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Maritime Headquarters with Maritime Operations Center: A Research Agenda for Experimentation

Susan G. Hutchins,[1] William G. Kemple,[1] David L. Kleinman,[1] Scot Miller,[1] Karl Pfeiffer,[1] Shawn Weil,[2] Zachary Horn,[2] Matthew Puglisi,[2] and Elliot Entin[2]

[1]Naval Postgraduate School, Monterey, CA
[2]Aptima, Inc., Woburn, MA

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POC: Susan G. Hutchins
Graduate School of Operational
and Information Sciences
1411 Cunningham Rd.
Naval Postgraduate School
Monterey, CA 93943
831.656.3768
shutchins@nps.edu

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Abstract

Maritime Headquarters with Maritime Operations Centers, or more specifically the MOC, (MOC) represents the nexus of Joint and Navy transformation initiatives, lessons learned in the Global War on Terrorism, and progress toward the *Sea Power 21* vision. Developing effective globally networked MOCs will require continued development, refinement and acquisition to deliver near-term enhancement to Navy warfighting capabilities, while transforming the future maritime force to fulfill its role in *The Cooperative Strategy for 21st Century Seapower*. While much is known about MOC employment, more must be learned to achieve its full operational potential. A comprehensive campaign of experimentation is being designed to test the full MOC capability across the entire range of military operations including engagement with joint, interagency and multinational partners. The Adaptive Architectures for Command and Control research program can contribute to this experimentation campaign. In line with the theme of this year's symposium – C2 and agility – this paper describes an experiment conducted to determine the effectiveness and efficiency of two different MOC organizational structures in conducting a mission planning activity that requires use of scarce intelligence, surveillance, and reconnaissance resources.

Introduction

Maritime Headquarters with Maritime Operations Centers, or more specifically the MOC, (MOC) represents the nexus of Joint and Navy transformation initiatives and experiments, lessons learned in the Global War on Terrorism, and progress toward the *Sea Power 21* vision. Developing effective globally networked MHQs with MOC will require continued development, refinement and acquisition to deliver near-term enhancement to Navy war-fighting capabilities, while transforming the future maritime force to fulfill its role in *The Cooperative Strategy for 21st Century Seapower*. While much is known about MHQ w/ MOC employment, more must be learned to achieve its full operational potential. A comprehensive campaign of experimentation is being designed to test the full MOC capability across the entire range of military operations including engagement with joint, interagency and multinational partners. The Adaptive Architectures for Command and Control (A2C2) research program can contribute to this experimentation campaign.

In line with the theme of this year's symposium – C2 and agility – Navy strategy envisions a network of scalable maritime headquarters, with the agility to transition between command roles, and to deploy forward command elements rapidly as needed to meet the requirements of the Combatant Commander. Senior Navy leaders have stated a need to refocus and enhance the Navy's ability to function at the operational level of war and to train commanders capable of commanding at that level (U.S. Fleet Forces Command, 2007). The MOC was conceived to enable these capabilities while providing a degree of standardization among the maritime headquarters (MHQ with MOC CONOPs, 2007).

An example of the agility inherent in a MOC is the following. During a recent exercise, three missions emerged in a short period of time. In one of them, pirates seized a ship and the MOC formed an operational planning team (OPT) to develop several alternate courses of action (COAs).

These COAs were presented to the combatant commander, who then made the final decision. During this discussion, the two-star questioned if they would be better served to be a Joint Task Force (JTF) rather than a Joint Force Maritime Component Commander (JFMCC). In either case, the operation would involve forces from different services and Special Operations Forces, but timing was going to be critical. As the CJTF, the two-star could give direct orders to all forces involved, but as a JFMCC, it would be through a supported/supporting relationship. It was pointed out, however, that if they became a JTF, this mission would be their single focus, and it would be necessary to stand up a separate JFMCC to deal with the other missions. After thoughtful discussion, it was decided that the combatant commander would remain the JFC, and the two-star undertook all of the missions as the JFMCC.

It is the structural and associated process alternatives for organizing future Navy C2 that is the main theme of our research.

Background

The U.S. Navy continually introduces new concepts of warfighting in response to a changing world and ever-changing technology. To be effective, these new force concepts must be accompanied by concomitant changes in the C2 architecture – across dimensions of process and organization – and in turn the C2 architecture must be congruent with the mission and must be able to adapt to changes in the mission. The A2C2 research program involves a multi-disciplinary approach for conducting research to develop theories and models for C2 organizational analysis. Our guiding principle is to design for mission congruence and facilitate adaptation to changes in mission or forces. We validate these theories and models via team-in-the-loop experiments.

For over a decade, the Naval Postgraduate School (NPS), as part of the Office of Naval Research (ONR) A2C2 program, has been conducting empirical research to design and analyze adaptive C2 structures for future U.S. Navy and Joint forces. (Diedrich, Entin, Hutchins, Hocevar, Rubineau, & MacMillan, 2003; Entin, Diedrich, Kleinman, Kemple, Hocevar, Rubineau, & Serfaty, 2003; Hess, Entin, Hess, Hutchins, Kemple, Kleinman, Hocevar, & Serfaty, 2000; Levchuk, Kleinman, Pattipati, Kemple, & Luoma, 2000; and Hutchins, Kemple, Kleinman, and Hocevar, 2005). Through the integration of analytical modeling, human-in-the-loop experimentation and computer simulation, the research has followed a "model-test-model-experiment" paradigm wherein models and associated simulations define and guide experiments, and the results from the experiments are fed back to improve and enhance the models. The goal is to inform, educate, and influence command and control leaders to modify C2 structures and processes.

This year we shift our research focus to the Maritime Headquarters with Maritime Operations Center (MOC). Our research method for this new focus area entails (*i*) identifying key C2 issues via literature and attendance at MOC events (such as, operational assessment group workshops, exercises, limited objective experiments, working groups), (*ii*) interacting with the Fleet and other subject matter experts, and (*iii*) analysis of selected points and paths in the research space via A2C2 model-driven experimentation and NPS officer-student involvement. Potential research issues and questions include identification and exploration of potential "trouble spots" or friction points and recommending alternative organizational structures/ processes; adaptation and scalability across structures/ processes; and coordination with *external* forces and entities/agencies including information and command flows in combined operations and coordination between MOCs.

The A2C2 research program has developed a multi-disciplinary research agenda to conduct experimentation on issues critical to this new way of organizing at the operational level of war. In this paper we describe our first experiment, conducted in winter 2009. Our preceding experiment "From Expeditionary Strike Group (ESG) towards Maritime Headquarters with Maritime Operations Center (MHQ w/ MOC)," conducted in February 2008, served as a stepping stone from issues associated with ESGs to those associated with MOCs (Entin, Weil, Hutchins, Kleinman, Hocevar, Kemple, and Pfeiffer, 2008). This 2008 experiment continued our A2C2 model-guided research focusing on ESG-Intelligence, Surveillance, and Reconnaissance (ISR) organizational design issues.

Planning in response to changing conditions was incorporated as a key element of our 2008 ESG experiment for two reasons. First, a complex interplay exists between ISR activities and anticipated task requirements, particularly the need for periodic situational updating of task status. Second, as depicted in Figure 1, a large part of the work performed by the MOC involves operational planning. The need to make optimal use of ISR assets is a critical element at both the tactical and operational levels of war. Given limited primary ISR assets, teams must utilize secondary assets, exploit overlaps in mutual capabilities, and share workload.

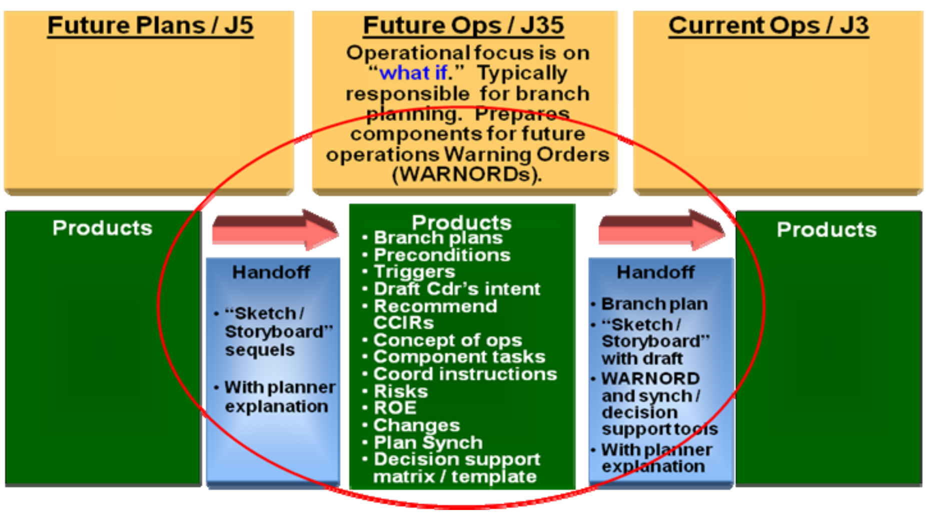

Figure 1. Managing Planning on three Event Horizons.[1]

Model-based analysis, in concert with the University of Connecticut (UConn), was used to identify suitable levels of ISR assets for inclusion in the scenario and for a reduction-in-assets stressor event that precipitated team replanning. Objectives for last year's experiment were threefold, to: (1) continue our model-guided experimentation; (2) bring closure on ISR research questions that emerged in experiment 10; and (3) explore new paradigms for MOC laboratory research, such as how to effect a plan-play-plan cycle in a controlled laboratory setting.

Maritime Headquarters with Maritime Operations Center Experimentation

A MOC empirical research campaign is under development where the envisioned emphasis is on *operational versus tactical* activities, and *planning versus reacting*. Because of its complexity, its

[1] From Selected Slides from VADM Marty Chanik Brief, Second Fleet, 25 Oct 07.

mission to oversee large operations, and its dynamic structure, the MHQ w/MOC is an ideal organization for research on organizational structure, command and control, and the process of mission planning. Based on a review of doctrinal materials (NWP 3-32, NTTP 3-32.1) and discussions with members of the 2nd Fleet (MHQ w/MOC Project Team-MMPT), we have identified three specific research areas that are highly relevant to the MHQ w/MOC organization and are aligned with the foci of the A2C2 research program. These areas are: adaptation, the assessment/planning/execution cycle, and coordination/collaboration. Our interactions with the Fleet are intended to spur discussion about areas in which to focus the A2C2 program's attention and to generate hypotheses to be explored via model-based/model-embedded experimentation.

Our roadmap for MOC experimentation includes the following steps: (1) determine areas of overlap with research foci of A2C2; (2) seek out relevant MOC issues; (3) observe/study MOC organizations and processes to determine appropriate experimentation environment and methodology; and (4) find a solution path amenable to A2C2 methodologies, e.g., rapid response planning, adaptive planning. Since the MOC was designed to effectively integrate the planning elements of Current and Future Operations (COPS and FOPS) to provide more rapid, accurate resource allocations that are consistent with the vision of the Commander as well as the requirements of battle, we have focussed on the Operations Center for our first experiment.

Expanded Role for Intelligence, Surveillance, and Reconnaissance

The MOC is responsible for a plethora of operational activities, a vast majority having nothing to do with warfighting. It is the Intelligence/ISR cells of the MOC that must interpret a key ISR tenet, "know the enemy" very broadly. For example, the MOC must consider many unusual facts for informing anti-piracy operations. Altogether different would be the information needed to successfully conduct non-combatant evacuation operations in The Congo. Supporting humanitarian civic actions in West Africa requires a completely different set of information, from developing an understanding of cultural differences to establishing the identity of crucial social networks. ISR depends on the application of sophisticated information gathering technologies and assets, as well as human intelligence (HUMINT). How should the MOC, and specifically the ISR cell(s) within the MOC, organize so that critical information requirements are met?

The element within the MOC that provides critical information to support COPS and FOPS cells in performing their planning mission is the ISR cell. With the goals of effective planning and accurate resource allocations in mind, it is important to determine the most effective way ISR personnel should be organized within the MOC structures to best accommodate to different mission types. We choose to focus on the pivotal role of ISR for several reasons. ISR is critical to all phases of an operation; this means ISR assets are in high demand and sometimes short supply. Moreover, as the military continues its transformation, the way ISR assets are employed will need to evolve as well. The traditional focus on asset management is currently morphing into a collective management and synchronization planning framework where greater priority is placed on requirements management (e.g., priority information requests). This new framework views collection management as the "primary forcing function" for the pace, and quality of intelligence (Downey and Guvendiren, 2008). This new way of thinking views intelligence as supporting the entire range of operations which can include as many, or more, non-kinetic operations as kinetic. Further support for a focus on ISR related issues is found in a capabilities-based assessment (Second Fleet, 12 Oct 2007), where the top four issues identified by the MHQ w/ MOC Project Team are listed in Table 1, with their relative rankings of importance.

Table 1. MHQ with MOC Tasks in Prioritized Order.

MHQ with MOC Capabilities-Based Assessment Identified Tasks	Weighted Value
Process and Exploit Collected Operational Information	217.53
Collect and Share Operational Information	215.25
Disseminate and Integrate Operational Intelligence	214.12
Produce Operational Intelligence and Prepare Intelligence Products	211.53

The MOC is a very large organization with a wide range of responsibilities. For this research, we elected to focus on a small section of the MOC, that is, FOPS, COPS, and ISR. The MOC was designed to effectively integrate the planning elements of COPS and FOPS to provide more rapid, accurate resource allocations that are consistent with the vision of the Commander as well as the requirements of the battle. An element within the MOC that provides critical information for the COPS and FOPS to perform their planning mission is the ISR cell. With the goals of effective planning and accurate resource allocations in mind, it is important to determine the most effective way ISR personnel should be organized within the MOC to best accommodate different mission types.

In the following sections we describe our methodology, role responsibilities, and decision aids that were used to support participants in performing their tasks.

Method

Two possible configurations of ISR personnel are: centralized in an ISR cell as it is currently done or decentralizing the ISR personnel by integrating an ISR capability into both the COPS and FOPS cells. Current organizational research suggests that the use of centralized decision making tends to increase speed of response when the environment is stable and predictable (Moon, Hollenbeck, Ilgen, West, Ellis, Humphrey, Porter, 2000). In contrast, the use of decentralized decision making results in more rapid, time-critical responses in dynamic less predictable situations (Moon, et al, 2000). Thus, the current research investigates differences in effectiveness between centralized and decentralized MOC ISR personnel.

Experimental Design

The purpose of the current study was to determine the effectiveness and efficiency of two different MOC organizational structures for conducting planning. For this purpose an experiment was developed with one between-group independent variable (ISR organizational structure: ISR embedded within COPS and FOPS cells, versus separate cells for FOPS/COPS/ISR).

Participants

Participants in the study were military officers enrolled in two graduate-level courses at NPS in Monterey, CA. The age of participants ranged from 26–42 years (mean = 33 yrs.) and they had been in the service for a mean time of 10 years. Most were in the Navy, six were in the Marine Corps, all but one were male, and several had been involved with a MOC in a former assignment. There were 24 total participants, partitioned into four teams of six individuals. All teams had three roles, each filled by two participants. These roles consist of personnel in the MOC in charge of COPS, FOPS, and ISR. As noted above, each team had one of two organizational structures, such that participants were separated into two cells (COPS and FOPS, each with an embedded ISR representative) or three independent cells (COPS, FOPS, and ISR).

Scenario

The current study has as its focus an operational-level resource allocation scenario as an environment in which COPS and FOPS cells integrate ISR information to plan for and implement effective assignment of available assets to mission tasks. During this scenario, all MOC teams were asked to accomplish two goals, to: (1) address the demands of the current operation (COPS), and (2) devise an asset allocation plan for the next phase of the operation (FOPS). The scenario consisted of a hostile country (Red) that has begun to invade a bordering country (Brown) that is adjacent to an island nation (Green). Both Brown and Green countries are allies of the participant MOC teams (Blue). Activities to be handled by the participant MOC team include: working with limited ISR resources to address a current plan; develop a plan for the allocation of incoming resources that will arrive in time for the next phase; and supply both COPS and FOPS with accurate and timely ISR information.

Geographically, the conflict/scenario was ongoing in two disjointed maritime areas, Area A and Area B, that Red had declared to be “do not enter” zones. Ongoing operations to break the area denial, supported by ISR assets, are monitored and assessed by the current operations (COPS) cell. Two participants served in COPS, one for Area A and one for Area B. The future operations (FOPS) cell was planning for follow-on operations. Two team members served in FOPS, one focused on Area A and one on Area B. ISR assets were also needed to conduct Intelligence Preparation of the Environment (IPE) so that future planning would be highly accurate. The remaining two (ISR) team members coordinated to ensure IPE was performed.

Communication among cells occurred with text-based chat and voice communications over an audio net. The standard procedure for communicating between cells required FOPS to request ISR information from the ISR cell (or ISR representative embedded in FOPS), which in turn, interacted with COPS to determine/direct the release of assets to obtain this information. An important trade-off in this scenario was that the release of key assets from current activities reduced the performance of current operations and resulted in a penalty/risk for COPS. On the other hand, failure to obtain the highest quality ISR information in response to a FOPS request resulted in a penalty for ISR. Participants in each role were provided with decision aids to compensate for any lack of expertise in planning at the operational level.

This scenario provided a sufficiently challenging task of the type expected of MOC cells in situations that are not interrupted by unforeseen changes in the environment. The scenario was developed to induce tension between COPS and FOPS regarding their competing requirements for use of ISR assets. Other situations that create tension over ISR assets might arise from a request for information (RFI) from higher authority. In these situations, tradeoffs must be made between using an asset for a *current* task versus use of that asset to obtain information to support a *future* task. As in many organizations, the desire of the individual cells to excel in their own domain must be balanced with the need to coordinate with other cells to optimize overall organizational performance. This creates a “dynamic tension” within the organization.

Figure 2 depicts the sequence of activities with centralized ISR personnel, where FOPS sends a request, via the ISR cell to COPS, to request an ISR-capable asset package to conduct IPE. The subsequently collected information is needed by FOPS to support their future planning task.

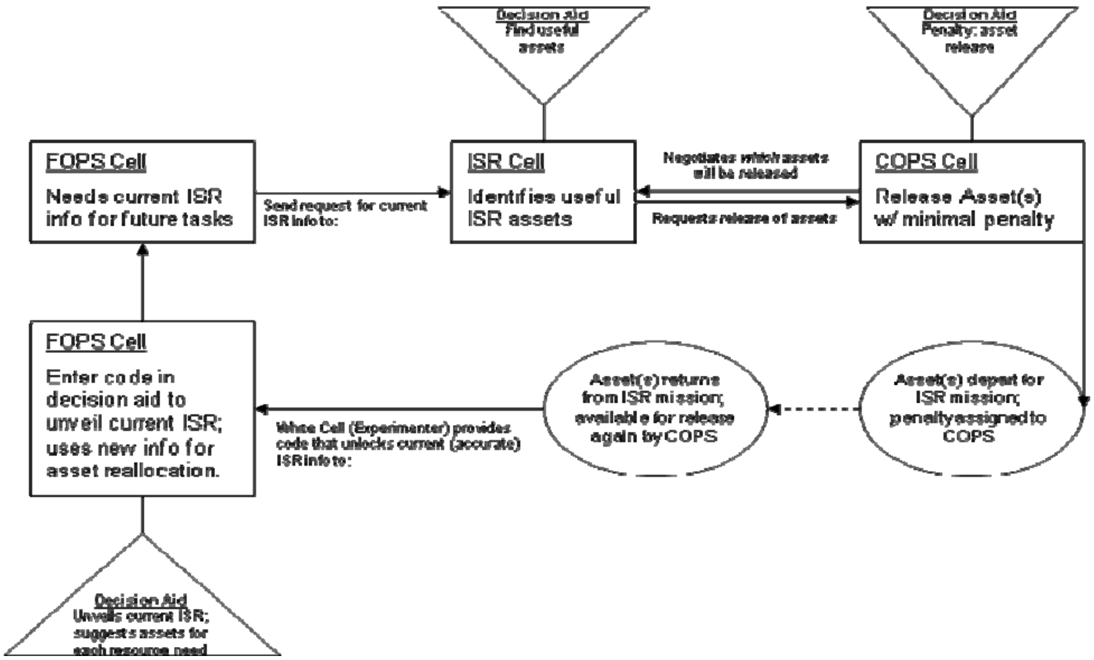

Figure 2. Sequence of Tasks with Centralized ISR Personnel.

Figure 3 shows the sequence of activities with decentralized ISR personnel.

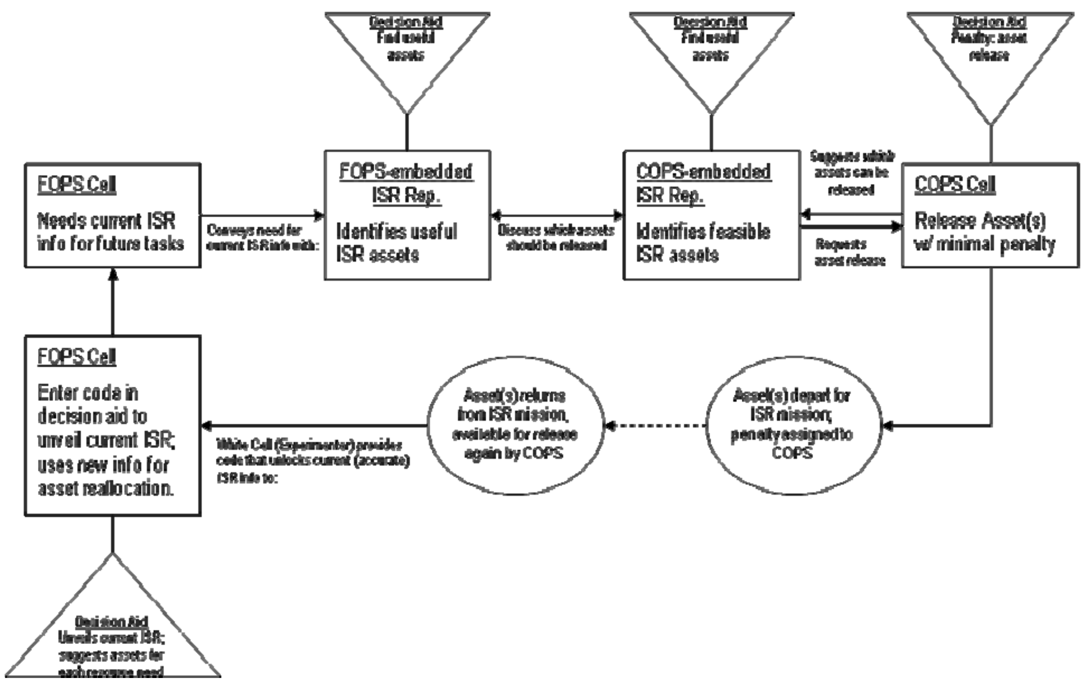

Figure 3. Sequence of Tasks with Decentralized ISR Personnel.

Procedure

Prior to beginning the experiment, participants were presented a two-hour lecture on MOC functions, planning, and activities at the operational level of warfare. The goal of this lecture was to provide an introduction to the study, purpose, roles, and responsibilities within the MOC, as operational-level issues typically lie outside of the expertise of many NPS students. Such information provided a framework for the participants to understand their goals and responsibilities in this experiment.

The eight-hour experiment was structured in four two-hour blocks as follows:

In the initial Block 1, participants were briefed on the scenario background, the details of the fictional conflict, the role of the team members, scenario materials, individual participant roles, types of information they will receive, decision aids that will assist with task performance, and the deliverables expected of them at the end of each phase. Experimenters then guided the participants through the training activity, which consisted of a limited version of the tasks they were to perform during Blocks 2 and 3. An experimenter sat with each team member to provide one-on-one training to facilitate rapid learning of all aspects of the task.

During Block 2 the focus was on resource allocation for the planning tasks. The FOPS cell was asked to develop a plan that required obtaining IPE information which required use of COPS-controlled assets which were conducting current operations. Communication among FOPS, ISR and COPS cells and acquisition of ISR information were necessary for successful planning. During Block 2, observer-based measures of team process and communication were completed in addition to the administration of self-response measures of team process and productivity to team members.

Block 3 was a continuation of the planning task which began in Block 2. A plan summarizing asset allocation plans was to be completed by the cells at the conclusion of Block 3. During Block 3 observer-based measures of team process and communication were completed in addition to the administration of self-response measures of team process and productivity to team members at the end of the block.

In the final Block 4 of the experiment, the experiment hot wash was conducted. This included administering several surveys: an end of experiment survey, a process and organization survey, and a FOPS/COPS/ ISR end of experiment survey. Following the team's completion of the surveys, a group discussion was held where the responses to the survey topics were discussed as a group with each team. At the completion of all experimental sessions, an after-action review took place, where the entire group was debriefed on the goals for the experiment, some initial results were presented, and participants could provide their feedback.

Role Responsibilities

Future Operations Cell (FOPS). The FOPS cell was charged with building an executable plan. This plan requires the FOPS cell members to make decisions regarding allocation of a given set of assets to a given set of tasks. This complicated process involves many possible realistic solution sets. To simplify this process due to the experiment time constraints, the number of tasks was limited to twenty-three, or roughly 11-12 in each area A or B. However, the combination of over

40 various assets that needed to be assigned to tasks is large. This creates a challenge for the FOPS players, but one that is manageable within the given time constraints of the experiment, especially as FOPS players were provided with an interactive decision aid that bundled available assets into 3-4 viable packages (courses of action) for a user-selected task.

To best allocate assets to tasks, the planners must obtain estimates of enemy position, strengths, intentions, and various task attributes/requirements. This is called Intelligence Preparation of the Environment (IPE), and is performed by assets capable of performing ISR operations. Those include ISR-only assets such as Rivet Joint, U-2, unmanned air vehicles (UAVs), as well as multi-mission platforms that have both ISR and tactical capabilities, such as SSNs and P-3s. Collecting, collating, and making sense out of all this ISR information and applying it to the allocation challenge is very time consuming.

Commander's guidance directed that FOPS obtain updates to the initial estimates of task requirements (provided by the experimenter) by submitting requests for information (RFI) to ISR and in turn from ISR to COPS. When the ISR assets completed their update for a given task, it is likely that the estimated requirements for task execution could change significantly. For instance, planning for anti-submarine or undersea warfare (USW) in Area A may initially indicate that 2 P3 aircraft, a destroyer and 2 submarines (SSNs) would be needed. But when ISR assets are used to update the IPE, FOPS will learn that only 2 P3s and one SSN are needed. Obviously FOPS would like ISR and COPS to select ISR assets that provide the best quality information in response to the IPE request.

Intelligence, Reconnaissance, and Surveillance Cell (ISR). The objective for ISR was to assist FOPS in obtaining the best current IPE information for FOPS tasks in Areas A and B. Constraints for this objective were: (*i*) the quality of IPE delivered depends on the ISR asset option used; (*ii*) COPS takes on risk by redirecting their assets away from current tasks, so there was likely to be resistance when particular assets were requested; and (*iii*) interaction between ISR and COPS was limited to chat. ISR needed to remain updated on the status of forces in the area of responsibility via information from COPS.

Complicating this process is the fact that there was a finite set of ISR resources. Current operations (monitored and adjusted by COPS) require ISR mission support to increase the likelihood of task success. But, if ISR assets are diverted to improve IPE, and subsequently to improve FOPS' plan, ineffective execution of current tasks is likely. Therefore, ISR provided COPS with two or three alternatives for ISR asset allocation for IPE on any specific task. A table-based lock-up decision aid was provided to ISR that gave the relative probability of IPE success for each of these ISR alternatives. For example, IPE on the task "Surface Surveillance in Area A" (which would provide FOPS with current information upon which to build an asset allocation plan to best execute the task) could be accomplished with: 1) Joint Surveillance and Target Attack Radar System (JSTARS) and P3 with a 100% probability of success, 2) unmanned air vehicle (UAV) and P3 with a 90% probability of success, or 3) an air expeditionary force with a 40% probability of success.

The ISR cell was scored on the overall probability of success for the ISR asset packages that COPS selected for satisfying the various IPE requests as forwarded from FOPS. It was in ISR's best interest that the ISR package with highest probability be used. But it was in COPS' interest to use the ISR package that would incur the smallest decrease in the performance of ongoing tasks.

Current Operations Cell (COPS). The COPS cell was responsible for management of current assets, with authority to release assets. Their objective was to redirect assets from their current task to obtain IPE information needed for FOPS planning. Since ISR-capable assets are scarce, assets dedicated to current operations need to assist. Because these assets under COPS control have unique responsibilities for accomplishing the current tasks, removing these assets for ISR usage increases vulnerability and risk for the current operation. An additional constraint was that the two COPS players were each responsible for an area of the overall area of responsibility, either Area A or Area B. A COPS player could request an ISR asset from the other COPS player, who had the same tension created by wanting to excel at his immediate COPS task. To perform this function, COPS needed to maintain situation awareness of current asset locations including monitoring the real-time, evolving risk of releasing assets and decide which assets to release. The COPS cell was scored on their decisions, based on their consideration of the tradeoffs involved regarding the release of ISR assets for other tasks.

Materials

Communication Tools. Participants within each cell communicated via headset to facilitate the audio recording of all within-cell communications for later analysis. Inter-cell communication regarding the status of assets and requests for information occurred via text-based Chat.

Decision Aids

Throughout the experiment, several decision aids were used to provide subject matter content knowledge to cell members and to simulate the consequences of allocating resources in a particular manner. Data for all measures during the experiment will be captured by the decision aid software. Three decision aids served to inform decision making for each of the three roles: (1) a paper matrix listing a range of appropriate ISR packages for each future task (for use by ISR); (2) an electronic decision aid that displayed a penalty for removing an asset from its current task (for use by COPS); and (3) an interactive requirements matching tool that gave a rank-ordered set of packages to best satisfy the resource requirements of a user-selected task (for use by FOPS). These programs were written in Matlab and were developed by UConn for this experiment (Bui, Han, Mandal, Kleinman, and Pattipati, 2009).

Decision aid for FOPS players. This tool provided FOPS players with a list of N $\leq$4 asset packages suitable for assignment/allocation to a user-selected task along with their associated accuracy scores. A player would typically select one task of interest, from a displayed list and would also deselect assets from a second displayed list that were *not* available (or not being allocatable) for the task being considered. The user would then invoke the decision-aid algorithm. The initial information (i.e., resource requirements) for a task being considered by FOPS was purposely made to be incorrect by as much as $\pm$30%. Thus, it was incumbent upon FOPS to not base their asset allocations upon poor data. FOPS would only obtain correct data for a task after an IPE request was acted upon by ISR and COPS. The FOPS decision aid display showed whether each task's information was current or old.

Outputs: The participant saw: (1) A listing, giving the best N options for how to process the selected task. Each option showed (a) the percent accuracy attainable, using a suitable formula and (b) the one or two resource categories in which more capability was being allocated than needed with a percentage of "overkill." These options were listed in order of accuracy. A flag set next to each task clearly showed whether the resource information on that task was validated or correct. Table 2 provides an example of asset packages that were available and how this information was presented to the participants.

Table 2. Sample FOPS Decision Aid Information.

ISR confirmed	Option 1	Option 2	…	Option N
List of needed assets	2P3 + DDG	SSN + P3 + CG	…	SSN + CG
Accuracy	100%	90%	…	80%
1st wasted resource	C2 (by 25%)	BMD (by 10%)	…	Fires (by 15%)
2nd wasted resource	Strike (by 20%)	CMD (by 7%)	…	AAW 5 (by 10%)

Decision aid for COPS players

This was the major piece of software for redirecting (ISR) assets. The purpose was to assist COPS players regarding the consequences of redirecting an ISR asset from an ongoing/current task to gather information as per a request for either (a) a FOPS task, in the form of a RFI, as received via ISR (b) a commander's critical information request (CCIR), or (c) an urgent RFI from a subordinate task force.

The information displayed to the COPS players included: (1) A list of tasks that were currently being executed, by name, along with their vector of task requirements. (2) For each of these tasks the list of assets, by name, along with their vector of resource capabilities that were assigned to that task. The COPS player could select an asset package and obtain feedback on the risk incurred in conducting the current task if a specific ISR-capable package was diverted to conduct IPE, and the duration of that risk. Data for all measures during the experiment were captured on computers made available to all participants.

User-supplied inputs and subsequent outputs: These constitute actions that players would take. Actions were done for *one or more* (user-selected) ISR assets at a time. Users were able to select any ISR assets, from any task, to be temporarily removed or redirected from that task. This is entirely a "what if" action. An on-off switch was used for this action. For each task in which assets were considered for removal, the decision aid showed the adjusted percent accuracy that would be obtained (during the period of removal) as well as a resultant "risk" that was explained to the players.

Measures

Performance measures include team process measures and outcome measures. The effectiveness of the plan produced by FOPS, at the conclusion of the experiment, is the main dependent measure. Team process measures were collected during Blocks 2 and 3.

Data Collection Plan

Several surveys were administered to capture and rate teams on inter- and intra-cell communication patterns. These included observer-rated and participant-rated items. Team communications were audio recorded for analysis of inter-and intra-cell communication. Text chat was captured for analysis of time-stamped formal requests for information. Performance logs were recorded to maintain records of the time and content of FOPS ISR requests (completed by ISR), asset release by COPS (compared by COPS), and the asset package selected to fulfill FOPS ISR requests (completed by ISR).

Model-based Measures. Model-based measures, developed in conjunction with University of Connecticut, were used to score ISR asset allocation decisions. The FOPS plan was scored at the conclusion of the experiment on the feasibility of the plan across tasks (that is, for the overall mission) and the quality of the plan on a task-by-task basis.

Penalties incurred. COPS score was reduced due to asset releases on each task as releasing the asset decreases the accuracy percentage for the game. Moreover, sending the same asset away a second time incurs a non-linear (i.e., increased) penalty. Similarly, the ISR score was decremented due to the reduced quality of the response to a request for information. Convincing COPS to use the best package to address the RFI will net a 100% score; using an asset package that represents a less-than-ideal alternative will result in a reduced score for ISR.

FOPS was scored on their plan at the conclusion of the experiment. Scoring criteria include the feasibility of the plan across tasks (overall mission) and the quality on a task-by-task basis. COPS was scored on the percentage of risk adopted by releasing assets, where each asset release results in a penalty decrease for that task. Releasing the same asset multiple times exponentially increases the penalty incurred. Moreover, if a specific asset is released multiple times, that asset becomes unavailable for use by FOPS. ISR was scored on the package adopted by COPS in response to a FOPS request. Each FOPS request can be satisfied through use of three package options such that using any of the three packages will obtain the ISR information required by FOPS. Using the "best" option will net a 100% score; use of the other two packages will result in a reduced percentage ISR score.

RESULTS

The current study was designed to examine the performance and communication differences between two MOC organizational structures that differ in their management of ISR assets. In one condition, ISR personnel were split and embedded into both COPS and FOPS cells. The second condition placed ISR experts into a co-located cell, with members handling requests for ISR assets from unique battle areas.

Table 3. Raw scores for primary study criteria.

	2-Cell Condition (ISR in FOPS & COPS)						3-Cell Condition (ISR its own cell)					
	Team A			*Team B*			*Team C*			*Team D*		
	Area A	Area B	*Total*	Area A	Area B	*Total*	Area A	Area B	*Total*	Area A	Area B	*Total*
Team Score (across Cells)	--	--	**237.1**	--	--	**241.4**	--	--	**211**	--	--	**247.15**
FOPS: task plan score	81.5	68.5	**74.7**	85	73.9	**79.2**	92.9	81.6	**87**	89.8	85.1	**87.4**
ISR: quality % achieved	82.5	87.5	**85**	84	81	**82.5**	87	91	**89**	80	78.5	**79.25**
COPS: ability to avoid incurring risk*	--	--	**77.4**	--	--	**79.7**	--	--	**35**	--	--	**80.5**
Commander's Requests to FOPS (values = task frequency)												
"Complete all tasks"	11	11	**22**	10	11	**21**	11	11	**22**	11	12	**23**
"No task scores *under* 70"	2	6	**8**	1	1	**2**	0	1	**1**	0	0	**0**
Latencies (values = avg. time, in minutes)												
Team: Time to fulfill FOPS request	0:18	0:23	**0:21**	0:20	0:17	**0:18**	0:19	0:21	**0:20**	0:18	0:19	**0:19**
ISR: Time needed to obtain current info	0:16	0:20	**0:18**	0:18	0:19	**0:18**	0:16	0:19	**0:18**	0:23	0:17	**0:20**
COPS: Time taken to commit assets	0:03	0:05	**0:04**	0:07	0:04	**0:05**	0:02	0:04	**0:03**	0:08	0:04	**0:06**
COPS: Time until assets return with info	0:15	0:18	**0:16**	0:17	0:16	**0:17**	0:15	0:16	**0:15**	0:19	0:15	**0:17**

Note: * Area-level scores for COPS were measured on a separate metric representing amount of risk incurred. The COPS total score was transformed to be compatible with total scores from FOPS and ISR.

Performance Quality

Differences in total scores between teams (see Table 3) suggest that the team-level performance does not differ directly as a function of the two conditions. However, there are initial patterns within the data that deserve more detailed analysis. Trends within the data suggest negative relationships between ISR performance and the performance of COPS and the team as a whole (see Table 4). Across all teams, as ISR performance increases, COPS incurs greater amounts of risk (r = -.85, p = .15). Similarly, as ISR performance increases, the final team score decreases (r = -.94, p = .06). In contrast, COPS performance was positively related to the performance of the team as a whole (r = .98, p < .05), indicating that the ability for COPS to avoid incurring large amounts of risk is a critical piece to the effective operation of the entire MOC team. The inverse relationship between COPS and ISR is not unexpected, as the study was designed to promote a conflict between the ISR request for particular asset types and the ability for COPS to redirect those assets with ease. It should be noted for all analyses that the power to achieve significance is very low due to the small team-level sample size (N = 4). Further analysis will be conducted to investigate the determining factors that may influence these relationships.

Table 4. Correlations among team- and cell-level performance scores.

	1	2	3	4
1. FOPS Plan	1			
2. ISR Quality	-0.05	1		
3. COPS Risk Avoidance	-0.48	-0.85	1	
4. Final Team Score	-0.29	-0.94	.098*	1

Note: * = p < .05.

Performance Latency

Initial analysis indicates very little variation between conditions regarding the latency with which various stages of performance were completed. These measures, shown in Table 4, indicate that all four teams were similar in the time it took to process a FOPS request for current IPE information, the amount of time needed for ISR to obtain current information from ISR assets, the amount of time taken by COPS to commit assets for the FOPS tasks, and the time needed for assets to return with current information. While it could be expected that the two-cell condition (i.e., bottle-neck chat communication between ISR players) could result in longer performance latencies, this was indeed not the case. These teams demonstrated very similar latencies to those teams in which the ISR players were dedicated to particular battle areas and worked in parallel (three-cell condition). Further analysis will be conducted to determine whether quality and frequency of communication (as rated by observer-based and self-report surveys) relate to performance latencies.

End of Experiment Survey Responses
Participants indicated the tempo was very realistic and they had enough time to think about options, yet they felt the time pressure. Participants thought the experiment was a reasonable extraction of processes at the operational level of war.

Conclusions

MOC research at NPS aims to bring model-based research and experimentation together through our time-tested A2C2 approach of model-driven experimentation, wherein models guide design of experiments and the results of experiments help shape model refinements. In addition, NPS is a major conduit for Fleet interaction in order to become informed about and understand key issues relating to MOC, and bring them into a laboratory setting for scientific investigation. As such, NPS research over the next three years will involve an integration of outreach activities, model development, and experimentation. These efforts will be conducted in concert with, and in collaboration with our colleagues at the University of Connecticut (UConn), Aptima, Inc., San Diego State University (SDSU), and Pacific Science and Engineering (PSE).

Recommendations and Future Research

Our roadmap for MOC experimentation includes the following steps: (1) determine areas of overlap with research foci of A2C2; (2) seek out relevant MOC issues: (3) observe/study MOC organizations and processes to determine appropriate experimentation environment and methodology; and (4) find a solution path amenable to A2C2 methodologies, e.g., rapid response planning, adaptive planning.

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