C2 Rising

A Historical View of Our Critical Advantage

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Life can only be understood backwards, but it must be lived forwards.

—Søren Kierkegaard

The command and control (C2) core function can be somewhat difficult to grasp. For example, consider the service publication *Global Vigilance, Global Reach, Global Power for America*. This compelling piece lays out concise, one-page descriptions of the original five Air Force core functions: air and space superiority; intelli-

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gence, surveillance, and reconnaissance (ISR); rapid global mobility; global strike; and C2.[1] The first four core functions have power and clarity. They are the legacy of the air and space nation. However, when readers reach the fifth core function, they are led to believe that the meaning of C2 is maintaining networks in the cyber age. Yet, in terms of grasping C2, networks do not explain that concept any more than missiles explain air superiority or bombs define global strike.

America's greatest advantage in war fighting lies not in the quality of its people, ideas, weapons, or planes but in the systematic integration of those elements via C2. Going back to Napoleon, modern thinkers have consistently made this observation. Men such as Field Marshal Helmuth von Moltke (the Elder) and the US Air Force's Col John Boyd mark a steady rise toward identifying C2 operations as the prime integrator of military power in terms of people, ideas, weapons, and machines.[2]

To analyze the concepts of these thinkers, Carl von Clausewitz offered a helpful distinction. He taught that the *character* of war will change while certain aspects in the *nature* of war never change. Both the changing and the unchanging aspects are always at play in war, and both merit our devoted study.[3] Moltke, Marshal of the Soviet Union Mikhail Tukhachevskii, Air Chief Marshal Hugh Dowding, and Boyd were forced to think about C2 operations based on the evolving character of war in their day but also produced insights about C2 fundamentals in the nature of war. They navigated (1) the rise of industrial-age warfare, (2) the new operational level of war, (3) the range and speed of the aviation age, and (4) the beginning of information-age warfare. At the same time, they found that universal C2 sub-functions and concepts are inherent to the unchanging nature of war. Both the changing and unchanging aspects of C2 in their works represent a constant movement toward viewing C2 as our critical advantage (or its neglect—our critical weakness). Moreover, we can now observe these same universal sub-functions across industries ranging from NASA's mission control to national power grids. Seeing the nature of C2

through both the eyes of its greatest contemporary thinkers and universal forms can also make this subject more tangible to anchor our views of how we fulfill these sub-functions in the future.

A Six-Stage History of Modern Airpower Command and Control

Until Waterloo, military C2 in war was predominantly a single-man, single-battlefield affair. While empires like Greece, Persia, and Rome had periods of "grand strategy," the portrait of C2 in ancient warfare is framed largely through individual battles—often great ones. In these battles, the commander could apprehend the scope of the battlefield and control it with an officer corps and signals.

Napoleon Bonaparte. (From "The Emperor Napoleon in His Study at the Tuileries," *Wikipedia: The Free Encyclopedia*, accessed 1 June 2014, http://en.wikipedia.org/wiki/File:Jacques-Louis_David_-_The_Emperor_Napoleon_in_His_Study_at_the_Tuileries_-_Google_Art_Project.jpg.)

In this stage, Napoleon was a transitional figure in expanding the art of C2. His dispersed armies often moved along a wide front and then converged on the day of battle. One division would engage, and the

others would "march to the sound of the guns." Often, a corps would arrive at the 11th hour of battle, providing decisive reserves and the margin of victory. This era, stage one, is represented by the looming of industrial-age warfare and an expansion of C2 art by Napoleon.

Helmuth von Moltke (the Elder). (From "General von Moltke," Wikimedia Commons, accessed 1 June 2014, http://upload.wikimedia.org/wikipedia/commons/8/8f/General_von_Moltke.jpg.)

By 1870, revolutions in transportation (the train) and communication (the telegraph) expanded the commander's operations over many battlefields simultaneously. These revolutions changed the character of war for Moltke during the Franco-Prussian war. In 1932 Russian theorist Georgii S. Isserson captured Moltke's role by noting that "Moltke the strategist was faced with a completely new problem of coordinating and directing combat efforts, tactically dissociated and dispersed in space to achieve the overall aim of defeating the enemy."[4] Until then, only the strategic and tactical levels of war existed. This new phenomenon, the nascent emergence of an operational level in war, was something separate from the tactical and strategic levels.[5] Moltke observed

that new transportation and communication phenomena allowed forces to "move divided and fight united" (largely how we fight today).[6]

This change in the character of war indirectly shaped C2 history in the ideas of Moltke. He thought that winning strategies would now involve having what he called a "system of expedients" to take advantage of the opportunities found at this new level of war. He went as far as saying that "strategy *is* a system of expedients" (emphasis added).[7] Two key leaps in Moltke's observation transfer to C2 theory: (1) warfare now required a systems approach to accommodate its broader character, and (2) the system with the best inherent adaptability in responding to fog and friction ("expedients") would prove superior. This idea created a quiet turn toward a C2 profession ushered in by revolutions in technology and the character of industrial-style warfare.[8]

C2 systems in this era were simple compared to modern ones. In Moltke's era, such systems were also remarkably high functioning:

> A relatively small staff (even Moltke's General Staff in 1870 numbered only approximately seventy officers, as against close to a million men that it controlled during hostilities against France), some wagons with filing cabinets and maps, a pool of mounted orderlies, and such technical contrivances as field telescopes, standards, trumpets, drums, and pigeons (later supplemented by telegraph and telephone) formed the sum total of command systems.[9]

Even until World War I, fielded forces used carrier pigeons for C2 communication at the Battle of Verdun—less than 100 years ago.[10] Yet, in these simple systems, Moltke and the Prussians adapted to a new level in war while grasping the systems approach we still use today. Thus, Moltke's era, stage two, is marked by the front edge of an operational level in war and foresight into systems warfare.

Mikhail Tukhachevskii. (From "Mikhail Tukhachevsky," Wikimedia Commons, accessed 1 June 2014, http://upload.wikimedia.org/wikipedia/commons/6/66/Mikhail_Tukhachevsky.jpg.)

The next great leap in understanding modern C2 came in the brutal form of the Red Army. The genius of that Soviet war machine, Mikhail Tukhachevskii, advanced many characteristics of modern warfare, including airborne paratroopers and tanks. He was also fascinated by how airplanes could (1) transform the concept of range (what he called "deep battle") and (2) provide unparalleled observation and integrated firepower to advancing forces (what he called "airmechanization"). One could argue that the Germans married the same ideas in the blitzkrieg concept that crippled Poland and Western Europe in 1939 and 1940.

By 1924 Tukhachevskii had begun to grasp the new complexity of C2 by articulating its sub-functions inherent to the nature of warfare. In that same year, he had five of the six functions we use today in Air Force Tactics, Techniques, and Procedures (AFTTP) 3-1, *Theater Air Control System 2013*, and by 1937, six of six.[11] In 1937 Tukhachevskii even conceptualized these C2 functions performed in the air, where a bird's-eye view would offer maximum awareness to both commanders and shooters:

> Communications aircraft carry out the following tasks: (a) delivery of orders and collection of situation reports, (b) maintenance of communications between divisions, [and] (c) battlefield surveillance. Translators note: "Voiskovoi" now normally implies "divisional, organic to divisions," but here probably includes corps as well. "Liaison with tanks" (lit. fr. "accompaniment of tanks") is a complex concept [to translate]. The same term is now used for artillery support of the leading elements of a mobile force once they have broken loose. In this Regulation [from Tukhachevskii] it implies a mixture of guiding the tanks navigationally and tactically, reporting their progress back, and probably controlling the fire of their supporting artillery.[12]

Here we see that Tukhachevskii imagined something like the Joint Surveillance Target Attack Radar System (JSTARS) well before we Americans built it. His era, stage three, is marked by the post–World War I operational level of war and articulation of unchanging C2 functions in the nature of war.

From Tukhachevskii forward, a scientific quest occurred to feed C2 functions with more situational awareness (SA). Radar and radios became the backbone of these SA feeds.[13] Thus, as soon as technology allowed, radar became central to modern forms of C2. The British "Dowding" system of radar, observers, and mission controllers represents the classic leap into this stage of C2.

Hugh Dowding. (From "Hugh Dowding," Wikimedia Commons, accessed 1 June 2014, http://upload.wikimedia.org/wikipedia/commons/7/7c/Hugh_Dowding.jpg.)

Britain's Air Chief Marshal Hugh Dowding, a veteran of World War I, had a brilliant mind and reserved character (thus the nickname "Stuffy"). In 1936 he became head of the United Kingdom (UK) Fighter Command and offered an alternative view to that of strategic bombing advocates such as Giulio Douhet (Italy), Hugh Trenchard (England), and William "Billy" Mitchell (United States). Dowding wanted deterrence based on "fear of the fighter" planes. As the theory went, if an island nation like England possessed a dominant fighter force, then no significant attack on the homeland would take place from the air. As Stephen Bungay points out, however, Dowding knew that "all the fighters in the world were of little use if they could not find their enemy."[14] To address this kill-chain problem and match the Luftwaffe, Dowding pushed to develop a nationwide awareness system of costal radars known as "Chain Home."

In theory, at the heart of Dowding's system were the human problem solvers running C2 operations:

> The quality of the information depended crucially on the skill and experience of the operators, for judgment as well as calculation played a role. They had to work very fast, or their information was useless. They were also under pressure, as lives depended on the accuracy of their reports. . . . [They had] rigorous performance measures, and so improved constantly. Operator skill was paramount to the system's effectiveness. . . . For the system to work, everybody in it had to practice.[15]

Officers and enlisted troops in this system performed C2 sub-functions as we know them today. Shooters needed to be oriented and paired dynamically on a grand scale. Problems woven into the nature of war demanded human judgment and intervention. Basic forms of order to air operations were necessary to execute decentralized missions. Real-time assessments had to be made, relayed, and acted upon. Radars fed the mission controllers, who functioned as "sheepdogs," herding the fighter squadrons into battle to save their nation. To this day, the United States uses the Dowding model to guard its airspace via the Western Air Defense Sector and Northeastern Air Defense Sector.

The Operations Room at Headquarters Royal Air Force Fighter Command, Bentley Priory. (From Imperial War Museum, © IWM [C 1869], http://www.iwm.org.uk/collections/item/object/205195170. Reprinted with permission.)

Interior of the Sector "G" Operations Room at Duxford, Cambridgeshire. The call signs of fighter squadrons controlled by this sector can be seen on the wall behind the operator sitting third from left. The controller is sitting fifth from the left, and on the extreme right, behind the Army liaison officer, are the R/T operators in direct touch with the aircraft. (From Imperial War Museum, © IWM [CH 1401], http://www.iwm.org.uk/collections/item/object/205195667. Reprinted with permission.).

After the success of this air defense system, large radars were eventually placed on airborne early warning aircraft like the E-2 and EC-121. In theory these platforms became extended-range and air-mobile versions of the defensive Chain Home radar model.[16] This period, stage four, is marked by increased depth in battlespaces from the speed and range of the aviation era in full swing and sophisticated SA feeds used by teams of controllers to form a complex, adaptive defensive system.

Photo courtesy Public Affairs, 116th Air Control Wing, Robins AFB, Georgia

An airborne JSTARS crew bears much resemblance to the Royal Air Force control room 70 years later.

John Boyd, pilot. (From Wikimedia Commons, accessed 1 June 2014, http://commons.wikimedia.org/wiki/File:JohnBoyd_Pilot.jpg.)

Although the Dowding system emerged from defense, Col John Boyd ushered in a comprehensive dimension to C2 using competition fundamentals. Airmen recognize Boyd's observe, orient, decide, act (OODA) loop as a model for obtaining air dominance in war.[17] In theory, if our OODA loop is shorter than that of our enemies, we end up on the proper side of fighting. Less well known is Boyd's presentation "Organic Design for Command and Control," in which he brings OODA to a system-wide level reminiscent of Moltke's call for a system of expedients. Boyd thought that bringing the OODA concept to a system level could maximize our capacity for independent action, calling these qualities "initiative and adaptability." At the same time, this system could ensure that all actions at the speed of air war would remain aligned to the commander's intent and vision. He referred to this quality and the reduction of friction as "harmony." Yet, all three of these

qualities hang on the ability to produce "insight" on a system-wide level. Thus, a key distinction of Boyd's trust-based C2 system involves adding system-level "insight" to the defensive "expedients" found in the Dowding model.[18]

In principle, Boyd added a comprehensive quality to C2 operations whereas the Dowding system was defensive from inception. In doing so, Boyd advanced yet another level of detail to the concept of Moltke's "expedients" from stage two. The Dowding system concentrated on defensive expedients while Boyd extended expedients to include the proactive production of insight motivated by competition fundamentals.

Whether or not we think of it this way, we moved toward Boyd in the form of the theater air control system (TACS), within which both ISR and C2 enterprises feed offensive air operations in a way the Dowding system did not.[19] Today we can witness our move in this direction by noting the sheer size of US Central Command's intelligence, surveillance, and reconnaissance division—comparable to the size of the air and space operations center's combat operations floor. The early TACS and these modern expansions began to transfer the OODA concept past a four-ship to an entire complex, adaptive system for harnessing airpower and producing insight.[20] Thus, changes in Boyd's era are marked by the front edge of the information age, including computer-based C2 and adding system-wide "insight" to the defensive expedients found in the Dowding model. This multistage view of C2 history shows that C2 theorists navigated megatrend-type changes while gaining insight into C2 fundamentals at the same time (table 1).

Table 1. Six stages of modern command and control operations

Stages of Modern C2	*Waypoints*	*Navigating Megatrends*	*Discovering Fundamentals*	*Key C2 Result*
Stage 1	Napoleon (France)	The looming of industrial-style warfare	Expanding C2 art in the single leader, single battlefield model	Pushed C2 art
Stage 2	Moltke (Prussia)	Transportation and communication revolutions	A "system of expedients" over multiple battlefields	Envisioned systems warfare
Stage 3	Tukhachevskii (Russia)	New operational level of war and the front edge of the aviation age	"Expedients" refined into clear C2 sub-functions	Made C2 tangible
Stage 4	Dowding (United Kingdom)	Range and speed of the aviation era in full swing with increasing battlespace depths	Sophisticated SA feeds and teams of controllers performing C2 sub-functions form an adaptive system for defense	Systematized feeds and teams
Stage 5	Boyd (America)	Computer-based data management and the front edge of the information age	Transferring competition fundamentals into a system of "insight"	Incorporated competition fundamentals
Stage 6	Uncertain	Network-centric C2 operations and cyber warfare	Uncertain	Uncertain

Stage one characterizes C2 in most of human history. Stage two introduces systems warfare and the C2 concept of "expedients" (rapid adaptations). Stage three transfers expedients into detailed and intrinsic C2 sub-functions, which are enduring C2 fundamentals in the nature of war. Stage four introduces elaborate SA feeds into a defensive C2

system with sensors, radios, operators, and observers matched to the range and speed of the aviation era in full swing. Airborne early warning aircraft appear in this stage to extend and geographically transport the stage-four model. Furthermore, because the Air Force came into being during this stage (by means of the 1947 Key West agreement), our C2 core function was then known as "air defense." Stage five added a comprehensive and offensive edge to C2 functions via Boyd's description of competition fundamentals designed to create maximum insight and adaptability at a system level. During this stage, the Massachusetts Institute of Technology created the Semi-Automatic Ground Environment (SAGE) system for the Air Force, introducing the role of computers for processing large amounts of information in a C2 system.[21] Stage five also resulted in offensive-spirited systems like JSTARS (the very name containing the terms *target* and *attack*). Appropriately, the name of this service core function migrated from *air defense* to *command and control* in this stage.

In stage six, our work is characterized by network-centric warfare as a stronger shift into the information age acts upon our military C2 systems. The Department of Defense commissioned the Command and Control Research Program as a means of understanding the effects of the information age. On the one hand, program authors David Alberts and Richard Hayes follow Boyd in calling for a system of insight that empowers the "edge" of our systems. They aggressively concluded that "traditional approaches to Command and Control are not up to the challenge. Simply stated, they lack the agility required in the 21st century."[22] On the other hand, Col Jeffrey Vandenbussche, USAF, notes how militaries operate in a context of increased political sensitivity and thus may need to remain traditionally hierarchical at times to check-and-balance risk vertically.[23] Additionally, other futurists have predicted that stage-six C2 will be known as knowledge-centric warfare (KWAR) in which winning and losing boils down to pure strategies of competitive knowledge.[24]

To ground our perception of stage six, we would do well to revisit Clausewitz's distinction between the "character" and "nature" of war. Its *character* may change (e.g., information-age networks and cyber warfare), but its fundamental *nature* does not (e.g., C2 sub-functions and war being characterized by fog, friction, and chance). Both deserve our devoted study. No matter what we conclude about the changing character of C2 operations in stage six, it is equally important to recognize the unchanging C2 sub-functions and competition fundamentals woven into the very nature of war. The future of our C2 core function should feel like grasping the current megatrends without letting go of the C2 universals.

Unchanging and Tangible C2 Sub-functions

Tukhachevskii wrote extensively on C2 from 1924 to 1936 before he was executed as a result of a fabricated charge of treason in Stalin's "Great Purge" of 1937. His work remained inaccessible until 1987, when Richard Simpkin published an English translation. There are three key aspects of Tukhachevskii's C2 writings in stage three: (1) C2 planes extend a commander's influence over the chaotic and deepening battlespace, (2) using "functions" helps define C2 concretely, and (3) the similarity of Tukhachevskii's functions to ours demonstrates the unchanging nature of the C2 sub-functions in war.

First, Tukhachevskii began to leverage aircraft for C2. In the 1936 Russian Field Service Regulation, he wrote that "the complexity of the modern battle turns a particularly bright spotlight on the question of command and control" to include the use of planes.[25] His writings span levels (operational/tactical) and mediums of war (air/land/sea) with an emphasis on land war, based on his stage of history. Yet, without question, he viewed aircraft in a C2 role to

1. drive reconnaissance and surveillance that feed all other C2 functions,
2. deliver dynamic orders,

3. collect situation reports or battle damage assessments,
4. bridge and maintain line-of-sight communications in depth, and
5. help link combined-arms fighting ("airmechanization").[26]

Tukhachevskii also captured the often-neglected tactical level of C2, writing that "due to complexity, real control of the battle must necessarily imply control of the entire tactical process."[27]

Second, using "functions" to comprehend C2 constituted a major leap toward grasping its meaning. Complex concepts are often defined this way. For instance, macroeconomists use this approach to understand money. Specifically, if something serves as (1) a medium of exchange, (2) a store of value, and (3) a measure of wealth, then it is money. To a macroeconomist, it does not matter if this means Polynesian stones of varying sizes or commoditized Monopoly money. If something serves those three functions, we call it money. In the same way, if something fulfills these C2 functions, we call it C2 at the tactical level of war.

Third, Tukhachevskii's writings have strong parallels with our own tactical service doctrine (table 2). In 2009 the Air Force traced the same basic set of Tukhachevskii's tactical C2 functions in AFTTP 3-1, *TACS*. These correlations help demonstrate a universal quality of C2 work found in the nature of war.

Table 2. Tukhachevskii and modern tactical service doctrine

Tukhachevskii's Writings	*AFTTP 3-1, TACS: Tactical C2 Functions*
• thorough reconnaissance (p. 193) • adoption of a plan that matches the situation (p. 193) • organization of physical security of communications and resupply (pp. 193, 194) • systematic control over reconnaissance and surveillance (p. 207) • imminent threat-warning arrangements for physical security and air defense (p. 208)	Orient shooters
• orders that lay down the final missions with locations and times (p. 100) • concentration of forces on a single, clear-cut, and clearly stated aim (p. 150) • allocation of tasks to troops (p. 193)	Pair shooters
• responsiveness to changes in the situation (p. 193)	Solve problems
• dynamic need to lay down intermediate [fire support coordination measures] (p. 100); provisions for cooperation (p. 193); setup of "control arrangements" (p. 152) • issue of orders in good time (pp. 193, 208) • observation of the way orders are carried out at lower levels (p. 193) • collation and observation of friendly forces (p. 208) • organization of communications (p. 208) • provisions for all arms [fires] cooperation in each phase of the operation (p. 208) • policy on radio use (p. 208) • means of maintaining uninterrupted communications with mobile forces and rearwards (p. 208)	Bring order
• personal initiative (p. 193)	Speed decisions
• prompt passing of reliable information downwards and sideways and of situation reports upwards (p. 193)	Produce assessments

Source: For the page references, see Richard Simpkin, *Deep Battle: The Brainchild of Marshal Tukhachevskii*, trans. Richard Simpkin and John Erickson (London: Brassey's Defense Publishers, 1987).

These tactical C2 sub-functions also have numerous C2 tasks in our doctrine that *fulfill* each function. However, staying above the task level of detail, we can describe our current tactical sub-functions by using Boyd's OODA loop terminology.

- F1, orient shooters: increase shooter/sensor SA and threat warning by providing SA. Battle management and ISR fusion tasks in this function enhance the observe/orient steps of Boyd's OODA loop.
- F2, pair shooters: improve economy of force in dynamic situations. Use of SA orchestrated from sensors enhances the decide step of Boyd's OODA loop.
- F3, solve problems: apply resourcefulness for adaptive execution of the air tasking order. Countless problems resolved at the tactical level require critical thought to ensure the commander's intent and mission accomplishment. This function surrounds every step of the system-wide OODA loop. Problem solving brings harmony or dynamic order to operations.
- F4, bring order: employ routine force accountability and overwatch integrating sensors, fires, and friendly locations. This function surrounds every step of the system-wide OODA loop and brings static order to operations.
- F5, speed decisions: streamline and minimize processes fusing combat identification and applications of the rules of engagement. This function lies at the heart of the decide step in Boyd's OODA loop.
- F6, produce assessments: convert information into accurate estimates of situations in all directions—down to a joint terminal attack controller (JTAC) and up to the combined force air component commander (CFACC). This function pervades each step in Boyd's OODA loop.[28]

These functions manifest in current phenomena of our tactical C2 operations. Our C2 jets have massive radars for finding and early warning to *orient shooters*.[29] *Pairing shooters* produces economy of force, guided dynamically to the commander's intent (when the air plan meets reality); it is the reason that Air Force C2 players immerse in shooter/sensor formats, norms, and tactics, techniques, and procedures. *Solving problems* lies at the heart of C2. Continuous problem solving at a level above a four-ship (or two-ship these days) addresses Clausewitz's problem that war is characterized by fog, friction, and chance. Problem solving at the tactical level creates the resourcefulness needed to implement an air tasking order and align solutions to the commander's intent. *Bringing order* creates the minimum structure necessary to enable optimization and adaptation of air assets at the speed of air operations. *Speeding* (good) *decisions* represents the essence of the OODA loop transferred to an area-of-responsibility scale. The *producing assessments* function moves key conclusions 360 degrees down to the JTAC and up to the CFACC at the speed of air operations. This function allows the system to "think" beyond a single flight of aircraft or bombers in near-real time with accurate estimates of the situation.[30]

The historical continuity between our functions and Tukhachevskii's reveals an apparent permanence of these sub-functions. This C2 pattern should also guide our visions of how we perform them in future war. In real conflict of any scale, someone has to fulfill these poorly understood C2 functions embedded in the nature of war. The tactical C2 functions help define C2 in broader terms that most warriors can understand and perhaps value as an "advantage."

History Shows That Work Remains

At the same time, we cannot say that C2 is fully understood. For example, at the next level of war, we can observe other sub-functions, but they are not quite unified at this time. Tukhachevskii captured other functions that seem to apply to the operational level of war:[31]

- optimizing assets
- producing operational thought
- pairing cross-theater fires
- weighing strategic value of tactical actions
- providing theaterwide warning
- organizing scramble orders
- delegating authority to maximize independent action
- ensuring interoperability
- performing cross-nation coordination
- issuing dynamic orders
- controlling phases

A second source of operational functions comes from historian Martin van Creveld, another champion of the functional approach to C2 as reflected in the vast sweep of history depicted in his book *Command in War*. He articulated that an ideal C2 system has functions to gather, distinguish, distribute, estimate situations, develop objectives, analyze, adapt, decide, plan order, and monitor.[32] Yet, "Annex 3-30, Command and Control," sketches operational C2 functions as planning, directing, coordinating, controlling, tasking, executing, monitoring, and assessing air, space, and cyberspace operations.[33]

Among Tukhachevskii, van Creveld, and "Annex 3-30," one finds a general picture of functions at the operational level of war, but they are not quite in sync (table 3). With the addition of complexity, tactical and operational levels also share identical functions (like assessment)

while other functions are completely different (further complicating our efforts to grasp the art and science of C2). In stage six, we must work toward a comprehensive taxonomy of C2 functions to be more surgical about how we design C2 systems for any environment. Adding the C2 joint capability areas shows some, but not identical, similarities.

Table 3. Operational C2 functions in Tukhachevskii, van Creveld, Air Force doctrine, and C2 joint capability areas

Tukhachevskii	*Van Creveld*	*"Annex 3-30"*	*C2 Joint Capability Areas**
• Optimizing assets • Producing operational thought • Pairing cross-theater fires • Weighing strategic value of tactical actions • Providing theaterwide warning • Organizing scramble orders • Delegating authority to maximize independent action • Ensuring interoperability • Performing cross-nation coordination • Issuing dynamic orders • Controlling phases	• Gathering information • Distinguishing (filtering) • Distributing (displaying) • Estimating situations • Developing objectives • Adapting • Deciding • Planning • Ordering • Monitoring	• Planning • Directing • Coordinating • Controlling • Tasking • Executing • Monitoring • Assessing air, space, and cyberspace operations	• Planning • Organizing • Understanding • Deciding • Directing • Monitoring

*See "Joint Staff J6: Warfighting Mission Area (WMA) Architectures," accessed 7 June 2014, https://sadie.nmci.navy.mil/jafe/jid/JCAs.aspx.

C2 of Anything

Between stages four and five, large-scale C2 operations began to spread across multiple industries. The similarity of the sub-functions across industries is telling, perhaps pointing toward what we could call "universal C2" and continuing to underscore the criticality of C2. For example, NASA mission control is famously committed to the success of its astronauts who venture out into complex and potentially fatal missions. The activities in Houston during a space shuttle mission bear a remarkable physical similarity to those in our TACS—headsets, booms, radios, consoles, logs, and situation displays—hinting at some universality of C2 in any complex endeavor. In Houston, mission controllers orient astronauts, pair them to tasks necessitated by the mission, solve problems for them (famously for *Apollo 13*), bring order to a mission through norms such as a countdown, speed decision making at the pace of manned spaceflight, and continuously produce assessments of the mission (out to the astronauts and up to the president). As such, they are basically performing the same AFTTP 3-1 C2 functions for a completely different mission.

NASA photo

NASA mission control for space shuttle launch STS-128.

All complex operations in this era seem to stumble upon the need for high-functioning C2 systems. Carrier war rooms, nuclear reactor control rooms, the National Military Command Center, the Federal Emergency Management Agency, and command posts around the world all resemble each other in both function and form. The apparent universality of C2 offers more evidence for the need to have full-time, adaptive problem solvers directly connected to operations—individuals who will watch over and act upon any complex human endeavor. This universal phenomenon has even spawned the parallel academic discipline of operations management—a requirement in the complex systems of the industrial age.

Universal C2 is a growing subject of study across industries. In the 2007 essay *Development of a Generic Activities Model of Command and Control*, British authors examined a range of C2 operations: national power grids, railway networks, air traffic systems, emergency services, and the UK military (three different service examples). They sought "to provide a research tool that may be applied to any command and control domain."[34] While the authors focused only on communication tasks instead of coordination actions and critical thought, the result is clear similarities in the form of a taxonomy that slices across industries. The researchers found an aspect of universal C2.

Coming back to military operations, we see that universal C2 is also evidenced in the steady reemergence of ad hoc forms today wherever C2 voids exist. Air Combat Command (ACC) has various "C2 of ISR" initiatives that focus on the orientation, pairing, and problem solving associated with the employment of sensors as opposed to shooters. In another ad hoc form of C2, US Special Operations Command (SOCOM) has experienced busier air operations in "the funnel" over special operations forces (SOF) objectives in the 9/11 era. These busier air operations have demanded creation of new tactical air coordinator (airborne) (TAC[A]) players devoted to SOF missions. Regardless of the air player who takes on this new role, it performs exactly the same

TAC(A) tasks common to full-time problem solvers in a large close air support fight.

In both the ACC and SOCOM examples, why are there grassroots pushes for an ad hoc C2 arrangement? C2 voids were discovered. Why do they exist? The C2 sub-functions were not being fulfilled. We observe the need for tactical C2 in new forms wherever C2 voids exist in complex operations. This is just another way to observe the universal need for tactical C2 as any operation increases in complexity or precision. In these voids, we can observe how C2 sub-functions engender from the nature of war and how the functions simply take on new forms as required by the changing character and scope of war.[35]

Conclusion

The six-stage concept history shows an increasing need to think about C2 operations in terms of advantage. Both the changing *character* and the unchanging *nature* of war point to a general rise in the significance of C2 operations. Regarding the character of war, the bloom of industrial-age warfare led Napoleon to become a transitional figure pushing the art of C2. The front edge of an operational level in war forced Moltke to think about a "system of expedients." He saw so much advantage in a system of adaptations that he labeled this strategy itself. For Tukhachevskii, the operational level of war made a full arrival in his World War I experience, forcing him to think and shed "a particularly bright light" on the subject of C2 to include fundamental sub-functions that do not appear to change. The range and speed of the aviation era in full tilt forced Dowding to create a new air defense system with elaborate SA feeds. With this C2 system, he helped to save England. Finally, early forms of the information age surrounded Boyd as he envisioned a C2 system that produces pure competitive advantage in the forms of insight, initiative, adaptability, and harmony.

These same men came upon unchanging aspects of C2 in the nature of war itself—like the C2 sub-functions. Tukhachevskii was the first

modern warrior to write about sub-functions of a C2 system in stage three. This functional view allowed him to creatively fulfill these unchanging functions, including an early pitch for C2 aircraft. These sub-functions and concepts like OODA mark a quest to trace this invisible profession with the tangible. The quest itself parallels a general rise in the significance of C2 operations as its own subject and a form of advantage.

In stage five, C2 operations also proliferated across industries. One can find very similar sub-functions as another hint at the universal quality of C2 work. As history unfolds before us, the ad hoc emergence of new C2 arrangements pops up wherever C2 voids occur. These voids appear in many forms, but all derive from ignoring the sub-functions—offering another indication about their universal quality and importance.

As we move forward in stage six, C2 may remain an elusive service core function. We know its significance and often address it, but rarely with deep satisfaction.[36] C2 is perplexing for several reasons. When we say "C2," we bound several subjects at once: the people who do C2, doctrine, competencies, skills, platforms, technologies, systems, authorities, tasks, sub-functions, and effects. Addressing any one of these "boxes" alone can lead to only partial understanding and dissatisfaction.[37] Other compounding factors add to the perplexity of C2: the range/speed of air operations, C2 across varying levels of war, joint differences in doctrine and capabilities, C2 as a junction of art and science, Colonel Boyd's three science problems (uncertainty, incompleteness, and entropy of SA), continuous joint interoperability dilemmas, unrehearsed C2 in international coalitions (e.g., Libya), a new era of cyber war, performance of C2 across the full range of the Department of Defense's operations with limited training, and a host of unarticulated social factors that create friction points in C2 operations.

In the end, C2 theory has come a long way since the use of carrier pigeons in Verdun less than 100 years ago. In some ways, we are only just beginning to grasp the enormity of what has been achieved and

what is yet to be achieved. Our C2 operations are a critical advantage over adversaries who must perform the same hard work in complex operations. Although such operations are by no means new, grasping the changing and unchanging aspects of C2 like our theorists will foster our C2 mastery into the future. The full power of our people, ideas, platforms, and weapons would remain untapped without a high-functioning C2 system that is strong in the fundamentals. ✪

Notes

1. Department of the Air Force, *Global Vigilance, Global Reach, Global Power for America* (Washington, DC: Department of the Air Force, 2013), 4–9, http://www.af.mil/Portals/1/images/airpower/GV_GR_GP_300DPI.pdf.

2. In response to the idea that technology won Operation Desert Storm, Secretary of Defense Les Aspin addressed the meaninglessness of technology without C2 when he stated that "we know how to orchestrate [technology] in a way that makes the sum bigger than all the parts." Benjamin S. Lambeth, *The Transformation of American Air Power*, Cornell Series on Security Affairs (Ithaca, NY: Cornell University Press, 2000), 152.

3. Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1984), 88, 593. Clausewitz discusses how commanders should judge the unique "kind of war" (i.e., the character of war) they face without turning war into something "contrary to its nature" (p. 88). Later he notes that "every age had its own kind of war" and that war retains "a universal element with which every theorist ought above all to be concerned" (i.e., the nature of war) (p. 593).

4. Quoted in Harold S. Orenstein, trans., *The Evolution of Soviet Operational Art, 1927–1991: The Documentary Basis*, vol 1, Cass Series on the Soviet Study of War 7 (London: Frank Cass, 1995), 59.

5. In *Evolution of Soviet Operational Art*, Isserson defines an operation "as a chain of combat efforts, continuous along a front, uniform with respect to depth, and united by an overall plan for defeating the enemy or opposing him. The primary mission of operational art as the study of conducting an operation was the unification of separate combat efforts, not directly connected tactically, in space along a front, in time and in depth to achieve an overall assigned aim, that is, *bringing an entire chain of combat events into an active system*, coordinated along a front and in the depth, which purposefully and successively leads to the defeat of an enemy" (emphasis added) (p. 66). It is commonly believed that the operational level of war did not fully emerge until World War I. Here I simply imply that Moltke was observing the front edge of that evolution and that it began to shape his thinking.

6. Helmuth von Moltke, *Moltke on the Art of War: Selected Writings*, ed. Daniel J. Hughes, trans. Daniel J. Hughes and Harry Bell (Novato, CA: Presidio Press, 1993), 12. Before the Prussians, Pierre de Bourcet of the Ancient Regime in France pioneered an early version of this concept toward the end of the eighteenth century in his treatise *Principles of Mountain*

Warfare and gave rise to the "divisional system" in the French armies of the revolution and Napoleon. The French used flag semaphore to communicate; Moltke used the telegraph.

7. Moltke, *Moltke on the Art of War*, 47.

8. Richard Simpkin, *Deep Battle: The Brainchild of Marshal Tukhachevskii*, trans. Richard Simpkin and John Erickson (London: Brassey's Defense Publishers, 1987). Tukhachevskii referred to these professionals as "special groups of forces . . . formed for purposes of operational direction" (p. 100).

9. Martin van Creveld, *Command in War* (Cambridge, MA: Harvard University Press, 1985), 4.

10. Alistair Horne, *The Price of Glory: Verdun 1916*, unabridged ed., Penguin History (London: Penguin, 1993), 258.

11. See the next section for details. In short, five of these six functions are characterized by 1924 (Simpkin, *Deep Battle*, 97–101). By 1937 he adds "adoption of plans" fed by reconnaissance, which we term "orient shooters" (ibid., 193). One finds elemental functions of C2 throughout his writings, including this definition of C2: "The essence of command and control lies in thorough reconnaissance; adoption of a plan which matches the situation; allocation of tasks to troops; provisions for co-operation; the issue of orders in good time; observation of the way orders are carried out at lower levels; prompt passing of reliable information downwards and sideways and of situation reports upwards; responsiveness to changes in the situation; showing personal initiative; and organization of physical security, of all means of communication and of resupply" (ibid.).

12. Ibid., 202.

13. Ibid., 142–43. Tukhachevskii notes that the radio would transform from a means of communication to a "direct combat resource" for controlling aircraft and the like (ibid., 142–43).

14. Stephen Bungay, *The Most Dangerous Enemy: An Illustrated History of the Battle of Britain* (Minneapolis: Zenith Press, 2010), 45.

15. Ibid.

16. Edwin Leigh Armistead, *AWACS and Hawkeyes: The Complete History of Airborne Early Warning Aircraft* (St. Paul, MN: MBI Publishing Co., 2002), 4.

17. Grant Tedrick Hammond, *The Mind of War: John Boyd and American Security* (Washington, DC: Smithsonian Institution Press, 2001), 2.

18. Frans P. B. Osinga, *Science, Strategy and War: The Strategic Theory of John Boyd*, Strategy and History (London: Routledge, 2007), 190.

19. The US Army is coming closer to Boyd's concept of maximum adaptive initiative with the evolving concept of "mission command," defined as "the exercise of authority and direction by the commander using mission orders to enable disciplined initiative within the commander's intent to empower agile and adaptive leaders [at subordinate levels] in the conduct of unified land operations." Army Doctrine Publication (ADP) 6-0, *Mission Command*, May 2012, 1, http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/adp6_0_new.pdf. This is a modern reformulation of *Auftragstaktik* in the German army as mission-type orders debuted at the battle of Verdun and were applied extensively at the battles of Riga and Caporetto. By 1918 the entire German army had been trained in this philosophy as part of the infiltration tactics that guided the Ludendorff offensives in the West. As adapted from ADP 6-0 (FM 6-0), the mission command philosophy "matches the nature of complex military operations. During complex operations, unexpected opportunities and threats rapidly present them-

selves. Operations require responsibility and decision-making at the point of action. Through C2, commanders initiate and integrate all military functions and operations toward a common goal—mission accomplishment" (p. 1). The Air Force is cautiously flirting with this concept—once again—in the form of "distributed control." See Lt Col Alan Docauer, "Peeling the Onion: Why Centralized Control/Decentralized Execution Works," *Air and Space Power Journal* 28, no. 2 (March–April 2014): 24–44, http://www.airpower.maxwell.af.mil/digital/PDF/Issues/2014/ASPJ-Mar-Apr-2014.pdf.

20. The loops we commonly think of within the TACS now are find, fix, track, target, engage, and assess (F2T2EA) in Joint Publication 3-60, *Joint Targeting*, 31 January 2013, or "find, fix, finish" in Special Operations Command. Yet, the tactical C2 functions in AFTTP 3-1 use both OODA and F2T2EA to explain the substance of each tactical C2 sub-function.

21. Thomas Parke Hughes, *Rescuing Prometheus*, 1st ed. (New York: Pantheon Books, 1998), 16. SAGE is a stage four/five "boundary" system since it has the same purpose as the Dowding model but uses computers in advanced ways—a characteristic of the emerging stage five or Boyd model. By using computers for C2 in basically the same way we use them today, SAGE is placed here in the beginning of stage five.

22. David S. Alberts and Richard E. Hayes, *Understanding Command and Control*, Future of Command and Control (Washington, DC: CCRP Publications, 2006), 2.

23. Jeffrey Vandenbussche, "Centering the Ball: Command and Control in Joint Warfare" (master's thesis, School of Advanced Air and Space Studies, Air University, 2007), 67, 68.

24. Mark Ashley, "KWAR: Cyber and Epistemological Warfare—Winning the Knowledge War by Rethinking Command and Control," *Air and Space Power Journal* 26, no.4 (July–August 2012): 58, http://www.airpower.au.af.mil/digital/pdf/issues/2012/ASPJ-Jul-Aug-2012.pdf.

25. Simpkin, *Deep Battle*, 165.

26. Ibid., 193, 202, 136–37.

27. Ibid., 148.

28. This function lost its parallel wording in the 2012 version of AFTTP 3-1, *TACS*. However, the simple construction of "produce assessments" in 2009 is in common use today, including a 2013 Joint Requirements Oversight Council memo addressing the meaning of manned C2 platforms.

29. Recent experiences in the JSTARS have led to broadening the C2 customer base beyond "shooters." For example, when we orient a ship toward a nonkinetic interdiction at sea, we have supported a "finisher" rather than a shooter per se. Similarly, in operations with several ISR assets all cooperating for one mission, our wide-area radar and communication capabilities have lent to organizing "sensors." Whether we are working with shooters, sensors, or finishers, we have observed that the C2 sub-functions remain the same—like the nature of war.

30. C2 is completely scalable across levels of operations. Producing assessments happens at all levels of war and may be best captured by the relationship of METT-TC, OODA, and "shoot-move-communicate" cycles. The Army acronym METT-TC stands for subjects that require constant assessment, such as mission, enemy, terrain and weather, troops and support available, time available, and civilian considerations. METT-TC represents assessment subjects for the application of Boyd's OODA information cycle, which then, in turn, feeds the entire "shoot-move-communicate" action cycle down to a single warrior (the "A" in OODA). Here in AFTTP 3-1, *TACS*, the "produce assessments" function is designed to capture what happens in aggregate at a tactical level of air operations within the battlespace

where the SA of the actual fight is highest (line-of-sight sounds, the tone of human voices, sights, intuition, local signals intelligence, cumulative line-of-sight radio traffic, local human intelligence from sensitive site exploitation, real-time radar instead of data-link symbols, the feel of weather and topography, etc.). Aggregate examples of tactical assessments would include, "Suspect convoy, 20 vehicles, heading S on Highway 1 with civilian shields" or "Wolf 52 has not checked back in with Wolf 51; last known location x, y, z. Searching." Confusion enters when we assume that the intelligence process-evaluate-disseminate cycle in its various phases is conflated with assessment in the action cycle represented by METT-TC, OODA, and shoot-move-communicate (and vice versa). Assessments in the intelligence and action cycles should marry, as many have pointed out, but the work of each represents different competencies and skills that require constant integration. A Green Beret in an Afghan village, an F-15E flight lead performing close air support, and an intelligence officer doing Phase 2 multi-intelligence fusion all require different competencies and skills to assess in their situations even though all are "assessing."

31. Simpkin, *Deep Battle*, 98–99, 108, 149, 150–52, 168, 208, 250, 256.

32. Van Creveld, *Command in War*, 6–7.

33. Curtis E. LeMay Center for Doctrine Development and Education, "Annex 3-30, Command and Control," 1 June 2007, 75–76, 81–84, https://doctrine.af.mil/download.jsp?filename=3-30-Annex-COMMAND-CONTROL.pdf.

34. N. A. Stanton et al. *Development of a Generic Activities Model of Command and Control* (Uxbridge, Middlesex: Defence Technology Centre for Human Factors Integration, August 2007), 1, http://dspace.brunel.ac.uk/bitstream/2438/1634/1/Development_of_a_generic_activitied_model_of_command_and_control_Stanton_et_al(postprint).pdf.

35. One can see several contemporary examples of C2 voids in Department of Defense operations. First, the joint air-to-ground integration cell (JAGIC) is a close-air-support-centered initiative to address gaps in the TACS in the old air support operations center's sphere of influence. Second, the dynamic air response coordination cell (DARCC) is an ad hoc C2 node that has been forming for approximately two years to deal with an Air Force–Navy seam for reroling aircraft to new missions (see also Dalman, Kopp, and Redman in this issue). Third, JSTARS was tasked to Libya as an ISR asset but filled numerous C2 voids by chance rather than design (see also Matlock, Gaustad, Scott, and Bales in this issue). As mentioned above, Air Force Special Operations Command and C2 of ISR projects are driven largely by C2-function-based voids. In these five contemporary examples, we see C2 voids appear wherever the C2 sub-functions are not fulfilled.

36. One can observe the perplexity in the numerous initiatives that still address fundamental issues about the meaning of C2. Examples include the National Research Council research to "Realize the Potential of C41" (1996–99); the Command and Control Research Program paper "Understanding C2" (2006); the US Air Force Warfare Center's TACS Tiger Team (2006–8) led by Col Keith Bretscher; the ACC Tiger Team led by Col Francis Xavier; the "C2 Framework" brief (2009) by Col Gary Crowder, USAF, retired; the JAGIC initiative by Col Gator Neal, USAF, retired, and Col El Cid Neuenswander; the Headquarters Air Force–commissioned "ABM Crew Study" (2010); Lt Gen William Rew's AF/A9 brief on C2 (ca. 2009 and beyond); AFTTP 3-1, *TACS*, articulation of C2 tasks, functions, and authorities (2006–9); the Service Core Function Master Plan for C2 (2009); the C2 white paper by Col Tank McKenzie (former 505 ACW/CC) (2010); ACC's "TACS Functional Concept" (2008); the US Air Force Warfare Center's "Re-Blue" briefs in 2009 on defining C2; current ACC initiatives to

define "distributed C2"; and Lt Col Beep Zall's current C2 definition project at the USAF Weapons School (2014), to name a few.

37. The acronym DOTMLPF (doctrine, organization, training, materiel, leadership and education, personnel, and facilities) provides a cross-reference for the problem of partial solutions to building a program of any kind. Dr. Craig Admundson of Cask LLC defined each term the following way in a briefing: doctrine—the way we fight (e.g., emphasizing maneuver warfare combined air-ground campaigns); organization—how we organize to fight (divisions, air wings, Marine air-ground task forces, etc.); training—how we prepare to fight tactically (basic training to advanced individual training, various types of unit training, joint exercises, etc); materiel—all the "stuff" necessary to equip our forces (weapons, spares, etc.) so they can operate effectively; leadership and education—how we prepare our leaders to lead the fight from squad leader to four-star general/admiral (professional development); personnel—availability of qualified people for peacetime, wartime, and various contingency operations; and facilities—real property (installations and industrial facilities, such as government-owned ammunition production facilities that support our forces). New thinking or changes in any one of these areas could be incomplete if taken out of context with the whole institutionalization process represented by DOTMLPF.

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