Improving Operational Situational Awareness with Collaborative Technologies

John Kruse
Center for the Management of Information
University of Arizona
Tucson AZ, 85721
wkruse@cmi.arizona.edu

Abstract

The American military spends a great deal of its resources in efforts to outmatch potential opponents. Usually this takes the form of better equipment, morale and training. Nonetheless, the most important facet of the military operation is leadership. There are, however, few concrete methods that can be applied to lend the commander a reliable advantage. One such approach that has proven successful is that of increasing the operational tempo to a rate that cannot be matched by the adversary.

This article presents a qualitative field investigation of an effort to introduce a group support system (GSS) into the daily work of the staff of the US Navy’s Commander Third Fleet (C3F or COMTHIRDFLT). This application is directly targeted at providing an operational advantage by speeding the commander’s decision-action cycle.

1. Introduction

The Commander of Third Fleet is a Vice (three star) Admiral. He has been designated a Joint Task Force (JTF) commander. In this role, he would assume command of all regional forces assigned to him in order to fight a coordinated battle with air, land and sea forces. To aid him in marshalling his forces, he maintains a staff of approximately 50 officers and 120 enlisted personnel.

In addition to handling the routine operations of the unit, the military staff is designed to gather information, generate possible courses of action and advise the commander. Above the lowest tactical echelon, it is simply impossible for the commander to personally handle all of the intricacies and details of an operation.

During WWI, the American Expeditionary Force (AEF) found that it was not organized to handle large-scale coordinated operations. Specifically, there was a shortage of trained staff officers and the existing staff organization was inefficient. In response, the Army adopted the British Army’s proven staff organization.

The other services later adopted this scheme and modified it to fit their circumstances. The Navy has expanded the staff to include new roles. The Third Fleet staff uses “J Codes” (J stands for Joint) to identify staff by function:

- **J1** – Administration and Personnel
- **J2** – Intelligence
- **J3** – Operations
- **J4** – Logistics
- **J5** – Plans (beyond 48 hours out)
- **J6** – C4I (Command, Control, Communications, Computers, Intelligence)

A senior officer known as an Assistant Chief of Staff (ACOS) leads each of the functional J codes. Each ACOS reports directly to the commander, though their actions are directed by the Chief of Staff (COS). The ACOS of any group is typically referred to by his/her J code. For example, the Logistics ACOS is referred to as the ‘J4’. The ACOSs are responsible for coordinating their sections efforts with the commander and the rest of the staff on a continual basis.

The Center for the Management of Information (CMI) has worked with COMTHIRDFLT for over three years to identify collaborative processes and technologies that can improve the effectiveness and efficiency of the staff. Typically, CMI has daily contact with the staff and participates in all underway and operational periods.

This article details the experiences that CMI has had in introducing and supporting a Group Support System (GSS) to enhance the workings of the COMTHIRDFLT staff and command. The first part of the paper is designed to show the theoretical background and underpinnings of this effort. The second part describes the actual experiences at COMTHIRDFLT. The final section discusses some noted trends and the future course for this work.

The development and fielding of this collaborative technology is guided by the principles of Action Research [2].
1.1 Military Advantage

Soldiers and students of military operations have long been interested in isolating the specifics of success on the battlefield. Certainly, the tangible factors have always been at the forefront of this search. For instance, in this country our leaders have readily acknowledged that we are willing to trade money for blood. One need only look at the $2 Billion price tag on each B-2 Spirit stealth bomber to see the focus on top of the line equipment.

Additionally, there is widespread agreement that training is an important factor in preparing the military to win. This is evident in the massive training exercises our forces participate in and the stress we put on professional education. As Patton once said, “A pint of sweat will save a gallon of blood.”

It is evident, however, that the size of forces cannot be ignored. Sheer numbers can overcome even the best trained, motivated and equipped force when it is forced to fight. Thus, the key for a smaller force is to choose its fights. This is where the less tangible factor of leadership comes into play.

In most circumstances, superior leadership can obviate the opponent’s advantages. In Vietnam, for instance, the U.S. started the war with the best trained and equipped army and navy in the world. The superior strategy and patience of the communist leadership, however, eventually outwrought these factors.

Developing excellent leadership is still elusive. Classical military theory is filled with axioms for situations that are difficult to even recognize. For example, people are fond of quoting Sun Tzu, but does a statement like, “He will win who knows when to fight and when not to fight,” really help a commander? Instead, commanders and staff need to isolate specific attainable methods for ensuring success against the enemy.

2. The Decision and Execution Cycle

In a conflict situation, a general pattern emerges for the command and control of forces. Commanders try to understand the situation and anticipate potential enemy actions. In effect, this is a kind of theory building about the situational picture. Then they try to take action to expand their own options and limit those of their opponent. By doing so, the commander hopes to control the conditions and continue to force his will on the enemy until victory is attained. Most people instinctively recognize this sequence, but as with most decision theory the iterative nature is largely ignored. People generally view decisions and their accompanying situations as though they are discrete. In an adversarial conflict nothing could be further from the truth. Each decision and action builds on the last.

2.1 OODA Loop

The Korean War was unique in many ways. In the shadow of nuclear weapons, the super powers could not afford to face off directly. So they acted with and through surrogates in smaller containable conflicts. The emergence of air warfare with jets was one of the most interesting facets of this war.

On the surface, the air combatants had comparable tactical fighter forces. The UN forces flew the North American F-86 Sabre, while the North Korean, Chinese and Russian air forces flew the MiG-15. On paper, each of these fighters could be expected to win its share of battles. Surprisingly, this was not the case. The F-86 had a staggering 10:1 kill ratio over the MiGs. One man in the Air Force was interested in finding out why the outcome was so one sided.

Colonel John Boyd was a fighter pilot that dissected the Korean tactical fighter match-up to find that the telling advantages of the F-86 were not in weaponry, power or maneuverability. Instead, the two factors that most often provided victory were pilot visibility and hydraulic systems [6].

The F-86 had a bubble canopy that afforded the pilot the opportunity to more easily and quickly identify the MiGs. This paid benefits by allowing the pilot to quickly determine the disposition and intent of the enemy and to find a way to engage. The MiGs on the other hand, couldn’t observe as well and were stymied in their efforts to know the situation and apply a tactic.

Additionally, the F-86 had a hydraulic system that let the pilot fly with little physical effort. The MiGs had no such system. MiG pilots were forced to manhandle the rod and cable controls and wrestle their fighters into difficult maneuvers. All of this exertion took time and as the fight wore on, the pilots would grow exhausted and act and react even slower.

In his “Aerial Attack Study”, Boyd developed a theory that quantified the ability of aircraft to transition between maneuvers and different potential energy states [1]. This work was instrumental in the design of such fighters as the F-16. Later, he revisited his work in an effort to ferret out some more general lessons. What emerged was the Observe, Orient, Decide and Act (OODA) Loop and some accompanying theories about applying it to gain the advantage.

2.2 Observe

During the Observe phase of the cycle the decision-maker (DM) takes in data from all the different available sources. This is not to say that all sources are treated
equally. In many cases, important observational sources are ignored either because of constraints or by design. It is important to note, however, that the data gathered in this stage will be the basis for all future understanding and action. Thus, the decision-maker must strike a balance between the costs of the source, the time involved, the reliability and validity of the data and most importantly, the usefulness of the data.

2.3 Intelligence Sources

In a large-scale operation, the commander and staff can anticipate receiving information from myriad sources. On the lowest level, there is HUMINT or human intelligence. This is comprised of reports from troops in the field and first person sources. Because of the large number of potential sources and experience of the observers, HUMINT can lend a great deal to the commander’s situational awareness. A more centralized form of information is SIGINT, or Signal Intelligence. The sources of this kind of intelligence are found at several levels of the organizational hierarchy. All of the services have electronic intelligence assets. In the JTF, these range from aircraft to ships to tactical ground units. Additionally, the national command structure has access to strategic SIGINT listening sources located throughout the world. The Joint Task Force also has access to a great deal of imagery that can help to determine the disposition of forces, equipment and the operational situation. Again, the sources of this intelligence come from within the JTF and from national intelligence sources. One of the most surprising intelligence resources to emerge recently is that of the news media. Quite often, CNN is the first one on the scene. Strangely enough, potential adversaries often ignore the strategic and tactical risks of courting the media in order to garner political support. The military hasn’t ignored this and television broadcasts have become an integral data source for the Third Fleet staff. There are no perfect information sources in the battlespace. The “fog of war” introduces a great deal of uncertainty even in the realm of electronic observation. People have a tendency to filter observations through their own judgments, experiences and feelings [9]. Additionally, any intelligence source is potentially subject to deception.

2.4 Orient

The Orient phase of the OODA loop is the most important. Without a proper orientation, the commander can’t take effective action. He/she will be striking blindly with only luck as a guide. The decision-maker, or commander, orients himself by using the data gathered in the observe phase to build a mental model of the situation. There is some competition in this phase between the need to move rapidly and the need for an accurate model. By moving slowly, one fails to take advantage of opportunities. On the other hand, if one moves too rapidly, there is a greater chance for inappropriate action [8]. These needs must be balanced in attempt to maximize effectiveness. Weick and Roberts argue that there really is no collective situational awareness; instead they hold that the collective mind is the product of intertwined processes and actors [10]. In other words, the actors don’t really have a clear knowledge of the whole system; they merely need to know their role and heedfully perform it. We would argue that this may be true for a mechanistic system like a flight deck, but the primary purpose of a staff is to make sense of a fuzzy and complex situation for the commander. Heedful staff work demands a greater knowledge of the situation and an indoctrination into a greater collective understanding. A decision-maker’s orientation will on a large part depend on his/her previous experiences, culture, genetics and a host of other factors. Thus, it is even more important that the observations be integrated into a working mental model so that these biases don’t render the decision-maker ineffective. The orient phase has feedback loops to influence further observation. Additionally, this phase implicitly controls the observation and action phases.

2.5 Decide

There are many different decision making theories that have been espoused over the years. Most of them have been normative in nature, or they have treated decision-making as though it were a purely analytical exercise. For example, subjectively expected utility (SEU) was born in the world of economics. It assumes that the utility of an outcome weighted by its subjective probability should be the mechanism for choosing the associated course of action [5]. The theory has been widely criticized because it has little basis in fact. It is fairly easy to demonstrate that people do not generally use this decision strategy. In response, others have tried to modify the theory to better represent what happens with real decision-making [7]. One also can utilize a highly rational method like SEU and settle on an irrational course of action. There are, however, some newer theories that are derived from actual naturalistic decision-making. One such approach is that of Image theory [3]. Image theory holds that people have three different representational structures or “images” that shape how they think about decisions. The first of these is the value image that represents the principles of the
decision-maker. The second is the *trajectory* image. It is the representation of the decision-maker’s goals. The third image representing plans is the *strategic* image. This allows the decision-maker to develop and evaluate possible courses of action that have the potential to achieve his/her ends while remaining in tune with the decision-maker’s images.

Image theory holds that decision-makers will apply a *compatibility test* to prospective courses of action. In the compatibility test, the decision-maker will assess candidate actions with respect to the three images. If a candidate action is in tune with the decision-maker’s principles, goals and plans, then it advances for further consideration. If not, it is dismissed. If only one candidate survives, it is adopted. Often, the compatibility test is an intuitive rather than analytical exercise.

If multiple candidates survive, they are assessed in a *profitability test*. This is a head-to-head evaluation of each candidate and is more in tune with SEU. It is a more analytical technique than the compatibility test. If no candidates survive, the decision-maker will go back and evaluate options and possibly develop new candidates.

It should be noted that Image theory doesn’t recognize the idea of group decision-making. Instead, it looks at the group as being the context for the decision. In our case, the staff may develop courses of action and help to shape the commander’s mental model. He/she is, however, the only one to actually make the decision.

In the case of a military unit, the leader will develop what is called the “commander’s intentions”. This is a focused statement that details what the commander’s goals are for an operation, how he intends to accomplish the goals and what kind of end-state he/she desires.

The commander’s intentions help to frame the operation for subordinate commanders. It is used to specifically define important features for orienting the collective mind of the JTF. If things should not go according to plan or if contact is lost, the subordinate commander can continue to act in accordance with the commander’s wishes.

The commander may then issue a specific plan or leave the details to the staff and/or subordinate commanders. This depends largely on the commander’s style, the complexity of the operation, the experience level of subordinates and a number of other factors.

### 2.6 Act

The Act phase is the final step in the OODA loop. Here, the staff and subordinate commanders move to actually bring the plan to fruition. This phase then ties back into the beginning of the OODA loop. The commander and the staff will observe the effects of the action and will begin to reorient themselves to the updated situation.

Realistically, in a team endeavor like this, the commander’s actions usually end with the issuing of the operations order. He may clarify some points, but major changes in the plan will either require another iteration of the OODA loop or will be handled by subordinate commanders. Again, the commander’s intentions are an important input to the Act phase because the JTF commander may not be available. The subordinate commander’s mental model of the situation needs to be closely aligned with that of the commander so that he/she can act without direct supervision. The importance of orienting the collective mind really becomes apparent in this phase.

### 3. Compressing the OODA Loop

Boyd posited that in the fighter duel, the F-86 pilot could observe the situation more readily. This allowed him to start to build situational awareness more quickly and integrate this into his mental model of the fight. He could then decide what to do. The F-86’s hydraulics would then allow him to shift between actions more quickly. Ultimately, the American pilot could be expected to move through the OODA loop faster than his opponent.
enemy to become paralyzed and ineffective. This is often referred to as “getting inside” of the enemy’s OODA loop [6].

Boyd then found that he could generalize the OODA loop to a much larger scale. When viewed in terms of this approach, one can easily find many historical situations where this has been true. In the early stages of WWII for instance, the French had a large well-equipped standing army. In spite of this, it quickly dissolved in the face of the fast-paced German blitzkrieg. The French weren’t defeated because they were outfought on an individual level. Their defense disintegrated because the Germans were operating at a pace they were totally unprepared to match.

3.1 Sustainable Competitive Advantage

Obviously, the advantages of a compressed OODA loop are not realized in the single masterstroke. One can really only expect to maintain a competitive advantage through repeatedly forcing the enemy back on his heels and wresting control of the situation from him. Applying this methodology can provide a real advantage, provided the opponent doesn’t disengage or purposefully slow down the battle. Commonly, the application of this theory is referred to as speeding up the operational tempo (OPTEMPO).

4. Experiences

Traditionally, CMI has been involved mostly with collaborative meetings and electronic meeting software (EMS). During a visit to one of the collaborative spaces onboard the USS Coronado, the C3F J2 Intelligence ACOS proposed the use of the EMS to support an ongoing twenty-four hour per day meeting for his staff. A test application GSS was approved and implemented soon after.

Up to that point, the J2 (intelligence) staff was separated throughout the ship as is illustrated in Figure 2.

![Figure 2. Intel Spaces](image)

The J2 was primarily made up of cryptologists, analysts and watch officers. The cryptologists would receive information from a variety of sources. When they saw something noteworthy, they would record it in their paper-based logs. The analysts, in turn, would communicate with the cryptologists and read their logs to try to find information that might provide a greater understanding of the situation. For instance, an analyst might conclude from increased activity on a satellite photo that a submarine was about to put to sea. The analysts would record their findings in their own logbooks. The watch officers would then circulate among the analysts trying to tie together higher levels of information into a synthesized situational picture of the opposition. For example, the watch officer might conclude from the new submarine going to sea and increased mining activity that the opponent was going to attempt to blockade a port.

With intelligence staff spread throughout the ship, the watch officers found it difficult to maintain situational awareness. It could easily take a watch officer up to half an hour to communicate with all of the analysts to develop his/her greater situational picture. The use of the GSS allowed the entire J2 staff the ability to immediately enter items of interest in the collaborative log. These data would then be immediately propagated throughout the computers of the other staff members. The analysts would have immediate access to the cryptologists’ entries. This allowed them to quickly scan for important items that might have greater meaning. They could then post their analyses on-line for the whole community. The watch officers, in turn, would synthesize the data more quickly into knowledge that the commander could use.

Even though the software used was just a general purpose EMS application, this software gave the staff the ability to perform in way that was previously impossible. The J2 section built their processes around the GSS.

4.1 Command-Net

With the success of the Intel Logs, CMI and the staff then moved to expand the collaboration to other areas. The first of these new applications of the technology was in support of the Battle Watch Captain (BWC). The BWC is a watch pulled by representatives of all of the functional communities in the command (ground, air, undersea warfare, intelligence, weather and oceanographics and C4I). These representatives all support the Battle Watch Captain as he/she supervises the forces and the battle. It is the BWC’s job to monitor the pulse of operations so that he/she can brief or alert the commander as to the current situation. The BWC operates out of the Joint Operations Center (JOC) that serves as the nerve center for the joint task force. The requirements for the BWC log were quite
different than for the Intel log. It required less analysis, but a wider audience would share the data. In fact, the BWC log is on the desks of the Admiral, the chief of staff, all of the ACOSs and a number of other interested parties. Users consistently agree that the BWC log allows them to quickly and efficiently update their situational awareness without interrupting the watch. Additionally, they have noted gains from having a wider group of people aware of the potential problems and opportunities facing the JTF. In this way, the Command-Net application directly supports a compressed orient phase that also provides a more accurate collective model.

We have also found that Command-Net helps to set and reinforce standards for what is considered salient information by the staff. On several occasions, we have noted situations where log users would correct other users for making inappropriate entries. These corrections were taken to address a perceived straying from topic or an inappropriate level of detail. This facet of the application may tend to assist in building the collective mind of the group.

To differentiate the collaborative logs and give users a common name, we started to call them Command-Net. Otherwise, CMI tended to take a hands-off policy towards the use of the application. We found ourselves frequently responding to requests for ad hoc logs that would be used and then shut down at the completion of the exercise. During one exercise in 1998, there were five logs running simultaneously.

CMI researchers instructed users how to operate the application, but let the community decide how it would be utilized. As a result, each Command-Net implementation has taken on a personality all its own. While the Intel log is used for analysis, the BWC is more of a traditional log and the Coalition Exercise Control Group (CECG) log was used as a planning tool for coordinating the war game.

There are, however, some trends that are immediately obvious for all logs. The amount of traffic is directly proportional to the amount of action in the exercise. During periods of intense play, such as prior to an amphibious landing, the log activities would peak. It should be noted that the log activity would quickly drop off after the users reached a threshold point where they were too busy to make log entries. In the JOC, the solution was to task an assistant BWC with actually making the Command-Net entries.

Additionally, we have found that the flavor of an ad hoc log will be directly influenced by the experiences of the early users of that log. For example, during two different exercises the Joint Air Operations Control (JAOC) log was used. In one situation the first watch officer was inexperienced with logs in general. He set the tone for the log by making a few very terse entries. This pattern carried through for the remainder of the exercise. During another exercise an officer who had extensively used the BWC log initiated the JAOC log. As a result, it began to mirror the Battle Watch log.

### 4.2 Expanded Command-Net Usage

In the spring of 1999, CMI was asked to install Command-Net on an aircraft carrier that would soon be deploying with another fleet. A CMI researcher flew out the next day to get underway with the ship. Over the next twenty-four hours, he set up the log with a new set of users, and put together a users’ guide. At one point, he made an appointment to train users. When he arrived for the appointment, he found they were already using Command-Net for several hours.

The success of this use of Command-Net led to the installation on a guided missile cruiser in the same command. In this case, the researchers had to take two trips to the ship. The first installation was unsuccessful because the person selected to act as the administrator didn’t have a computing background and wasn’t comfortable working with the guide. Although the barriers to use are low, there are still some requirements for technical expertise. CMI researchers are due to evaluate the success of these installations during the fall of 1999.

One consistent request for the Command-Net logs is for them to work within larger groups. Senior commanders have asked CMI to implement Command-Net to work as a distributed log for use throughout the JTF. This, however, is problematic with the current GSS software. The satellite communications between ships in the JTF are sometimes interrupted. The current software can’t tolerate these disruptions in server connections.

### 4.3 Java Prototype I

Although the Command-Net program has been a complete success in Third Fleet, CMI realized early on that only a specialized logging application could provide the level of support and simplicity that would be needed for fleet-wide use. In the case of the Intel log, a senior enlisted man was trained in three hours to provide technical support. He was able to easily take on this role. On the other hand, we did comparable training with a sailor on the guided missile cruiser and had a complete failure the first time around. The application needs to be easily serviced and highly reliable.

Generally, we have found that it is not enough to have a senior officer as the champion of the software. The success of the GSS is largely dependent on the ability and responsiveness of the technical support staff. Because Command-Net quickly becomes central to operations, any interruption in the use of the GSS is highly disruptive.
On the guided missile cruiser, one of the researchers was approached about use of Command-Net to replace the engineering section's logs. After a short discussion, however, we determined that the chief engineer required a level of reliability that is not available at this time. We advised him to continue using his paper based logs.

The most trying problem that CMI has run into with developing the prototype has been the variability of Java implementations between web browsers. After many trials, the CMI staff settled on requiring a Java plug-in for the browser. This would force users to download the plug-in, but the increased reliability was judged to be worth the inconvenience.

4.4 Java Prototype II

CMI has already started to plan a second generation Command-Net application. The Java server that had been developed was found to be wanting. Specifically, it was more than adequate for smaller scale applications, but the overhead demanded by an application like Command-Net would cause the system to bog down. Effectively, the system just doesn't have the responsiveness required when the number of users goes beyond twenty. Although we have found that the requirement for responsiveness is dependent upon the type of log, users will still shy away from using Command-Net when the network slows its operation.

In response, CMI's technical team is creating a new architecture that promises to serve Command-Net well into the future. It will provide a hybrid application that combines Java applets with server side 'servlets'. We feel that such a system will provide better responsiveness and reliability while allowing us to shorten development times.

5. Conclusions and Future Directions

This paper describes the development and fielding of a GSS to meet the needs of the staff and commander at the operational level. The building and application of this technology has been governed by the reigning theory espoused by military thinkers. Although Boyd's OODA Loop theory is simplistic and doesn't capture many of the nuances of complex decision-making, it does explain the adversarial decision-action cycle and how it can be applied to gain and maintain operational advantage.
This research is exploratory in nature, but we feel that it has already been successful as a proof of concept. The initial fielding of the GSS based on existing software has been in effect for several years now. The first specialized prototype has been developed based on observation of the staff, interviews and analysis of the use of the initial GSS. We are now prepared to install and use this first prototype in November 1999. We will take the lessons learned from this development to guide the next version of Command-Net that CMI plans on testing in the spring of 2000.

This program has given CMI researchers a unique and valuable opportunity to learn about and test ideas for GSS development and application. Additionally, we believe that it will yield some ideas about the nature of decision-making at the operational level. Though this GSS has been developed with the specific needs of the Navy in mind, we think that it is generalizable enough to be useful for any organization with distributed staff working in a fast-paced environment. Eventually, we hope to test this, and find what different requirements there are in a non-military context.

6. References


