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"C2 for Complex Endeavors"

# Extreme C2 and Multi-Touch, Multi-User Collaborative User Interfaces

**Tracks**: Collaborative Technologies for Network-Centric Operations, Concepts, Theory, and Policy, C2 Architectures

**Authors**: Robert Regal, Don Pacetti

**POC**: Robert Regal, SSC-Charleston

**Organization**: Office of the Chief Engineer,

Space and Naval Warfare Systems Center Charleston

**Address**: PO Box 190022

N. Charleston, SC 29419

843-218-5058

robert.regal@navy.mil

The purpose of this paper is to introduce two things, the concept of Extreme C2 and a technological implementation for this collaborative, net-centric concept. Extreme C2 is a concept that applies elements of the eXtreme Programming (XP) concept. This collaborative development technique can increase the adaptability and quality of software, something of high value in the complex domain of enterprise software. When fused with net-centric concepts, Automated Battle Management Aids (ABMAs) and new human interface techniques, the application of this concept to C2 should be able to produce similar benefits for planning in military operations, particularly complex, multi-faceted operations. This concept will be demonstrated through the use of a multi-touch, multi-user interface screen built on top of net centric services. The paper will provide the results of a case study from a SPAWAR Charleston experiment about Operationalizing FORCEnet. We will evaluate the impact of Extreme C2 with Multi-Touch Multi-User (MTMU) technology on metrics like agility and speed of decision.

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# Acknowledgements

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# Introduction

Military organizations face many challenges in the modern age of warfare. Their responsibilities are increasing beyond traditional military roles of power projection and country defense into areas like peacekeeping, humanitarian assistance and counter-insurgency. These new warfare areas not only require traditional military capabilities like logistics and force protection but also need capabilities to influence the adversary likely using non-kinetic means. As the Army's new counter-insurgency manual states, "Arguably, the decisive battle is for the people's minds." [1]

Network Centric Warfare (NCW) is a concept for operations designed around the challenges modern warfare presents. This concept was based on observations of networking and its related technical theories. In general, this analogy has been effective in exploring some of the benefits of NCW; however, there are limitations inherent to the analogy that has the potential to cause some weakness. Most NCW treatments seem to gloss over certain social and human aspects that can cause some trouble for the technical oriented analogy. This paper attempts to examine some of these issues, discuss a concept called Extreme C2 and demonstrate the implementation of some of the premises of Extreme C2 as designed in the Multi-Touch, Multi-User (MTMU) device.

## *NCW Challenges*

Network Centric Warfare has been presented as a concept for future warfare in an uncertain and information rich world. The major tenets of NCW are:[2]

- A robustly networked force improves information sharing.
- Information sharing and collaboration enhance the quality of information and shared situational awareness.
- Shared situational awareness enables self-synchronization.
- These, in turn, dramatically increase mission effectiveness.

The operations in both Iraq wars and Afghanistan illustrate some of the massive successes of NCW. Complex maneuvers, theater wide situational awareness, remote planning are all among the successes of NCW[3]. However, as many of the examples make clear, solely focusing on the technical changes required for a NCW capable military did not provide the massive increase in capability NCW promises. The technical improvements enabled a change in the operational execution (process) which created the dramatic gain in performance. Networked information of precision munition hits can enable logistic deliveries through or much nearer to combat areas with significantly less risk. Include other example here… However, the majority of warfighting is still accomplished in the fashion it was during the cold war. Modernization into the information age is a slow process.

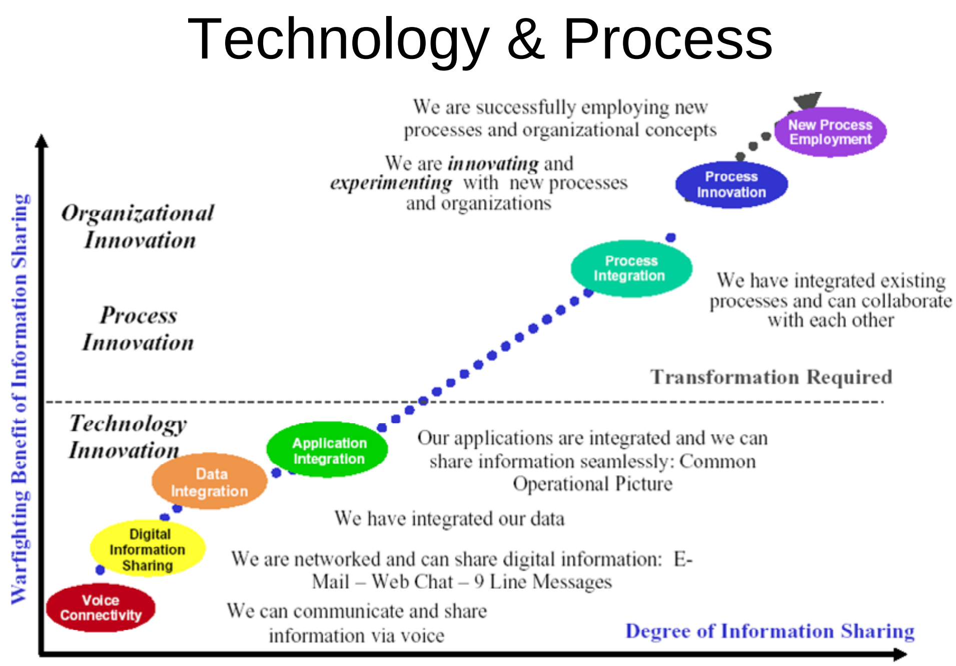


**Figure 1. Garstka's Conception of the Benefit of Information Sharing** [4]

The chart above, taken and modified from an earlier Garstka and Cebrowski slide illustrates the challenge below. Technical improvements associated with NCW have been made, but we are still lagging behind on the process improvements. Two notable areas where much process innovation remains (and technical innovation to support it) are social interaction processes and human interaction processes (both graphical and informational).

**Social** - The challenges in Iraq demonstrate how large the social dimension is. The battle for the minds of the people was not successful early in Iraq. The military, with its large networks, constant data streams and widely dispersed, highly available assets made numerous social mistakes. To blame these mistakes on NCW is unfair, however the linkage between the networked information, absence of cultural awareness and the social realities created a situational awareness leading to faulty predictions. In non-traditional mission contexts, the social consequences of actions must be considered as importantly as the military consequences. Process innovations are required to transform the information and power of the network to include the following issues.

- Influence – Strategic Studies Group XXV[5]emphasized the concept of influence and how critical it was to use this as a metric for success.
- Internally and externally, social networks, cultural norms & mores all affect how actions are interpreted.
- Leadership needs a source which is not implicit in the design of NCW. Relying on spontaneous self synchronization to generate organization is unproven, particularly when dealing with novel circumstances.

- Presence - Interactions between people, even standing side by side, are important as they allow gestures and facial patterns to be interpreted. Telecommuting is not an answer for every type of problem. Telepresence is not presence. Loss of the human to human interaction also causes loss in the sharing of experience and challenges in leading[6].
- Interpretation – Cultural issues can cause people to assume they both share the same interpretation, while differing underlying cultural backgrounds can cause those interpretations to be divergent.
- Social Network Limitations - Potentially limited by Dunbar's number, suggesting that knowing the right people is more important than maxing out the number of people you know. This places a limit on the size of a social network's effectiveness providing a limiting case for Metcalf's law in relation to a social network.

**Human Interaction** - Net Centric Warfare illuminates the high dimensional problem space. The problem space in conflicts has always been very complicated and has required a reductionist approach to managing the complex data into information useable by warfighters. NCW can help warfighters look at larger pieces of the kinetic puzzle. However, this can be just as paralyzing as it is empowering due to information overload. Each of the following high dimensional information issues also has a corresponding issue regarding manipulation of that information. These issues require process innovation (and perhaps some technical innovation) to be ameliorated.

NCW enables decision making at the edge[7] because it allows any user to acquire whatever information is needed. However, the ability to manipulate this information can still be a barrier to entry to decision making since the interface requirements are arduous and create artificial complexities.

**Graphical** – Graphical representations of the battlespace have been in use for ages, ranging from tabletop maps to more complicated (Global Command and Control System (GCCS), Cooperative Engagement Capabilty (CEC) and/or Command Post of the Future (CPoF) type displays. As more information about the battlespace is available to the network, the user needs a way to visualize them and many 3D visualization tools are available or in development. Some of the key issues in the graphical dimension are:

- High dimensional space manipulation- For example, it is typically difficult to manipulate a three dimensional space with a 2 dimensional input (a mouse pointer moving in two dimensions). Multiple mouse or keyboard clicks may be required in order to accomplish this.
- Hierarchy traversal – Hierarchies are common methods for represented information and can be found all over the place like menus or filter hierarchies. Hierarchal menus hold a myriad number of options and tools are hidden which can be hard to use. Hierarchies do not accurately reflect all the linkages between options and can be limiting.

**Informational** – Some of Tactical Action Officer (TAO) stations consist of 18 different monitors arranged around a single chair and controlled by multiple trackballs, a kvm and a keyboard. Often times the TAO also uses a headset to listen to multiple audio channels at the same time. Some of the key issues requiring innovation in the informational dimension are:

- Rigid Interfaces – It is hard to organize information for a person, since each task requires different organization structures and each person has differing organizational styles. Hard coding information processes into systems can be limiting. At times such limitation can be very effective since it can streamline a process which is critical in time sensitive operations like Strike or TAMD. In other operations where novel solutions are often required (OOTW stuff, Psyops, etc), rigid interfaces can be limiting of the solution space.
- Sensemaking[8 9] – Too often the myriad of convoluted relationships between information can be lost. To combat this, techniques must be integrated with the service/component layer of NCW. Tools like Non Obvious Relationship Awareness (NORA) need to be available to trace information pathways and match patterns.

The point of the above discussion is that while information is certainly available, it is not as useful as it could be because it is a) too overwhelming in volume and b) too difficult to manipulate. The goal can no longer be to just provide information to the warfighter, it must be to provide information that is ready for decision and to provide processes to manipulate information in the most natural and simple way possible.

# Extreme C2

Extreme C2 is an experimental, in development concept for C2 that lies on top of and requires NCW. It attempts to remedy some of the above deficiencies by promoting a set of practices and concepts. These practices hope to ameliorate the issues described in the first half of the paper. Extreme C2 is about using the information available through NCW to produce information ready for decision and allow it to be used and manipulated as simply as possible, thereby enabling the full potential/effects of NCW to be.

## *Software Development Analogy*

Some of the practices and concepts in Extreme C2 were inspired by considering an analogy between an agile software development process called Extreme Programming[10] (XP) and agile C2 processes. Agile software development processes focus on the challenge of coping with a changing set of requirements prevalent in software development projects (the number one cause of failure in software development projects is often cited as requirements creep). This major source of failure of large software development projects can cause lots of cascading coding changes and dramatically increase costs. Social issues are also present, mainly within the team and between the team and customer. Much like in the military, the software development team consists of people who have widely varying skill sets and knowledge bases.

## *Key Features of Extreme C2*

**Pair Programming** - This is a practice of Extreme Programming. In XP, two programmers sit at a single terminal and work on a part of the problem. One writes code while another watches and makes comments and focuses on the big picture. After some time they trade off.  Technically, this process has been studied as a part of distributed cognitive theory.

> "A system with multiple actors possesses greater potential for the generation of more diverse plans for at least three reasons: (1) the actors bring different prior experiences to the task; (2) they may have different access to task relevant information; (3) they stand in different relationships to the problem by virtue of their functional roles … An important consequence of the attempt to share goals and plans is that when they are in conflict, the programmers must overtly negotiate a shared course of action.  In doing so, they explore a larger number of alternatives than a single programmer alone might do.  This reduces the chances of selecting a bad plan." [11]

There is also some empirical evidence linking pair programming to increased productivity, reduced error rate and reduced rework likelihood[12]. Particular benefit appears to be observed when the challenges are strongly algorithmic, new and multi-disciplinary.  Repetitive tasks frequently will not benefit nearly as dramatically from Pair programming is not productive for every task, as it seems, complex problem solving will benefit much more than standard prescribed solution processes. By the same analogy, Extreme C2 may be more ideal for novel planning processes where the situation has not been considered before.

Pair programming is often balked at because of the notion that two people can do more work together than singly is counter-intuitive in a software development environment. Indeed, typically for a given task, the amount of time spent is between 15% and 70% more than a single coder working on the same task. [12] [13] [14]   However, some [12] [13] report that the error rate is reduced in this situation which theoretically saves time and effort in the long run due to decreased rework.  Nawrocki[15] et al also suggests that it is easier to predict the progress of pair programmed tasks, e.g. how long they will take. Another challenge for pair programming is the long standing work alone culture of programming. It can take some investment in the beginning to get the team to get acclimatized to this process.

*Operational example* – Two army planners are sitting down to work out a plan for the securing of a strategic site.  One begins developing a plan while the other watches and discusses the development of the plan.  The first develops a plan that places a logistics route too close to a mosque, something the other planner has experience with.  The second planner discusses this issue with the first and they modify the plan accordingly. Later during plan development, they switch places.  The second planner is now focused on providing air support to cover operations near the strategic site and plans the use of 10 aircraft.  The first planner recalls something from an operational briefing the previous day and mentions that the aircraft may not be available due to a contingency operation scheduled for that time.  They adjust the plan accordingly.

This example illustrates two of the benefits of pair C2.  First, the planners avoided developing a plan with a route flaw in it.  Different planners have different experience sets.  The two planners shared information about mosque sensitivities and the plan is better off for it.  Second, since one planner was always available to focus on the larger picture issues (local sensitivities or aircraft availability), the team was much less likely to generate plans that were incompatible with the larger operational and strategic goals.

Typically in software development, as in military operations, errors have a greatly increased cost down the road and this reduction in the error rate outweighs the additional cost of the dual coding practice, particularly in novel situations.

**Automated Regression Testing** – XP favors developing the software fitness acceptance tests early in the process. After every development cycle these tests are automatically run on the product. This has two benefits. The first is a clear definition of what the product needs to be able to do early in the development process and the second is the development of metrics to determine product fitness.

In the military analogy, some types of plans have clear metrics and if they are established early enough, it is possible to measure the effectiveness of these plans. For example, in planning for a downed pilot scenario, Combat Search and Rescue (CSAR), the metrics could be AoU size, average time to location.

Embedded simulation can take the place of automated regression testing in this analogy. If the metrics for success are defined early on, then plans can be simulated on location to provide instant feedback. Clearly there are limitations to the degree that simulation can be used to validate the fitness of plans, however, in many cases tools exist to simulate subsections of plans (network traffic, sensor coverage). These tools should be used in a transparent manner as the quick first cut for plans and low level C2 decisions.

*Operational Example* – In the CSAR scenario discussed above, the embedded simulation tool, Satellite Tool Kit (STK), could provide quick feedback in regards to the percent coverage, revisit rate, AoU metrics. The UAV/Aircraft/Satellite/Ship search paths could be fed in and quick measurements could help to determine the fitness of the solution. This process becomes quick enough if the embedded simulation tools and the planning tools can share plan information effectively (something hopefully easy with NCW technologies).

**Cultural Lens** – Working with other partners is a fact of life in the DoD, regardless of whether these partners work as a State Department analyst in Washington DC at or as a the mayor of a small town near Fallujah. Even within the DoD, there is substantial cultural difference between the Navy, Marine Corps, Army and Air Force.

These cultural differences manifest in two distinct and critical ways. First, there are symbological differences. Symbols include icons, gestures and language (especially idiomatic expressions like jargon and slang). If the partners each have different interpretation of these symbols and make the assumption that all partners share that interpretation, then faulty decisions can be made. A classic example[16] is the loss of the Mars Climate Orbiter in 1999 due to a navigation error caused by overlooking the translation between two different units of measurement. Similar problems can exist in COP symbology.

Technology can assist with this challenge. Symbols can all be mapped and with sufficient rigor problems like this can be substantively reduced. Technically, this is a much more tractable problem than the challenge presented by cognitive challenges.

Cognitive processes differences are the root of the most challenging cultural issues faced by collaborators. Often times social issues, like a loss of face or perceived indecisiveness can be crippling to the larger effort. Unlike symbological differences, cognitive differences can not be observed or broken simply into a technically solvable problem. However, to aid with collaboration with cognitively different parties, Klein et al have developed a model called the Cultural Lens[17]. A Cultural Lens is a model to allow those involved in C2 operations to see their world as if through the eyes of other participants. The Cultural Lens concept is not only valuable in understanding the conflicts among collaborators; it is also a useful model to describe the relationships between allies and adversaries. The Cultural Lens model can also help more accurately predict the influencing effects that a course of action (COA) may generate. Influence creation and manipulation is much more important in less traditional operations like peacekeeping, humanitarian assistance and counter-insurgency.

Of course, effort needs to be placed on symbolical mappings and keeping technical interpretation of data as uniform as possible, however, the major challenge in dealing with cross cultural allies *and* enemies is the cognitive element. NCW is not a cognitive framework for employing collaborative, cross culture C2; it is a technical oriented framework for employing collaborative, single culture C2. Consequently, there have been many challenges for NCW in the Global War on Terror.

An article[18] by Noah Shachtman in Wired magazine is illustrative of these issues. He discusses how the major challenges of the war were not the killing of the combat forces of Iraq, but rather the creation of buy in from the populace. Since the majority of current operations in Iraq focus on counter insurgency and security, it ends up being the social relationship with a foreign culture that is the most important element of success. Shachtman presents vignettes which illustrate where a purely technical approach has not been successful in Iraq. Social relationships become critical to the success of many less traditional missions. These vignettes stand in stark contrast to the successes of what Schachtman contend Garstka and Cebrowski envisioned early in the life of NCW, "a single network enabled process: *killing.*" [18] In this age, it is clear that net centric killing is only a subset of what Network Centric Warfare needs to be.

To successfully cope with the social ramifications of courses of action, the military needs to utilize the Cultural Lens model as a part of its operational toolkit. Perhaps if planners at lower levels had access to such a tool, it would've reduced the impact of the insurgency early on and helped them understand how to better formulate plans to cope with their new allies and adversaries.

**ABMAs** – The wide array of information available to warfighter can be overloading and misleading. Tools need to be developed to crystallize the information into actionable information ready for decision. The tools are called Automated Battle Management Aids (ABMAs). ABMAs are heavily reliant on services or components built into a NCW infrastructure. Each ABMA can have two major phases.

The first phase is the information distillation phase. In this phase, the information is pulled from the network and analyzed automatically. Once patterns are matched or key alert criteria are met, the relevant information is sifted from the pool of information and presented to the warfighter as information ready for decision. During this phase, filtering and pattern matching occur to help crystallize the relevant information. The second phase is the automated process execution phase. Once a conclusion has been reached (either by an ABMA or a human decision maker), an automated process can be kicked off.

A full discussion of ABMA[19] capabilities and goals are not within the scope of this paper, however they are critical to reducing the dimensionality of the information presented to the user.

*Operational Example*: A downed pilot ABMA might automatically calculate the area of uncertainty, identify the local search assets, calculate optimal search paths, notify pilots/operators to be on alert, update the ATO, update situational awareness information and await approval of the operation. This example is futuristic, but the horizon is not far.

**New Forms of Interaction** – Often times we focus on the figure 1 and discuss how technical changes alone provide diminishing gains without process innovation. Typically, the focus is on high level process change, however at a micro level, process change is just as important. Maneuvering through a 3D battlespace the same way we currently manipulate maps (with a mouse and keyboard) is akin to driving a plane with the same controls you drive a car with. Consequently, we need to focus on new modes of control to cope with this influx of information and develop new ways to manipulate it.

*Gesture based* – As has often been pointed out, gestures are a key piece of human non-verbal communication. Gestures can be captured through haptic devices, like touch screens. Currently, the Apple iPhone makes limited use of this type of control in it's built in maps application. Two finger points, if pinched together, zoom out on the map. The same two points, if pushed away from each other, cause the map to zoom in. This gesture makes it very simple and natural to control orientation and scale on the map. It is much more effective than a single point, mouse based type of control system and is quick to learn.

*Eye Tracking* – Eye tracking technology uses a sensor to monitor the position on a computer screen on which the eyes are focusing. This is currently used as a method for measuring mental processes and their relationship to the user interface, however, it can be used as a method of control. For example, perhaps a system with an eye tracker would know where to position alerts to ensure that the alerts are noticed most effectively. Also, nearly any sort of dragging or selecting (mouse like) action could be done by looking at an object on the screen and moving your eyes to the new desired location. Something similar is done already for disabled people (disabled by ALS for example). They are able to read email and browse the web using only their eyes as controllers.

*Neural Interfaces* – Direct neural interfaces are already in development. These devices can connect directly to nerves (peripheral or inside the skull) and control electronic devices. Some have been designed to connect directly into the optic nerve and provide sight for blind people. This type of interface is certainly distant, however it will be the most efficient at controlling high dimensional information and tasks.

## Operationalizing FORCEnet

In late 2007, SPAWAR Charleston created an exploratory demonstration to evaluate the path of FORCEnet (the Navy's implementation of some NCW concepts). The reason for this demonstration was to illustrate the transitional steps from the present to the future of FORCEnet. To do this, the current state (baseline) of technical and operational processes had to be captured. The following vignette is typical of the types of operations considered. This vignette is important to consider in relation to the future operations of FORCEnet where the technology and processes are much different. It is also important to note that all of the concepts present in Extreme C2 are not incorporated into this vignette.

## *The Present*

Picture a typical Joint Operations Center (JOC) manned by a U.S. Navy staff. A Staff Tactical Watch Officer (STWO) has a Situational Awareness (SA) display window open, that is a stove-piped application running on a proprietary workstation, with hard-wired, point-to-point interfaces. He is examining unit locations, readiness data, threats, etc. He has to constantly adjust filter settings and open application windows in order to review the current operational situation for all assigned mission areas. He's studying the coastline near an enemy port, since he is supporting a Marine Expeditionary Unit (MEU) which is executing a counter insurgency mission, and is dealing with enemy combatants attempting to infiltrate arms and equipment along the coast. On the other side of the JOC is another watch stander, supporting the STWO. He's also looking at the current situation, however he's focused on the latest intelligence picture; latest INTEL summaries, position of surveillance assets (UAVs, etc.), with the focus on threats to the MEU, insurgent activity, etc. He is currently attempting to get access to Predator UAV feeds, but he has to coordinate this action with the staff Joint Intelligence Center, with is located in a remote area of the building.

Suddenly, a tactical satellite radio command net crackles to life with an announcement from the Air Warfare Commander (AWC) that a transport aircraft has gone down in the ocean. At the same time a tactical chat circuits get so busy that the STWO has to pull watch standers off of tactical watch stations in order to ensure no chat messages are missed. Alerts also pop-up on the several stove-piped SA consoles, at various watch stations throughput the JOC – No two tactical decision aides show the same location for the last known position of the missing aircraft. The aircraft was piloted by a US ally, who has requested our assistance in searching for and rescuing the crew. The watch stander who was previously looking at Intelligence data wraps-up what he is doing, and tries to reestablish his SA – he has to close several windows, and change filter settings. Before he completes this task the STWO directs him to start building a Search and Rescue (SAR) information package. The watch stander has to consult with several personnel in the JOC, who are manning stove-piped tactical watch stations, in order to complete this task. His first ordeal is to manually resolve last known position of downed aircraft, Area of Uncertainty (AOU), recommended search pattern, and location of all available SAR assets (in this case UAVs, ESG helicopters, and any fixed-wing assets), readiness status of all available assets, information on the aircrew (list of souls onboard, photographs, personnel files, etc.), information on the missing aircraft (survival equipment, cargo, etc.) . once all the information is obtained the watch stander manually selects SAR assets and plots a path for each asset to search, within the predicted AOU. No embedded simulation tool is available to support identification of coverage and rates the effectiveness of the paths the search pattern he has chosen. No Automated Battle Management Aid (ABMA) are available to make suggestions as to how the path could be improved (e.g. minimal time, maximal coverage in AOU). After this laborious process a tentative search pattern is finally passed to the STWO, along with identification information. The STWO takes the belated information package and assigns tasks, based on his current SA, resource availability, optimal search patterns, etc. Once the the SAR effort is underway, the STWO and CICWO resume planning for the day's MEU support operations, but have to completely reconfigure their stove-piped workstations to display the required information.

Another alert pops up – this one is for an imminent threat to the MEU. Indications and Warning (I&W) information has been received that insurgent forces are attempting to deliver an arms cache to units within the MEU's Area of Responsibility (AOR). This I&W package indicates that the arms delivery will be performed by a dhow, attempting to hide amongst heavy coastal shipping. The Course of Action (COA) best suited for countering this threat is for ESG assets to conduct Visit Boarding Search and Seizure (VBSS) of all suspected arms carriers in our AOR. INTEL sources also suggest that terrorist leadership may be present on the suspect vessel. The STWO must now reconfigure his tactical displays to begin analyzing possible options for countering this threat. The other watch standers assists him by reconfiguring their tactical disploays and manually putting together a VBSS package that includes AOU, list of suspect vessels, last known location, available search and VBSS assets, etc. The STWO has to wait for the VBSS package, to begin to issue tasking.

## *The MTMU*

In 2007, SPAWAR Charleston purchased a large Multi-Touch, Multi-User (MTMU) screen. The MTMU is a large touch screen, 8 feet wide and 3 feet tall and is elevated three feet above the ground. The standard mode of operation is for two individuals to stand side by side and work on the screen. Controlling the screen is done by gesturing while touching the screen. Typical gestures include simple mouse-like gestures (poking, dragging) and more complex gestures like making circles. An arbitrary number of points or gestures can be recognized by the device. Any form of graphical media can be displayed on the screen.


**Figure 2. Photograph of the MTMU[20]**

As a caveat, the results presented here are in no way authoritative in terms of metrics, however they represent the initial experimentation phase of continuing research into user interface measurement and design for military purposes. The experimentation phase was solely intended to determine the viability of this particular method of control. In the future, SPAWAR Charleston is interested in performing more formal tests to evaluate and measure the effectiveness of this interface.

*Case study* – One commonly performed task is the calculation of quick intercept between an intercepting unit and a target. The Global Command and Control System (GCCS) has a tactical decision aid (TDA) built in that performs this task. This task was performed by a retired Senior Chief. The chief used the GCCS TDA to calculate the intercept location and time between his the interceptor and target. An eye tracking technique was used to measure the path of his eyes and the time required to complete this activity. In circumstances where the ships' data was all present (speed and bearing), the chief took between 25-30 seconds. The eye's track was interesting during this test as well since it showed the convoluted path between clicks in the dialog box and the map. Numerous and forth glances, context switches, occurred reducing the effectiveness of the process.

An intercept TDA was developed for use with the MTMU map widget. The process for using it is simple, the first ship touched is the interceptor and the second ship is the target ship. The TDA instantly plots the intercept location, time, required bearing and ship paths. The different control mechanism resulted in a dramatic reduction in execution time and simplification of the process for calculating and displaying an intercept. Similar TDAs have been developed in Charleston for the MTMU including a range and bearing TDA and a Closest Point of Approach TDA.

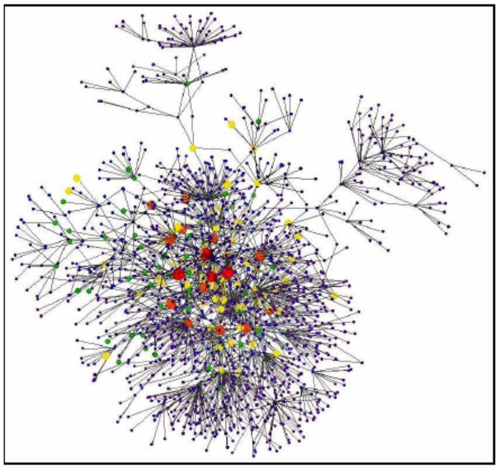

**Figure 3. Decision Complexity for C2 Activity**[21]

Figure 3 illustrates the mental complexity of the GCCS TDA process. Click here, shift focus, click here, shift focus, click here. If processes like this can be improved, then the small savings can add up dramatically over the course of an operation.

## *Pair Planning*

In the Schachtman article[18818], there is a section that describes the Army's Human Terrain Teams (HTTs). These are groups of tech mavens, social scientists and local culture experts that are embedded into brigades and regimental combat teams. The embedding of these teams is critical since success depends on real relationships with the cultural surroundings. NCW alone can provide this service through reachback to an expert in the United States, however this is significantly less effective[188] than the presence of social and cultural experts in the field. This leads to the conclusion that telepresence is not optimally effective for all operations and that significant benefits can be achieved to experts in differing fields working physically next to each other.

With a screen like the MTMU, there is ample room for two servicemen to work side by side. These two people can work together as described in the pair programming practice described earlier. Their differing backgrounds, roles and skills all contribute to a better solution to novel problems. In addition, unlike a computer, the entire board is a productive space, so each user is capable of pursuing independent sub-tasks as needed to support the common task. As a result of this interface, pair work becomes much easier and more effective.

## *ABMA technology*

An ABMA was created for demonstration with the MTMU. The ABMA monitored various RSS feeds and informational services. Once sufficient information was available to match a pattern, the ABMA accumulated the relevant information (graphical, textual, videos, geographic – all cross linked) and packaged it up. The ABMA also pushed notifications to various concerned people and to the MTMU users. The specific pattern matched for this was the likely delivery of arms and leadership to insurgents via white shipping.

On the MTMU, the alert would pop up when a specified confidence criterion was met. The user(s) could use it to produce a list of events that lead to the pattern match (events like reports of swarming boats in a particular area and the theft of small arms. The ABMA also allowed the user to view and manipulate photos. These photos were associated with the textual events and are graphically linked using color coding. Some of the photos included satellite imagery of the port and an image of the insurgent leadership target. A map was also accessible through the ABMA which linked geographically all the events and photos. Each of these pieces of information was easy to manipulate and allowed intelligence officers to create their own package of actionable intelligence. The speed and ease with which this could be accomplished made choosing a course of action (COA) more expeditious.

## *The Future*

Picture a typical Joint Operations Center (JOC) manned by a U.S. Navy staff. An 8' x 3' screen is there to support JOC operations, and on the left side of the screen, a Staff Tactical Watch Officer (STWO) has a map application open and is examining Situational Awareness (SA) (unit locations, readiness, threats, etc.) tools on the map. He creates a lens that filters out everything but the surface and littoral pictures. He's studying the coastline near an enemy port, since he is supporting a Marine Expeditionary Unit (MEU) which is executing a counter insurgency mission, and is dealing with enemy combatants attempting to infiltrate arms and equipment along the coast. To the right of the screen is watch stander, supporting the STWO. He's also looking at a map, however he's focused on the latest intelligence picture; latest INTEL summaries, position of surveillance assets (UAVs, etc.), with the focus on threats to the MEU, insurgent activity, etc. He is currently observing Predator UAV feeds.

An alert pops up - a transport aircraft has gone down in the ocean. The aircraft was piloted by a US ally, who has requested our assistance in searching for and rescuing the crew. The watch stander standing next to the STWO on the multi-touch, multi-user display wraps-up what he is doing, shrinks it down, and moves it to another part of his desktop. Along with the alert, a Search and Rescue (SAR) information package is made available. The watch stander opens the package, which contains a map with appropriate SA information – last known position of downed aircraft, Area of Uncertainty (AOU), recommended search pattern, and location of all available SAR assets (in this case UAVs, ESG helicopters, and any fixed-wing assets), readiness status of all available assets, information on the aircrew (list of souls onboard, photographs, personnel files, etc.), information on the missing aircraft (survival equipment, cargo, etc.) are all packaged-up. The watch stander selects SAR assets and plots a path for each asset to search, within the predicted AOU. This set of paths is sent to an embedded simulation tool which identifies the coverage and rates the effectiveness of the paths the chosen. Then an Automated Battle Management Aid (ABMA) makes suggestions as to how the path could be improved (e.g. minimal time, maximal coverage in AOU). The tentative search pattern is then passed to the STWO, along with identification information. The STWO takes the information package and assigns tasks, based on his current SA, resource availability, optimal search patterns, etc. Once the the SAR effort is underway, the STWO and his assistant resume planning for the day's MEU support operations.

Another alert pops up – this one is for an imminent threat to MEU. Indications and Warning (I&W) information has been received that insurgent forces are attempting to deliver an arms cache to units within the MEU's Area of Responsibility (AOR). This I&W package indicates that the arms delivery will be performed by a dhow, attempting to hide amongst heavy coastal shipping. The Course of Action (COA) best suited for countering this threat is for ESG assets to conduct Visit Boarding Search and Seizure (VBSS) of all suspected arms carriers in our AOR. INTEL sources also suggest that terrorist leadership may be present on the suspect vessel. The STWO begins to analyze possible options for countering this threat. The CICWO assists him by putting together a VBSS package that includes AOU, list of suspect vessels, last known location, available search and VBSS assets, etc. The STWO reviews the VBSS package, begins to issue tasking.

## Conclusion

In conclusion, NCW is a great start at linking in information to all extremities of the military organization. However, it reveals limitations in the military's processes, particularly in relation to human interactivity and social challenges. To this end, some re-tooling of processes needs to be done. The intent of this paper was to accentuate some of the challenges the military faces as its technology level advances and present some focus areas to ameliorate any resulting problems. These focus areas or practices are collectively represented as a concept called Extreme C2. The last section of the paper presented a demonstration and a technology that encompassed the practices of Extreme C2. This technology was used to demonstrate that the subset of practices of Extreme C2 provide some tangible benefits. Moving forward, the author would like to see the military establishment study and possibly implement some of these practices. There is great potential for process innovation and performance gains to be made in this area.

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