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14. ABSTRACT

In today's military, the same advancements which are rapidly expanding network centric warfare and information dominance capability are also risking to overwhelm the U.S. Observe, Orient, Decide, Act (OODA) Loop with so much information as to seriously impede its ability to function above the tactical level of warfare. Although not manifested in the current conflict due to the relatively slow operational tempo, this situation, left unchecked, will severely hamper operational tempo in future major operations. This paper explains why a data overload of the U.S. OODA Loop is poised to occur and provides two recommendations to fix the issue. These two recommendations, focused on command and control and data management practices, work in concert to ensure U.S. forces remain capable of executing OODA Loop functions faster than future adversaries. In command and control, the United States should practice decentralized execution for major operations. In data management, operational commanders must relearn how to build situational awareness without watching sensor feeds from tactical assets. Without these two adjustments, future foes, even less capable ones, may be able to execute an OODA Loop faster than U.S. forces and thus gain a significant advantage.

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<u>Information Dominance or Information Overload?</u>
<u>Unintended Consequences of 'Every Soldier and Platform a Sensor'</u>

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

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3 May 2010

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Abstract

In today's military, the same advancements which are rapidly expanding network centric warfare and information dominance capability are also risking to overwhelm the U.S. Observe, Orient, Decide, Act (OODA) Loop with so much information as to seriously impede its ability to function above the tactical level of warfare. Although not manifested in the current conflict due to the relatively slow operational tempo, this situation, left unchecked, will severely hamper operational tempo in future major operations. This paper explains why a data overload of the U.S. OODA Loop is poised to occur and provides two recommendations to fix the issue. These two recommendations, focused on command and control and data management practices, work in concert to ensure U.S. forces remain capable of executing OODA Loop functions faster than future adversaries. In command and control, the United States should practice decentralized execution for major operations. In data management, operational commanders must relearn how to build situational awareness without watching sensor feeds from tactical assets. Without these two adjustments, future foes, even less capable ones, may be able to execute an OODA Loop faster than U.S. forces and thus gain a significant advantage.

INTRODUCTION

In the 1970s, Air Force Colonel John Boyd developed a time based theory of conflict that was illustrated in his Observe, Orient, Decide, Act (OODA) Loop diagram.[1] Boyd's philosophy stressed that to win in combat required "a commander to operate at a quicker OODA Loop than does his opponent."[2] To succeed in this endeavor, a commander must act and react faster than his enemy, relying on both outside information and internal perceptions to guide his decisions.

In today's military, the same advancements which are rapidly expanding network centric warfare and information dominance capability are also risking to overwhelm the Observe portion of the United States OODA Loop with so much information as to seriously impede its ability to function above the tactical level. This situation, left unchecked, will severely hamper U.S. operational tempo in future conflicts. To rectify this problem, this paper will make an argument for changing the way data is processed and presented to operational commanders in concert with a renewed focus on decentralized execution for major operations.[3] These steps will ensure U.S. forces remain capable of executing an OODA Loop faster than their adversary, exactly as Boyd originally intended.

Without these two adjustments, future foes, even less capable ones, may be able to execute an OODA Loop faster than U.S. forces and thus gain a significant advantage. The end result for the United States could be a repeat of the Roman performance at the Battle of Cannae in 216 BC, where despite overwhelming superiority, the Romans were unable to adapt to battlefield conditions and a cunning plan by their adversary and were summarily defeated.[4]

JOHN BOYD'S OODA LOOP

Boyd's OODA Loop provides a useful framework to guide an analysis of data systems and how a commander must use information to guide decisions and action processes in a time constrained environment. In Boyd's model, 'Outside Information' is a key feeder during the Observe portion of the OODA Loop.[5] In combat, it's essential that a commander absorb information and circumstances, orient both for the situation, and then decide and act quickly. Successful commanders will execute this entire process faster than their adversary and thus reach the optimum speed for the OODA Loop.[6] A commander who is unable to execute an OODA Loop as fast, or faster, than the enemy, risks falling farther and farther behind in making relevant decisions to the point of unraveling and ceasing to effectively function.[7] Data gathering lays the crucial foundation to properly starting the Observe function and it's here that U.S. forces have excelled for decades. However, the Observe function also contains the seeds of OODA Loop demise if changes are not made.

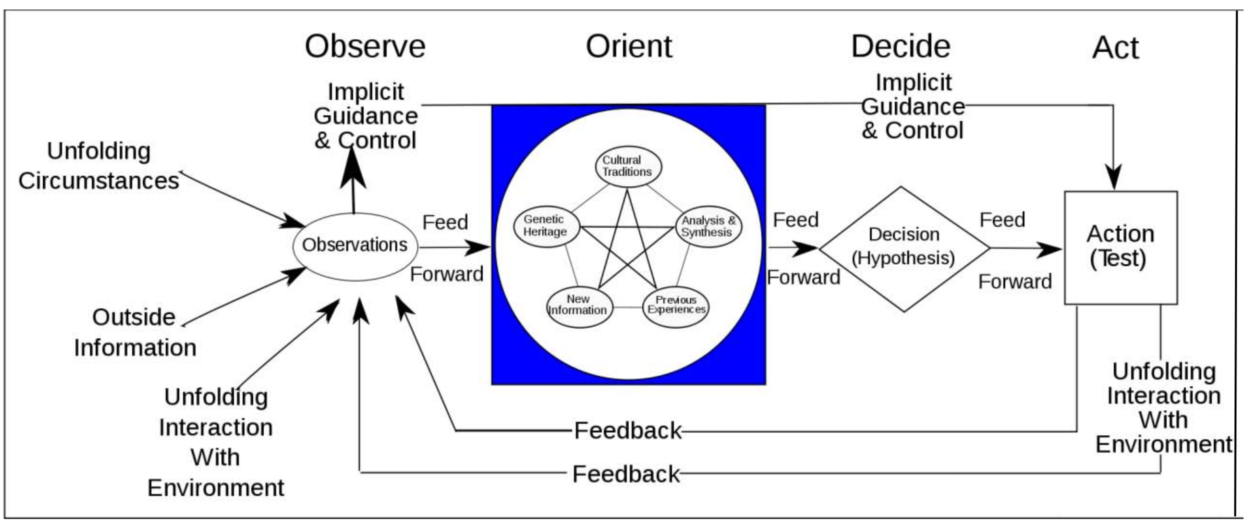

Figure 1. Boyd's OODA Loop[8]

INFORMATION OVERLOAD IS A REAL POSSIBILITY

> I had dreamed of such an Olympian view of the Battlefield. Now I watched in real time as Predator UAVs transmitted night-vision video of TLAMs and JDAMs silently blasting air defense radar sites and C2 buildings
>
> General Tommy Franks, opening strikes of OEF in 2001[9]

While intelligence exists to inform a commander, allowing them to make better and quicker decisions, the important role intelligence plays in the military can be seen in both stated and implied terms. Joint Publication (JP) 3-0 *Operations* flatly states, "Enabled by timely Intelligence, Surveillance, and Reconnaissance (ISR), the goal is to provide the ability to make decisions and execute those decisions more rapidly than the adversary."[10] In more subtle terms, the 2010 Quadrennial Defense Review mentions the word 'information' or 'intelligence' 73 times in just 120 pages of text.[11] Both highlight the importance of intelligence in executing the first step of the OODA Loop, for without proper and timely information in the Observe phase, the entire OODA Loop process would be faulty from inception. The military has long understood this requirement and continues to push for more intelligence, quicker, with higher fidelity. Recently, the Secretary of the Air Force (SECAF) said it best, stating "One thing that has happened in these conflicts [Iraq and Afghanistan]…is the expectation of combatant commanders for situational awareness 24/7/365; that appetite has been established and I do not see that changing."[12]

The far reaching effects of this desire for Situational Awareness (SA) is a set of extremely capable and highly networked systems delivering incredible amounts of data to command centers around the globe. Airborne systems such as the MQ-1 Predator and MQ-9 Reaper are providing nearly 1,000 hours of Full Motion Video (FMV) every single day,[13] while the Army's Force XXI Battle Command Brigade and Below system is installed on over

67,000 platforms and providing an ability to share information via voice or data.[14] Additionally, the Navy recently upgraded their P-3 aircraft with a data link capable of transmitting aircraft sensor information to other ground or naval platforms.[15] These systems and successors soon to follow are placing a huge amount of data into the U.S. OODA Loop in attempting to meet the situational awareness desires of individual combatant commanders.

However, the impending OODA Loop problem doesn't revolve around the actual data per se, but rather how today's operational commanders are trying to personally gather and analyze it. An example of current operations is presented in Figure 1 below with a picture of the Air Operations Center (AOC) for Iraq and Afghanistan.[16] Maps of both countries are presented in the center of the wall, immediately flanked by seven different video feeds from MQ-1 aircraft and a single feed from the weather forecaster. Since MQ-1 and MQ-9 aircraft now combine to fly over 40 continuous Combat Air Patrols (CAP), additional displays can also be configured which provide individual users an ability to view 12 or more video feeds simultaneously on a single desktop screen.[17] Monitors can then be grouped together to gain enough display space to watch all the desired video feeds. The resulting architecture allows a commander to view over 40 simultaneous data feeds from MQ-1 and MQ-9, notwithstanding other sensors that also feed into command centers.

Figure 2. Air Operations Center[18]

While the AOC depicted in Figure 1 is just one instance of high data inputs to a commander, it raises important questions on human and organizational data management. How much data can one person absorb and still make timely decisions? How many simultaneous sensor feeds will be too many for an operational commander to handle? Psychology experiments in human processing power suggest operational commanders may have already exceeded the limit.[i] Human visual processing power is limited by several factors, most notably is the amount of data that can be stored in Visual Short Term Memory (VSTM).[19] Human capacity for VSTM is generally estimated at four items, meaning an average person can be expected to watch four scenes simultaneously and properly identify changes.[20] While some persons have a VSTM capacity higher than four, it would be extremely unlikely to expect all operational commanders to have a VSTM above 40.[21]

Furthermore, persons attempting to watch multiple scenes are subject to an "attentional blink" paradigm, where detecting changes in a second scene is severely impaired by the attention spent on the first.[22] In layman terms, this means that once something catches your eye and you begin focusing or thinking about it, you are much slower to see or act on other visual stimuli. In warfare applications, attentional blink paradigm would present a serious challenge to humans if they tried to watch 40 separate sensor feeds. Even if an operational commander could simultaneously scan all the video feeds, their scan would break down if they stopped for even a moment and focused on a single video.[23] In effect, current operational commanders have become highly accustomed to sensory inputs like Predator video, but VSTM and attentional blink will limit their cognitive capacity to handle all the data.

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[i] While Psychologists have not directly studied an AOC to find the limit of human processing power for Predator video feeds, their general studies in human visual cognition are readily applicable to the AOC situation

HISTORICAL PERSPECTIVES ON DATA OVERLOAD

Current operational commanders are not the first persons faced with a cognitive overload of data. The development of the Combat Information Center (CIC) in the USN provides useful insight on how an organization viewed and ultimately solved a problem of ever increasing data flow to their operational commanders at sea. While American Commodore's were still using spyglass to see the enemy and signal flags to communicate with their forces in the Spanish War of 1898, they would use radios and radar as the dominant means for both sending and receiving information just a few years later. [24] For the Navy, development of radio and surface radar fundamentally altered the human experience of warfare at sea and placed a premium on cognitive skills for processing the large quantities of information now available to naval commanders.[25] To assist the commander in this new era, the CIC was developed, albeit neither overnight nor without growing pains.

The Navy first conducted experiments with wireless telegraphy in 1899 and integrated this equipment onto ships on a large scale during Fleet Problem Number One (FP1) in 1923.[26] After action reports from FP1 identified issues that fleet commanders faced by not having the "means to manage and process all available tactical information" in the new age of wireless communications.[27] These issues were primarily due to lack of proper facilities and procedures.[28] By early 1940, the Navy faced an additional data challenge when integrating surface radar aboard ships.[29] Intelligence gleaned from early radar began as a large mass of raw data that was difficult to interpret. Commanders realized radar data had to be analyzed and transferred to a plot to be of useful intelligence in the prosecution of naval warfare.[30] Wireless communication and radar integration onto ships had combined to literally overload commanders with data and force the Navy to rethink data management for its fleet forces.[31] The Navy was learning that operational success was derived not only from dependable equipment, but also from an effective system for managing data.[32]

In 1940, the CIC solution began to take shape in a radar plotting room meant to accommodate both the radar and existing systems such as wireless communications and intra-ship telephones.[33] This data management concept was further refined in 1941 as the Navy recognized the need for a Command and Control (C2) facility which could assimilate all the new information, but then issue also direction.[34] Additionally, this new C2 facility needed to be staffed with highly qualified personnel. The official CIC was coined in January 1943 with a stated requirement to "maintain the necessary plots based on observations of the various radars so that a general picture would be presented continuously and systematically."[35] Finally, the CIC was required to "provide a procedure and technique for applying this information to tactics, ship-handling, and control of own weapons in order that the commanding officer can make full use of the capabilities of the equipment."[36]

In the span of 20 years, the USN was able to integrate two new technologies which greatly increased the amount of data available to its fleet commanders, but also solve the data management problem caused by radar and wireless telegraph. While initially struggling with data management during FP1 in 1923, the Navy adapted and learned how to properly manage data for the effective use by seagoing commanders. These advancements, which eventually spurred the development of the modern CIC, were realized as a large organization experienced growing pains in handling large amounts of data by individual commanders. This phenomenon is similar to what U.S. forces are experiencing today with the continued growth of sensor and system data available to nearly all operational commanders.

PRESENT DAY OODA LOOP CASE STUDIES

MQ-1 Predator aircraft operating today in Iraq and Afghanistan provide several good case studies that are indicative of the larger problem because the system is still relatively new, yet exhibiting warning signs of data overload. Additionally, like the Navy's data problem that spurred the CIC, issues caused by MQ-1 FMV are correctable with a proper assessment of data management. Furthermore, while MQ-1 FMV is monitored in many operations centers without benefit of prior analysis, the network architecture enables multiple commands immediate access to task an MQ-1 crew. This network architecture is presented in Figure 2, while the case studies will examine issues that have occurred as a result.

Case #1: Operating Enduring Freedom (OEF) – 2001

During the opening hours of OEF, the Commander of US Central Command (CENTCOM/CC), General Tommy Franks, was watching Predator FMV of the battle and noticed that three targets near Kandahar had not been struck.[37] General Franks immediately assumed that the Joint Forces Air Component Commander (JFACC) was not following his targeting priorities and became furious.[38] Later the same night, Franks was watching a Predator feed that was displaying a suspected Taliban leadership convoy.[39] General Franks proceeded to talk directly with the Predator operator regarding picture quality, fuel status, and Hellfire missile considerations, eventually directing the MQ-1 to strike one of the vehicles with a missile.[40] This sequence took over 90 minutes to complete and at multiple points the CENTCOM/CC was talking directly with the pilot of a single aircraft and directing aircraft tactics based upon the Predator video.[41]

While General Franks was still able to manage the overall war effort despite being occupied with one aircraft for over 90 minutes, the warning signs of impending problems

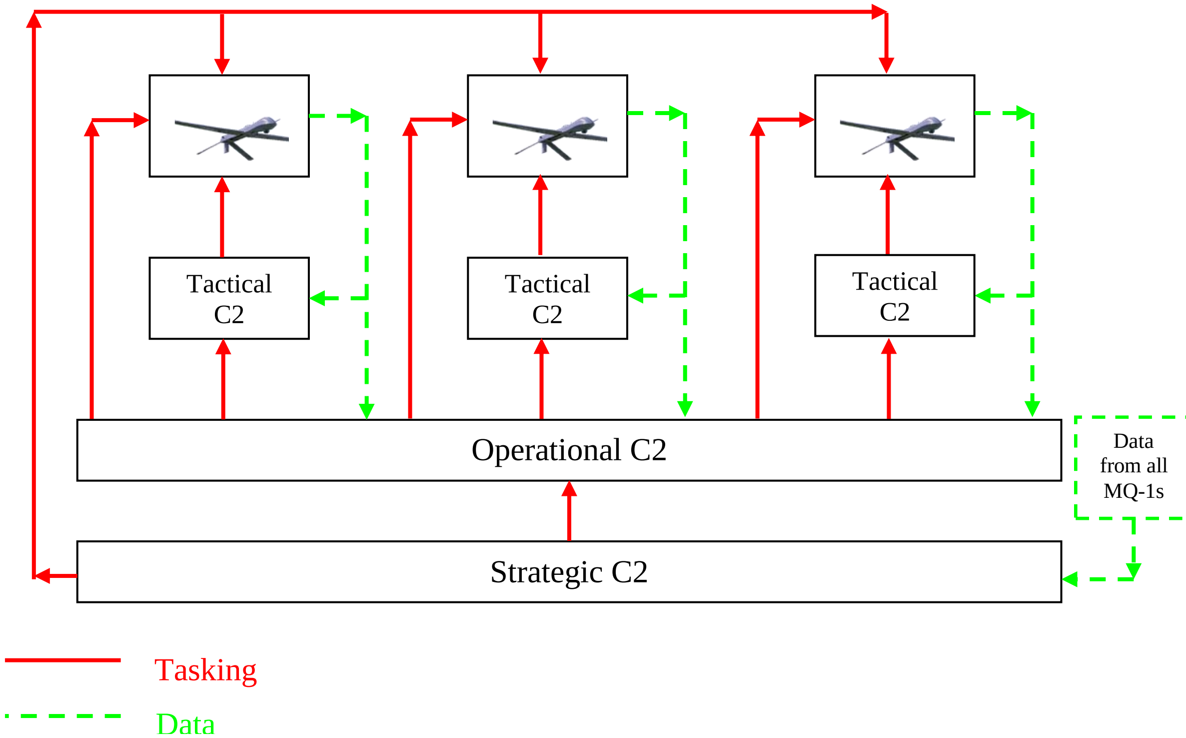

Figure 3. Predator tasking and data architecture

with the U.S. OODA Loop are readily apparent. First, the CENTCOM/CC assumed Predator video was providing actual Bomb Damage Assessment (BDA), vice raw, unanalyzed data. In real time, he couldn't have known why the targets weren't hit, and the list of possible reasons was extensive. Maybe the bombers were delayed for weather or maintenance or had been reassigned to higher priority targets. Maybe the weapons were delivered but missed their targets. Regardless of actual reason, Franks was negatively impacting his own decision processes as he attempted to personally interpret the Predator video and further risked faulty decisions by executing an OODA Loop with incomplete information. A better approach would have been to allow the BDA process to run its course and pass him the actual intelligence.

Moreover, Franks took advantage of the Predator network architecture to skip at least two subordinate commanders in the chain of command and work directly with the pilot of a single aircraft for over an hour.[42] This action undermined the authority of the lower echelon commanders and further consumed Frank's time. If this set precedent, future major operations could be characterized by slow tempo as tactical commanders continually delay action while waiting for higher echelon approval. In 2001, these delays were mitigated because CENTCOM only had a few sensors to manage and thus less information to digest. However, this isn't the case today, where literally hundreds of sensors are providing FMV.

Case #2: OEF Personnel Recovery (PR) Operation - 2007[43]

In November 2007, an MQ-1 was tasked to support a PR operation for two friendly Missing In Action (MIA) in Afghanistan. In the search area, an On Scene Commander (OSC) was directing the operation, including assignment of search patterns to all the aircraft involved. During the operation, the MQ-1 pilot was repeatedly contacted by higher echelon commanders and directed to a different search grid than the one previously issued by the OSC. Unfortunately, the higher echelon search grid didn't account for other aircraft in the area and the resulting search had the MQ-1 looking in the same area as another asset.

In this situation, the higher echelon commander was executing the Observe portion of their OODA Loop based primarily upon the Predator video and also not coordinating with the OSC. This resulted in a search that lacked coordination among tactical and operational commanders and slowed the tempo of the entire mission. Had the OSC been permitted to maintain control of all assets, the MIA search would've been conducted faster and more effectively. Working in this manner would have also kept the mission coordinated between the tactical and operational commanders and ensured the OSC was working in a decentralized execution environment.

A LOOK INTO THE FUTURE

Continued development and fielding of new sensors and systems will further increase the amount of data available to operational commanders, placing additional stress on data management aspects of the U.S. OODA Loop. Today there are already over 12,000 ground robots and 5,500 unmanned aircraft supporting combat operations, with new systems continually in development.[44] Most notably, the Army and Air Force have stated a desire to make every soldier and platform a sensor,[45] while the Navy has gone even further, stating a vision of "Every platform is a sensor. Every sensor is networked."[46] Further examination of the Air Force provides evidence of this growth. By 2013, the MQ-1 and MQ-9 will increase to 65 CAPs, providing over 1,500 hours of FMV every day.[47] If General Franks were to attempt a repeat of his 2001 OEF actions, but spend just 20 minutes with each of these 65 CAPs, he would have a little more than 2 hours left each day to eat, sleep, and attend to the remainder of his duties as CENTCOM/CC.

Moreover, increases into the Observe portion of the U.S. OODA Loop go well beyond systems like Predator. Instead, the largest growth will likely occur in individual sensors. New designs for ground robots could have a network capability built in, while older robots like the Army's Talon could be upgraded to include this functionality.[48] This would provide the robot's sensor feed to commanders in real time along with the troops on the ground. Additionally, technologies such as the robotic suit for an individual solider will have excess carriage capacity available for sensors that could be networked into higher headquarters just like Predator.[49] Future war may well be characterized by sensors and lightweight networking gear that can make every soldier and platform a provider of information in the same sense as traditional ISR systems.

DATA OVERLOAD BECOMES EVIDENT

Due to these aforementioned factors, data overload within the Observe portion of the U.S. OODA Loop is poised to occur in the next major operation conducted by U.S. forces. But before presenting the details of the overload manifestation, it's important to begin with a review of some assumptions that drove this conclusion. These key assumptions concerning data management practices and the tempo of current operations can help identify exactly which future operations will or won't experience data overload. These same assumptions also provide insight into solving the overall issue.

The first assumption is that the conditions for data overload at the operational level of warfare exist today. Given the psychology studies used earlier, it's logical to say operational commanders already have access to much more data than their brains can process and analyze in a reasonable amount of time.[50] However, the second assumption is that the current operations tempo in Iraq and Afghanistan does not require operational commanders to think quickly in executing OODA Loop operations. Because coalition forces largely dictate the tempo and location of all major action, the current OODA Loop is not stressed for time. Thus, the slow tempo of current operations is effectively preventing a manifestation of data overload in the current conflict. However, the final assumption is that operational commanders, having become highly accustomed to seeing and analyzing huge amounts of raw data in the current conflict, will attempt these same actions during future war.

Using these assumptions and the behavioral characteristics described earlier, the resulting conclusion is that an overload of the U.S. OODA Loop is poised to manifest during the next major combat operation. This would likely occur in a state versus state war. In keeping with Boyd's theory, overall success in this scenario will largely hinge on the ability to execute OODA Loop functions faster than the enemy.[51] However, if operational commanders attempt to execute the next major operation in the same manner as General Franks executed OEF, but are presented with 100 times the data, the U.S. OODA Loop will run a serious risk of grinding to a near standstill. This would permit future adversaries a distinct advantage in OODA Loop operations, ceding both initiative and operational tempo to the enemy. While a slower OODA Loop may not, in itself, effectively spell defeat for U.S. forces in future conflict, it should be of enough concern to warrant serious attention into possible fixes and solutions to the problem.

Furthermore, while pinpointing the exact moment data overload will occur in the next conflict is difficult, the conditions which will cause it are readily identifiable. First, operational commanders must be presented with more data than their cognitive processes can handle. Second, the enemy must display a level of agility and audacity that forces the U.S. to exhibit flexibility and make decisions in a time compressed environment. These two conditions could occur anytime during the next major operation, but are more likely to occur early in the conflict while an enemy still maintains the bulk of its combat potential and the U.S. is still working hard to develop a full understanding of the enemy order of battle, force capabilities, and intentions.

HOW TO SAVE THE UNITED STATES OODA LOOP

> Information should be properly constrained as an aid to, not the master of, operational commanders and their staffs
>
> Milan Vego, Joint Operational Warfare[52]

Correcting the impending data overload with the U.S. OODA Loop requires changes in two areas, tasking authority and data management. In tasking authority, the current paradox of decentralized execution from joint doctrine must be fixed. By implication from previous examples, this means upper echelon commanders such as the CENTCOM/CC should not be talking directly with an MQ-1 pilot. Instead, upper echelon commanders should be providing mission orders and tasking to lower echelon commanders and then expecting those lower echelons to both execute and provide relevant situational updates. Boyd embraces this concept within his OODA Loop briefing, stating "there must be flexibility in command based upon a common outlook and freedom of action that encourages lower level combat leaders to exploit opportunities…within a broad loosely woven scheme laid down from central command."[53] JP 1 *Doctrine for the Armed Forces of the United States* further supports this notion, stating "unity of effort over complex operations is made possible through decentralized execution of centralized, overarching plans."[54]

Figure 3 below outlines this new tasking and control authority. In this construct, mission orders and tasking are passed from strategic, to operational and eventually tactical units. But the actual control of individual assets and sensors only occurs at the tactical level of warfare. The left side of Figure 3 displays a grouping of infantry who've recently disembarked from a Stryker armored vehicle, while the right side of the figure shows joint airpower supporting a ground commander. Reestablishing the standard of decentralized execution will require time and training to break the patterns established during the current

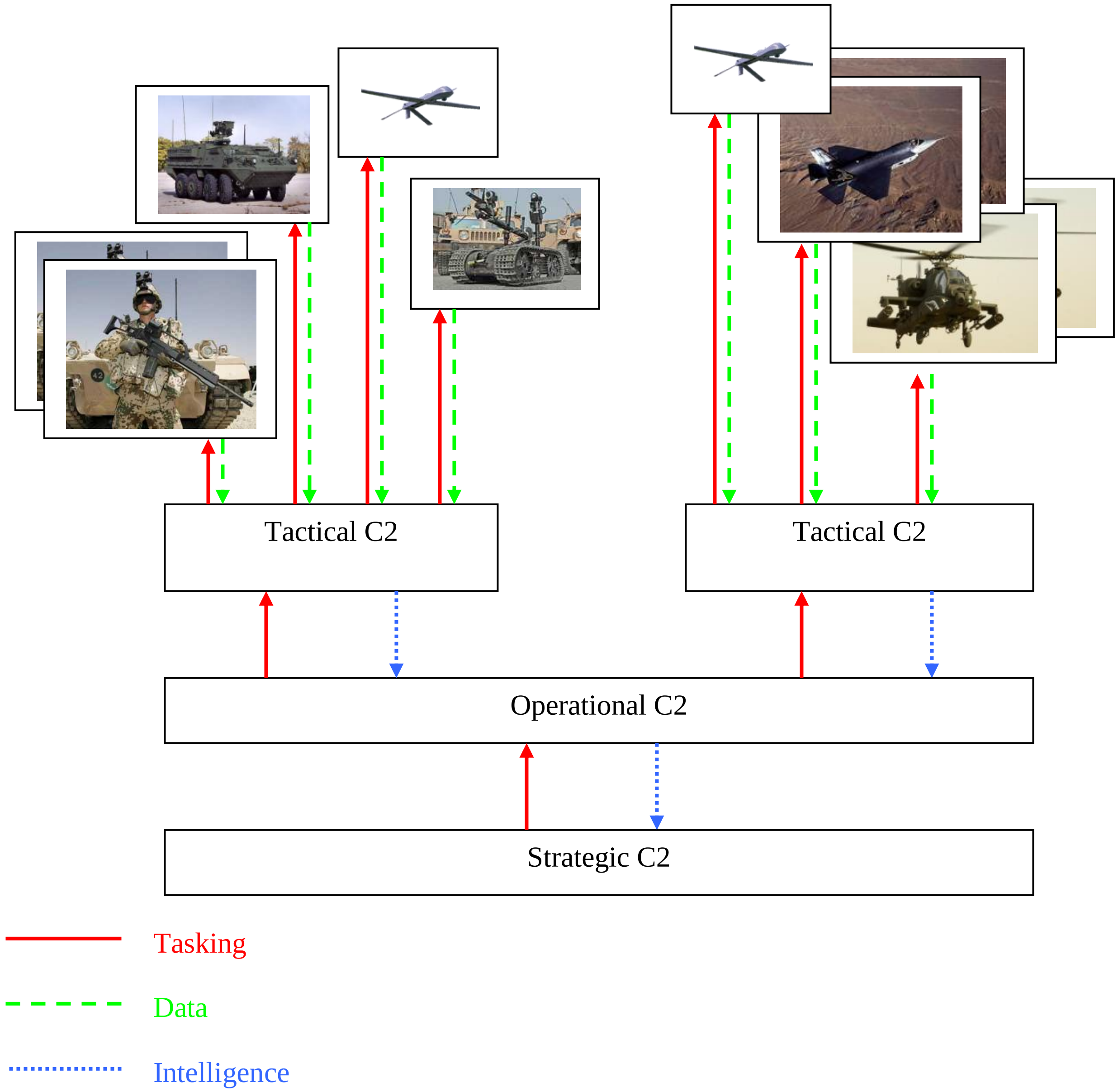

Figure 4. Proposed data and C2 architecture

conflicts in Iraq and Afghanistan. This training must occur prior to deployment to ensure standards and procedures can be rehearsed and refined prior to combat employment. Using the JFACC as an example, AOC staffers have an opportunity to train at the AOC schoolhouse in Hurlburt Field, Florida, or during live-fly exercises such as Red Flag. Both of these training opportunities focus on preparing units and individuals for deployment to a combat AOC and provide an ideal environment that places both tactical and operational units in realistic settings where new procedures can be both learned and refined. Mastering decentralized execution here will better prepare JFACCs and their staffs for C2 of actual combat operations.

Solving the data overload problem requires a similar restructuring of the network architecture, as successors to General Franks do not have the time to simultaneously watch 65 separate Predator feeds plus all the new sensors that have been fielded since 2001. Operational commanders must relearn how to build situational awareness without watching sensor feeds from tactical assets. To alleviate this problem, data must be observed and processed at the lowest possible level of warfare while concurrently ensuring timely intelligence and reporting is passed to higher echelon units. Figure 3 also displays a breakdown of how the data will flow in this new architecture, where only the tactical level command center would be viewing and analyzing the sensor data in real time. Using Predator as an example in Figure 3, once the FMV is converted to intelligence needed by higher echelon commands, it would be immediately forwarded. In this new architecture, higher echelon commands will no longer watch Predator or other sensor footage in real time along with tactical units in attempts to build SA. An additional option to make this architecture more effective is to provide liaison officers from operational commands down to the tactical units to assist in the gathering and forwarding of relevant intelligence to the operational commander. This could be a temporary or permanent situation, depending on the needs of individual commanders and the overall scope of the conflict. In new combat theaters, liaison officers would be immediately needed. However, once the theatre stabilized to a predictable operating tempo where the operational commander's intelligence requirements were well understood at all levels, the liaison officers may be unnecessary.

As with decentralized execution, pre-deployment training will be the key to refining and learning these procedures. Training events such as Red Flag and Army National Training Center rotations provide an opportunity for operational commanders to master the art without overloading their cognitive processes. It's also important to note that this training must occur in an environment which places U.S. forces in a major operation against a capable adversary, requiring hastened OODA Loop operations to be successful. Without this environment, the requirement to refrain from watching individual sensor feeds and instead allow the subordinate commander and staff to provide SA and intelligence is greatly reduced, negatively impacting the overall learning opportunity.

Training to these new standards will be difficult, due primarily to the near addiction higher echelons have developed for continuous data streams from assets like Predator. But for this construct to work, operational commanders must embrace the established doctrine of decentralized execution while permitting their lower echelons and staffs to analyze and process data appropriately in order to prevent overwhelming an individual commander's limited time. Finally, educating commanders on the perils they'll face in future state versus state conflict if they continue 'operations normal' with sensory inputs may prove extremely useful in convincing the military to fully embrace this concept.

COUNTER-ARGUMENTS

The two main counter-arguments to these changes revolve around a commander's responsibility to accomplish the mission. First, as the initial OODA Loop step is stated as "Observe," what better way for a commander to observe than to personally watch the sensor feed? Although within a commander's prerogative to personally watch sensor feeds, as many currently do so, the danger actually resides in future war. In future major operations, huge amounts data will be flowing into operations centers. If commanders then apply their current habit patterns, science tells us all but the superhuman will have their cognitive processes overloaded.[55] The more effective approach is to have the data analyzed and processed, then presented in a manner that adds to a commander's SA. Individual commanders may have different preferences on how this intelligence is presented, but the end goal should be to present the relevant information without overloading the commander's cognitive capability.

The second counter-argument states that if the commander is ultimately responsible for the success of a mission, then shouldn't this responsibility drive them to personally view all sources of information and directly control assets as required? While this ideal works well for small or slow-tempo operations such as counter-piracy, it breaks down during major operations. In counter-piracy, with only a handful of assets to manage and a small enemy force, a commander likely has enough cognitive capacity to watch individual sensor feeds without becoming overloaded. But in a major operation, if an operational commander tried to view all sensor feeds and direct individual assets, they would be risking loss of SA on the overall battle as they focused on a small portion. The risks inherent here suggest a better course of action is to have the commander use intelligence to maintain SA without focusing on individual sensor feeds or centralized execution.

CONCLUSION

Both the growing proliferation of networked sensors and ISR systems in the next few years and possible state versus state conflict threaten to overwhelm operational commanders with data. This situation will result in an overall slowing of the US OODA Loop, hampering both operational tempo and tactical initiative. Although this problem is already manifested today in systems like the Predator, solutions enacted now will not only benefit current Predator operations but also positively impact future wars where many more data gathering systems will populate the battlefield. However, left unchecked, this predicament will permit future adversaries to think and act quicker than U.S. forces, thereby dominating Boyd's OODA Loop.[56]

The fix to the impending data overload in the U.S. OODA Loop comes in two parts. First, the current C2 structure must be modified to provide tactical level commanders direct control authority over individual sensors and ISR systems. Second, data gathered from sensors and ISR systems should be observed, analyzed, and acted upon at the lowest possible level of warfare, while relevant intelligence must still be rapidly passed along to higher echelon units.

These changes to the C2 structure and data handling procedures for networked sensors and ISR systems will ensure all commanders are provided the timely, relevant intelligence they need to make informed decisions, while ensuring tactical level commanders have the latitude required to maintain the initiative in a decentralized execution environment. These actions will further ensure that future sensors and ISR systems will not overload the U.S. OODA Loop with data at operational and strategic levels, helping secure information and OODA Loop dominance in future conflicts.

NOTES

[1] Robert Coram, *Boyd, The Fighter Pilot who Changed the Art of War* (New York, NY: Back Bay Books, 2004), 327-44.
[2] Ibid., 339.
[3] U.S. Office of the Chairman of the Joint Chiefs of Staff. *Doctrine for the Armed Forces of the United States*, Joint Publication (JP) 1, 14 May 2007 w/ Change 1 20 Mar 2009, I-17
[4] Encyclopedia Britannica Online, s.v. "Battle of Cannae," http://www.history.com/topics/battle-of-cannae (accessed 20 Apr 2010).
[5] Frans P.B. Osinga, *Science, Strategy and War, The Strategic theory of John Boyd* (New York, NY: Routledge, 2007), 231.
[6] Ibid., 141.
[7] Ibid., 49.
[8] Ibid., 231.
[9] Malcolm McConnell, *American Soldier, General Tommy Franks* (New York, NY: Harper Collins Books, 2004), 287.
[10] U.S. Office of the Chairman of the Joint Chiefs of Staff. *Operations*, JP 3-0, 17 September 2006 Incorporating Change 1 13 February 2008, III-3.
[11] Office of the Secretary of Defense, *Quadrennial Defense Review Report February 2010*, http://www.defense.gov/QDR/images/QDR_as_of_12Feb10_1000.pdf (accessed 9 Apr 2010).
[12] Gordon Lubold, "As drones multiply in Iraq and Afghanistan, so do their uses," *Christian Science Monitor*, 2 March 2010, http://www.csmonitor.com/USA/Military/2010/0302/As-drones-multiply-in-Iraq-and-Afghanistan-so-do-their-uses (accessed 1 Apr 2010).
[13] Travis Burdine, e-mail message to author, 20 Mar 2010.
[14] Program Executive Office Command, Control, and Communications-Tactical, **"**Project Manager, Force XXI Battle Command Brigade and Below." http://peoc3t.monmouth.army.mil/fbcb2/fbcb2.html (accessed 30 Apr 2010)
[15] Lockheed Martin, "Lockheed Martin Upgrades Eight P-3C AIP Aircraft with Tactical Common Data Link Systems." http://www.lockheedmartin.com/news/press_releases/2005 (accessed 30 Apr 2010).
[16] Although picture is not dated, author personal experience verifies this was the Air Forces Central (AFCENT) AOC configuration in 2007
[17] Author personal experience from 2006-2009
[18] http://iangela.typepad.com/meanmuse/files/caoc.jpg (accessed 20 Apr 2010)
[19] Rene Marois and Jason Ivanoff, "Capacity limits of information processing in the brain," *Trends in Cognitive Sciences* 9, no. 6 (June 2005): 296-305.
[20] Ibid.
[21] Ibid.
[22] Ibid., 296
[23] Ibid.
[24] Timothy Scott Wolters, *Managing a Sea of Information: Shipboard Command and Control in the United States Navy, 1899-1945. (*Massachusetts Institute of Technology Libraries, Sep 2003), 15-19.
[25] Ibid., 18
[26] Ibid., 18, 113-118.
[27] Ibid., 114
[28] Ibid., 127-129.
[29] Ibid., 207-209.
[30] Ibid., 222-225.
[31] Ibid., 244-245.
[32] Ibid., 207-209.
[33] Ibid., 223.
[34] Ibid., 244.
[35] Captain H. A. McClure, "Destroyer PCO/PXO Lectures," April 1944, National Archives, College Park Maryland (NACP), Record Group 38 – General Records of the Chief of Naval Operations, (RG 38), Records of the United States Fleet Commander in Chief (COMINCH), Box No. 1162, quoted in Wolters, 244.

[36] Ibid.
[36] Ibid.
[37] Malcolm McConnell, *American Soldier, General Tommy Franks*,288.
[38] Ibid.
[39] Ibid., 289-294.
[40] Ibid.
[41] Ibid.
[42] Ibid., 290.
[43] Based on author personal experience supporting a PR operation in Nov 2007
[44] Dr. P.W. Singer, "Tactical Generals, Leaders, Technology, and the Perils of Battlefield Micromanagement," *Air & Space Power Journal*, Summer 2009. Christopher Drew, "Drones are Weapons of Choice in Fighting Qaeda," *The New York Times*, 16 March 2009, http://www.nytimes.com/2009/03/17/business/17uav.html (accessed 30 Apr 2010)
[45] Fred Donovan, "Army to Deploy Hand-Held Devices to Make Every Soldier Into a Sensor," *Aviation Week*, 29 April 2004. Interview of Lieutenant General David Deptula, Deputy Chief of Staff for ISR, USAF, during the 2009 Avalon International Air Show, http://www.ausairpower.net/DT-Deptula-March-2009.pdf (accessed 30 April 2010)
[46] Jack N. Summe, "Navy's New Strategy and Organization for Information Dominance," *Chips*, January-March 2010, 19.
[47] Travis Burdine, e-mail message to author, 8 Mar 2010.
[48] Defense Aerospace.Com, "Army Debuts New Tool to Defeat IEDs", http://www.defense-aerospace.com/page/home.html (accessed 30 April 2010).
[49] Mark Jewell, "Robotic Suit could usher in super soldier era," *MSNBC.Com*, 15 May 2008, http://www.msnbc.msn.com/id/24651455/ (accessed 30 April 2010)
[50] Rene Marois and Jason Ivanoff, "Capacity limits of information processing in the brain," 296.
[51] Frans P.B. Osinga, *Science, Strategy and War, The Strategic theory of John Boyd*, 141.
[52] Vego, Milan, "Operational Factors,"*Joint Operational Warfare*. Newport, RI: Naval War College, reprint, 2009 III-72.
[53] Frans P.B. Osinga, *Science, Strategy and War, The Strategic theory of John Boyd*, 159.
[54] U.S. Office of the Chairman of the Joint Chiefs of Staff. *Doctrine for the Armed Forces of the United States*, Joint Publication (JP) 1, 14 May 2007 w/ Change 1 20 Mar 2009, xvi.
[55] Rene Marois and Jason Ivanoff, "Capacity limits of information processing in the brain"
[56] Frans P.B. Osinga, *Science, Strategy and War, The Strategic theory of John Boyd*, 177.

BIBLIOGRAPHY

Robert Coram. *Boyd, The Fighter Pilot who Changed the Art of War*. New York, NY: Back Bay Books, 2004.

Frans P.B. Osinga. *Science, Strategy and War, The Strategic theory of John Boyd*. New York, NY: Routledge, 2007.

Malcolm McConnell. *American Soldier, General Tommy Franks.* New York, NY: Harper Collins Books, 2004.

U.S. Office of the Chairman of the Joint Chiefs of Staff. *Doctrine for the Armed Forces of the United States*, Joint Publication 1, 14 May 2007 w/ Change 1 20 Mar 2009.

U.S. Office of the Chairman of the Joint Chiefs of Staff. *Operations*, Joint Publication 3-0, 17 September 2006 Incorporating Change 1 13 February 2008.

Steven J. Luck, Edward K. Vogel. "The capacity of visual working memory for features and conjunctions," *Nature*, no. 390 (20 November 1997)

Office of the Secretary of Defense. *Quadrennial Defense Review Report February 2010*, http://www.defense.gov/QDR/images/QDR_as_of_12Feb10_1000.pdf (accessed 9 Apr 2010).

Gordon Lubold. "As drones multiply in Iraq and Afghanistan, so do their uses." *Christian Science Monitor*. 2 March 2010, http://www.csmonitor.com/USA/Military/2010/0302/As-drones-multiply-in-Iraq-and-Afghanistan-so-do-their-uses (accessed 1 Apr 2010).

Program Executive Office Command, Control, and Communications-Tactical. **"**Project Manager, Force XXI Battle Command Brigade and Below," http://peoc3t.monmouth.army.mil/fbcb2/fbcb2.html (accessed 30 Apr 2010).

Lockheed Martin."Lockheed Martin Upgrades Eight P-3C AIP Aircraft with Tactical Common Data Link Systems." http://www.lockheedmartin.com/news/press_releases/2005 (accessed 30 Apr 2010).

Rene Marois and Jason Ivanoff. "Capacity limits of information processing in the brain," *Trends in Cognitive Sciences* 9, no. 6 (June 2005).

Timothy Scott Wolters, *Managing a Sea of Information: Shipboard Command and Control in the United States Navy, 1899-1945*, Massachusetts Institute of Technology Libraries, Sep 2003.

Dr. P.W. Singer. "Tactical Generals, Leaders, Technology, and the Perils of Battlefield Micromanagement." *Air & Space Power Journal*, Summer 2009.

Christopher Drew. "Drones are Weapons of Choice in Fighting Qaeda." *The New York Times*, 16 March 2009, http://www.nytimes.com/2009/03/17/business/17uav.html (accessed 30 Apr 2010).

Fred Donovan. "Army to Deploy Hand-Held Devices to Make Every Soldier Into a Sensor." *Aviation Week*, 29 April 2004.

Jack N. Summe. "Navy's New Strategy and Organization for Information Dominance." *Chips*, January-March 2010.

Mark Jewell. "Robotic Suit could usher in super soldier era." *MSNBC.Com*, 15 May 2008, http://www.msnbc.msn.com/id/24651455/ (accessed 30 April 2010)

Vego, Milan, *Joint Operational Warfare*. Newport, RI: Naval War College, reprint, 2009