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A C2 Hidden Profile Experiment

Topic 3: Information Sharing and Collaboration Processes and Behaviors

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Abstract

At ICCRTS 2008, JHU/APL presented “A Review of Cognitive Metrics for C2” (Natter, Ockerman, and Baumgart, 2008). One of the significant gaps revealed in the literature review was understanding and evaluating information sharing and collaboration processes. This year, to address this gap, JHU/APL applied a well-established paradigm in communications and group dynamics research, hidden profile tasks (Stasser and Titus, 2003), to the C2 domain. Hidden profile tasks test groups’ ability to share and deconflict information that is distributed across multiple roles. JHU/APL developed and piloted a realistic C2 hidden profile experiment to explore information sharing and collaboration in a simulated carrier strike planning task, with collaboration between three warfare commanders: Sea Combat Commander (SCC), Air Defense Commander (ADC), and Strike Commander (STKC). This pilot study suggests that hidden profile tasks can support the understanding and analysis of agile C2 information sharing and collaboration processes and behaviors.

A C2 Hidden Profile Experiment

Human cognition is a critical component of C2 agility as warfighters detect pertinent changes in operational situations, adapt their thought processes and respond appropriately – often more easily than the systems that support them. Although an understanding of human and team cognition would enhance C2 agility, as explored in "A Review of Cognitive Metrics for C2" presented at ICCRTS 2008, there is a significant gap in team evaluation and collaboration techniques.

Current team assessment techniques like team task analysis (TTA), team cognitive task analysis (TCTA), team behavioral assessment methods, and team communication assessment methods provide insight into some aspects of a team, but are lacking in providing objective, quantitative collaboration and team performance results. Team task analysis (TTA) methods develop an understanding of knowledge, skills, and abilities and tasks that require taskwork and teamwork, but do not necessarily provide insight into the level of interdependence of the tasks or quantitative results. In addition, TTA techniques do not emphasize information flow through the team or team collaboration. (Stanton et al, 2005; Holton & Baldwin, 2003) Arthur et al, 2005, noticed this and incorporated elements of interdependence into the initial development of three team task analysis scales. TCTA methods are decision focused and describe the cognitive processes associated with team decision making; however, TCTA methods fall short in providing objective, quantitative results related to team performance. (Stanton et al, 2005; Salmon et al, 2006) Team behavioral assessment methods generally involve subject matter expert and/or self ratings on questionnaires. (Stanton et al, 2005) The limitation of team behavioral assessment methods are that they are subjective and usually administered post-hoc since they can be disruptive to team tasking. (Stanton et al, 2005) Team communication assessment methods can provide information like frequency of communications between nodes and mode of communication, but typically require a great deal of statistical and or content analysis to understand social network patterns. (Stanton et al, 2005; Butts, 2008) As these methods demonstrate, studying team cognition can be particularly difficult because it includes not only multiple individual information processing, but also group information sharing, transactive knowledge, communications processes, and other group dynamics.

In order to address the gaps in team assessment and collaboration, JHU/APL investigated the application of hidden profile tasks to analyzing C2 team performance. The hidden profile experimental paradigm (Stasser & Titus, 2003) was invented over fifteen years ago, and has flourished in social psychology and communications research. This is partly because hidden profile tasks require teams to make informed decisions by sharing information and collaborating in an information-rich environment, where the problem of information overload has become ubiquitous. One aspect of hidden profile tasks that distinguish it from other information overload studies is that it is inherently focused on a group, rather than on an individual, and is consistent with other social psychology and communications research. Groups often perform poorly and fall into certain predictable mistakes when dealing with distributed information (Stasser & Titus, 2003). One of these errors is a focus on common knowledge at the expense of unique information held by only one group member. In hidden profile tasks, even when unique information is entered into conversation, it tends to be ignored in group decisions.

Characteristics of hidden profile tasks are:

- Distribution of information such that no single person can see the entire picture;
- Deceptive first impressions followed by biased selection of evidence to fit this impression;
- Tendency of groups to share common knowledge and ignore uniquely-held knowledge;
- Time and resource pressures that prevent consideration of all evidence

Since solving hidden profile tasks depends on a combination of trust, good collaboration practices, and adequate technology, hidden profile tasks reveal how groups interact, coordinate, collaborate, and make decisions under pressure. These tasks are useful for both experimental studies of group work and evaluation studies because they yield quantitative results. Group decisions are scored through comparison to known optimal solutions. Group processes are scored by tracking the flow of specific pieces of information, coding use of evidence, and analyzing other aspects of collaboration process that have been shown to correlate with successful outcomes.

JHU/APL developed and piloted a realistic C2 Hidden Profile task pilot study to explore information sharing and collaboration between three warfare commanders in a simulated carrier strike scenario. We conducted three study sessions using our C2 Hidden Profile task with former Navy planners playing the Sea Combat Commander (SCC), Air Defense Commander (ADC), and Strike Commander (STKC) roles. The warfare commanders had to collaborate via text chat to develop a course of action to support strikes on three targets while providing force protection. In accordance with the hidden profile paradigm, the commanders were provided with shared and unique information and shared and unique updates. Although each warfare commander had different objectives and offensive and defensive capabilities, they had to reach a consensus on how to allocate assets and minimize risk to the mission and own forces. Results showed that even experienced planners are vulnerable to Hidden Profile task biases and mistakes.

Methods

Carrier Strike Group Planning Background

The C2 hidden profile task was designed to emulate the second (course of action (COA) development), third (COA analysis), and aspects of the fourth phases (COA comparison and decision) of Naval Warfare Planning (See Figure 1), because these phases require a great deal of collaboration. (Navy Warfare Development Command, 2007)

During the mission analysis phase, the CSG generally reiterates the goals and purpose of the mission so that the CSG understands their main goals and tasks and can provide their interpretation of the mission to higher authorities for feedback. Once the CSG receives approval, they begin to develop typically three to five courses of action for the mission. They analyze the COAs for validity and then move into the fourth phase of comparing the COAs and presenting them to the Admiral (Composite Warfare Commander) for approval. Once they receive approval, they move into the orders development phase and then transition into execution. (Navy Warfare Development Command, 2007)

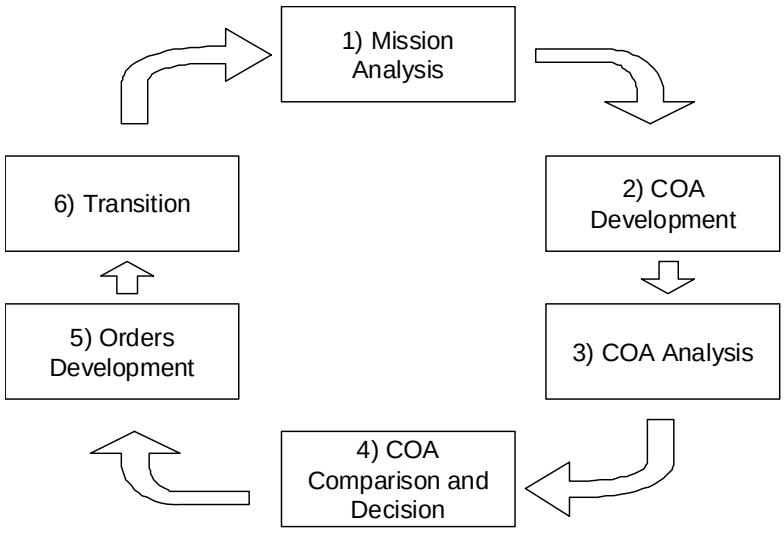

Figure 1. Naval Warfare Planning Phases (Navy Warfare Development Command, 2007)

The hidden profile task explored the information sharing and teamwork between three tactical warfare commanders: Sea Combat Commander (SCC), Air Defense Commander (ADC), and Strike Commander (STKC) in a simulated carrier strike group (CSG) (See Figure 2). In general, the SCC's responsibility is to protect against surface and undersea threats, the ADC's responsibility is to protect against air threats, and the STKC's responsibility is to hit targets of interest. The inherent conflict between these warfare commanders is that the SCC and ADC have defensive priorities, while the STKC has offensive priorities. Also, many of the strike group assets can support and impact multiple tactical mission areas. For example, a submarine with the capability to shoot tomahawk missiles can be used by the SCC to investigate undersea threats or by the STKC to launch tomahawk missiles at targets. Likewise, an enemy submarine equipped with an anti-surface cruise missile concerns the SCC and the ADC because it poses both an undersea threat and an airborne threat. Because of these overlaps, the warfare commanders have to negotiate to determine how to allocate assets and minimize risk to mission and their own forces. The warfare commanders brief their COAs to their superior, the composite warfare commander (CWC) who ultimately accepts or rejects the COA (See Figure 2). For this study, experimenters acted as the CWC.

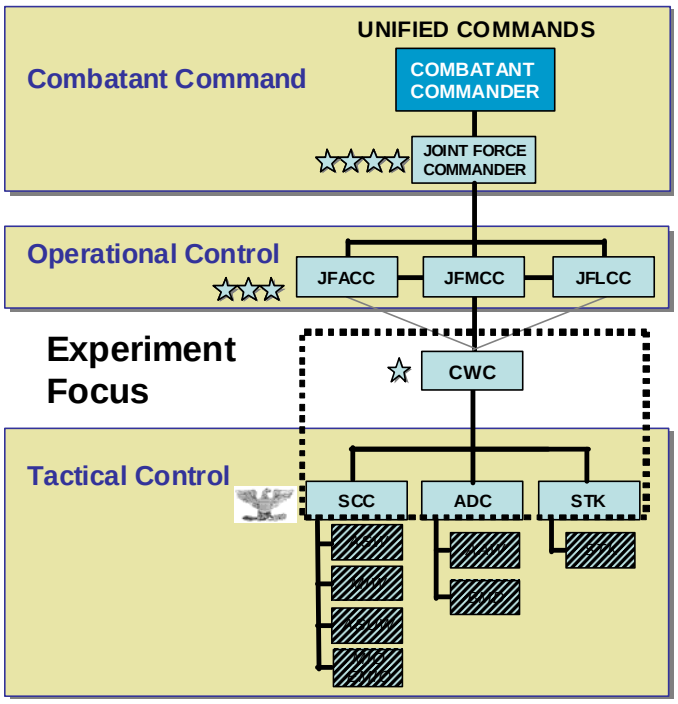

Figure 2. Command Structure (experiment focus in dashed box)

Task Realism

The authors leveraged and applied CSG planning observations to the task design and collaboration considerations. The authors attended Nimitz (CSG-11) planning work-ups including the Naval Tactical Planning (NTP) and Combined Warfare Commanders' Conference (CWCC) courses. The authors conducted interviews regarding CSG planning with members of the CSG-11 planning staff and training syndicate leads at Tactical Training Group Pacific (TACTRAGRUPAC). The authors also observed CSG planning while underway on the forward deployed George Washington (GW) CSG . The GW is also the permanent flag ship for Command Task Force-70, which is the CSG component of Battle Force Seventh Fleet, which contains Destroyer Squadron 15 (DESRON-15), and Carrier Air Wing 5 (CVW-5). To add realism to the task, all materials were reviewed by subject matter experts in Naval Warfare Planning, and when possible, leveraged by existing planning training scenarios or associated documentation. The experiment was reviewed and approved by the Johns Hopkins University Homewood Institutional Review Board (HIRB).

High-Level Study Summary

The task was run three times with three different teams of experienced planners to evaluate team performance and collaboration in planning a realistic naval mission versus a regional power. The scenario was loosely based on the unclassified Sea Viking 04 scenario and some training scenarios from TACTRAGRUPAC. The scenario was set in the seventh fleet area of responsibility around the Indonesian islands. The mission, called Sulawesi Deterrence, was to deter or neutralize weapons of mass effect (WME) targets on the island of Sulawesi.

Mission Analysis Read Ahead Materials

Since the experiment focused on COA development and analysis, the participants were provided read-ahead materials to summarize the first phase of planning, Mission Analysis. They were instructed to read this material before arriving for the experiment. The read-ahead documents included a warning order (WARNORD), blue force brief, enemy order of battle, background on Sulawesi, and a weather brief.

Operational Context

The WARNORD summarized the context for the scenario. The island of Sulawesi in Indonesia was chosen for its interesting naval geography. The scenario was completely fictional, based on characters and situations that bear no relationship to any real-world situation in Indonesia. In this scenario, a rogue governor of Sulawesi, Moamar Da'Eshi, wished to either convert Indonesia into a Muslim country or to have Sulawesi secede and become a separate state. Da'Eshi is tied to a fictional terrorist group, Asian Jihad, and has an uncertain level of influence with the Indonesian military.

Of primary importance to the US task force is intelligence reports of three targets linked with WMEs. Target 1 was a chemical factory used to produce a nerve agent, which could be used as a WME. Target 2 was where WME experts were living and working. Target 3 was a well protected terrorist training camp.

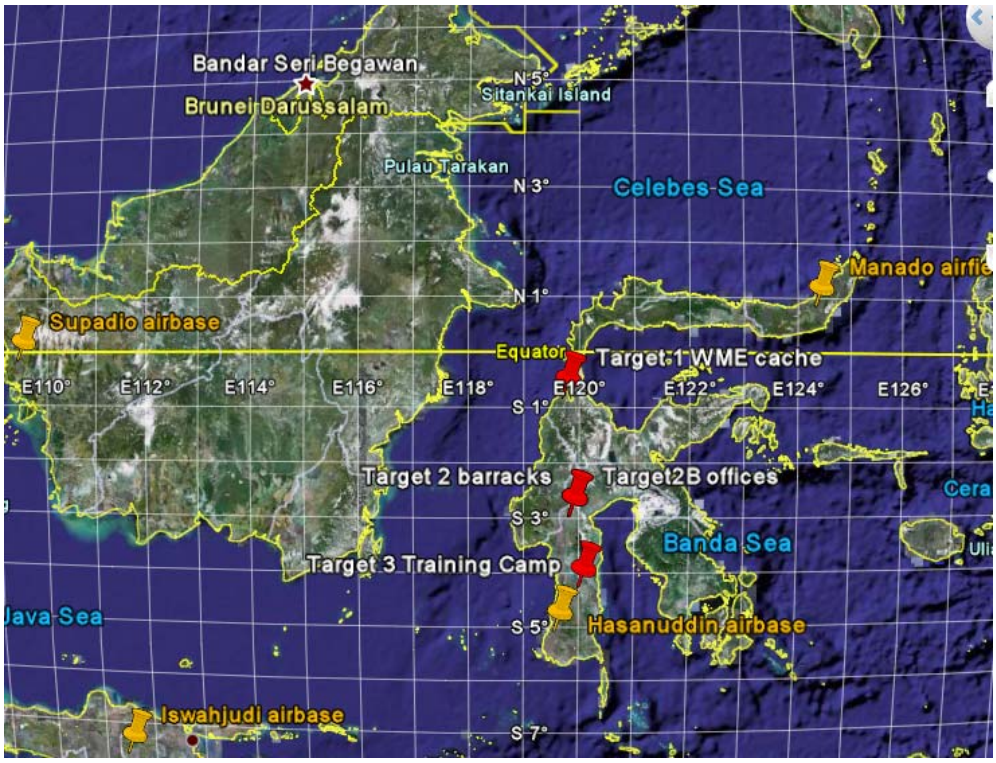

Figure 3. Three possible CVOA locations: Celebes, Java, and Banda seas

Another threat to the CSG was a terrorist small boat attack. The WARNORD also indicates that Da'Eshi, a former submarine commander, is expecting a US attack and his goal is to sink a US aircraft carrier. The CSG is requested to conduct a show of force and be prepared to quickly execute a strike on the targets.

Detailed Task Description

The task took approximately eight hours to run and was broken into three phases. During Phase I, the warfighters were instructed to choose one of the three seas that surround Sulawesi to operate in (Java, Celebes, or Banda). During Phase IIA, the methods of strike had to be described for targets 1, 2, and 3, and a carrier operating area needed to be determined within the Celebes Sea. During Phase IIB, the force protection plan, including the position of ships around the carrier, needed to be delineated; the strike timeline needed to be specified; key risks to mission and own forces needed to be described; and a plan needed to be outlined for exiting the Celebes Sea.

Figure 4 shows the documents that were available to all roles, and the documents that were made uniquely available to each warfare commanders throughout the hidden profile task.

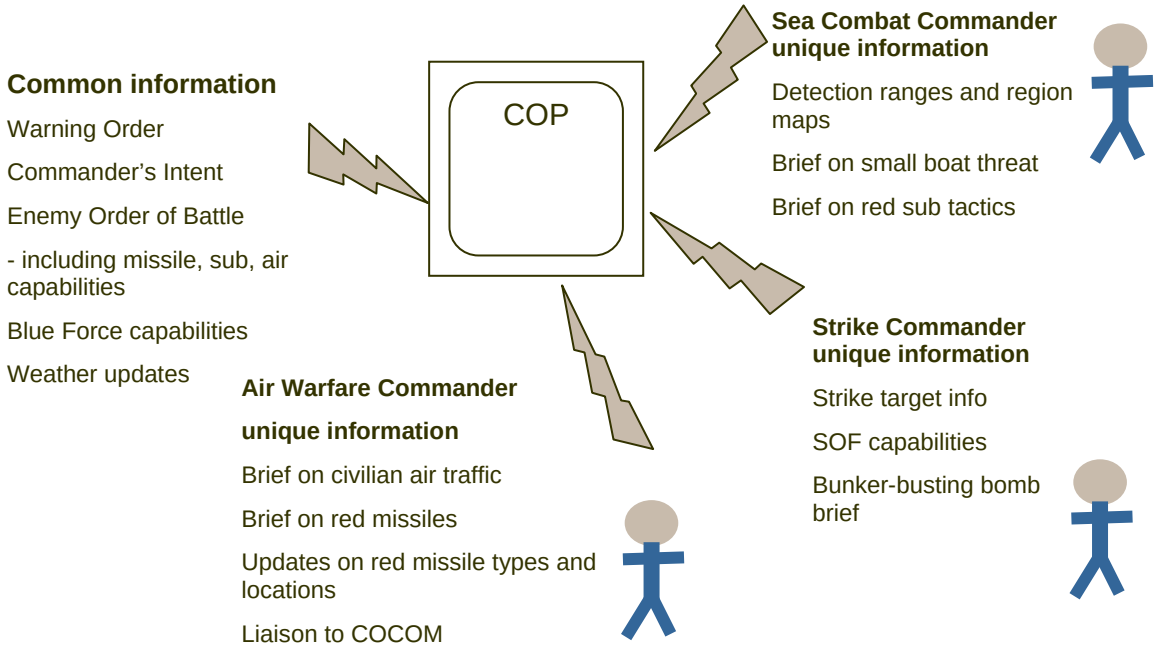

Figure 4. Distribution of briefing information among three warfare area commanders

Phase I: At the beginning of an experimental test session, participants signed consent forms, and experimenters answered any questions regarding the read-ahead materials. Then experimenters provided a quick introduction and training session on the tools that the warfighters would use (See Experimental Set-Up Section). During Phase I, the participants were provided shared knowledge including an execution order (EXORD) to complete a strike on the WME targets on Sulawesi, while minimizing risk to own forces. A rule of engagement, emphasized to all warfare commanders, was to avoid direct confrontation or destruction of Indonesian military assets. All participants were provided a Powerpoint template to brief the selection and rationale for the sea of choice to the experimenters playing the CWC. To justify the sea choice, they were instructed to identify the suitability for strike and identify the risks to their forces in the sea of choice. They were also provided templates to submit requests for additional information (RFIs),

if necessary, and a template to submit requests for additional resources. They were told that they could modify and add to the slide template as needed. The unique information was distributed such that only the ADC was provided with enemy air positions and information about enemy missiles; only the SCC was given red naval positions, sound velocity profiles, bathymetric data and information about enemy submarines and missiles; and only the STKC was provided informational documentation regarding the WME and additional target information. The team was given approximately two hours to complete Phase I. At the conclusion of Phase I, participants completed a workload and situation awareness questionnaire (see Appendix) and spoke briefly about their lessons learned and general impressions of the task.

Phase IIA: During Phase IIA, the warfare commanders were told that the CWC chose to operate in the Celebes Sea for Operation Sulawesi Deterrence regardless of which sea was chosen in Phase I. Experimenters told participants which sea to operate in as a "restart" to the problem, so that potential mistakes would not carryover into the next phases. The shared information was a Phase II EXORD, which included transit time to the Celebes Sea and constraints on strike completion. Shared information also included a PowerPoint template that they would use to brief to the CWC at the end of the phase. The unique information was distributed such that only the SCC received information on ASW helicopter support and enemy naval positions; the ADC was provided with enemy air positions and information about enemy missiles; the STKC was provided a special forces brief. The team was given approximately 90 minutes to complete Phase IIA. Again, when Phase IIA was finished, participants completed the questionnaire and spoke briefly about their lessons learned and general impressions of the task.

Phase IIB: Phase IIB consisted of adding detail to the draft of the COA developed during Phase IIA. Again, the warfare commanders were provided with a PowerPoint template of the presentation due to the CWC at the end of the phase. The first shared deliverable was a description of the force protection plan including the formation of assets around the carrier. The second shared deliverable was a strike timeline, which was requested in 2-4 hour increments with key assets and events. The third shared deliverable was a description of the key risks to mission and own forces. The fourth and final shared deliverable was an outline of an exit plan from the Celebes Sea. The team was also allowed approximately 90 minutes to complete Phase IIB. At the completion, as in prior phases, participants completed the questionnaire and spoke briefly about their lessons learned and general impressions of the task.

Sample Hidden Profile Problem - Submarine Deployment

To better understand the task and team decisions that were made, we will describe one important scenario decision that followed the hidden profile of information distribution. A critical decision for teams in this task was how to use the submarine, the USS *Newport News*, accompanying the carrier strike group. This resource was needed by two role players, the SCC and the STKC, who required the submarine for missions that were not necessarily compatible. The main enemy threat to the task force was several unlocated adversary submarines. Submarine detection and threat mitigation would be an overriding concern throughout the scenario, and the task force's own submarine was the best detection and mitigation platform available for this task. Therefore, the SCC would likely be counting on the Newport News to protect one of the carrier's flanks. However,

careful reading of the Strike commander's information would show that special forces were going to be needed to guide the strike on target #1. The best option for inserting special forces or Seals in the crowded straits was using the submarine's dry dock. This placed a second, even more critical demand on the single CSG submarine.

This dilemma had these possible solutions:

> If the STKC and the SCC realized this conflict early enough in the scenario, there was a single solution that would allow the submarine to fulfill both roles. The ideal solution would detach the Newport News from the CSG and send it on a route from the south up through the strait of Makassar where it could attempt to detect enemy submarines along the way. It would perform the special forces insertion, then stay in the northern neck of the strait to guard against submarine approaches through the straits. This would require the Celebes Sea to be chosen as the carrier operating area (CVOA).
>
> A second, less optimal but still viable, solution would be to again choose Celebes Sea, but send the submarine along a northern route along with the rest of the fleet. This would require a much longer transit time, because the submarine typically travels slower than the rest of the fleet, and would not allow the submarine to perform anti-submarine detection up through the strait, but would allow it to perform both the special forces insertion and provide limited ASW coverage.

All other solutions, including strikes from other CVOAs would require the submarine to choose between the two roles, resulting in a sub-optimal use of resources.

This problem fits the definition of a hidden profile problem because information is distributed among role players, and the correct solution to the problem requires sharing and processing of unique knowledge. In the results section we describe the three pilot groups' solutions to this problem.

Participants

Experimenters distributed a recruitment e-mail soliciting JHU/APL employees with prior Naval planning experience to participate in a one-day team study of collaboration metrics for command and control. Experience in and/or knowledge of Anti-Submarine Warfare (ASW), Surfare Warfare (SuW), Anti-Air Warfare (AAW) and/or Strike planning was required, but expertise was not. Participants were compensated for their time and were e-mailed read-ahead materials.

Participants had an average of approximately 5 years of experience in military C2, multi-mission planning, and multi-mission COA development. The minimum amount of tactical planning combined across the ASW, AAW, and Strike domains was 6 years and the maximum amount of combined tactical planning experience was 17 years. The average combined tactical planning experience was approximately 12 years.

Data Collection

These documents were collected from each group: consent forms and background questionnaires, text chat logs, human factors questionnaires administered after test phases, researcher observation notes from debrief with participants and during experimentation, and PowerPoint briefs submitted following each phase.

Experimental Set-Up

Each warfare commander was supplied with a geospatial plot of the situation, the template of the briefing product they were responsible for, and communication software. Google Earth was used for the geospatial plot and experimenters created overlays to visualize threat and own force data. The displays were static, but were updated at the beginning of each phase. Microsoft PowerPoint was used as the template and briefing product. The sharing software was MeetingPlace, which has text chat and the capability to share Powerpoint presentations synchronously.

The participants were told that the only way that they could communicate was via text chat, so although the SCC and STKC were physically collocated, they behaved more as though they were distributed. In a typical CSG, the ADC is located on a cruiser and the SCC and STKC are located on the carrier, so to mimic this situation, the ADC was located in a separate room. Figure 5 depicts the experimental set-up.

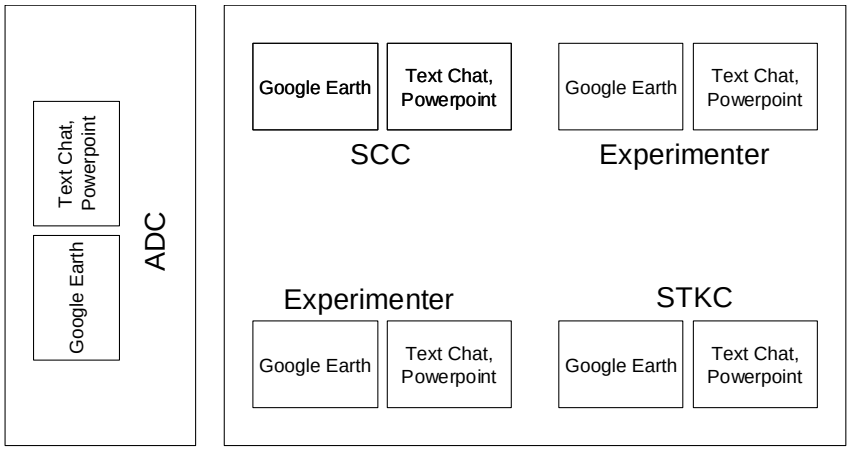

Figure 5. Experimental Set-Up, with location of each of the warfare area commanders and computer monitors

Measures- Scoring

To evaluate the quality of planning products, we developed a scoring rubric. Rubrics were based on input from subject matter experts (SMEs) from each of the warfare areas, and were reviewed for validity and appropriateness by two SMEs. The final rubric assigned points for these aspects:

Identification of threats. The team was asked to identify air, missile and submarine threats. Submarine threats were to be specific as to which boat was a threat from which direction; missile threats were to be specified by type and location; air threats were to be specific as to airfield and aircraft type. There were also several non-conventional threats that should have been identified; including small boat attacks, threat of Red forces using commercial shipping or air traffic to mask a pre-emptive attack, and threat of attack on refueling airplanes or special forces on the ground. Finally, the possibility of weather disrupting the strike timeline should have been considered.

Strike design. The effectiveness of the team's strike plans was scored. This aspect of the rubric gave points for appropriate use of assets, a timeline that took into account

travel time and possible resource conflicts, appropriate assignment of strike weapons to targets, and strike plans that avoided collateral damage to civilian air traffic, shipping traffic, and bystanders near the strike area.

Additional information and assets. The scenario included a set of RFI responses that would be given to teams only if requested. Scoring rubric gave points for requesting appropriate information. The scenario also had two types of support assets—a refueling tanker for strike aircraft and a P3 Orion maritime patrol aircraft for ASW support—that would be made available on request. The scoring rubric gave points for requesting these assets.

Finally, the experimenters gave points for aspects of the plan that did not fit into the pre-established rubric but were appropriate and added value to the plan. Two of three plans received these 'extra credit' points for RFIs and plan aspects dealing with Red force communications intelligence, which was a weak point of the scenario and rubric.

Measures - Questionnaires

A background questionnaire was administered to obtain information and knowledge regarding participants' knowledge, skills, and abilities. It also included a section on pre-study preparation to determine if participants understood the read-ahead material and Mission Analysis phase of planning.

A human factors questionnaire (See Appendix) was completed by participants following each phase and subphase in test sessions 2 and 3. To leverage human factors subjective questionnaires used for individual workload and situational awareness, experimenters modified the NASA Task Load Index (TLX) and Situational Awareness Training Technique (SART) and fused them. Experimenters determined that SART's supply and demand of information probes were very similar to workload, so the third question from the 3-Dimensional SART regarding Situational Understanding was included. The next part of the questionnaire included open-ended questions to capture some of the rationale behind the choices reflected in the PowerPoint briefouts. The open-ended questions were tailored to be applicable to the tasks involved in the just completed phase.

At the conclusion of the study, an overall questionnaire (See Appendix) was administered. It contained the modified, fused NASA TLX/SART that was filled out for that particular individual, then there was a teamwork section where the individual rated their perception of aspects of the team. The teamwork part was written in the same form as the NASA TLX and had a seven-point likert scale. The questions were assembled from several teamwork attribute definitions (See Appendix). The teamwork sections included teamwork mental model, information sharing, implicit coordination behavior, task interdependence, team performance, and team dynamics.

Results

Hidden Profile Results

Table 1 shows how the three pilot sessions scored as compared to the maximum possible score according to the rubric developed for Phase I. Because of the detail in the rubric, and the short time available to teams to construct their plans, we did not expect any team

to approach a perfect score. As Table 1 shows, none of the teams approached perfection, with the highest scoring team earning 77 of 221 possible points.

These scores suggest that we were successful in creating a C2 task that was difficult enough to be useful for future research. Many experimental tasks are hampered by 'ceiling' effects where all scores are close to maximum, preventing insightful analysis of variance. Our pilots showed that experienced teams, given a weak set of supporting tools and coordination practices, score in the low-mid range on this task. The considerable room for improvement means that the task will be useful for evaluation of future planning systems, operational practices, and other innovations.

Scoring- Phase 1	**possible pts**	**Group1**	**Group2**	**Group3**
SUM	**221**	**77**	**40**	**53**
Banda sea assessment	**54**	**11**	**12**	**13**
Suitability for Strike:	21	1	5	9
Known risks to forces:	33	10	7	4
Celebes sea assessment	**60**	**16**	**9**	**14**
Suitability for Strike:	24	7	0	6
Known risks to Forces:	36	9	9	8
Java sea assessment	**57**	**12**	**6**	**16**
•Suitability for Strike:	21	3	0	7
•Known risks to Forces:	36	9	6	9
Ranking	20	20	10	10
RFI's	21	9	3	0
Request for additional assets	9	9	0	0

Table 1: Scores for three pilot groups compared to optimal solution

An important follow-up question to the results in Table 1 is to ask, even if the three pilot groups diverged from the scoring rubric, did they agree substantively with each other? The answer is no (See Table 2).

	Group1	Group2	Group3
Group1		0.13	0.17
Group2			0.55

Table 2. Correlations between group scores

Table 2 shows a simple correlation of scores using the scoring rubric points assigned, correlating scores along categories. Inter-group correlations were relatively low.

Group responses to example hidden profile problem (Sub Insertion)

We previously described one example issue related to conflicting requirements for operational use of the task force's single submarine. As described, two different warfare area commanders—STKC and SCC—would need the submarine asset for two different missions. Because of the way information was distributed, deconflicting the use of this resource would be a difficult problem, thus subject to typical hidden profile errors. How did the three pilot groups address this issue?

None of the three groups recognized this resource conflict until Phase II of the exercise. At this point the task force was located in the northern Banda sea and it was too late to send the submarine on the optimal route, which was through the strait of Makassar to the west side of the island.

Group 1 recognized the conflict near the end of phase 2, while constructing the strike timeline. To resolve the conflict, this group decided not to insert special forces to locate target 1, and instead planned an unaided airstrike. Our strike SMEs believed that this was unlikely to succeed based on the target description and characteristics. Therefore, the lack of special forces inserted from the submarine posed a serious risk to mission success.

Group 2 planned to use the submarine to perform both missions: inserting special forces and performing ASW in the strait. This was the optimal resolution to the resource conflict. However, the plan called for the submarine to transit to Makassar through the Celebes sea, which introduced a delay. This group did not include submarine transit time in the strike timeline. Therefore, as described, the strike plan included a serious oversight that posed a threat to mission success.

Group 3 planned to use the submarine for both missions, and also included the submarine transit time into the strike timeline. This group successfully resolved the example hidden profile submarine deployment issue in a way that our SMEs judged likely to succeed.

Questionnaire Results

Questionnaires were administered in the first test session after all three runs and after each run in the second and third test sessions because the authors noticed after the first run that other data collection opportunities could be leveraged. Results showed that all teams had approximately equal individual workload and situation awareness scores from the modified, fused NASA TLX/SART (scale 1 low-7 high: roughly 4 and 5 respectively).

In test sessions 2 and 3, where questionnaires were administered after each phase, average workload generally decreased over time and average cognitive workload showed more apparent decreases over time (See Figure 6).

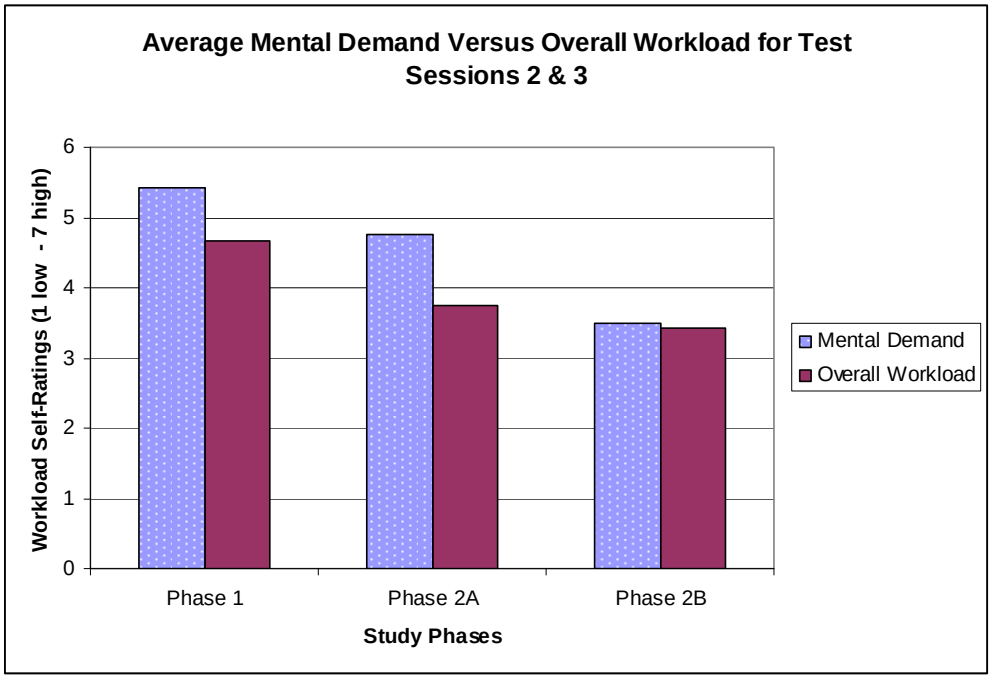

Figure 6. Average Mental Demand Versus Overall Workload for Test Sessions 2 & 3

An interesting result from the questionnaires was that Team 2 had higher ratings on the team attributes than the other teams, and yet their score on the hidden profile task was the lowest. Although Team 2 thought they had a better teamwork mental model, implicit coordination behavior, team performance, team dynamics, and more task interdependence than the other teams, the hidden profile task revealed that they did not collaborate as well as they thought. This is significant because it reflects that the team was over confident in their assessment of their performance. Situations in which participants are confidently wrong are significant because they can lead to serious errors and catastrophes (Sniezek, 1992).

Comments on the technology suite

Post-surveys also asked pilot group members for their comments on both the technology set and experimental setup.

All groups had comments on the relatively limited set of planning and communications tools available. Some comments were:

> "Communications channels poor for Phase I. Warfare commanders got focused on own tasks and delayed answering questions some times."
>
> "Lack of voice comms hampered coordination."
>
> "Available tools were not suited to the task."

> "Electronics once mastered [Google Earth and Powerpoint] seemed to enhance displays and prep of briefing slides, but not necessarily planning process."

No doubt this baseline set of tools was far from the optimal configuration. However, the first author's observation of naval planning exercises suggest that this toolset is not unrealistic. Because this pilot is considered a baseline study, this task may prove useful for demonstrating the efficacy of better planning tools and communication suites.

Discussion

By reading planning documentation, interviewing and observing carrier strike groups in planning training and actual planning, and interviewing subject matter experts, we developed an understanding of the planning tasks and considerations. We leveraged this knowledge to craft a realistic carrier strike group hidden profile planning task involving three roles and a large, distributed information set. This pilot study demonstrated how the dynamics and scoring methods of hidden profile can be applied in a C2 context.

We found the hidden profile approach to have potential as an effective method for evaluating C2 team performance, and implicitly, decision making and collaboration. The hidden profile task was a natural fit for CSG planning because of the inherent interdependence of the warfare commanders.. The warfare commanders have different offensive and defensive priorities and distinct areas of expertise, yet need to work collaboratively to mitigate risks to the mission and own forces. Warfighters are inundated with information and have to filter and prioritize what to share and what to filter or withhold from the team. This predicament is not unique to CSGs, and hence the hidden profile task generalizes to many other aspects of C2.

One of the most significant advantages of hidden profile tasks is that it provides "ground truth" and an associated scoring rubic, which defines and quantifies team performance. The ability to define and quantify team performance provides baseline information. The baseline could be compared to future collaboration tools, other system capabilities, and other variables to evaluate their impact on team performance. The rubric scoring range also provides a spectrum of team performance. Although these are potential results of the hidden profile task, this rubric requires further testing and verification and validation before it would be able to be used in these ways, especially since it would be very difficult to define "good enough."

We chose to design the hidden profile task to be product based and for the warfare commanders to communicate via text chat to cut down on analysis time, which had both pros and cons. Basing results on the briefing products decreased analysis time because the teams were graded based on what was included in the brief. The negative aspect of the score focusing on the product, not the process was that we were unable to credit teams for work-arounds, creativity, and other strategies used. However, this may not be a significant weakness since the CWC or decision maker sees the products, not the process, and makes decisions based on the products. Requiring the warfare commanders to communicate via text chat made content analysis much easier than transcribing audio, but impacted realism. In typical CSGs, the AAW commander is not collocated with the other warfare commanders and relies on text chat, secure phone, video teleconferencing, etc. for collaboration. Also, warfare commanders frequently use chat systems to collaborate with each other. Although warfare commanders use text chat, since they also have other

modes of communication available, some of the participants complained that this made the task slightly unrealistic.

The significance of the hidden profile approach is that unlike many of the existing team assessment methods, the hidden profile task provides objective, quantitative, non-intrusive team performance results well suited to C2 task performance analysis.

Future Directions

Future use of the hidden profile paradigm, and this specific task, will provide a new instrument for the study of C2. In particular, we intend to pursue:

- Research in C2 that focuses on the group-level process of information sharing and collaborative planning.
- Evaluation of future systems, including planning and communication tools that can be improved with well-validated tasks that are sensitive to the most difficult aspects of collaboration.
- Training in C2 practices that can provide evaluation and rapid feedback to both intact and ad-hoc groups.

Although this pilot study involved a small group, experimentation via hidden profiles can be extrapolated to include an increasing number and variety of participants and support collaboration and other C2 social behavior research. Using the hidden profile technique will help better understand, evaluate and improve diverse and physically distributed teams so that they can adapt to changing situations, be better coordinated, and become more agile.

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Participant AAW SCC Strike Test Session 1 2 3

Directions: Please read the title and description, then mark the block in the rating column that most closely represents your opinion.

INDIVIDUAL

Modified NASA TLX Subjective Workload Questionnaire

***Please note that the scale for Performance goes from Good to Bad as opposed to Low to High.**

Title	**Description**	**Rating**
MENTAL DEMAND	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)?	Low High 1 2 3 4 5 6 7
PHYSICAL DEMAND	How much physical activity was required (e.g., mouse clicking, typing, copying and pasting, scrolling, etc.)?	Low High 1 2 3 4 5 6 7
TEMPORAL DEMAND	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?	Low High 1 2 3 4 5 6 7
PERFORMANCE	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?	Good Bad 1 2 3 4 5 6 7
FRUSTRATION LEVEL	How discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?	Low High 1 2 3 4 5 6 7

(Please turn over)

Comments and Suggestions:

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Modified Situational Awareness Rating Technique (SART) Questionnaire

Title	Description	Rating						
ATTENTIONAL RESOURCE DEMAND	Did you feel that the number of variables you had to track was manageable or did you feel overwhelmed? Was the frequency of change in the situation high or low? Was the situation complex?	Low						High
		1	2	3	4	5	6	7
ATTENTIONAL RESOURCE SUPPLY	Did you feel ready for activity? Did you feel that you had to really focus during the situation or did you feel you could multitask?	Low						High
		1	2	3	4	5	6	7
SITUATIONAL UNDERSTANDING	How much information was received and understood? Did you know how to evaluate the data?	Low						High
		1	2	3	4	5	6	7

Comments and Suggestions:

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TEAMWORK

Teamwork Mental Model

Title	Description	Rating						
SKILL FAMILIARITY	Did you feel that you knew the other warfare area commander's task-relevant abilities?	Not at All						Very Well
		1	2	3	4	5	6	7
INFORMATION NETWORK	Did you know which of the other warfare area commanders could provide relevant information about specific facets of the COA development?	Not at All						Very Well
		1	2	3	4	5	6	7
GOAL UNDERSTANDING	Did you feel that the other warfare area commanders understood the mission objectives?	Not at All						Very Well
		1	2	3	4	5	6	7
EXTERNAL CONSTRAINTS	Did you feel that the other warfare commanders were aware of the battle rhythm and deadlines for deliverables?	Not at All						Very Well
		1	2	3	4	5	6	7
INTERNAL CONSTRAINTS	Did you feel that you understood each others' roles (i.e., tasks and responsibilities) and who was supported and supporting?	Not at All						Very Well
		1	2	3	4	5	6	7
COLLABORATION RULES	Did you and your team members agree on effective patterns to collaborate in order to develop COAs?	Not at All						Very Well
		1	2	3	4	5	6	7
SCOPE	Did you feel that you and the other warfare commanders shared a common understanding of the level of detail needed for developing COAs?	Not at All						Very Well
		1	2	3	4	5	6	7

Comments and Suggestions:

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Information Sharing

Title	Description	Rating
INFORMATION FLOW	How efficiently did you feel that information was passed from who had it to who needed it?	Inefficiently Very efficiently 1 2 3 4 5 6 7
INFORMATION FLOW QUANTITY	Did you feel that the amount of information shared was too much or too little?	Too Little Too Much 1 2 3 4 5 6 7
INFORMATION FLOW QUALITY	Did you feel that the other warfare commanders provided information that was task-relevant?	Extraneous Relevant 1 2 3 4 5 6 7
INFORMATION FLOW SPEED	How timely did you feel other warfare commanders responded to your information requests and questions?	Very Late Prompt 1 2 3 4 5 6 7

Comments and Suggestions:

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Implicit Coordination Behavior

Title	Description	Rating

NEED ANTICIPATION	Did other warfare commanders pass on task-relevant information to you and the other warfare commanders without being asked?	Never						All the Time
		1	2	3	4	5	6	7
WORKLOAD SHARING	When you or one of the other warfare commanders experienced high workload, did other warfare commanders complete your or another warfare commmander's part of the task without being tasked?	Never						All the Time
		1	2	3	4	5	6	7

Comments and Suggestions:

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Task Interdependence

Title	**Description**	**Rating**						
INTERACTION	How often did you obtain information and advice from the other warfare commanders in order to complete your tasks?	Never						All the Time
		1	2	3	4	5	6	7
WORKING TOGETHER	How often did other warfare commanders obtain information and advice from you?	Never						All the Time
		1	2	3	4	5	6	7
INTERDEPENDENCE	Did you feel that the task was more individual or team oriented? In other words, did the task require more individual contributions	Individual						Team
		1	2	3	4	5	6	7

	or team cooperation?							
COLLABORATION CLOSENESS	How much compromise and negotiation was required to develop appropriate COAs?	None						A lot
		1	2	3	4	5	6	7

Comments and Suggestions:

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Team Performance

Title	**Description**	**Rating**						
THREAT ASSESSMENT	How well do you think you performed as a team at identifying threats and risks to mission and own forces?	Not at All						Very Well
		1	2	3	4	5	6	7
RISK MITIGATION	How well do you think you performed as a team at risk mitigation to mission and own forces?	Not at All						Very Well
		1	2	3	4	5	6	7
USE OF RESOURCES	How well do you think that external (reach back) and internal assets were utilized?	Not at All						Very Well
		1	2	3	4	5	6	7

COA QUALITY	Did you feel that you and the other warfare commanders produced quality COA(s)?	Not at All						Definitely
		1	2	3	4	5	6	7

COA DEVELOPMENT SPEED	Did you feel that you and the other warfare commanders produced COA(s) efficiently? (within time constraints)	Felt Rushed						Lots of Time
		1	2	3	4	5	6	7

Comments and Suggestions:

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Team Dynamics

Title	Description	Rating						
CONFIDENCE	Did you have confidence in and trust the other warfare commanders?	Not at all						Definitely
		1	2	3	4	5	6	7
CONFLICT RESOLUTION	Did you think that the team resolved conflicts well? (Was working together “a test of wills” or “a meeting of the minds”?)	Low conflict						High conflict
		1	2	3	4	5	6	7

Comments and Suggestions:

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