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Assessment of a Model-based Organizational Design Methodology in Bridge to Global '99[1]

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Abstract

This paper presents the application of our model-based laboratory-validated organizational design methodology to synthesizing Joint Task Force (JTF) C2 architectures for the operational war

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game “Bridge to Global '99”. It illustrates the process of deriving an “optimal” organization and instantiating the candidate scenarios and resultant organizational design(s) in the MAGTAF Tactical Warfare Simulator (MTWS). The “Bridge to Global '99” project sets the stage for the application, testing, and refinement of the A2C2 organizational design methodologies in realistic settings with operational experts, while signifying the value of model-based experimentation as a precursor to large-scale war games. The corresponding modeling and design effort, illustrated in this paper, represents an important step toward the ultimate transition of relevant research findings and technology for organizational design to the operational community.

1. **Introduction**

1.1 ***A Historic Overview and Motivation***

The Adaptive Architectures for Command and Control (A2C2) research project is a multi-disciplinary effort sponsored by the Office of Naval Research. The project’s aim is to establish a body of knowledge in current and future joint command and control, and to develop and test theories of adaptive C2 architectures. A guiding principle of the A2C2 research is that a practical knowledge of the mission-driven interactions among three key architectural dimensions of the organization, i.e., a task structure (“who does what”), a resource/asset structure (“who controls what”), and an organizational/command structure (“who reports to whom”), is a prerequisite to designing organizations with superior performance. Over the past several years a detailed and formal analytical organizational design methodology has been developed to first model/decompose the mission using a graph-theoretic construct, and then to “optimally” allocate tasks and assets to decision-making nodes in the organization following a multi-step iterative algorithmic design procedure [Levchuk et al. 1996, 1997, 1998]. This design process has been tested and refined through a concomitant series of laboratory-based, team-in-the-loop, experiments conducted at the Naval Postgraduate School. The environment used to conduct the real-time experiments was the Dynamic Distributed Decision-making (DDD) simulator [Kleinman et al., 1996], a basic research tool that enables empirical control over task, resource, and organizational parameters in a laboratory setting.

A general objective of DoD-sponsored basic research is to ultimately transition innovative findings and technology applicable to designing superior organizations to the operational community. This process often takes years, and is hampered by the gulf that exists between research and practice. However, in early 1999 a unique opportunity arose. Commander, Carrier Group One (CCG-1) asked the ONR/A2C2 program to provide CCG-1 and MCCDC staff with training and exposure to alternative Joint Task Force (JTF) C2 architectures in preparation for their participation in the Global '99 War game. The ensuing project that emerged was termed “Bridge to Global '99”. Among its objectives was to transition promising current and future A2C2 concepts to the fleet, with emphasis on Network-Centric Warfare (NCW), and to demonstrate the value of model-based experimentation as a precursor to large-scale war games. A key piece of this activity involved the application, testing and refinement of the A2C2 organizational design methodology in realistic settings with operational experts. In June 1999, at the Naval Postgraduate School, officers from CCG-1, MCCDC and elsewhere participated in a series of laboratory experiments, seminars and discussions, one objective of which was to test and evaluate the A2C2-designed architectures.

1.2 ***Resolving Challenges in Modeling Global '99***

The Global '99 mission and scenario presented several orders of magnitude increase in the complexity over the types of missions that had been previously modeled in A2C2 experiments, and for which the optimized (JTF) C2 organizations were designed. Moreover, the operational setting did not immediately lend itself to the degree of specificity offered by the representational paradigm in the DDD, from which our modeling methodology has originated. Thus, the following challenges were faced in applying a design methodology to the Global '99 mission:

(1) Reducing the scope and scale of the problem to one that was manageable for both modeling and simulation at NPS,

(2) Selecting one or two vignettes (or time slices) as scenarios that present "rich" candidates for modeling,

(3) Applying the organizational design procedure to derive an “optimal” organization, and

(4) Instantiating the candidate scenarios and resultant organizational design(s) in a gaming simulator at NPS that would offer more operational “realism” to participants than does the DDD. The simulator selected for this effort was the MAGTAF Tactical Warfare Simulator (MTWS).

While focusing on the *application* of the model-based organizational design methodology to the operational war game, as envisioned in Global '99, this paper illustrates the process of selecting and modeling the corresponding example mission scenarios and the process of designing the concomitant organizations to optimize *predicted* team performance. Comments on the efficacy of the organizational design, as elicited in after-action reviews from the war-fighters who participated in the BTG activity, as well as other data and results, covering additional aspects from BTG, will be addressed in a companion paper.

Some of the issues related to applying our organizational design process to designing the optimized organization(s) that are amplified in this paper include the following. A prerequisite to the application of the A2C2 design methodology is to define the *assets* (type and number) that are available to the organization, and to list the *tasks* that these assets are likely to be applied against. The latter is obtained via a functional or task decomposition of the mission [Levchuk et al. 1998]. For example, in an overarching mission of breaking an enemy’s area denial (one of the vignettes examined in BTG'99), some of the tasks are: establishing ISR over the area, establishing air superiority (with an attendant list of sub-tasks), clearing enemy subs, clearing enemy SAGs, etc. The precedence by which these tasks and subtasks are envisioned to be conducted in time can be modeled via a “precedence task graph” that represents a mission plan. The assets are the blue forces order of battle, described to a level commensurate with the level of task decomposition.

The first step in the organizational design algorithm is to associate to each task the "minimal" set of assets, termed an asset “package”, that will assure successful completion of the task. Each package so constructed is devised with an “economy of force” (e.g., over two sets of assets that can complete a given task, the algorithm picks up the one that contains the smallest number of assets and/or has less of its combined capability not utilized, or "idle", while completing the task). In general, there are several different asset packages that can be used to successfully complete a given task. In order to determine these asset packages, the DDD-based formalism associates with each task a numerical set/vector of *requirements* and to each asset a set of *capabilities* (see [Levchuk et al. 1997] for details). The algorithms match task requirements with asset capabilities, thereby constructing all feasible asset packages - on a task-by-task basis. (Subsequent steps in the design procedure determine which asset package is “best” to use and which decision-making node/nodes should control each asset). When we approached the modeling of the missions/vignettes selected for BTG'99, a similar formalism, to guide the selection of asset packages, did not exist.

We approached this challenge in two different ways. For the first mission scenario we worked closely with staff at CCG-1 (and NWC) to mimic the DDD formalism. We first defined the elements for a vector of asset capabilities and task requirements as: [C2, strike, fires, AAW, BMD, CMD, AsuW, USW, MIW, ISR, BDA]. The ISR element was further refined into air, surface and ground components. Next, for *each* asset numerical values were assigned for each of the elements in the vector, thereby giving to each asset a vector of capabilities. For example, a DD-21 was assigned values [1,8,250,2,0,2,0,0,0, …]. Next, for each task numerical values were assigned for the task requirements. For example, the task of “AEW of area A” was assigned requirements C2=5, AAW=5, ISR=5. Going through this process for all assets and all tasks was labor intensive, but beneficial with respect to follow-on steps in the modeling process.

The second approach, utilized for the second mission scenario (land counter-attack), followed a different path. Here we interacted with war-fighters at MCCDC to *directly* specify the asset package(s) they would employ against each of the tasks in the mission decomposition. While straightforward, this approach gives fewer degrees of freedom to the subsequent design. Moreover, additional constraints were placed on the design by MCCDC such as the desire to assign all the Marine assets in the MEF to a single decision-making node.

The organizations that emerged from the design process were constrained a priori to have four nodes. In the first scenario a two-level design was produced that included a CJTF node and sub-nodes that were effectively subordinate JTFs. For the second scenario, a three-level design emerged that reflected a supporting-supported relationship between two of the subordinate JTFs. The paper will detail these organizations, and how they were constructed via the design process.

2. **Modeling Global '99: An Overview of Design Process**

This section overviews the C2 architecture design process, along with candidate organization designs, for the Global 99 mission that was provided to the A2C2 modeling team. The analytical design approach has been developed and refined by researchers at the University of Connecticut, Aptima, Inc., and the Naval Postgraduate School over the past 3-4 years. More detailed information on the general design process may be found in the Proceedings of the CCRT Symposium for years 1996-1999.

2.1 ***Primary Design Objective***

The *primary* organizational design objective is to maximize achievable tempo of operations. This is accomplished by focusing on a number of sub-objectives that include maximizing parallel task processing, reducing coordination/communication related delays, optimally allocating assets and responsibilities to individual nodes/decision-makers (DMs), and balancing workload distribution among nodes/DMs. The design criteria are thus multidimensional, and include a number of factors that either directly or indirectly affect organizational performance and processes. The algorithmic design process consists of five major steps (see section 5 for discussion) that are iterative in nature. The overall process is shown in Figure 1, with the outputs of each step in the process shown on the left. Note that for purposes of discussion in this section, a "DM" is considered as the surrogate for the information processing and decision-making element within an individual organizational node. Although we recognize that any given node is likely to be composed of a number of people who make decisions and act collectively.

2.2 *Design Input Requirements*

The input provided for the design process was as follows:

(a) <u>Available Operational Assets</u>, i.e., a list of available forces or *assets* with which to conduct the mission.

Specifically, in the current experiment, the Phase 1 design considered Blue forces that would be available in Theater by 10 days. The Phase 2 design considered Blue forces that would be in Theater by 45 days. By example, a partial list of Phase 1 (Blue) forces included:

- Naval Forces: 2 CVN/x, 4 CG , 4 DDG, 5 SSN, 36 P3C, 2 MCM, 4 MH-53, 1 DD21;
- ISR Assets: 4 AWACS, 2 JSTARS, 2 U-2, 2 UAV, 2 RC-135;
- Marine Forces: 1 MEU/SOC (embarked), 1 MEF (forward deployed in Green);
- Air Forces: 2 AEF.

(b) <u>Operational Tasks</u>, i.e., a list of individual *tasks* – either specified or implied – that must be accomplished to perform the overall mission. For example, the overall mission in Phase 1 is to break Red's area denial. As this mission is decomposed further, *some* of the tasks relevant for its completion include:

- Negating Red subs operating in the SOG;
- Providing TAMD of Blue forces;
- Providing AEW of SOG;
- Clearing mines in straits/choke points;
- Conducting strikes vs. Red airbases

(c) <u>A Task (Precedence) Graph</u> to provide an illustration of the precedence and cause-effect dependencies among tasks, as well as (expectations for) a time requirement estimate for the completion of each task. In addition to defining task prerequisites, the *Task Graph* specifies which tasks can be processed in parallel. Typically the Task Graph represents the way in which a commander (or a planning cell) would plan to accomplish the mission, subject to his/her available assets – it is a "road map". An example of a partial Task Graph, relevant to the mission activities in the SOG area for Phase 1, is shown in Fig.1.

When there is a need to continue processing a task past the beginning of its "successor" tasks (as, for example, with AEW tasks), we indicate that by drawing the cause-effect relationship arrow from the inner portion of the task node, rather than from its end-edge-portion.

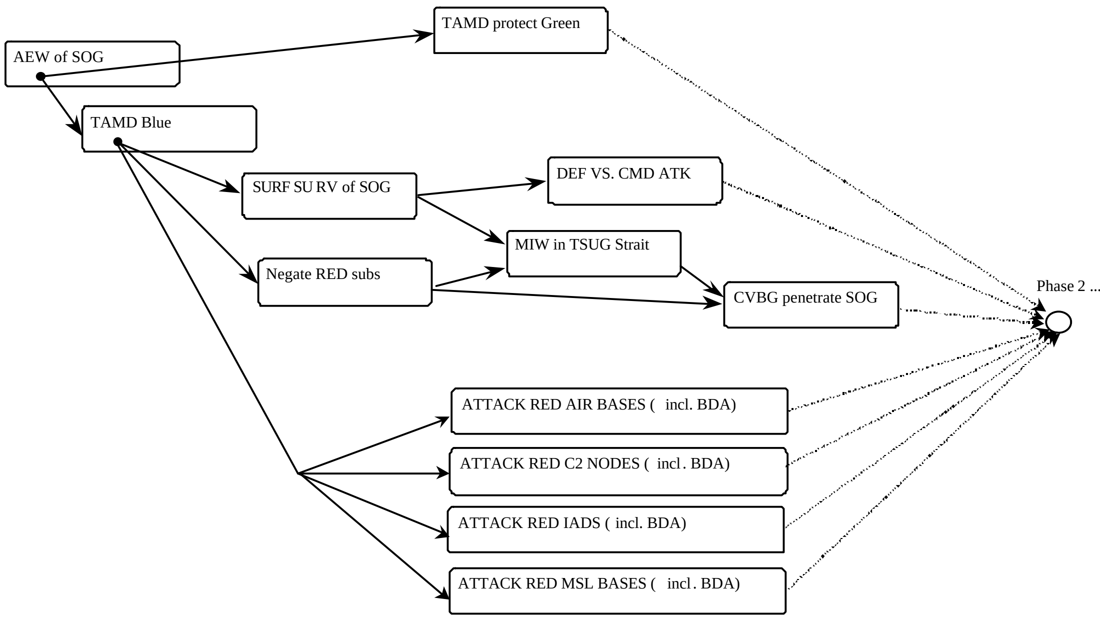

Fig. 1: A portion of the Mission Task Graph (Corresponding to Area A, Phase 1)

(d) The assets required to accomplish each task: For each of the tasks defined in (b) and listed on the Task Graph, we specify a subset of the assets listed in (a) needed to accomplish the task with some acceptable confidence (e.g., with 95% probability). A set of assets that will accomplish the task is called a *Force Package*. Often, there is more than one feasible Force Package per task indicative of alternative ways to accomplish that task. For each task, the organizational design approach requires as input a listing of these alternative ways of task processing. There are two ways for obtaining these asset sets.

Method A: This approach enumerates/lists Force Packages *directly* on a task-by-task basis, generally via knowledge elicitation from a Subject Matter Expert (SME). The organizational design modeling for Phase 2 used this approach, with help from MCCTC.

Method B: An alternative to specifying asset packages is to specify asset *resource capabilities* and corresponding task *resource requirements* both with reference to a common set of attributes relevant to the problem at hand. This was the modeling approach followed in Phase 1. Working with CCG-1, the set of attributes was selected as:

A = [C2, STRIKE, FIRES, AAW, BMD, CMD, AsuW, USW(O), USW(CP), MIW(O), MIW(CP), ISR(Air), ISR(Surf), ISR(Gnd), BDA].

The requirements of each task were expressed in terms of the amount of STRIKE, ISR, etc. presumed needed for its successful completion. For example, several of the tasks for Phase 1 along with their resource requirements vector are given in Table 1.

T Req	TASKS	C2	Strike	Fires	AAW	BMD	CMD	ASuW	USW (O)	USW (CP)	MIW (O)	MIW (CP)	ISR (Air)	ISR (Surf)	ISR (Gnd)	BDA
5 D	NEGATE RED SUBS	2							10	5						
CONT	TAMD Protect GRN	5			10	10	10									
CONT	AEW OF SOG	5			5								5			
10 D	MIW in TSUG Strait	2										5				
24 HR	CVBG penetrate SOG	5			10		10	5					5	5		
30 D	DEF VS. CMD ATK	2					10							5		
15 D	SURF SURV OF SOG	2												5		
30 D	Attack Red air bases	2	5													3
45 D	Attack Red C2 nodes	2	6													5
45 D	ATTACK RED IADS	2	8													5

Table 1: An Example of Task Resource Requirements (Phase 1, Area A)

Similarly, for each asset a set of numerical resource capabilities was assigned. An example showing several of the Naval assets is given in Table 2.

ASSET	C2	Strike	Fires	AAW	BMD	CMD	ASuW	USW (O)	USW (CP)	MIW (O)	MIW (CP)	ISR (Air)	ISR (Surf)	ISR (Gnd)	BDA
CG	2	5	100	8	7	6	4	4	3	1	3	6	4		
DD-21	1	8	250	2		2				1	3	2	3		
DDG	2	5	100	8	7	6	4	4	3	1	3	6	4		
SSN		3					5	7	4	1	3	1	3	1	
P3 (6)							6	4	2				6		3
MCM										2	4				
MH-53										1	4				

Table 2: An Example of Asset Resource Capabilities

Having asset capabilities and task requirements described using a common set of attributes allows one to *construct* assets force packages that have – on an attribute-by-attribute basis – capabilities that meet or exceed the task requirements. Some of these packages may be infeasible due to constraints not modeled and must be removed as candidates. On the other hand, some of these packages may indeed represent novel ways to accomplish the task – ways that might not have been considered by following the approach of Method A. For the example of the selected Phase 1 tasks as shown in Table 1, the following Force Packages are generated (Table 3).

As a by-product, modeling the asset-to-task relationships via resource

TASKS area A	options 1	options 2	options 3
NEGATE RED SUBS	2P3+DDG	SSN+P3+CG or DDG	2SSN+CG or DDG
TAMD Protect GREEN	2 of {CG,DDG,PAC-3}+AWACS or RJ		
AEW OF SOG	AWACS+CAP	CG+AEF	DDG+AEF
MIW IN TSUG STR	2 of {MCM, MH-53}+DDG or CG	MCM+CG or DDG or CVN	MH-53+CG or DDG or CVN
CVBG Penetrate SOG	CVN+DD21+CG or DDG	CVN+CG+DDG	CVN+2CG
DEF vs CM Attack	2 of {CG,DDG}		
Survellance SOG	P3+AWACS or CG or DDG or RJ	CVN	2 of {GC,DDG}+AWACS
Attack Red air bases	CVN	AEF	DD21+RJ+(UAV or U2)
Attack Red C2 nodes	CVN	AEF+UAV	DD21+UAV+RJ
ATTACK RED IADS	DD21+UAV+RJ	CVN	

Table 3: An Example of Candidate Force Packages (Phase 1, Area A)

capabilities/requirements allows one to evaluate/envision the aggregated capabilities of individual nodes (and, consequently, all those tasks that a node/DM has the capability to do in addition to its assigned responsibility scope). Hence, one can evaluate a node's/DM's back-up capabilities.

One way of evaluating the adequacy of a design is to compare the DM-to-task allocation roles versus the resource-induced DM's capabilities, and to evaluate whether these capabilities allow the DM to carry out his/her assigned role(s).

2.3 *Achieving Design Objectives: Facilitating Parallel Task Processing and Reducing Task Processing Delays*

Some of the issues (relevant to the assignment of assets to tasks and to subsequent assignment of assets to DMs) that are addressed in the algorithmic design process are as follows:

2.3.1 *Allocation of different tasks to the same asset (or same asset packages), unable to process these tasks in parallel*, results in a sequential processing of the corresponding tasks. Therefore, whenever possible, the parallel tasks must be assigned to different assets (asset packages).

2.3.2 *Allocation of different tasks to the same DM in excess of DM's parallel task processing capabilities (or, equivalently, in excess of his instantaneous workload threshold)* results in sequential scheduling and processing (by the DM) of the tasks that can otherwise be processed in parallel. Therefore, whenever possible, the task-processing load should be evenly distributed among DMs (in order to balance the instantaneous DMs' workload, or, equivalently, to minimize the maximal instantaneous DM's workload).

2.3.3 Coordination delays, incurred due to communication channels' capacity limitations (and ensuing queuing of information messages through the channel), result in delaying of those tasks whose processing is contingent

required inter-DM communication. Secondly, whenever possible, the parallel tasks must be assigned to different DMs, to reduce the inter-DM coordination on task synchronization.

2.3.4 For some tasks, the processing time is contingent on the allocated amount of resources. Therefore, a sufficient amount of resources must be allocated to process critical tasks (i.e., those tasks that have several out-coming paths in the mission task graph) in order to reduce their processing time and, consequently, to accelerate the mission.

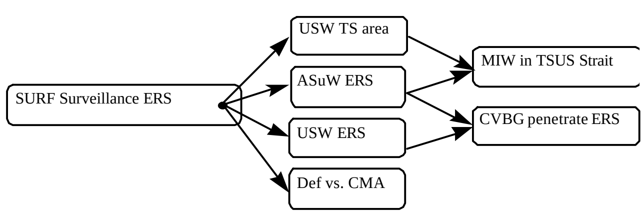

Fig. 2: Example of Critical and Parallel Tasks

In the above example (Fig. 2), Surf Surveillance ERS is a "critical" task (there are a large number of outgoing paths in a task graph. USW TS area, ASuW ERS, USW ERS, Def vs. CM Attack are "parallel" tasks (and should be assigned to non-overlapping resource packages, wherever possible).

2.4 ***Task Variables***

In order to evaluate the decision-making and information processing workload on each DM, and to estimate/minimize required inter-DM coordination, we decompose each task into four group of variables: (i) *information variables*; (ii) *decision variables*; (iii) *action variables* (otherwise called *operations variables*); and (iv) *outcome variables*. The composition of these variables delineates the associated decision-making and operational workload. In addition, the functional interdependencies among the task variables specify the *cause-effect information flow* among the mission tasks, stipulating the dynamics of the mission processing (the constructed information flow diagram provides an input into our design procedure).

An example of the cause and effect relationships among variables pertinent to a USW task is shown in Fig.3. This figure shows information requirements, the decision points, operations, and outcomes variables. It gives a finer breakdown of activities/requirements within a task for refining workload and time estimates – relative weights can be added to the activities as well. Thus, the development of such a diagram is not a specific requirement in the initial organizational design process, but serves to refine (through modeling) the workload imposed on the DM by the task.

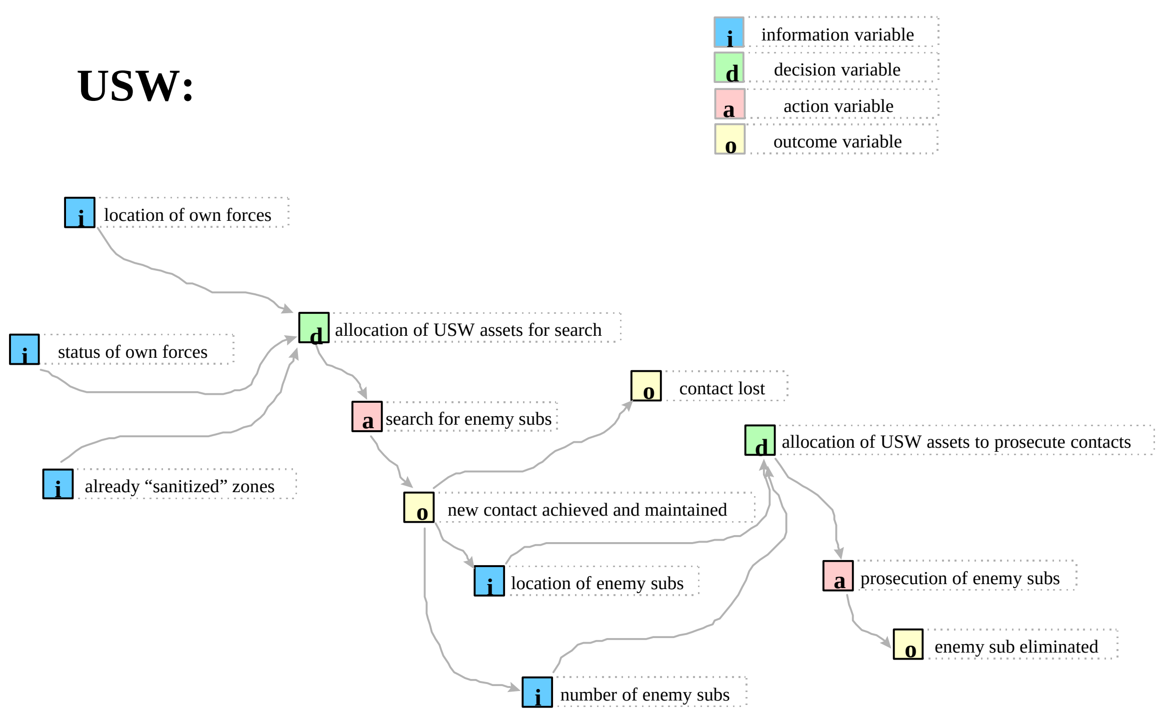

Fig. 3: Cause-effect relationships among USW Task variables

2.5 ***Overview of the Design Process***

The design procedure allows for integration of various algorithms that optimize mission schedule, resource allocation, information management and communication, coordination delays, decision-making workload, and so on. In this section, we describe our iterative five-phase organizational design algorithm, shown in Fig.4.

Phase I. Task-Resource Allocation/scheduling. The first phase of the algorithm determines the task-resource allocation and task sequencing that optimize mission objectives, taking into account task precedence constraints and synchronization delays, task resource requirements, resource capabilities, as well as geographical and other task transition constraints. The generated task-resource allocation specifies the workload per unit resource. In addition, for every mission task, the first phase of the algorithm determines a set of non-redundant resource packages capable of jointly processing a task. Alternatively, *our algorithm can use specified resource packages to process mission tasks as an input.* The information about resource packages is later used for iterative refinement of the design, and, if necessary, for on-line strategy adjustments.

Phase II. DM-Resource-Task Allocation. The second phase of the algorithm combines resources into non-intersecting groups, to match the operational expertise and workload threshold constraints on available DMs, and assigns each group to an individual DM to define the DM-resource allocation. Thus, the second phase delineates the DM-task-resource allocation schedule and, consequently, the individual operational workload of each DM.

Phase III. DM-Functionality (Roles) Allocation. The third phase of the algorithm designates information processing and decision-making functionalities among DMs (to expedite DM-task-resource schedule, defined in

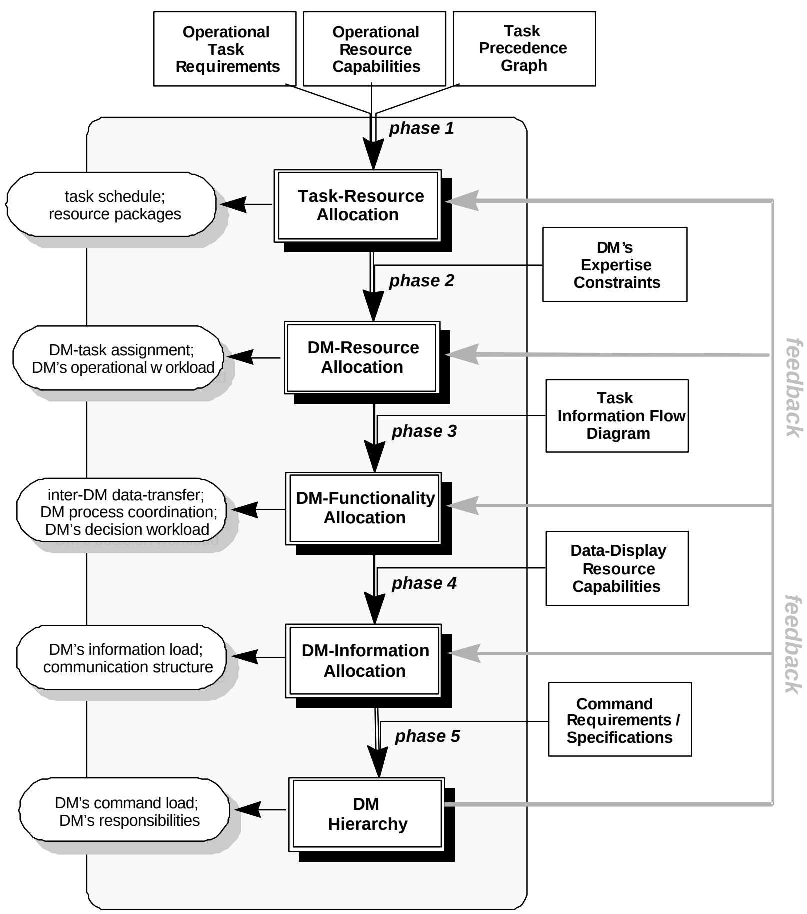

Fig. 4: Five Step Organizational Design Process

Phase 2) by allocating appropriate information task variables to DMs. In this phase, the decision-making workload of each DM is balanced to match the corresponding expertise and workload threshold constraints, and minimal required inter-DM coordination is estimated (based on cause-effect relationship among the information/decision/ action/outcome variables of various tasks). In addition, the roles / functionalities of DMs throughout the mission are specified, based on DM-task and DM-information allocation.

Phase IV. This phase of the algorithm defines the information access structure and communication structure among DMs by allocating sensor displays and data links to DMs according to the information requirements at each DM node (established in Phase III), information access constraints and displays and data links availability. It optimizes the information load of each DM, as well as communication among DMs.

Phase V. Finally, Phase V of the algorithm completes the organizational structure by specifying a DM command hierarchy to optimize the responsibility distribution and inter-DM control coordination, as well as to balance the control workload among DMs according to expertise constraints on DMs.

Each phase of the algorithm provides, if necessary, feedback to the previous stages to iteratively modify the task-resource and DM-resource allocation, as well as the information access and communication structures among DMs. The following sections present the organizational designs that resulted from applying the above procedure to the missions of Phase 1 and 2, as described in the Mission Game Book.

3. **Optimized Organizational Design for Phase 1**

The design results for Phase 1 (Breaking of Area Denial) are shown below. The design was carried out using Method B (numerical capabilities-to-requirements matches) for developing feasible asset/force packages for each task. The design assumes a four-node architecture, as per specifications in the Game Book. Although the design approach can construct "optimal"

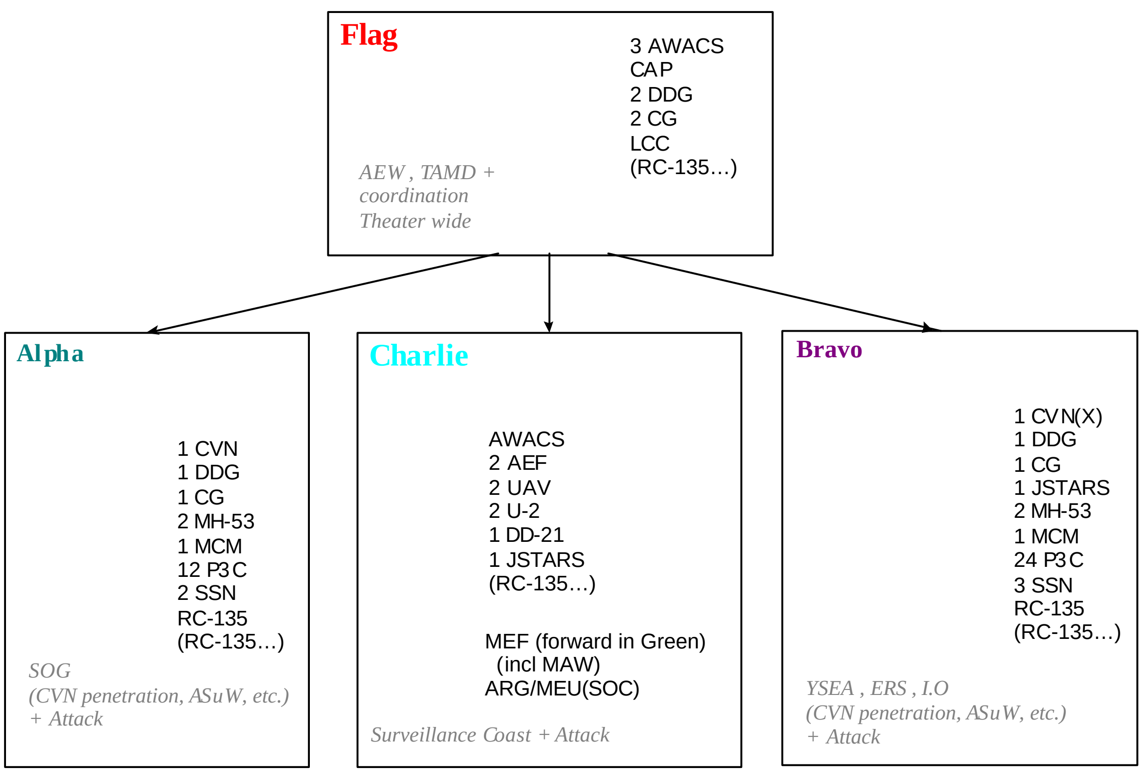

Fig. 5: C2 Architecture for Phase 1

organizations of different size, the number of nodes is assumed to be an input to the process.

3.1 ***Phase 1: Design rationale***

The design rationale involved a trade-off between balancing load and minimizing inter-DM coordination. After stipulating a number of different asset packages that can process each task, the design process begins by identifying the mission segments that are to be assigned to individual nodes in order to minimize the inter-nodal coordination. This is achieved by decomposing the mission into a set of mission segments, with all inter-related tasks that belong to the same mission segment being assigned to a single node. Next, the tasks are grouped according to their overlapping asset requirements and the inter-task information flow. The task groupings and the corresponding asset allocations define the geographic/functional responsibility of each node, as well as the node's workload. The *geographical* responsibility/scope for the four nodes in the organization, as generated by this design process, is: (i) global scope; (ii) Sea of Green (SOG), (iii) ERS/YSEA; (iv) Coastal/In-land area around Brown (including Coastal/In-land Red area). The primary *functional* responsibilities of the four nodes in the organization are: (i) AEW, TMD, and Theater-wide coordination; (ii and iii) ASuW, ASW, CVN Penetration and Attack; and (iv) Coastal surveillance and Attack coordination. The organizational design process reflects the symmetry of the mission structure that is carried over when defining the emerging roles and responsibilities of nodes in the organization.

The assets and concomitant responsibilities for each cell/node are detailed below.

3.2 ***Phase 1 Design: Assets, Roles and Responsibilities***

3.2.I. 'FLAG' Cell

<u>Assets:</u>

3 AWACS
CAP
2 DDG
2 CG
LCC
(RC-135… as available) – see NOTE

For some assets, there were no specifications as to quantity in the Game Book. For such assets, it is left to the command team to determine how many of these assets each node will obtain (notation: ASSET…, e.g. AWACS…).

<u>Roles & Responsibilities</u>: Flag's basic scope in Phase 1 is a "Theater-wide global action" (including AEW and TAMD, as well as coordination of his subordinate DMs)

Flag assumes a leading role in organizing / managing / completing the following tasks:

- AEW Theater-wide (SOG, ERS, and island O);

- TAMD Theater-wide (SOG, ERS, and island O);
- Coordination with Brown (including AEW and TAMD in Brown).

3.2.II. 'CHARLIE' Cell

Assets:

AWACS
2 AEF
2 UAV
2 U-2
1 DD-21
1 JSTARS
(RC-135… as available)
MEF (forward in Green), including MAW
ARG/MEU(SOC)

Roles & Responsibilities: Charlie's basic scope in Phase 1 is localized to the area covering the "Surface and Coast Surveillance and Attack Coordination (Attack Air-Bases etc.)"

Charlie assumes a leading role in organizing / managing / completing the following tasks:

- Surveillance Coast;
- ISR versus Red in Brown;
- Attack Red Air Bases;
- Attack Red C2 Nodes (together with Alpha and Bravo);
- Attack Red IADS (together with Alpha and Bravo);
- Attack Red Missile Bases (together with Alpha and Bravo);
- Mine Red Ports;
- Deploy MPF (for Phase 2);
- Assemble OMFTS (for Phase 2).

3.2.III. 'ALPHA' Cell

Assets:

1 CVN
1 DDG
1 CG
2 MH-53
1 MCM
12 P3C
2 SSN

RC-135
(RC-135… as available)

Roles & Responsibilities: Alpha's basic scope in Phase 1 is concentrated in "SOG" (with the emphasis on Attack in later stages)

Alpha assumes a leading role in organizing / managing / completing of the following tasks:

- Surface Surveillance of SOG;
- Defense vs. CMD Attack;
- USW in SOG;
- ASuW in SOG;
- MIW in SUG Strait;
- CVBG penetrates SOG.

In addition, Alpha is/can be involved in the following tasks:

- Attack Naval Bases from SOG (if any);
- Attack Red C2 Nodes from SOG (together with Charlie);
- Attack Red IADS from SOG (together with Charlie);
- Attack Red Missile Bases from SOG (together with Charlie).

3.2.IV. 'BRAVO' Cell

Assets:

1 CVN(X)
1 DDG
1 CG
1 JSTARS
2 MH-53
1 MCM
24 P3C
3 SSN
RC-135
(RC-135… as available)

Roles & Responsibilities: Bravo's basic scope in Phase 1 includes "operations in ERS, YSEA, and

Bravo assumes a leading role in organizing / managing / completing of the following tasks:

- Surface Surveillance of ERS, YSEA, and island O

- Defense vs. CMD Attack
- USW in ERS, YSEA, and island O
- ASuW in TS area
- MIW in SUG Strait
- CVBG penetrates ERS

in addition, Bravo is/can be involved in the following tasks:

- Attack Naval Bases from ERS
- Attack Red C2 Nodes from ERS (together with Charlie)
- Attack Red IADS from ERS (together with Charlie)
- Attack Red Missile Bases from ERS (together with Charlie)

4. **Optimized Organizational Design for Phase 2**

The design results for Phase 2 (OMFTS) are shown below. The design was carried out using Method A (direct approach) for developing feasible asset/force packages for each task, with inputs from the Marine Corps Combat Development Command (MCCTC).

4.1 ***Phase 2: Design rationale***

The primary constraint on the organizational design for Phase 2 was the need to allocate all MEF assets to the same node. This can result in a very high workload for that node. The design rationale for Phase 2 involved a trade-off among balancing the workload, minimizing the inter-DM coordination, *and* facilitating the supported-supporting relationships in the C2 hierarchy. Similar to Phase 1, after stipulating (different) asset packages to process each task, the design process identifies the mission segments that are to be assigned to individual nodes (in order to minimize the inter-nodal coordination). This is achieved by decomposing the mission into a set of mission segments, with all inter-related tasks that belong to the same mission segment being assigned to the same node. In particular, one such segment consists of all tasks that require MEF assets (assigned to Charlie). Next, the responsibility areas obtained in Phase 1 are modified to incorporate the MEF constraint. The tasks are now assigned to four groups corresponding to the following four areas of responsibility: (i) global area; (ii) SOG area; (iii) ERS/YSEA area; and (iv) MEF area. Next, the assets are combined according to their task signatures and the corresponding inter-task information flow, and each group of assets, (together with the corresponding tasks), is assigned to a node. The task/asset allocation defines the geographic/functional responsibility of each node, as well as the node's workload. The primary *functional* responsibilities of the four nodes in the organization are: (i) AEW, TMD, deep battle space shaping, and coordinating with Brown; (ii) tactical support for insertion of Marine Forces (including both Deep and Close battle space shaping), as well as Operations at Sea; (iii) Operations at Sea and Back-up functions; and (iv) insertion of Marine Forces. After estimating

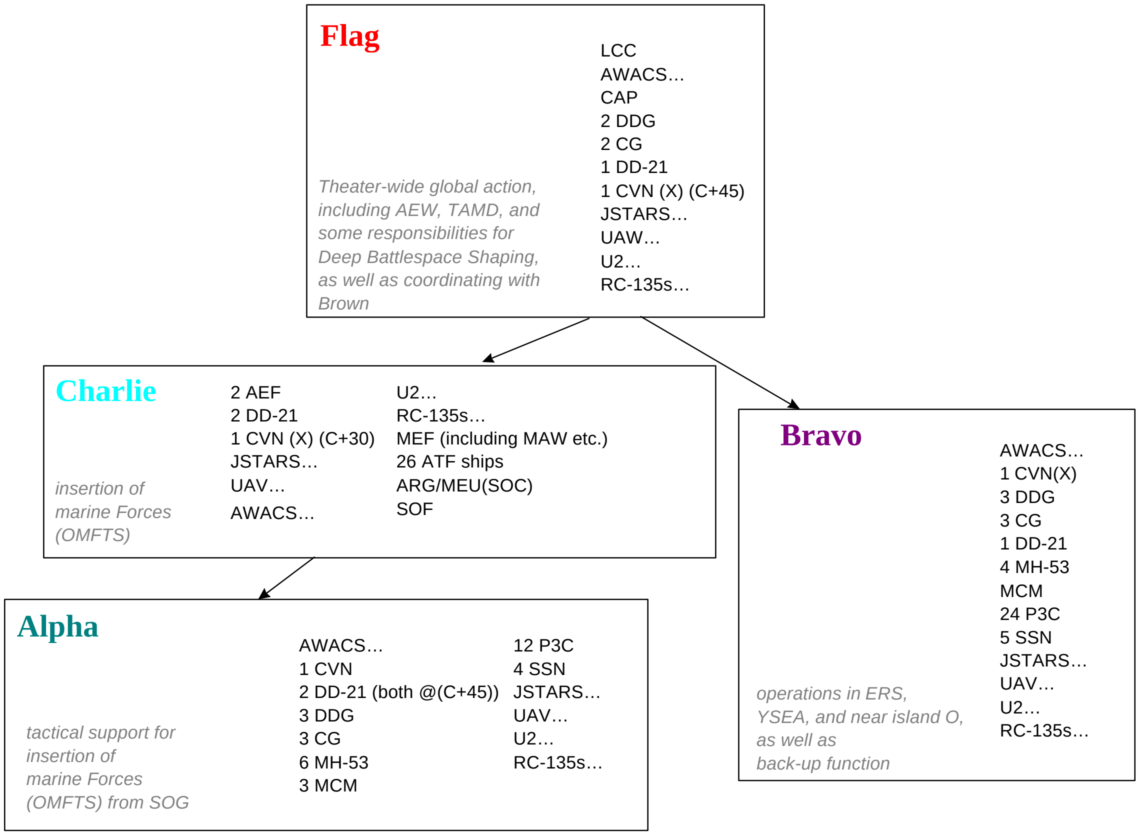

Fig. 6: C2 Architecture for Phase 2

the resulting workload and inter-node coordination, a C2 hierarchy is built to facilitate the supported-supporting relationships among nodes, defined by their functional responsibilities. Specifically, we note the highest inter-node coordination existing between Charlie (MEF area) and Alpha (SOG area). After evaluating several trade-off possibilities (among different hierarchies), Alpha was placed as a direct subordinate to Charlie to facilitate the existing supported-supporting relationships between those two nodes. The organizational design for Phase 2 reflects the shift in the original symmetry of the mission structure that is caused by insertion of the Marine Forces from the SOG area. The corresponding shift in inter-node coordination and the emerging supported-supporting relationships among nodes are reflected in the final design.

The assets and concomitant responsibilities for each cell/node are detailed below.

4.2 ***Phase 2 Design: Assets, Roles and Responsibilities***

4.2.I. ‘FLAG’ Cell

<u>Assets</u>:

LCC
AWACS…

CAP
2 DDG
2 CG
1 DD-21
1 CVN (X) (C+45)
JSTARS…
UAV…
U2…
RC-135s…

Roles & Responsibilities: Flag's basic scope in Phase 2 continues to include a "Theater-wide global action" (including some responsibilities for Deep Battlespace Shaping)

Flag assumes a leading role in organizing / managing / completing the following tasks:

- AEW Theater-wide (SOG, ERS, and island O)
- TAMD Theater-wide
- a part of BATTLESPACE SHAPING DEEP that includes
    - Maintaining Air & Naval Superiority
    - Targeting Command and Control Nodes
    - Targeting Known Enemy Positions in support of Ship to Objective Maneuver (STOM)
    - Targeting Enemy Indirect Fire Systems
      (These could be moved down to Charlie or Alpha)
- Coordination with Brown

4.2.II. 'CHARLIE' Cell

Assets:

2 AEF
2 DD-21
1 CVN (X) (C+30)
JSTARS…
UAV…
U2…
AWACS…
RC-135s…
MEF (including MAW etc.)
26 ATF ships
ARG/MEU(SOC)
SOF

Roles & Responsibilities: Charlie's basic scope in Phase 2 is localized to the area covering the "insertion of marine Forces (OMFTS)"

Charlie assumes a leading role in organizing / managing / completing the following tasks:

- a part of BATTLESPACE SHAPING DEEP that includes
    - Conducting Beach Surveillance

- Flying-in Flexible Deterrent Options
    - Inserting Recon Assets (HumInt, SigInt, ElInt, etc.)
- a part of POSITION ATF / MPF FOR STOM that includes
    - Positioning Naval Force to Conduct STOM
    - Defense of ATF / MPF
    - Rehearsal (MapEx, Virtual Assault, Commex)
- a part of BATTLESPACE SHAPING CLOSE that includes
    - LPZ-LPP Recon
    - Pre-Planned Fires for TAIs
    - NAI and TAI Recon (SCAR, AR)
    - LZ Recon
    - Insert Recon Assets (Organic to MEF)
    - Position for STOM (Logistics, Ammo, Stores)
- PRE ASSAULT OPS (Friendly)
- SURFACE ASSAULT
- VERTICAL ASSAULT
- LINK-UP

4.2.III. 'ALPHA' Cell

Assets:

AWACS…
1 CVN
2 DD-21 (both (C+45))
3 DDG
3 CG
6 MH-53
3 MCM
12 P3C
4 SSN
JSTARS…
UAV…
U2…
RC-135s…

Roles & Responsibilities: Alpha's basic scope in Phase 2 is localized to supporting the "insertion of marine Forces (OMFTS)" (including some responsibilities for Deep & Close Battlespace Shaping) from SOG

Alpha assumes a leading role in organizing / managing / completing of the following tasks:

- Surface Surveillance of SOG
- Attack Red (Msl/Air/Naval) Bases
- a part of BATTLESPACE SHAPING DEEP that includes

    - Target Known Enemy Positions in support of Ship to Objective Maneuver (STOM)
    - Conduct Mine Detection / Destruction
    - Prepare for Deception Operations
- a part of POSITION ATF / MPF FOR STOM that includes
    - Position for Deception Operations
- a part of BATTLESPACE SHAPING CLOSE that includes
    - Counter-Mine Operations
- Back-up and Support for Charlie

4.2.IV. 'BRAVO' Cell

Assets:

AWACS…
1 CVN(X)
3 DDG
3 CG
1 DD-21
4 MH-53
MCM
24 P3C
5 SSN
JSTARS…
UAV…
U2…
RC-135s…

Roles & Responsibilities: Bravo's basic scope in Phase 2 includes "operations in ERS, YSEA, and near island O", as well as a back-up function (if attrition results in depleting other DMs)

Bravo assumes a leading role in organizing / managing / completing of the following tasks:

- Surface Surveillance of ERS, YSEA, and island O
- Attack Red (Msl/Air/Naval) Bases
- Attack CDCM
- Attack Red C2 nodes
- Attack IADs
- Mine Red Ports
- Back-up for other DMs

5. **Summary**

This paper presented a detailed illustration of the application of our model-based methodology to synthesizing C2 architectures for the operational war game "Bridge to Global '99". The above process constitutes an important step exemplifying the transition of laboratory-tested research findings to the operational community. The design outputs from the optimization process showed the (model-predicted) congruency between the mission structure and that of the optimized organization: the optimized organizational design for the Phase I mimicked the original symmetry of the mission structure, carried over into defining the decision node roles and responsibilities, while the optimized design for the Phase 2 reflected the shift in the original symmetry of the mission structure (caused by the insertion of Marine Forces) via the corresponding shift in inter-node coordination and in the model-defined supported-supporting relationships among organizational nodes.

Playing the resultant "optimized" organizational design(s) in the MAGTAF Tactical Warfare Simulator (MTWS) gave us the opportunity to test our modeling and design methodology, developed in a laboratory-based context, in a realistic operational environment, which, in turn, provided us with better understanding as to the extent of possible model-generated results and with a useful feedback to guide future modifications of the model.

6. **References**

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