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Design of an Experiment to Investigate ISR Coordination and Information Presentation Strategies in an Expeditionary Strike Group

Track 7: Network-Centric Experimentation and Applications
Track 1: C2 Concepts, Theory, and Policy

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Abstract

This paper describes the design of an experiment that combines research of the Adaptive Architectures for Command and Control (A2C2) and the Command 21 programs, both sponsored by the Office of Naval Research. The experiment focuses on the nexus of organizational design and information presentation strategies – both of which are undergoing dramatic changes in form and function within the US military. The formation of Expeditionary Strike Groups (ESGs) is one example of the transformational vision provided in the Naval Operating Concept wherein an ESG provides a flexible force package, capable of tailoring itself to a wide variety of mission sets. In this effort, the objective is to examine experimentally how ESGs with alternative structures and processes – here specifically related to the incorporation of an ISR officer and different information presentation strategies – affects performance and information flow in an information rich planning and execution environment. We present the process used to develop the scenario environment in which the team-in-the-loop simulation experiment is conducted. This scenario reflects the new mission areas faced by ESGs that include Humanitarian Assistance/Disaster Relief (HA/DR), Maritime Domain Awareness (MDA) and Maritime Security Operations (MSO).

INTRODUCTION

A scientific challenge faced by the C2 research community is to understand how organizations can take advantage of networking, collaboration, distributed execution and resource sharing in dynamic, asymmetric and unpredictable mission environments. Within this context, our research focuses on the nexus of organizational design and information presentation strategies – both of which are undergoing dramatic changes in form and function within the US military. In particular, the formation of Expeditionary Strike Groups (ESGs) is one example of the transformational vision provided in the Naval Operating Concept (2003). An ESG is a small yet versatile military organization, capable of tailoring itself to accomplish and support a wide variety of mission sets from amphibious assault to disaster relief. Structural adaptability is a necessary characteristic of an ESG, and supporting-supported relationships are employed as enablers of structural adaptability with a reliance on non-traditional communication and coordination processes. Since 2003, ESG organizations have allocated command responsibilities in several ways, with each permutation affecting organizational dynamics differently. The ESG thus provides the C2 community with an opportunity to apply its theories and principles to assist in the understanding of a rapidly evolving, albeit fluid, operational construct.

This paper describes the design of an experiment to investigate intelligence, surveillance, and reconnaissance (ISR) coordination and information presentation strategies within an ESG. The effort is based on the combined background of theories, models, empirical results, and software tools of the Adaptive Architectures for Command and Control (A2C2) and the Command 21 (CMD 21) programs, both of which are sponsored by the Office of Naval Research. These research programs enjoy a long history in their respective areas. A2C2 has used model-based experimentation to design adaptive organizations for the US military (Diedrich, Hocevar, Entin, Hutchins, Kemple, and Kleinman, 2002; Entin, Weil, Kleinman, Hutchins, Hocevar, Kemple, and Serfaty, 2004; Hocevar, 2000; Hutchins, Kleinman, Hocevar, Kemple, and Porter, 2001; Hutchins, Kleinman, Hocevar, Kemple, 2005; Weil, Kemple, Grier, Hutchins, Kleinman, Hocevar, and Serfaty, 2006). The CMD 21 program has studied ways to organize and display information to support decision-making within the military (Moore, Schermerhorn, Oonk, and Morrison, 2003; Oonk, Smallman, and Moore, 2001, Oonk, Moore, and Morrison, 2004).

The A2C2 Program: Background and Approach

The A2C2 research paradigm integrates optimization, modeling, and simulation-based research efforts with psychology-based and experimental activities. The emphasis is on using model-based experimentation to investigate the relationships between mission requirements and organizational structure through human-in-the-loop experimentation. A major scientific contribution of the A2C2 program has been a methodology for the design and evaluation of organizations that are “congruent” to the mission requirements. This work has embodied algorithmic processes for “optimal” organizational design (Levchuk, Yu, Levchuk, and Pattipati, 2004) and procedures for developing scenarios with which to test and validate alternative C2 designs (Kleinman, Levchuk, Hutchins, and Kemple W.G. 2003).

In the A2C2 methodology, models produced by the modeling/simulation activities support the formulation of hypotheses, the determination of key variables and parameter values, and the prediction of organizational performance and processes of adaptation. An enhanced Distributed Dynamic Decisionmaking (DDD) team-in-the-loop simulator is used for empirical evaluation of activity-based missions and to compare alternative C2 structures (Kleinman, Young and Higgins, 1996). Data is collected and produced in a way that allows examination of the hypotheses, supports discovery, and is easily used for post-experimental model-data comparison.

The driving force behind the A2C2 program is the concept of *model-based* experimentation (Weil, et al., 2006). Theoretical and operational concepts provide the initial input to the process depicted in Figure 1, which moves in an iterative fashion through modeling and experimentation. Models are refined through consultation with subject matter experts and initial simulations, which produce definitions of scenarios and organizations, as well as guidance for experimental design and data collection measures. Operational concepts are informed and refined, based on data collected, and lead to additional cycles of modeling and experimentation. This model-test-model-experiment process yields well-specified hypotheses and precisely defined measures (Weil, et al., 2006). Resulting operational concepts are tested using operational decisionmakers to empirically validate the new organizational structures and processes.

However, for the process of model-based experimentation to be relevant, the issues being investigated in the laboratory and via computer simulation must reflect the major challenges faced in a changing military (Weil, et al., 2006). A2C2 and CMD 21 research focuses on employing *operationally anchored* model-based experimentation, such that the results of the empirical investigations provide decisionmakers with operationally relevant information.

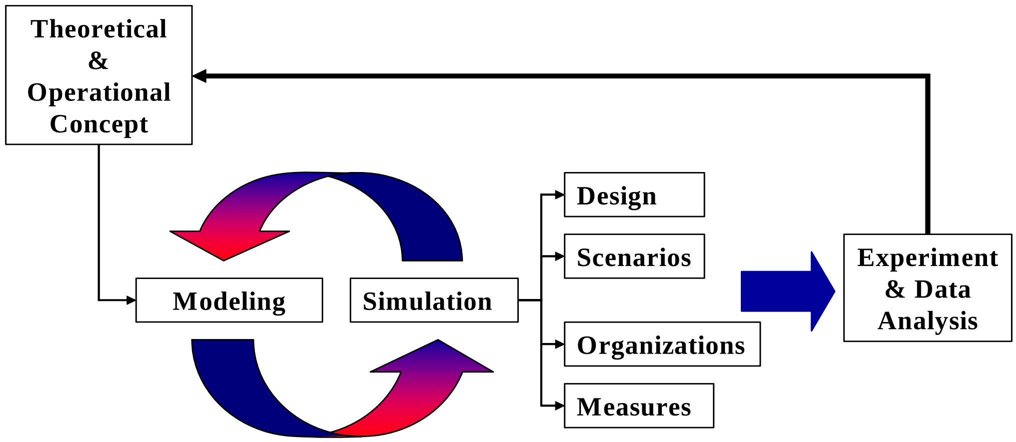


Figure 1: Process of A2C2 Operationally Anchored Model-based Experimentation.

The A2C2 program has a history of transitioning its findings to the operational community. Our methodology has been used for a number of applications to design C2 organizations that have been tested in multiple team-in-the-loop experiments. The first transition of A2C2 research to the Fleet involved the development of alternate organizational structures for COMCARGRU 1 to use during the 1999 Bridge to Global war game at the Naval War College. (Hess, Hess, Kemple, Hocevar, Entin, Hutchins, Kleinman, and Serfaty, 2000). The alternative ways of organizing operational forces were well received by RADM Pollaty and his COMCARGRU 1 staff. A second application of the A2C2 methodology was in support of OPNAV N6 to provide insights into enablers of self-synchronization within both functional and divisional C2 structures (Hutchins, et al., 2001). In 2004, the A2C2 researchers provided a comparative evaluation of the FORCEnet prototype structures and the CWC structures for the Strategic Studies Group. (This analysis conclusively demonstrated the versatility/value of model-based approaches for making informed decisions on command structures.) In an experiment conducted at the Naval War College we linked and demonstrated the DDD with CMD 21 tools to study optimization-based agent models for mission monitoring, re-planning and tactical decision support (Meirina, Yu, Ruan, Zhu, Pattipati, and Kleinman, 2004).

The CMD 21 Program: Background and Approach

In a network-centric environment, an increased availability of information from many sources (both humans and sensors) provides greater access to information for decisionmakers. A concomitant problem, however, is that this tremendous increase in information is often an impairment to decisionmakers. New forms of information management are required that will eliminate information overload and that will ensure that timely information is transmitted to the correct node, person, or system (Franklin, 2006). Current technology is insufficient in terms of providing reliable support for Naval warfighting capability (NRC, 2005). Research is needed to inform our understanding of information management issues, including accessing, processing, dissemination and presentation (Franklin, 2006).

Recent efforts sponsored by ONR have focused on the development of technologies, processes, and recommendations using cognitive models of decision making for real-time decision support. These and many other efforts have shared a common thread – the efficient and effective exchange of information and knowledge from one system, group, or individual to another in support of critical decision making. Building on the lessons learned from these efforts, ONR's Command 21 project (at SPAWAR Systems Center, San Diego) is conducting research and developing tools and business processes that support efficient and effective exchange of information and knowledge – what we refer to as "knowledge transactions" – between senior decision makers and their support staff in military command centers. Efficient and effective knowledge transactions, when facilitated by technologies that support the human process of information exchange, result in decision makers having access to the information they need when they need it, in a format that is easily understood and applied.

The current focus of CMD 21 research is on collaboration and information and knowledge sharing between multiple individuals in a group/team context when these groups are at different echelons of command. The research also investigates various means of supporting knowledge transaction through the enhancement of shared mental models using tools and business rules that help structure information requirements, alert decision makers to important events and changes, and facilitate efficient information exchange behaviors.

THE CONNECTION WITH ESG-1: OPERATIONALLY-DRIVEN RESEARCH

Upon being selected as the Commander ESG-1 (CESG-1) in 2004, RADM LeFever contacted the A2C2 and CMD 21 program sponsor at ONR to request that these programs engage with ESG-1 to help the Navy and Marine Corps develop an adaptive C2 architecture for his ESG. The goal was to examine structures and processes related to both planning and operations that would apply when the ESG operated as an unitary entity, or as part of a Joint Task Force (JTF) working directly for the Joint Force Commander (i.e., operating as a small JTF or as a theater reserve). Since ESG-1 formation and pre-deployment work-ups would be underway at the same time as we would be gathering needed information upon which to base our recommendations, a multi-year phased approach of model-based research was agreed upon (Weil, et al., 2006).

During the first phase of this research program, the A2C2 team developed a list of potential issues and recommendations for CESG-1's consideration. CESG-1 and his staff validated and prioritized this list to identify a small set of topics for which data would be collected during deployment to inform the initial modeling and experimental research (Weil, et al., 2006). These topics were drawn from collected research experiences, attendance at a number of training exercises, interviews with ESG personnel, reviews of the literature pertaining to ESGs, including lessons-learned from previous deployments, and actual ship-riding experiences by the research team. Seven topics were chosen for further study based on their importance to mission success, and were rank-ordered by the CESG-1 and his staff. The top three topics were: (1) restructuring the Amphibious Squadron (PHIBRON) cell for both Amphibious and Maritime operations, (2) the designation of an ISR Coordinator or Commander, and (3) analysis of hybrid Supporting-Supported structures and internal control.

During work-ups, CESG-1 had designated the ESG-1 Intelligence Officer (N2) as the ISR Coordinator, and information gathered in visits to ESG-1, both during and post-deployment, had identified several perceived strengths and weaknesses with this assignment, along with a few suggested alternatives. There were several differences of opinion, however, and this emerged as a rich candidate for the early research efforts and the highest priority item. Alternative C2 structures for ISR formed our first Independent Variable (IV) for the research reported in this paper.

Also, during the work-up period, the CMD 21 team identified opportunities to enhance the way that information was organized and presented to the ESG watch standers and decisionmakers. Based on observations and interactions with ESG personnel CMD 21 developed a prototype web-based information organization and presentation tool for ESG-1 use and evaluation during deployment. During the subsequent visits to ESG-1, strengths and weaknesses of this prototype were identified, and recommended improvements were gathered. The presence or absence of the improved version of this tool formed the second IV in the research outlined in this paper.

The next phase of our ESG related research program addressed the development of a realistic and contemporary environment or scenario that would enable study of a number of C2 issues relevant to an ESG, and support multiple research questions deemed salient by the ESG Commander and his staff. The next section describes this scenario design effort in detail.

As noted above, after completing the field-based phase of the research, the A2C2 and CMD 21 teams elected to undertake an experiment to examine questions about the incorporation of an ISR officer and different forms of information display. Thus, the effort reported in the rest of the paper focuses specifically on the incorporation of an intelligence, surveillance, and reconnaissance (ISR) officer, and aims to explore how ESGs with alternate C2 structures and different information presentation strategies affect performance and information flow in an information rich planning and execution environment. A question of interest is: “How do the C2 responsibilities of the ISR officer affect the organization in terms of (*i*) resource allocation, (*ii*) process and coordination efficiency, and (*iii*) performance/execution of the mission?” A second question asks how these factors change with different information sources, e.g., in terms of efficiency of resource allocation, coordination, and communication patterns. For example, are there fewer requests for information when a tool that structures the information space is used? Does that change with the authority levels of the information officer? Our focus on information presentation strategies is inspired by network-centric warfare concepts and CMD 21 research that aims to improve performance in both planning and execution.

SCENARIO DESIGN

A scenario, implemented within the confines of a dynamic simulation tool, provides an environment for examining relevant issues in ESG C2 and for testing new organizational constructs within a laboratory setting. The tool that has served us well throughout our A2C2 research program is the Distributed Dynamic Decisionmaking (DDD-III) simulator (Kleinman, Young, and Higgins, 1996). This tool is well suited for research into organizational design. It provides researchers with a structured and mathematically tractable environment for defining task/mission requirements, asset capabilities, and decisionmaker (DM) roles and responsibilities.

The scenario design was initiated as a project for the C4I Systems Evaluation class within the NPS Joint C4I Systems curriculum during the winter 2006 quarter. Students were tasked to outline a scenario, using a notional geographical area, which would: (1) exercise a large subset of the native capabilities resident within an ESG, (2) reflect the types of missions to which an ESG would be assigned, and (3) be commensurate with the DDD modeling construct. It was also important that the scenario be sufficiently robust as to allow the A2C2 team to study a *variety* of ESG-related C2 issues/topics in the future, as suggested via our extensive interactions with ESG-1 (Weil, et al, 2006), and not just the ISR dimension being discussed in this paper.

The class project itself was based on a prior NPS thesis (Bestesto, 2005) that categorized an ESG's elemental operational tasks (OPTASKS), its assets and its C2 organization, and showed how these could be represented within a DDD construct. The students were asked to select a relevant operational context, and weave the individual task elements into a correlated and temporal event chain that would constitute the "scenario." The class chose a humanitarian assistance/disaster relief (HA/DR) mission in a region of insecurity (e.g., insurgent threats, and terrorists) as the context for the scenario design. This was motivated by the kinds of missions that DoD has engaged in over the past three years, and might be expected to face in the years to come.

Geo-Political Background

The notional area of responsibility (AOR) for the scenario, as shown in Figure 2, is a 400x400nm area that involves primarily the countries of Asiland and Bartola. Politically, Bartola is a pro-western country, but internal rivalries have led to an insurgency hostile to the government that routinely attacks land facilities and merchant shipping. On the other hand, Asiland is a failing state, rife with maritime smugglers and anti-western terrorist groups that support the insurgent factions in Bartola. It is also likely that Asiland's Haven Island is being used as a base for local terrorist and pirate groups. Additionally, the international waterways in the AOR, especially the strait between the two countries, carry high numbers of merchant vessels and oil tankers.

Thirty days ago a HA/DR situation arose when the northern shore of Asiland was struck by a tsunami that caused massive losses to her civilian populace. Large numbers of Asiland citizens fled south, seeking help and assistance. However, this exodus quickly overwhelmed the meager resources of Asiland. Subsequently, many Asiland refugees began to cross the strait to fishing villages and refugee camps in Bartola. Within days, insurgents and terrorist factions in and around Asiland began to take advantage of the situation, moving their operations into Bartola by intermingling with refugees and smuggling weapons onboard fishing boats and merchant ships. Bartola's military was overwhelmed with tracking and locating the large numbers of refugee boats, as well as locating the terrorist/insurgent operatives using these boats and ships for illegal transfers.

The government of Bartola invited the United States to provide HA/DR to Bartola and the relief organizations operating within it. ESG-7 arrived in the region to assume these tasks three days before the start of our scenario. The ships of the ESG spent that time positioning themselves in the waters around Bartola and Asiland while developing the operational picture for both land and sea. Major sea and air lanes were identified, as well as several major ports, villages, refugee camps, roads, and cities/sites. These are shown in Figure 2.

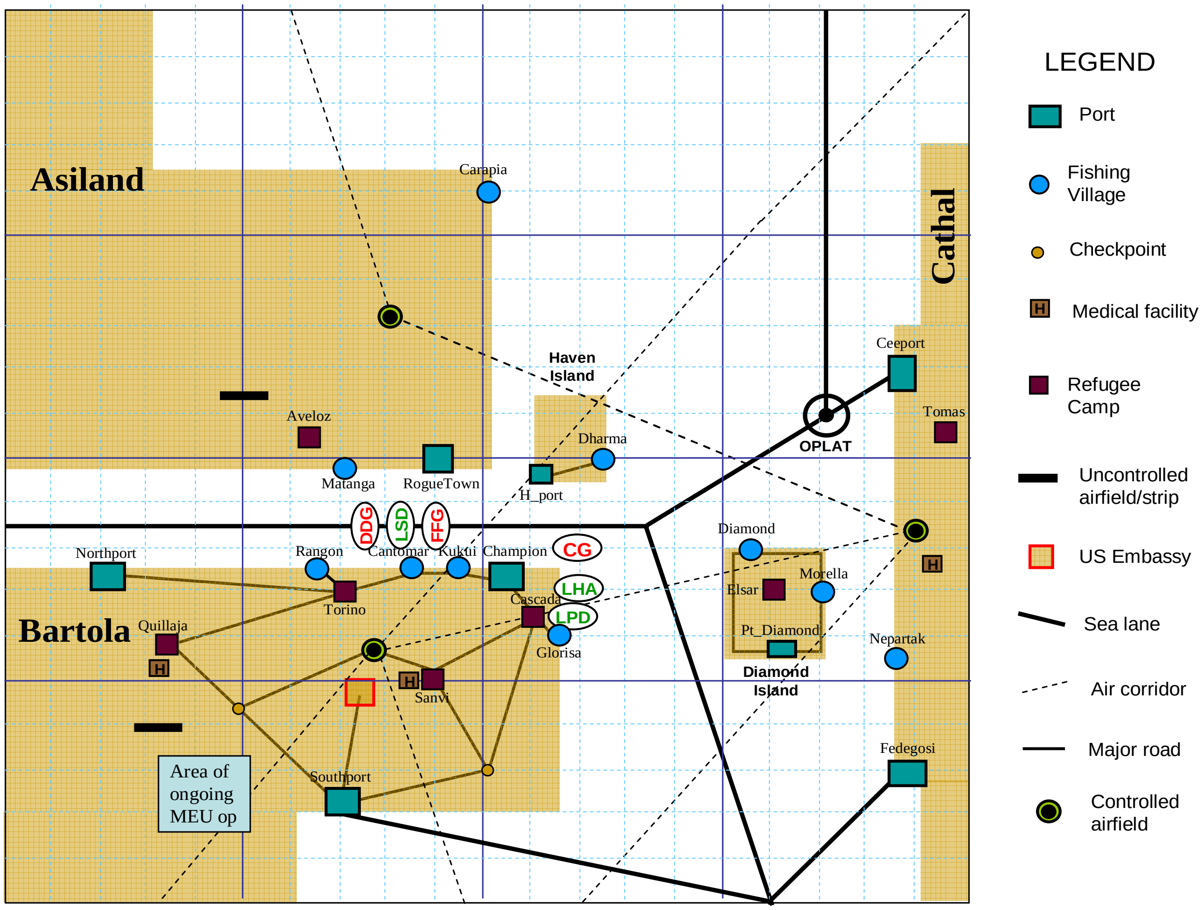


Figure 2: Notional Area of Interest for Scenario Development.

ESG-7 Organization of Forces

Although ESG-7 arrived in theater with its full complement of assets, a large uprising in the mountain areas in the southwest of Bartola forced Bartola's military units to respond. This led to a partial loss of control of the refugee situation in the North. The government of Bartola subsequently requested US forces to assist in dealing with the insurgency in the southwest and to protect relief efforts. The US agreed, and deployed the majority of the 31st MEU to support Bartola's actions. As a result, the *remaining* embarked ESG-7 forces included 4 UAV ISR assets, assigned initially to the ESG Commander (CESG), plus:

<u>Marine Expeditionary Unit (MEU):</u>
- 1 AV8B, 1 AH1, 2 UH1 (on the LHA)
- 2 MSPF (based on LSD and LPD)
- 2 RECC teams (deployed in Bartola)
- 2 SOF teams (deployed in Bartola)

<u>Sea Combat Command (SCC):</u>
- 3 RHIB (based on CG, DDG, FFG)
- 2 SH60 (based on FFG)
- 2 HH60 (based on LHA)
- 1 LCU and 2 LCAC

(Note, in ESG-1 the PHIBRON Commander was also the Sea Combat Commander (SCC), and was usually referred to as such. We use the terms PHIBRON and SCC interchangeably in the rest of the paper.)

Task Definitions
Tasks, in DDD parlance, are the activities/items that decisionmakers (DMs) must be concerned with and/or prosecute. Generally, tasks such as non-stationary contacts (maritime traffic, ground convoys, etc.) that arrive dynamically over time must first be detected, primarily via the use of an airborne asset. A task has attributes that define its overall state, such as hostile or cooperative, the presence of weapons, the type of cargo, etc. It is precisely the knowledge of these attributes (obtained via extensive and continual ISR) that, in turn, drives the decision as to what asset package is to be used to prosecute the task – if at all – and by whom. The major classes of tasks that have been introduced into the current scenario are described below:

Fishing Villages (FV): These are the major points of departure and entry of refugees, terrorists/ insurgents (commingled with the refugees), and weapons. There are four FVs in Bartola. ISR is required to continually monitor for the presence of refugees and weapons, and to learn crowd demeanor (normal or protesters or terrorists). The ROE calls for the prosecution/pacification of any FV with weapons and terrorists, however the assets to be employed differ depending on whether refugees are present or not.

Fishing Boats (FB): These are the vehicles by which various cargo (normal, refugees, weapons, or unknown) is brought into the FVs. The crew of a FB will have a particular temperament (cooperative, uncooperative, hostile). FBs may need to be visited, boarded, searched and seized (VBSS). The ROE calls to not board any FB containing *only* refugees. (Bartola authorities will handle these.) However, *any* FB with unknown cargo, or confirmed to have weapons onboard should be boarded. The temperament attribute will determine whether the boarding can be done with a RHIB team, or requires a MSPF (hostile temperament). A FB with weapons that is boarded is “detained,” i.e., removed from the scenario, thus negating its delivery of weapons. Oftentimes a VBSS will yield some intel relevant to other tasks/activities, and/or a “heads up” on insurgent future plans.

Sea Patrol Boats (PB): These fast boats ply the waters in the AOR. They could be from country Bartola or Asiland. The Asiland boats are subject to being commandeered by terrorists/ insurgents, who might use them to attack international shipping. The ROE calls for destroying any PB that is verified as being piloted by insurgents/terrorists.

Oil Tankers: Tankers ply the sea-lanes going to and from a local oil platform (OPLAT). ISR is needed to monitor their status (normal or hijacked). These big ships could be the targets of insurgents who might try to blow one up in a sea-lane. The ROE calls for protecting the tankers from attack by insurgent PBs and/or coastal missile sites.

Merchant ships/vessels (MV): These carry cargo (none, weapons, food or unknown) into the ports of Bartola. From there the cargo is typically loaded onto convoys that go to the refugee camps. The status of a MV could be harassed, hijacked or normal transit. We do not “attack” MVs, but protect them from attack by insurgent PBs and/or coastal missiles sites.

Refugee Camps (RC): There are several RCs located in the AOR; four are in Bartola. The ESG’s primary mission to is continually monitor these camps to be aware of any changes regarding the presence of weapons and the nature of the crowd demeanor (normal, protesters, terrorists/ insurgents). Weapons and/or terrorists arrive into a camp via convoys, or possibly via military ground patrols. (This is a parallel to the FB-FV link.) The objective is to keep weapons convoys from getting to the RCs, and to assure that food convoys make it through. Thus, there may be status changes in the RCs through the course of the scenario. As per the

ROE, RCs are not "attacked" – but the status of RCs is passed to future plans to determine what to do "tomorrow."

Truck Convoys: These ramble over the roads, typically from the ports to RCs, bringing cargo (refugees, food, or weapons). Each convoy is under the control of a particular country (Bartola, insurgents, UN relief, or an unknown group). The ROE calls for destroying any insurgent-driven convoy that contains weapons, using either an AH1 or an AV8.

Military Ground Patrols (GP): These are similar to PBs, but on land in Bartola. The country of a GP is either Bartola or insurgent or unknown. The ROE calls for destroying confirmed insurgent GPs (especially those that threaten food delivering convoys) using an AH1 or AV8.

Buildings/sites (or small enclaves): These are located on the various roads in known locations and could house terrorist/insurgent command cells. There may be activity (none, normal or suspect) going on in and around a building. The temperament of personnel in a building could be cooperative, uncooperative or hostile. Thus, buildings are somewhat of a ground analogy to the FBs. Oftentimes, checking out a building will yield some valuable intelligence as regards enemy future intent/plans. The ROE calls for destroying any building with confirmed suspect activity *and* hostile temperament.

Other task classes: The above task classes are the primary ones that demand ISR for the measurement of their attributes. However, the scenario includes additional task classes that require ISR in other capacities such as search/detection. These include rescue efforts (sea and land), location and destruction of SAM and coastal missile sites, and ISR mapping requests from higher-level authority. These are time-critical tasks that are injected into the scenario at specific times. In addition, the information needs of a (future) planning cell may trigger a *current* ISR task demand, e.g., the need to know the temperament and capability of a medical facility.

In order to build temporal detail into the scenario, individual tasks drawn from the above-noted task classes are woven into a series of 15-20 "vignettes" that are spaced over a real-world time period of approximately 18 hrs. Two examples of such vignettes are:

Example 1: Tanker Mobil_One has left the OPLAT and is going south in the sea lane. If not foiled, there is a suicide attack by an insurgent-commandeered PB as the tanker nears Diamond Island. If the suicide attack is foiled, there is a cruise missile attack on the tanker at a later location that can be stopped if the launcher is discovered and destroyed in time.

Example 2: RC Sanvi starts with no weapons and a normal crowd, but protests start because promised food is late. In the meanwhile, the UN food convoy enroute from Southport is held up by a rogue military ground patrol. Once US forces arrive, the GP lets the food convoy continue to Sanvi. If it does not arrive there on time, insurgents take over the RC.

Measurement of Task Attributes

The scenario has been designed/constructed to stress the (limited) ISR resources of the ESG, and to require multiple ISR sensors to learn all attributes of a task in order to resolve the uncertainty in how/if to prosecute the task, as well as providing a complete picture of the task's status. Thus, effective coordination of ISR assets among DMs is expected to be fundamental for the success of the overall mission, and is a main driver in the selection of our independent variables. A major aspect in this construction was the specification of which assets can measure the attributes of which tasks. Some assets have been assigned primary capability for measuring some attributes, while others have only a secondary capability for measuring some attributes. An asset/sensor with primary (P) capability will obtain an attribute measurement (faster and) at a further range than a sensor with secondary (s) capability.

The scenario has been designed through adjustment of task loading and arrival patterns such that successful ISR will require the use of secondary ISR assets. While the UAVs are indeed primary for many task classes, there are simply not enough UAVs to satisfy the often conflicting ISR demands that the scenario imposes on the SCC and the MEU. Table 1 shows the relationships between assets/sensors and their ability to measure the various task attributes.

	Fishing Village			Refg Camp		Med Facility		Bldg		Truck Convoy		GP	Fishing Boat		Oil Tkr	MV		PB
	Refugees	Weapons	Crowd	Weapons	Crowd	Temperament	Med Capability	Temperament	Activity	Cargo	Country	Country	Temperament	Cargo	Status	Cargo	Status	Country
UAV	P	P		P					P		P			P		P		P
MSPF													P	P	s	P	P	s
RECC	P		P		P	P		P	s	P	s	P						
SOF	P		P		P	P		P	s	P	s	P						
UH-1	s	s		s			s		s		s	s	s		s		s	s
AV8B																		
AH-1																		
HH60	s	s		s		s	P	s	s		s	s	s		s		s	s
SH60	s	s		s					s		s	s	P		P		P	P
RHIB													s	s	s	s	s	s
Ships													s		s		s	s

Table 1: Asset capabilities for measuring task attributes.

Warfare Commander Responsibilities
The MEU Commander (MEU-C) has authority for the ground portion of this operation. The MEU's primary task is to provide up-to-date information on the status of the fishing villages, buildings, ground military patrols and truck convoys in Bartola, and to take appropriate action if required. Additionally, the MEU-C should be prepared to coordinate with the SCC on hostile VBSS operations as well as security checks on refugee camps as requested via the CESG.

The SCC has been assigned responsibility for the maritime portion of the operation. The SCC's primary task is to execute the UN mandate to stop weapons shipments being carried by local fishing boats into Bartola. SCC's secondary objective is to provide maritime defense of international shipping in the AOR. Due to the potential presence of hostile forces aboard some of the fishing boats, coordination with the MEU-C will be required to execute some boardings.

All warfare commanders and/or decisionmakers (DMs) are expected to coordinate with each other to monitor refugee and security status in fishing villages and refugee camps. Additionally, DMs must be prepared to exercise the ESG Commander's tenants of Adaptive C2 in asset deployment; with particular attention paid to ISR tasking while operating in the AOR.

EXPERIMENTAL DESIGN AND INDEPENDENT VARIABLES

As stated earlier, one of the issues presented for CESG-1's consideration was the designation of an ISR Coordinator or Commander. Prior to our presenting this recommendation, CESG-1 had independently designated the ESG-1 Intelligence Officer (N2) as the ISR Coordinator. Our subsequent visits to ESG-1, during and post-deployment, had identified several perceived strengths and weaknesses with this assignment, along with a few suggested alternatives. There were several differences of opinion on all of these, however. Two main issues were whether oversight of ISR asset utilization should be centralized at the ESG-level or decentralized, and who should have tasking authority over the scarce ISR assets. This field-based issue motivated further data collection. The next section elaborates on findings reported in Weil, et al. (2006) to justify the design decisions regarding the ISR-Officer independent variable presented below.

Field-based Findings Related to ISR-Officer Independent Variable

There are three primary users of the information provided by ISR assets: the ESG, MEU, and SCC Commanders and staffs. Each has valid need for the real-time information that can be provided by assets such as the Scan Eagle UAV in the accomplishment of their planning and operational tasks. Some of the personnel we interviewed felt that the organization and process put in place by CESG-1 worked fine, and assured apportionment of the assets in alignment with CESG's intent. Others felt that it resulted in too high a priority being placed on the ESG-level requirements to the detriment of the subordinate components' (MEU and SCC) needs. Some of these personnel felt that the ISR asset utilization should be coordinated at the ESG level, but that the assets should be "owned" and tasked by the components – the ESG-level requirements could be handled by the components "supporting" the ESG planners. Still others felt that there should be *no* ISR Coordinator or Commander, and that the components should own and task the assets and self-synchronize to meet the ESG-level requirements. These observations formed the basis for our three levels of the Independent Variable – ISR officer. As discussed earlier, the presence or absence of the improved version of CMD 21's web-based information organization and presentation tool formed the second IV.

A 3 x 2 mixed experimental design was employed with five teams (four six-person teams and one five-person team), each split into two groups of decisionmakers (DMs). One group was concerned with current operations ("executors"), while the other group was concerned with future (24-72 hr) planning. Our first independent variable is the presence/non-presence of an ISR officer at three levels. Level 1 has *no single person* responsible for coordination of assets – the responsibility for ISR coordination is diffused over the SCC and MEU-C. At level 2 an *ISR Coordinator* is responsible for pushing/ pulling information among the participants and for coordinating use of ISR assets based on the Commander's Intent. Level 3 involves an *ISR Commander*, who has the same responsibilities as the ISR Coordinator and, additionally, owns all UAVs and allocates them on a case by case basis.

The three levels of the first independent variable are depicted in Figure 3 below. This continuum extends from self-synchronized ISR asset coordination, i.e., the SCC and MEU decide how best to employ the ISR resources, to the ISR Coordinator, who coordinates ISR asset use by managing the information flow between all players but does not control ISR assets, to the ISR

Commander, who in addition to managing the flow of information and directing use of ISR assets, owns primary ISR assets to allocate on an instance-by-instance level.

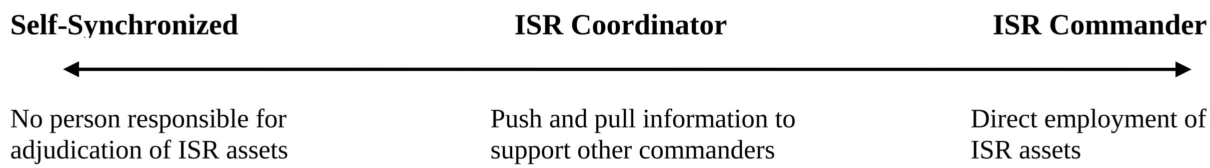


Figure 3: The ISR Coordination Continuum.

The second independent variable – information sources – emulates network-centric warfare concepts, and has two levels: the Multi-Mission Manager (M^3) and shared folders. All players have access to all information; however the way that information is organized varies: The organization of information emphasizes role-dependent information. When presented with the M^3 level of this variable, participants access information via "M^3 Pages" – web pages which integrate information from multiple sources into a single product. Information within the M^3 pages is organized around the participant's tasks. When the M^3 is not present, information is available, but organized in a shared-folder schema. The information space provides tactical information needed primarily by the future planners; however (different) information in the webspace is also needed by the execution DMs.

Independent Variables

Independent Variable 1: Levels of the ISR coverage independent variable are: (*i*) baseline where *no single team member* is responsible for the ISR duties, thus the responsibility for ISR is diffused among the team members who posses assets that can perform ISR duties; (*ii*) *ISR Coordinator* where one member of the team assumes the role of an ISR coordinator and is responsible for pushing/ pulling information among the other team members to coordinate use of ISR assets to perform tasks; and (*iii*) *ISR Commander*, where one member of the team assumes the role of an ISR commander and owns all primary ISR (i.e., UAV) assets, allocating them on a task-by-task basis, while also having the same responsibilities as the ISR Coordinator.

Table 2 presents the three levels of the ISR coverage independent variable in some detail. We can see that at the baseline level ISR duties and asset coordination are accomplished in a self-synchronized manner, i.e., team members decide amongst themselves how best to employ the ISR resources. At the ISR Coordinator level, the ISR coordinator manages the ISR sensor information flow among team members, but does not control ISR assets. Finally, at the ISR Commander level, the ISR commander owns all primary ISR assets and considers requests for asset use from the other team members.

Independent Variable 2: The two levels of the within-subjects second independent variable, information source organization, are: *(i)* the current or legacy system of shared folders, and *(ii)* the Multi-Mission Manager (M^3), which is designed to emulate network-centric warfare concepts. In both treatments, all team members have access to all of the information, however the way that information is organized varies. At the legacy level the information is presented in a shared-folder schema where all information is available but has no specific organization. At the M^3 tool level, the tool integrates information from multiple sources into a single product. Information within the M^3 pages is organized around the team member's tasks. An example of an M^3 page is shown in Figure 4. Note that the information space provides tactical information needed by both executors and planners.

	Levels of ISR Officer Independent Variable		
Functions	**Self-Synchronized**	**Coordinator**	**Commander**
Coordinate ISR assets	n/a	ISR-O	n/a – controls the assets
Direct ISR assets	SCC & MEU	SCC & MEU	ISR-O
Own ISR assets	SCC/MEU	SCC/MEU	ISR-O
Coordinate non-ISR	N/A	ISR-O	ISR-O
Goals	• MEU: on MEU • SCC: on SCC • ESG: n/a	• MEU: on MEU • SCC: on SCC • ESG: ESG (staff), MEU, SCC	• MEU: on MEU • SCC: on SCC • ESG: ESG (staff), MEU, SCC
Facilitate info exchange	No	Yes	Yes
Information access	Each from own assets (unless pushed out)	Information open to all	ISR-O has all Others – from own assets
Asset Transfer	No	No	No

Table 2: Description of Three Levels of ISR Coverage Independent Variable.

Figure 4: Example of an M^3 Page.

Execution and Planning

The experiment emphasizes both execution and planning activities, and their interplay, especially as regards their mutual need for ISR. Execution DMs are responsible for tactical execution while they engage in scenarios presented via the Distributed Dynamic Decisionmaking (DDD-III) simulation environment. Planning DMs are engaged in crisis action planning, which is used when only limited time (24-72 hours) is available for planning. Planning often entails the use of multiple ESG assets. Both groups require substantial ISR capability: executors require ISR resources to conduct the mission tasks and planners require significant ISR from both executors and from information-based assets. The execution group engages in a scenario, as discussed above, that is comprised of a series of discrete but interrelated tasks with defined military objectives that require a range of time sensitive responsibilities, as well as some unanticipated tasks that place demands on ISR assets.

Tasks performed by the planners focuses on the location and evacuation of refugees. The development of this mission plan requires significant information from the information space, as well as ISR information from the execution DMs. Information requests can be made via the ISR Officer or directly with execution DM equivalents. Figure 5 depicts the relationships and major subordinate commands (MSC) that comprise the two groups (shown here as triads) of DMs. Each MSC (Sea Combat Command or Marine Expeditionary Unit) is comprised of one executing DM and one planning DM. In addition there are two representatives from the ESG.

Team Structure: Roles and Responsibilities

Roles played by the experimental participants include the following: (1) SCC execution, (2) SCC planning – responsible for providing SCC input to future plan development, (3) MEU execution – includes elements of the air combat element (ACE), ground combat element (GCE), and land-based special-operations force (SOF), (4) MEU planning, (5) ISR officer, and (6) the ESG planning DM – who is responsible for providing input on the future plan development, integration of injects from both the SCC and MEU planning DMs, and serving as the liaison between the executors and the planners.

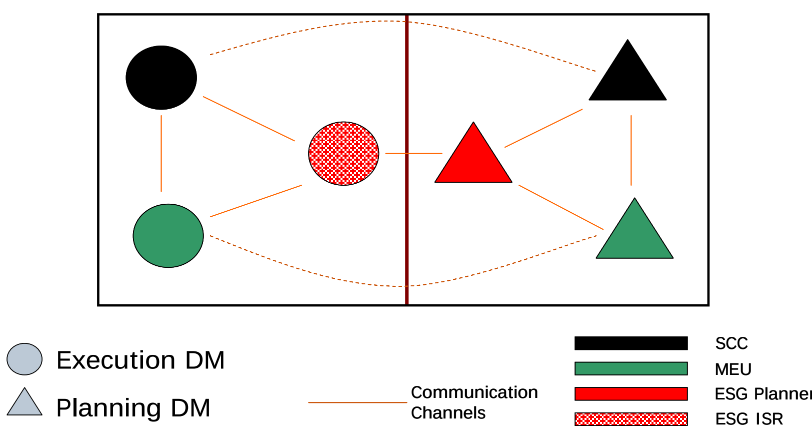


Figure 5: Schematic of Major Subordinate Commands for Execution and Planning DMs.

The team members designated as executors are responsible for tactical execution and engage the DDD simulation environment directly. The SCC execution role entails control of sea-based assets. Thus, this position is responsible for monitoring the attributes of boats and ships surrounding the countries of interests, prosecuting targets (VBSS, MIO) deemed to be hostile, keeping sea lanes open/safe for traffic, locating and neutralizing hostile coastal defense batteries, and providing defense to commercial shipping. The MEU execution role entails control of air combat elements, ground combat elements, and land-based special-operations forces. Thus, this position is responsible for defense of humanitarian and relief efforts, combat operations in the southern region of the battlespace, conducting HUMINT recon capability when required, and conducting non-combatant evacuations (NEOs) if required. The ISR coordinator role is responsible for reviewing sensor data, adjudicating resource scarcity issues among team members, and coordinating ISR asset use. At the highest level, the ISR commander "owns" all of the UAVs, and is responsible for locating all refugee concentrations, identifying and evaluating potential safe havens for refugee evacuation (especially the airfields), assessing the status of hospital facilities, and responding to ISR requests from higher echelons.

Team members designated as planners are responsible for planning future missions related to the evacuation of refugees to safe refugee camp locations. They are engaged in crisis action planning, which is used where limited time (24-72 hrs) is available for planning. Development of this mission plan requires significant information from the information space, as well as ISR information. Details of the planning task are presented below.

Assignment and Order of the Treatment Groups

Table 3 shows the assignment and counter-balancing ordering of the experimental treatments. "A – B" indicates the ordering of the information source organization levels, where A stands for the legacy system and B stands for the M^3 tool.

	Baseline		**ISR Coord**		**ISR Cmdr**	
	A - B	**B - A**	**A - B**	**B - A**	**A - B**	**B - A**
Team A			**X**			
Team B					**X**	
Team C				**X**		
Team D	**X**					
Team E						**X**

Table 3: Assignment and Order of Treatment Groups.

We can see from Table 3 that one team is assigned to a baseline condition (in which there is no ISR officer) and two teams each to the ISR coordinator and ISR commander conditions. In addition, the ISR-Officer treatment is replicated, that is, each team sees the treatment condition they were assigned to twice (while their planning counterparts experience M^3 vs. information folder conditions).

THE INFORMATION SPACE AND THE PLANNING TASK

The information space provides an opportunity for not only a more realistic reflection of the information domain than DDD is able to provide, but also allows for more complex experimentation on information management.

Planner Task

The effect of the M^3 pages on situation awareness and information exchange was investigated within the planner task of the experiment. Three participants from each team played the roles of three planners – an ESG Planner (ESG5), a MEU Planner (MEU5), and an SCC Planner (SCC5). At the beginning of each of two 45-minute phases of the experiment, the planners were asked to develop a plan for evacuating refugees, which they would be asked to submit to the ESG CDR (a a simulated "confederate" superior described further below). The MEU Planner was required to provide the ground portion of the plan, the SCC Planner was required to provide the maritime portion, and the ESG Planner was required to compile the plan for presentation to the ESG Commander. Thirty-minutes after the start of each phase, the ESG Planner received an e-mail requesting him/her to submit the plan by clicking on a hyperlink to a form which he/she filled out with answers to the plan questions.

During the first phase, planning involved selecting the best site for refugee evacuation while during the second phase, planning required determining the best way to secure the site and move the refugees. Participants were provided with a set of planning questions around which to structure their plan:

<u>Phase 1</u>: Selecting the best site

- Which village provides the most suitable site, considering the fact that many refugees may be injured and require medical assistance?
    - What factors contributed to that decision?
- Which other villages might also be considered if the first site does not provide sufficient capacity?
- Which villages did you rule out as evacuation sites?
    - What factors contributed to that decision?
- *What information was missing or not available* to you that you needed/would have liked to help you develop your plan?
- How confident are you in your recommendation of the most suitable site?

<u>Phase 2:</u> Securing and moving refugees

- What new information has been provided that is related to the situation and might affect the evacuation plan?
- What issues/problems do you foresee in evacuating the refugees?
- What resources are required to evacuate the refugees?
- What tasks do you recommend be conducted prior to evacuation that relate to:
    - Securing the evacuation site
    - Supplying the evacuation site
    - Securing the evacuation route
- *What information was missing or not available* to you that you needed/would have liked to help you make your decision?
- How confident are you in your recommendations?

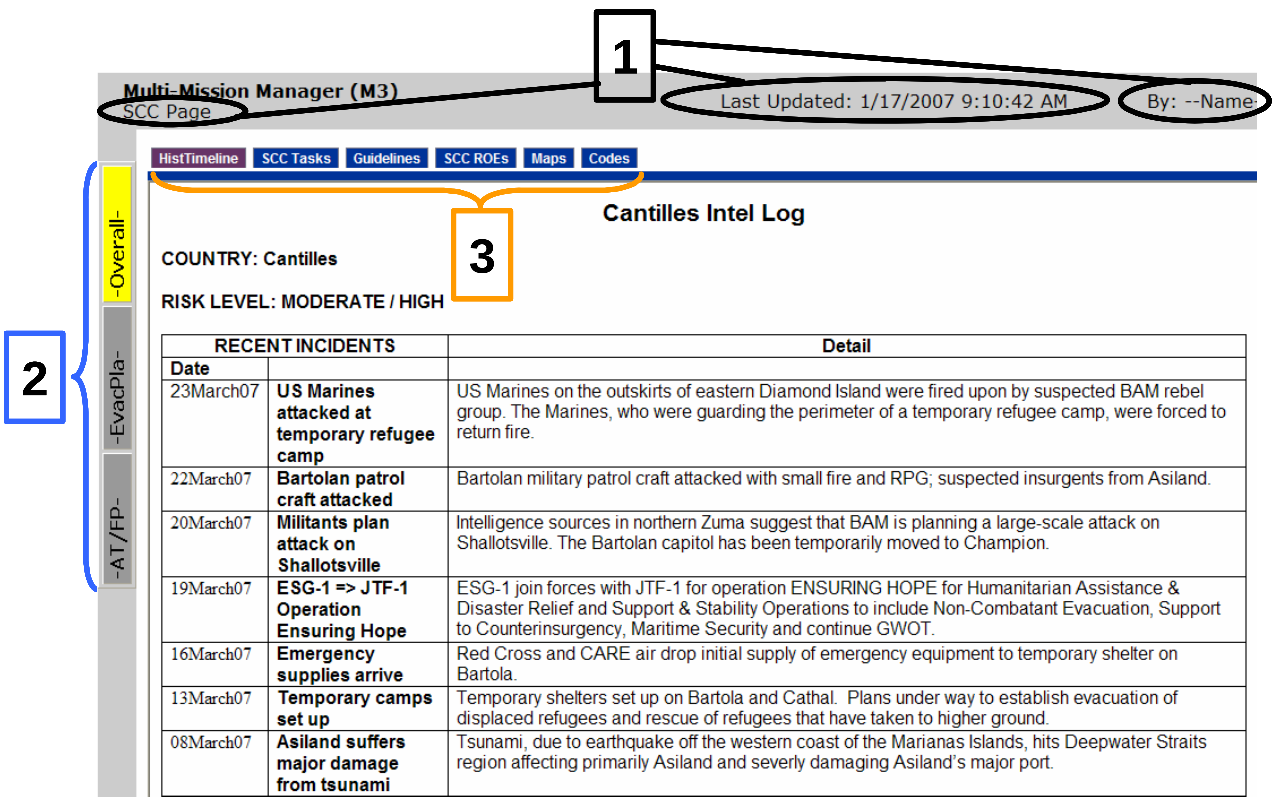
In both phases, the plan required identification of "missing information" and, in Phase 2, identification of relevant new information was required. In addition to providing a plan, the planners were also required to answer e-mails sent to them from the CESG. These e-mails were automatically sent to the planners based on a prescribed timeline. The planners were told that the e-mails were critical and they were instructed to answer the e-mails as quickly and as accurately as possible.

Information Sources

The primary source of information for the planners – for both the plan and answering e-mails – was the “information space.” Each planner had access to his/her own set of files within the space. Some information was available to at least two of the planners and some information was unique to an individual planner. Planners used one of two information space formats:

Multi Mission Manager (M^3) Page: The M^3 Page provided integrated and organized access to the information required by the planner. Figure 6 shows an example M^3 page, which is organized as follows:

1. Information about the purpose of the page, how recently it was updated, and who created it is provided at the top of the page.
2. The labeled tabs on the *side* of each page are called “Mission Tabs.” Users can click on these tabs to select and access more information about particular missions.
3. The labeled tabs on the *top* of each page are called “Information Areas.” Users click on these tabs to view a variety of different types of information relevant to the currently selected mission. Rolling the mouse over the tabs provides a preview of their contents. Many of the contents of the M^3 Page included hyperlinks to other files (also displayed within the M^3 Page).



RECENT INCIDENTS		Detail
Date		
23March07	US Marines attacked at temporary refugee camp	US Marines on the outskirts of eastern Diamond Island were fired upon by suspected BAM rebel group. The Marines, who were guarding the perimeter of a temporary refugee camp, were forced to return fire.
22March07	Bartolan patrol craft attacked	Bartolan military patrol craft attacked with small fire and RPG; suspected insurgents from Asiland.
20March07	Militants plan attack on Shallotsville	Intelligence sources in northern Zuma suggest that BAM is planning a large-scale attack on Shallotsville. The Bartolan capitol has been temporarily moved to Champion.
19March07	ESG-1 => JTF-1 Operation Ensuring Hope	ESG-1 join forces with JTF-1 for operation ENSURING HOPE for Humanitarian Assistance & Disaster Relief and Support & Stability Operations to include Non-Combatant Evacuation, Support to Counterinsurgency, Maritime Security and continue GWOT.
16March07	Emergency supplies arrive	Red Cross and CARE air drop initial supply of emergency equipment to temporary shelter on Bartola.
13March07	Temporary camps set up	Temporary shelters set up on Bartola and Cathal. Plans under way to establish evacuation of displaced refugees and rescue of refugees that have taken to higher ground.
08March07	Asiland suffers major damage from tsunami	Tsunami, due to earthquake off the western coast of the Marianas Islands, hits Deepwater Straits region affecting primarily Asiland and severly damaging Asiland’s major port.

Figure 6: Example M^3 Page.

Planners accessed the M^3 Page via their web browser and navigated the page using hyperlinks, and the “back” and “forward” buttons of the browser.

Information Space Folder: The information space folder represented the typical organization of information used by ESGs (based on previous observations and discussions). The folder contained all of the files that are provided within the M^3 Page, including the hyperlinked information. However, the information was simply included within a single folder and not organized in any specific way. Planners accessed the folder via a shortcut on the desktop.

Planners could also request needed information – specifically information that could be collected by ISR assets – from the executors. They were instructed to first look for information that they needed to develop their plan or answer requests for information (RFIs) within their own information space. Then, if they were not able to find it in the information space, they were to ask the other planners on their team to find it within their own information space. If the three planners were still unable to find the required information, they could then request the executors to provide it to them, for example via the tasking of an ISR asset.

Dynamic Information Web Space: Both the planners and executors were able to view the latest ISR available in DDD using a Dynamic Information Web Space. This tool was displayed throughout the experiment on each executor's workstation, and was provided as a file/link within each planner's information space. Participants could view the ISR information about a specific DDD item (e.g., Fishing Village Kukui) by selecting the class of information (e.g., Fishing Village) and the specific member of that class (e.g., Kukui) from drop down menus. After the item was selected, a time-stamped list of information was provided, with the newest information at the top.

Planning Task Measures

Data collected during the planning task of the experiment include following:

Planner Situation Awareness: Measures of task performance is used to evaluate the degree to which the two levels of the information space variable (M^3 Page vs. Information Space Folder) support the planners' situation awareness. These measures assess the planners' understanding of the situation relative to the actual situation depicted in DDD and the information space. The measures include: *(i)* the speed and accuracy of responses to e-mail requests from the ESG CDR; *(ii)* the accuracy of answers to questions within the plan; *(iii)* the accuracy at identifying new information; *(vi)* the accuracy at identifying missing information.

Information Exchange: The effects of the two levels of the information space variable on the efficiency and effectiveness of information exchange among the planners, and between the planner and executors, can also be evaluated. This assessment is based on the number and content of information exchanges via e-mail and via voice communications. Examination of these communications reveals how many of the required pieces of information were actually requested (effectiveness of information exchange), and how few irrelevant pieces of information were requested (efficiency of information exchange).

OVERALL TEAM MEASURES: EXECUTORS AND PLANNERS

As described above, the ISR independent variable has three levels: Level 0 has no ISR officer, Level 1 includes an ISR-Coordinator, and Level 2 includes an ISR-Commander. The empirical question before us was how each of the organizational structures changed C2 efficiency. To gauge this, we included dependent measures derived from multiple sources, each designed to capture fundamental aspects of C2. Communications-based measures, observer-based measures, and systems-based measures of performance were all employed.

Communications-based measures of performance

Communications was managed using a Voice over Internet Protocol (VoIP) application (BBNTalk; BBN Technologies Corp, 2006). This application allows rapid configuration of multiple communications channels, enabling emulation of real-world communications networks for small teams. Using a second PC-based software application, verbal communications between team members were captured by observers at an intermediate level of detail that incorporated both quantitative and semantic aspects of the communication stream (Orasanu, 1990; Entin, 1999). During the conduct of a scenario, a single observer listened to the communications in real time, using a laptop computer to code the source, recipient, time, and the type of the verbal communications among the team members. The observers coded the communication for the three execution team members plus an aggregate position representing the entire planning cell. Utterances were divided into three basic categories: transfers (e.g., provision of information), requests (e.g., demands for information), and acknowledgements (e.g., "Roger."). Both transfers and requests were, in turn, classified as requests/transfers for/of information (e.g., "Where is refugee camp Bravo."), action (e.g., "Perform a VBSS on fishing boat Tuna_02."), or coordination ("On my mark, execute VBSS on Tuna_02.").

The BBNTalk application also permitted recording of the experimental sessions. This recording segregates each channel, and within each channel segregates each participant. The recordings are time logged to allow for cross-comparison with the utterance classification described above or with the simulation events. Transcripts will be made from these recordings, and additional utterance classifications may be made for further inquiry. In particular, the latencies between particular critical utterances (such as requests for action) and the participant response within the DDD simulation will be derived from the recordings of the sessions.

The execution and planning cells were encouraged to talk about a number of tasks relating to the status of refugees, hospitals, and airfields. The ratio of within- versus between-cell communications is an additional measure that will be used to gauge interactivity. In addition to the dependent measures above, a range of hybrid communications/systems measures will be used. These measures will allow cross-comparison of voice request with action within the simulation.

Observer-based measures of performance

Several paper-based assessments were constructed to increase our understanding of team composition, scenario workload, and participant impressions. These assessments were given directly to the participants, and required both qualitative and quantitative responses.

- *Pre-experiment demographic form.* The participant population used for this study included military officers with a wide range of experiences. A pre-experiment demographic survey was used to gauge the amount of participant variability. Participant age, rank, language experience, and assignment history were captured. In addition, two questions about video game familiarity were included, as the simulation pace and windows-based interface is similar to some game applications.

- *Self-report workload.* The number of tasks required of the participants using the DDD was high, as the behaviors of interest require that the participants have to make decisions under moderate-to-high workload conditions. A variation of the NASA TLX survey (Hart and Staveland 1988) was presented to each participant at two points during the experiment. The scales used were: Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration. Each of these scales was anchored by "Low" and "High," with a description of each scale on an adjacent page.

- *Post-Experiment questionnaires.* Following the final session, participants filled out a brief survey reflecting on their performance. Both quantitative and open-ended qualitative questions were presented. The quantitative questions were presented on a seven point Likert-type scale, and included indications of information flow, coordination, asset allocation, task difficulty, and team efficiency. Open-ended questions were geared to elicit participant impressions of the ISR officer position.

Measures of team effectiveness and coordination are difficult to obtain through either self-report or simulation-based measures. As the effects of different C2 structures and processes could easily manifest themselves in the dynamics of the experimental teams, several observer-based measurement instruments were developed. For each experimental session, two experimenter/observers monitored execution team progress through the scenario. At the end of each session half, the two experimenter/observers completed the following two questionnaires.

- *Team Performance Assessment Form.* The primary observer form focused on (1) the allocation of time between managing information and allocating assets and (2) the overall participant performance on both ISR and kinetic tasks. Fifteen Likert-type scales were included, with clearly contextualized anchors for references. The experimenter/observers were trained on the purpose of the form and took narrative notes throughout the session to inform their final conclusion. The final scale in the survey was an overall measure of team performance, enabling a cross-comparison of component performance with subjective overall achievement.

- *Teamwork Assessment Form.* In addition to team performance, elements of teamwork were evaluated. These teamwork behaviors were taken from the current teamwork literature (e.g., Sims, Salas, Burke, 2004) and included communications, monitoring, back-up, coordination, and team orientation. Each measure was presented on a Likert-type scale, and included contextualizing anchors.

Systems-based measures of performance

The communications, self-report, and observer-based metrics provide critical insights into team performance and interaction. However, the subjective nature of these measures can be qualified by converging objective measures based on system states during the experiment. These systems-based measures come from two primary sources: the DDD and the Dynamic Information Space.

Simulation-based measures

The DDD simulator enables the collection of several variables related to individual and team performance such as latency to process a task, accuracy in processing a task, percentage of tasks processed, and percentage of tasks processed at 100% accuracy. In this effort, we focused on task completion latency and asset allocation. Table 4 describes some of the measures being used for assessment.

Dynamic Webpage Access Information

Participants were given access to a dynamic web page that provided information on task attributes (e.g., the cargo and temperament of a fishing boat). This page was a critical tool, and its effective use motivated task focus within the simulation. Data on access clock time, number of times a page was accessed, and user identity was collected. This data will be critical in determining if the different ISR Officer levels affected information access behaviors.

DDD-BASED MEASURE	CATEGORY	PURPOSE
Latency between "appearance" of task and detection	**Latency**	Indirect measure of participant workload and battlespac monitoring. Dependent on task location relative to task assets.
Latency between detection and first measurement/ISR	**Latency**	Measure of participant prioritization when compared to latency of concurrent task
Latency of measurement and conduct of task	**Latency**	Measure of participant task completion performance
Number of measurements by asset class divided by total number of measurements	**Asset Allocation**	Particular emphasis was placed on a subset of ISR tasks. The proportion of measurements on these asset classes indicates the effects of that emphasis
Proportion of primary and secondary ISR asset utilization for ISR tasks	**Asset Allocation**	Assets were designated as either primary (e.g., UAVs) or secondary (e.g., helicopters) ISR assets. The proportion of ISR tasks completed by secondary assets is an indication of task prioritization.

Table 4: Subset of DDD-based dependent measures.

CONCLUSIONS

Several innovations were seen in the design of this experiment. A new laboratory environment was constructed that incorporates a new and novel A2C2 scenario with a new capability to explore information and knowledge management issues. The scenario focuses on humanitarian assistance/ disaster relief in a hostile environment where many of the operational tasks require use of scarce ISR assets. The enhanced information space was added by researchers from the Command-21 research team. The M^3 Tool provides researchers with the ability to explore additional information and knowledge management issues in future experiments.

Development of the new scenario required us to operationalize a complex military environment, through abstracting and tailoring the mission tasks faced by an ESG into the DDD-III simulation. This process of developing a scenario that has currency for future experimentation evolved from researchers riding with ESG-1 during the initial and final phase of their deployment as well as through attending training courses for ESG-1.

A challenge faced by the research team was how to incorporate and integrate both dimensions of an ESG's overall C2 process – planning and execution – into a single experiment. These two functional areas interact with each other, i.e., the executors need to keep the planners informed of all developments to support the planning process, while the planners often request additional information from executors to guide their planning process. This two-way interaction was embodied in this laboratory environment to provide a venue for empirical testing of key topics of interest to ESG-1.

Results from this experiment (which was completed in March 2007) will be forthcoming in subsequent conference presentations and publications.

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