a set of criteria to determine levels of success to be expected[9].

Step Three: Course of Action Analysis

COA analysis examines COAs to identify relative advantages and disadvantages for comparison in the decision and execution stage of the MAP. The method of analysis used is based on a wargame of each COA against the enemy's most likely and most dangerous COAs. Wargaming validates each friendly COA, and determines workability, strengths and vulnerabilities post H-hour (the start of the operation).

Step Four: Decision and Execution

The modified COAs are compared to allow the commander to determine which COA will be developed as the plan. A final warning order is issued and the commander back–briefs his own commander while the plan is produced. Modifications that were made to the selected COA during COA analysis are incorporated into the final staff product.

At the conclusion of mission analysis, the enemy COG and CVs are drawn from the initial IPB and analysed to determine those able to be targeted or influenced by friendly forces. These targetable CVs are then consolidated with the list of essential tasks from mission analysis to determine the decisive events (DE). These DEs provide a focus for the development of own COAs and the remainder of the MAP. At the conclusion of the mission analysis, the commander provides commander's guidance to the staff confirming the mission, intent, DEs, and broad COA concepts based on the DEs in order to achieve his mission.

4. DISCUSSION OF THE CORE MODEL

The CORE® System Engineering tool was used to build an executable model of the Australian Army's Military Appreciation Process at the Brigade level.

The CORE MAP Model

The baseline model captured, in considerable detail, a MAP process in the form of a Functional Flow Block Diagram (FFBD). (See Figures 3, 4 below.)

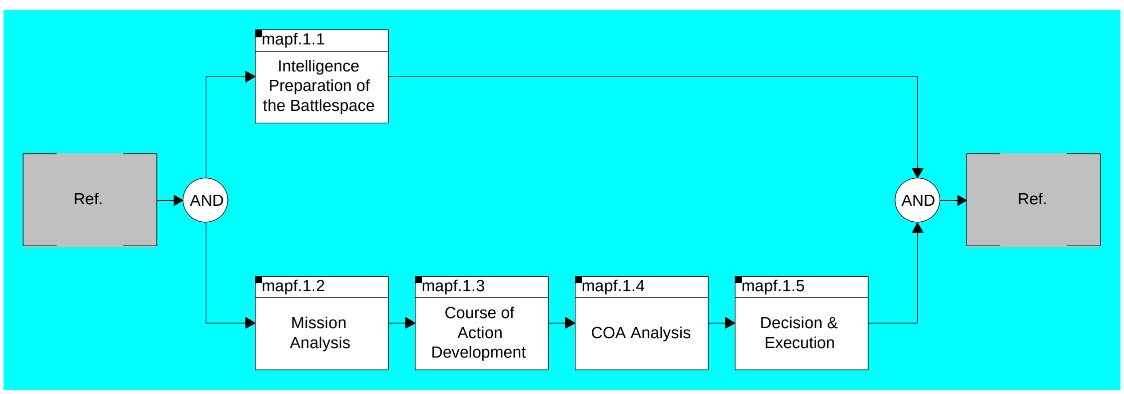

Figure 3: Top level CORE FFBD of a Brigade MAP process

Figure 3 represents a top level Brigade (Bde) MAP process as a series of logically linked functions. The CORE model is hierarchical, and each function can contain sub-functions. (A function that contains sub-functions is represented by the small black square in the top left-hand corner of the function). Functions flow sequentially or in parallel. Parallel flow is represented by an AND construct (Figure 3). The AND construct allows the modelling of separate functional flows that may occur at the same time (the IPB function in Figure 3, for example, occurs in parallel to the rest of a MAP process).

Each function has at least one HQ staff officer allocated to it (representing the component carrying out that function). Each function also has a specific duration, representing the average time it takes to complete it (based on estimates supplied by military personnel).

CORE permits decisions and iterations to be modelled. The OR (logical OR) branch construct allows alternative sequential functional flows, while the loop (LP) construct allows a particular sequence of functions to be repeated (see Figure 4). The decision to enter the OR or LP construct may be determined randomly or, as in our model, by decisions provided by a human user during the execution of the model using the CORESIM tool. Core provides a scripting language that allows user prompts, such as the one shown in Figure 5, to be created.

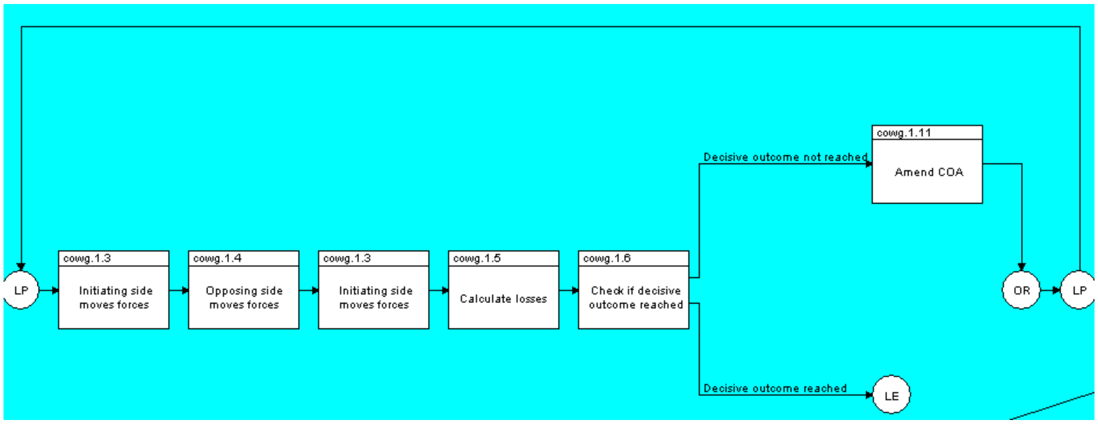

Figure 4: Part of the FFBD from Course of Action Analysis – Conduct the Wargame.

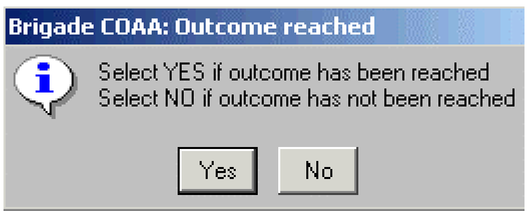

Figure 5: Dialog box that allows the user to control the functional flow of the Model during the Model's execution using CORESIM.

CORE also allows the flow of data items, representing the objects or products produced by a function, to be modelled. These are represented as the light grey rounded rectangles in Figure 6. Data items that must be received by a function before it can start are called triggers, and are shown as green rounded rectangles with double headed arrows in Figure 6.

Each data item is allocated an approximate size. The '*Broad Enemy COAs*' item in Figure 6 was allocated a size of 0.1 megabytes, representing the size of a standard word processing document. The size of a data item determines the time it takes to traverse a link. A link represents the physical connection between two components (ie. between the CSE and DFBHQ) and has a preset capacity. This ability to model the size of data items and the capacity of links means that CORE can determine the time taken to transmit the data item across the link.

Modelling Communications between Staff Elements

To evaluate the effects of the different communication methods required between a CLF and a FLF HQs, it was necessary to extend the baseline model of a MAP to model the communications occurring between staff elements. For example, the *'Combine overlays to produce final MCOO'* function, shown in Figure 6, implicitly includes internal communication between the S3 and the S3 staff. Under the proposed allocation of staff between the CSE and the DFBHQ however, the S3 and the S3 staff will be physically separated. It was therefore necessary to make their communications explicit, by adding the extra functions and data items shown in Figure 6.[5]

The Effect of Limited Communication Bandwidth on the Proposed CSE-DFBHQ Split

The effect of limited bandwidth was measured by comparing the time taken to run the two CORE models using the CORESIM tool. Each model had exactly the same functions and data items (taking the same time to execute and having the same size respectively). The only difference between each model was the physical links used to carry the data items between functions.

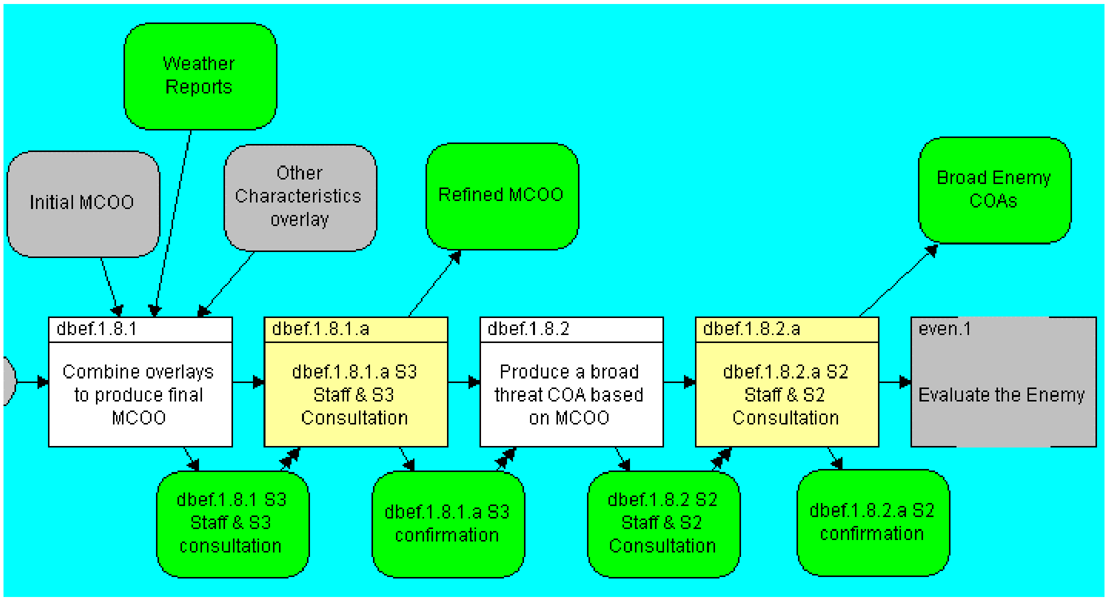

Figure 6: Modelling of communications between Staff elements.

Each data item in a CLF Bde HQ model, was allocated to either an 'internal LAN' link or a 'Face to Face' link (notionally representing the 'bandwidth' available when communicating face to face). The CSE–DFBHQ model allocated the data items to a 'CSE-DFBHQ' link which would provide approximately one fifth the bandwidth of the internal LAN[6].

5. EFFECT OF A FLF DESIGN ON BRIGADE – BATTLEGROUP PLANNING TIMES.

To simulate the effect of a FLF architecture on the planning cycle, a Battle Group MAP was added to both a FLF and CLF models. The BG carries out similar processes in planning as does the Brigade, but with assistance from the Brigade MAP products and a smaller sphere of responsibility, it can do so in less time. Therefore, a BG MAP was represented as a duplicate of a Brigade MAP, with each function's duration reduced by about one third. The BG planning process for a CLF architecture did

[5] If a function involved communication between more than 2 Staff groups, then the size of the data exchanged and the time taken to complete the consultation were increased proportionately.

[6] Data provided by staff in Communications Division, DSTO Edinburgh.

not begin until the Brigade OPORD/OPLAN (Operational Plan) was produced (as per the current process).

In a FLF model however, the BG MAP started when the Brigade published its initial warning order at the end of Mission Analysis. This becomes possible because, under a FLF architecture, all MAP inputs and outputs are digitised so they can be shared across the physically remote HQs, via robust distributed computer systems[7]. Further progress throughout the BG MAP then waits, at various stages, upon the receipt of the Brigade's MAP products: the COAs to be wargamed, the final warning order and the OPORD/OPLAN.

6. RESULTS

Effect of communication link bandwidth on Brigade HQ planning times

The baseline model was extended to model communication flows between staff within the HQ. Two models were developed, with each model only differing in the physical links used to carry the communications, ie. an internal Local Area Network (LAN) for a CLF Brigade, and a Satellite Link for those communications split across the CSE and the DFBHQ.

CORESIM® was used to execute both models. The times taken for each discrete event simulation to run showed that the delay in a MAP and thus the generation of Orders to subordinate Units caused by the smaller communication bandwidth between the CSE and the DFBHQ was insignificant (an increase in time taken of only about 0.16%). Figure 7 below, is a discrete event simulation timeline output diagram (for the top-level functions only) produced by CORESIM after executing a CLF Brigade HQ model. Figure 8 is the equivalent output for a FLF Brigade HQ model.

There is no discernible difference between the two simulation times. If we consider each time unit in the simulation to be a minute, then a CLF Brigade model took about 3 minutes longer than a FLF model. The whole MAP process however took about 28 hours, so a difference of 3 minutes out of 28 hours is clearly insignificant. (See Table 1 for details of the differences across the MAP.)

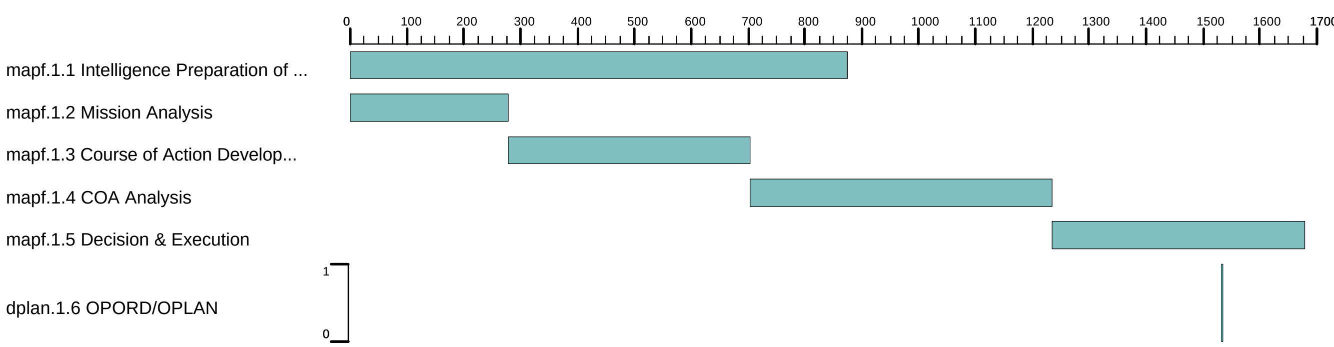

Figure 7: CORESIM Timeline output for a CLF Brigade HQ model

[7] This benefit therefore, does not actually require a FLF HQ. It requires the technology that allows a FLF architecture. This technology may become available in a future CLF HQ. There are however, potential benefits to BG planning arising from a FLF architecture that we have not modelled as yet. One such benefit would arise if BG planning staff were physically part of the CSE deliberate planning process.

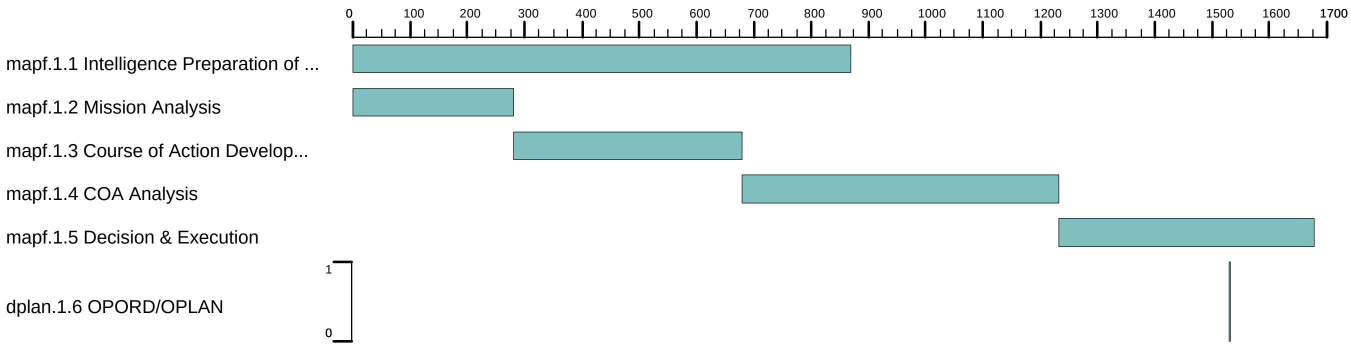

Figure 8: CORESIM Timeline output for a FLF Brigade HQ model

There is one caveat to this conclusion. The result is based on the assumption that the entire bandwidth of the CSE-DFBHQ link is available for a MAP process. There could however, be considerable data transmission delays if all communications between the two HQs occur across this link (particularly during an operation). The process modelled represents a deliberate MAP that occurs before an operation begins, and consequently data contention may not be a significant issue at this time.

This work does not address the issue of the difference in the quality of the communication process between the two models such as the effectiveness of face-to-face conversation compared with a video conference; nor does it attempt to establish the optimal allocation of staffing resources between the CSE and the DFBHQ.

Combined Brigade - Battle Group HQ planning times

A discrete event simulation timeline output diagram for the combined Bde-BG planning process based on a CLF Bde HQ is shown in Figure 9 below (with the Brigade and BG planning processes shown at a high level with triggers). In this scenario the BG planning process does not start until the Brigade's OPORD is received.

The timeline diagram for the combined Bde-BG planning process for a FLF HQ is shown in Figure 10 below. In this scenario BG planning begins as soon as the CSE planning staff finish Mission Analysis and produce the initial WNGO.

A comparison of the two scenarios shows that, in Figure 9, the BG planning process starts 2.5 times later, and finishes 1.3 times later. The benefit becomes less during the process because a FLF BG must wait for subsequent CSE planning products (such as the COAs to be wargamed). (See Table 2, for details of the differences across the MAP.)

This is an average significant improvement of 30% in planning cycle times. Assuming the simulation time unit equates to 1 minute, then a FLF planning scenario would save 14 hours (45 hrs total planning time for Figure 9, as against 34 hours for Figure 10).

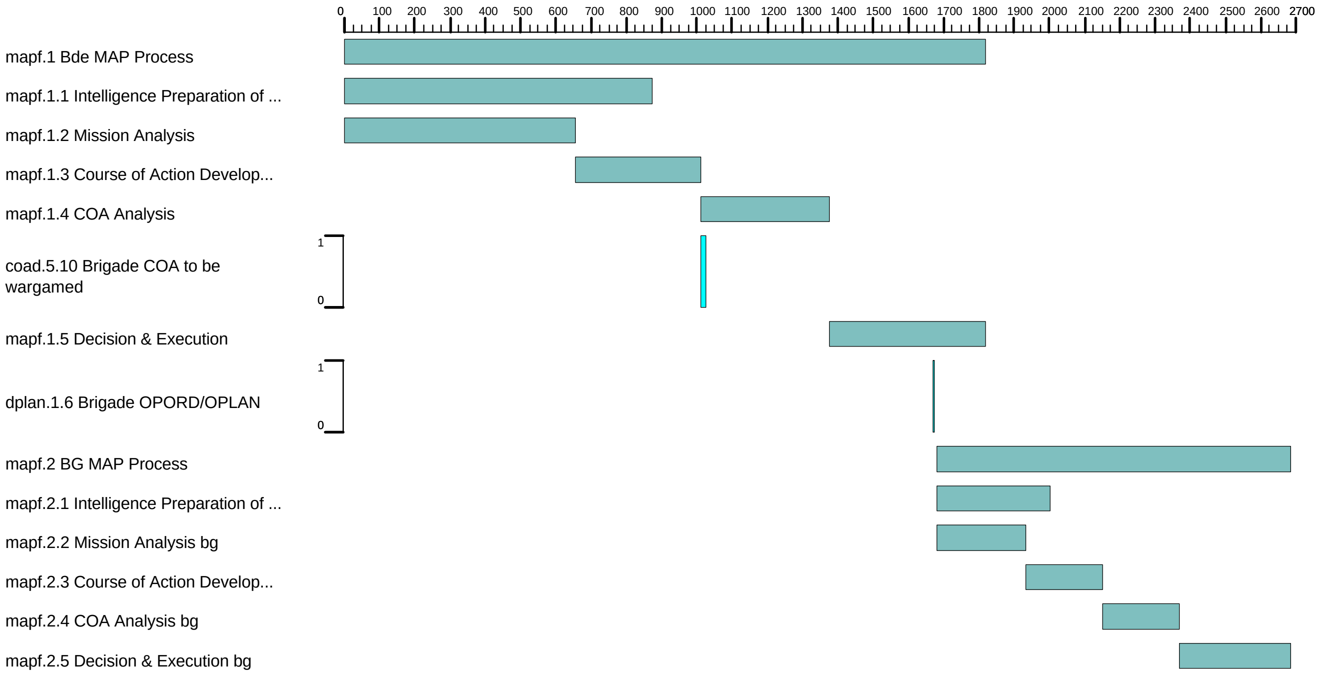

Figure 9: Bde–BG planning times based on Bde OPORD trigger for a CLF Brigade HQ

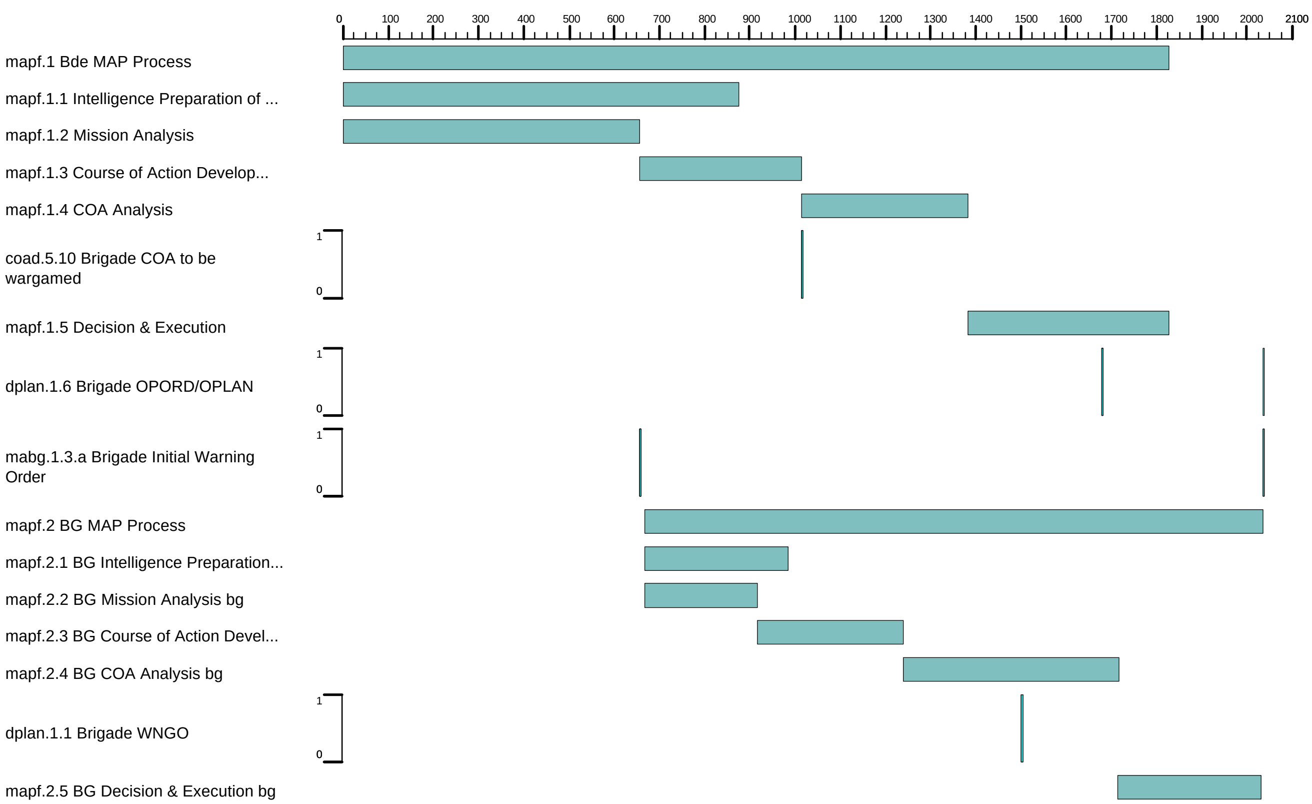

Figure 10: Bde–BG planning times based on a Bde initial WNGO trigger for a FLF Design, including the CSE and BG planning processes with triggers

7. DISCUSSION CONCERNING THE USE OF CORE

CORE has proved to be an excellent tool for modelling the functional flow of the Australian Army's military appreciation process. Its ability to capture and trace originating requirements to functional and physical system elements and to enable the mapping of the logical functional structure onto a physical architecture via links was extremely useful. The CORESIM functionality enabled quantitative measures to be obtained and the simulation tool was a useful way to develop a model with alternative functional flows depending on parameters entered at defined points in the simulation. CORE facilitates a systems engineering analysis of a complex dynamic system and enables the systems architects to perform what-if analyses to rapidly scope out and verify the behaviour of the alternative functional architectures to meet the originating requirements.

CORE is based on a traditional hard-systems engineering philosophy. If the human and decision making aspects of socio-technical systems are to be analysed more closely than the business process issues, then a soft-systems framework should be applied. In this work, the business process and its timeliness were the predominant issues, making CORE and CORESIM appropriate analysis tools.

Improvements Required in using CORE

There are however, a number of significant research needs that the CORE tool cannot easily meet:

1. Firstly, it is primarily a Systems Engineering tool designed to develop one architectural solution to a set of user requirements. It becomes time and resource intensive to use the tool to develop alternative architectures for comparative purposes. This is especially the case when the model becomes large and complex (in this work, a CLF baseline MAP model had 273 functions, and a FLF Brigade HQ staff communication model had twice as many).

2. While CORE can model alternate functional flows, it cannot change from parallel to sequential flows according to resource availability. The model developed here for example, assumes that staff are available to carry out the tasks that can be run in parallel. There is no way to dynamically change the model from parallel to sequential if staffing shortages occur. Making these changes manually is a resource intensive task. Other tools will need to be used to model dynamic changes to staffing allocations. A Petri Net model is currently being developed in LOD to dynamically model the staff activities in a Brigade HQ with various staff allocations assigned per activity. This model will reveal gaps and inconsistencies in allocation of staff resources.

3. CORE does not provide the ability for a conditional branching '*goto*' outside of an iterative loop construct which is needed when there is a requirement to initiate flow control outside of the current functionally decomposed system segment.

4. There are also problems when using triggers to initiate a function that logically precedes the function generating the trigger. This can cause a trigger control deadlock that causes CORESIM to crash.

5. There are a number of technical difficulties with the CORESIM product. In particular, data item triggers can be 'lost' if the link they are attempting to pass down is occupied. There is also a bug in the timeline display that prevents the use of 'large' data item sizes (say 128 kilobytes instead of 0.128 megabytes). While these problems can be worked around (by making the link's capacity equate to bytes per minute rather than bytes per second, for example) it does restrict the accuracy of the simulation, particularly where data contention becomes a significant contributor to time delays.

FURTHER WORK

It is hoped that analysing the products of a MAP will be carried out to further elucidate the priorities of the process (rather than highlighting functions, which exist to generate the products). For example the IPB process produces a lot of products, as seen below in Figure 11. The analysis of the products would then trace through the production and use of these products throughout operational planning.

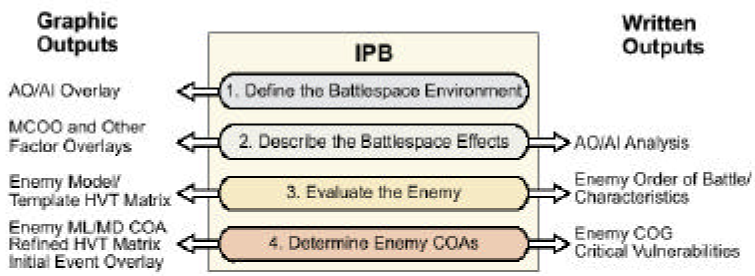

Figure 11: Diagram of Intelligence Preparation of the Battlespace Process and Outputs

8. CONCLUSION

It has been shown using the CORE systems engineering simulation tool that, on average, a FLF design will be able to carry out the Bde–BG MAP planning cycle 30% quicker than a current CLF Bde–BG HQ design. This implies that on average a FLF design will achieve the same quality plan 30% more quickly than the normal configuration. The difference produced by the varying communication bearer was shown not to be significant over the time of the planning process.

Decision Point:	Sup Comd's Intent Clear?	Change AO?	Accept Mission Analysis?	Discard COA	Develop more COA	Number of Coa's to develop	Outcome reached?	End state reached?	Comd accepts COA?	Comd Accepts Plan?	End MAP
Brigade only	52.02	75.01	192.02	793.76	980.26	994.29	1284.55	1294.55	1458.72	1655.12	1824.37
CSE-DFBHQ	52.04	75.02	189.4	796.48	982.85	996.89	1287.81	1297.81	1462.77	1658.74	1828.99
Cumulative difference	-0.02	-0.01	2.62	-2.72	-2.59	-2.6	-3.26	-3.26	-4.05	-3.62	-4.62
Times longer (FLF / CLF)	1.0004	1.0001	0.9864	1.0034	1.0026	1.0026	1.0025	1.0025	1.0028	1.0022	**1.0025**

Table 1: Comparison of Brigade only and CSE-DFBHQ CORE Simulation times at each decision point during the MAP

Decision Point:	Sup Comd's Intent Clear?	Change AO?	Accept Mission Analysis?	Discard COA	Develop more COA	Number of Coa's to develop	Outcome reached?	End state reached?	Comd accepts COA?	Comd Accepts Plan?	End MAP
BG MAP (CLF)	1701.57	1712.57	1748.58	2005.69	2126.47	2133.49	2305.37	2308.37	2427.54	2565.05	2686.32
BG MAP (CSE-DFBHQ)	684.32	695.32	731.33	1082.41	1205.87	1213.87	1648.85	1651.85	1771.01	1909.01	2030.3
Cumulative difference	1017.25	1017.25	1017.25	923.28	920.6	919.62	656.52	656.52	656.53	656.04	656.02
Times longer (CLF / FLF)	2.5	2.5	2.4	1.9	1.8	1.8	1.4	1.4	1.4	1.3	**1.3**

Table 2: Comparison of BG (CLF Brigade HQ) and (CSE-DFBHQ HQ) CORE Simulation times at each decision point during the MAP