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"C2 and Agility"

The New Chemistry of C2

Topic 7: C2 Approaches and Organization

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ABSTRACT: Drs. David Alberts and Richard Hayes' book Understanding Command and Control states that the purpose of C2 "has remained unchanged since the earliest military forces engaged." But implementing C2 effectively now in the era of transformation can break traditional notions by envisioning a chemical model which incorporates emerging and disruptive technologies arriving at exponentially faster rates. Like carbon chains in organic chemistry, the military C2 organization has grown by adding communications (C3), computers (C4), and other elements such as I (intelligence), S (surveillance), and R (reconnaissance). This primitive C4ISR model anticipates future concatenations of Complexity, Chaos, and Convergence. It further requires new challenges to the historic C2 model in which the Command and Control elements are inextricably bonded together. Breaking the traditional C2 bond and rearranging the growing chain of elements produces powerful new constructs not unlike chemical isomers which could more effectively target each stage of the spectrum of conflict. Isomers represent organizational morphings promoting agility across the spectrum where even the speed of humans can potentially hinder combat effectiveness. An adaptation to the traditional OODA loop is suggested in this paper.

Introduction

A necessary change in the military transition to the next generation of warfare is the maturing of "command and control" processes and semantics for leading and configuring the organization to meet emerging threats. In the book Understanding Command and Control, Drs. Alberts and Hayes state that the purpose of C2 "has remained unchanged since the earliest military forces engaged."[1] In a journal article, Dr. Alberts writes that agility, focus, and convergence might be the semantics that replace the linguistics of the term Command and Control.[2] He suggests that Command and Control are terms that no longer fit the transformation in warfare paradigm for the 21st century. He calls for new approaches to thinking about C2 by removing the "restrictive legacy of language and connotation" and by so doing he proposes replacing C2 with the terms Focus & Convergence, where "agility is the critical capability that organizations need to meet the challenges of complexity and uncertainty." This is particularly true when it is likely that future conflicts will necessitate coalitions which do not necessarily conform to a common semantic meaning of C2 terminology.

Indeed, semantics do constrain one's ability to think about a problem and its resolution. Nobel Prize laureate Bertrand Russell said, "Language serves not only to express thought but to make possible thoughts which could not exist without it."[3] With over 6000 languages and dialects in the world today, there are numerous words which have no direct correlation in another language and yet they uniquely describe an attribute in a specific culture remarkably well. Examples are omitted here, but differences in semantic interpretations of words often present misunderstanding between cultures, especially when coalition forces try to align themselves in a complex unity of effort. The substitution of terms Focus & Convergence for Command and Control by Alberts is an attempt to state the nature of emerging military requirements and harmonize understanding among coalition partners. As another alternative to C2, we can also turn to a common language between cultures that is universally agreed upon – the language of science – because the laws of science, at least for a given time, are universal and unambiguous.[4] Using the language of science, and in particular chemistry, to portray organizations which must be focused, convergent, and agile across a wide spectrum of applications may in fact allow coalition fighting forces to envision Russell's "thoughts which could not exist without it." So we turn to the language of chemistry in this paper to conjure up thoughts of fighting forces which can adjust, self-synchronize, morph, and apply themselves with agility to the full spectrum of conflict which is their new domain in 21st century conflict. This represents a paradigm shift from the art of war to a science of warfare as this paper will suggest.

Chemistry as a Methodological Model

The idea for using the language of chemistry as a model for understating organizational growth and adaptability is rooted in the legacy of the language of Command and Control (C2) itself. The C2 language symbology spawned the notion of the chemical model here. The letter "C" has been chained together and replicated over time in military semantics to form new terms as new technologies have been added to the historic term C2. Thus, as modern communications became available and instrumental for effective C2, the term Command, Control and Communications (C3) came into vogue in the 1970's. It is useful to recall a quote from General of the Army Omar Bradley, "although Congress can make a general, it takes communications to make him a commander."[5] And then another remarkable capability was introduced to the commander's tool kit, the computer (another "C" word), and this C was concatenated to C3 to form the notion of Command, Control, Communications, and Computers (C4). Add to this string the attributes of intelligence, surveillance, and reconnaissance and we semantically invent C4ISR to connote the "modern" organization with the latest capabilities. It is likely that to describe functionality needed for future endeavors, more terms may be added to C4ISR such as Complexity, Convergence, Chaos Theory, and Center of Gravity, and so forth. Thus we can envision organizations which are referred to as C5, C6, C7, C8, etc. as additional functionality is acquired by the organization.

From this semantic string of C terms, largely constrained by the English language and imposed on foreign language users, we can allow ourselves to make the leap into the language of chemistry for our new model, since we can readily observe that the letter C in chemistry is the symbol for Carbon which is arguably the most versatile and agile element on earth. Because of its ability to bond with near limitless other carbon atoms and many other elements (remember C4ISR), we can use the symbolic language of chemistry as an analogy to represent the notion of growing and adaptable human organizations which originated with C2. In this sense, the new chemistry of C2 affords a paradigm shift in the way we can visualize how military organizations must transform, not statically, but dynamically, as the conditions across the spectrum of conflict will require.

This paper explores the organic chemistry metaphor as applied to C2 for complex endeavors. We see similarities between the form and function of carbon-based molecules and the form and function of modern command and control. Carbon is the base element for organic chemistry. Although inorganic chemistry provides a multitude of useful and essential products, only organic chemistry can support life, living organizations, and other dynamic structures, both natural and synthesized. These organic compositions can be amazingly complex, just like man-made human organizations, which provide properties and attributes tailored to meet the environments for which they are designed. Carbon chains are therefore limitless and can model growing organizations. As human organizations grow, they also become more complex, not only by design but also in the manner by which they must be controlled, if they can be controlled at all. Indeed, as Alberts points out in discussions about "edge organizations," there may not be a commander-centric way of controlling the organization at all.[6] This idea can be contrary and disruptive to the military mindset and culture.

So as growth breeds complexity (for example, a modern city), human organizations must also try to adapt to the new complexities. These adaptations require agility to meet the new demands. If the organization cannot adapt fast enough, then the organization is ineffective, fails, or dies as a living organism would if it failed to adapt to a new environment. Adaptation does not necessarily require the addition of new elements, but can sometimes simply reorganize existing elements to make the adaptation possible. Human organizations do this as well. They often transform a hierarchical organization into a matrix organization for example, spreading existing talents across multiple problem domains to meet new demands or conform to a new environment.

In organic chemistry, compounds known as "isomers" are the rearrangement of the same elements to have different properties to meet different needs. Isomers have unique properties even though the composition and weight of the chemical compound have not changed. The chemicals compounds methane (CH_4 having only one C), ethane (C_2H_4, C-C), and propane (C_3H_8, C-C-C) are simple structures where carbon atoms and attached hydrogen atoms share a covalent bond (as denoted by the "-" symbol above) in only one way possible, and therefore, are not amenable to the creation of isomers. For example, there is no other way of rearranging the carbon chain of propane shown in Figure 1 below.

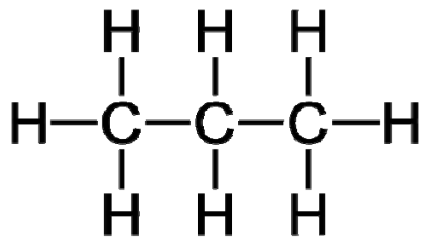


Figure 1. Chemical bonding arrangement in propane

We can think of small, human organizations which similarly are not disposed to or require rearrangement. But as organizations become more complex, they take on the ability to transform themselves in new ways because complexity allows for new constructs in the way chemical isomers can rearrange how carbon atoms can form new structures, beginning with two possibilities for butane (C_4H_{10}) in Figure 2.

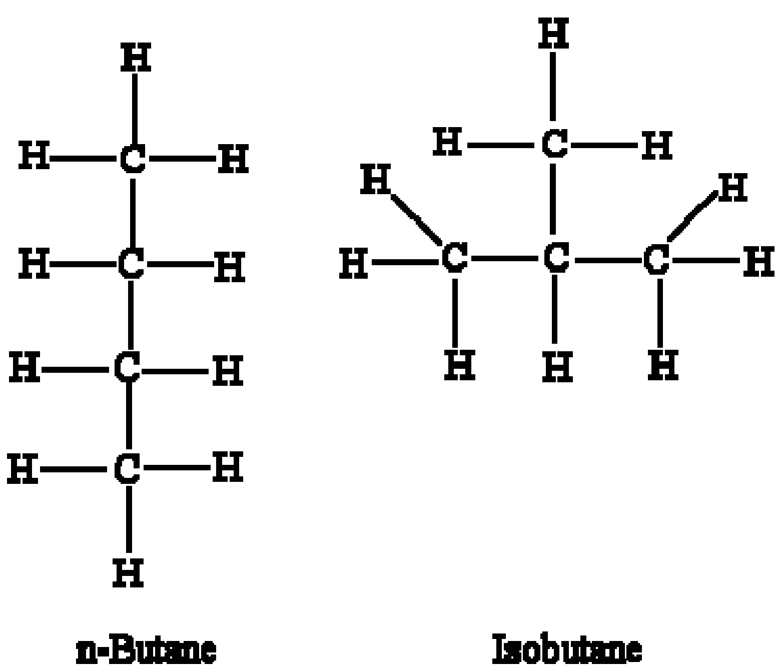


Figure 2. Butane isomers n-butane (left), isobutene (right)

Still, as technology, information, and networking infuse ever increasing complexity into human organizations, we can begin to imagine constructing more complex human organizations (referred to as C5, C6, etc.) with added powerful properties to adapt to new problem sets that must be solved. Simple organizations (referred to as C2 and C3) will not suffice and have already been discarded with the earlier paradigms of 20th century warfare which gave way to C4ISR network enabled organizations in the earliest conflicts of this century. Human organizations on the order of C5 could be vastly more complex yet with different strengths, abilities, and targeted applications. We can refer to our chemistry metaphor to portray how a C5 human organization can rearrange itself to make best use of its means through such rearrangement to produce specific properties (we'll refer to pentane's boiling and melting points later) for different applications as shown in Figure 3.

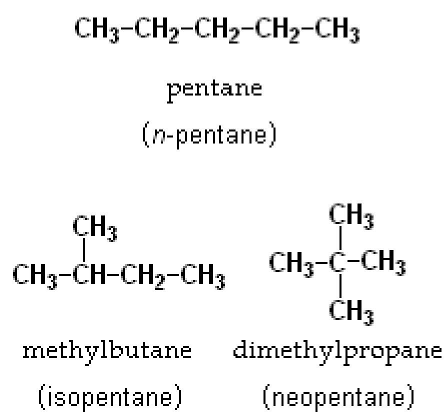


Figure 3. Pentane isomers: pentane, isopentane, neopentane

The limit of our portrayal of ever more complex organizations will end here with hexane (C6). It is sufficiently complex, varied, and geometrically interesting to make the leap to a later analogy requiring a six-sided surface. But first consider hexane and two of its isomers, 2-methylpentane: $CH_3CH(CH_3)CH_2CH_2CH_3$ and 2,3-dimethylbutane: $CH_3CH(CH_3)CH(CH_3)CH_3$. They are presented here not as a distraction, to be clever, or even to teach, but rather to explore the potential to reorganize from the same components. We see that 2-methylpentane (Figure 4) is a five carbon chain with one methyl (CH_3) branch

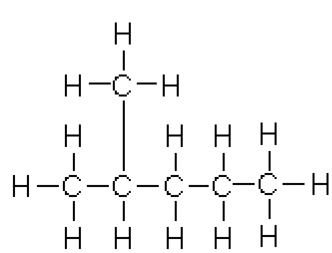


Figure 4. Hexane isomer 2-methylpentane

and 2,3-dymethylbutane (Figure 5) is a four carbon chain with two methyl branches

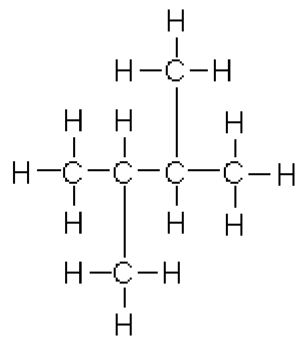


Figure 5. Hexane isomer 2,3-dimethylbutane

The reader can satisfy himself with counting the number of atoms in both of the above cases to be sure that we have only rearranged the elements of carbon and hydrogen and not added or subtracted. For sure, the composition and weight of the chemical compound have not changed. But the different arrangements of the elements of the same compound have given each isomer different properties to meet a specific requirement. For example, 2-methylpentane has a boiling point of 60°C and a melting point of -153°C, whereas for 2,3-dimethylbutane the values are 58°C and -128°C respectively. If the compound was an organization of a fixed set and number of components, the capability to rearrange its components would represent the measure of adaptability that an organization had to meet a different set of demands or exist in a different environment with different properties. On the other hand, the speed at which the organization could rearrange itself would be a measure of its agility. We define agility here as the measure of how quickly the human organization can adapt to its new environment.

C2 Agility for the Exponential Acceleration of Technology

The increasing rate of technological change is challenging our ability to lead organizations effectively. Change was not always as rapid as it is today. In the past, change would plot a linear curve. Now we not only expect change, but we anticipate it and even demand it in many ways. Today, the rate of change is non-linear or exponential. In the past, processes and structures lasted for decades. Change brought evolutionary surprise such as when vacuum tubes were replaced by transistors. Such cycles of change came slowly; maybe every half-century there would be such a paradigm shift. Now these cycle times are accelerating. Since the invention of the microprocessor, technology has become faster, smaller, and ubiquitous. Changes are abrupt. It is driven by Moore's Law, a consistent observation that the number of transistors on a chip doubles every 18 months on average. The "rupture" to "saturation" cycle of technology is shown below in the classic S-curve.

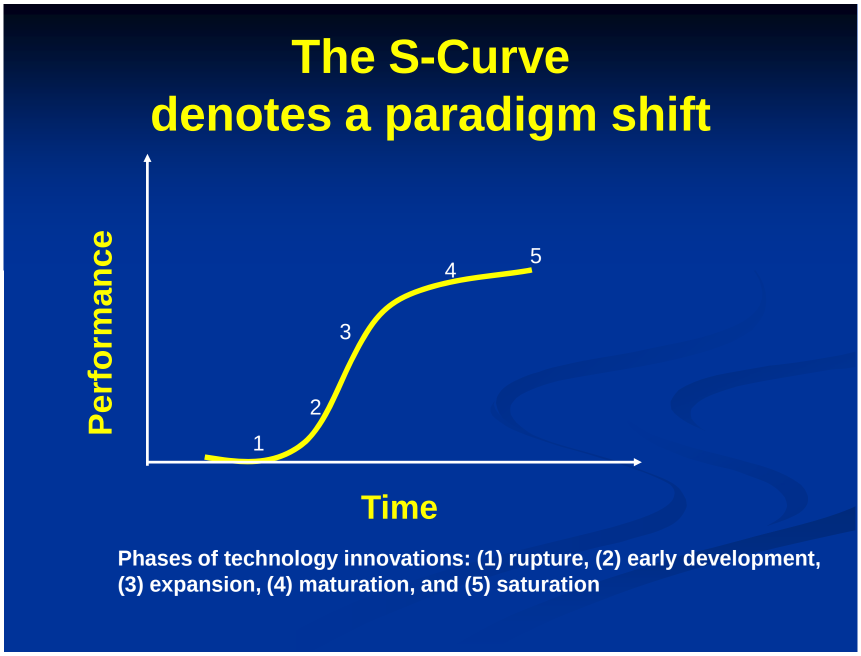


Figure 6. The S-curve phases of technology innovation

Older S-curves are supplanted by the emergence of a new technology in accordance with the rate of change currently driven by Moore's Law. Sometimes the new technology is termed a "disruptive technology" because it radically changes the way society reacts.[7] This is the case of information technology, the Internet, and the World Wide Web. Out of necessity for survival, organizations had to transform to an information-based culture or become defunct. In this age of Moore's Law rates of change, organizations must be agile. In the words of former General Electric CEO Jack Welch, "An organization's ability to learn, and translate that learning into action rapidly, is the ultimate competitive advantage."[8] Effective military organizations are no exception. In fact to be victorious, the ability of military organizations to act rapidly (faster than then the enemy) is essential. Logically, the more complex an organization is the more difficult it is to create change. The authors suggest that a larger organization presents more possibilities to reorganize into new structures to help achieve a competitive advantage. We noted earlier that there are no isomers, no opportunities to rearrange the simple structures of C-C and C-C-C carbon chains. We also suggest that when a human organization adapts faster than its competition it becomes a more agile organization than its competition. For military organizations, inertia, long procurement cycle times, and the unwillingness to let go of old paradigms can stand in the way of mission effectiveness across the full spectrum of conflict where old command and control methods may work in some scenarios, but are archaic in others.

Failure to insert new paradigms in a timely fashion leads to a vulnerability gap, a gap in which the enemy can take advantage of new technologies and methods faster than friendly forces can insert them into its own force. This is exemplified when the enemy quickly makes use of off-the-shelf technology while allied forces face elongated procurement cycles as indicated in Figure 7.

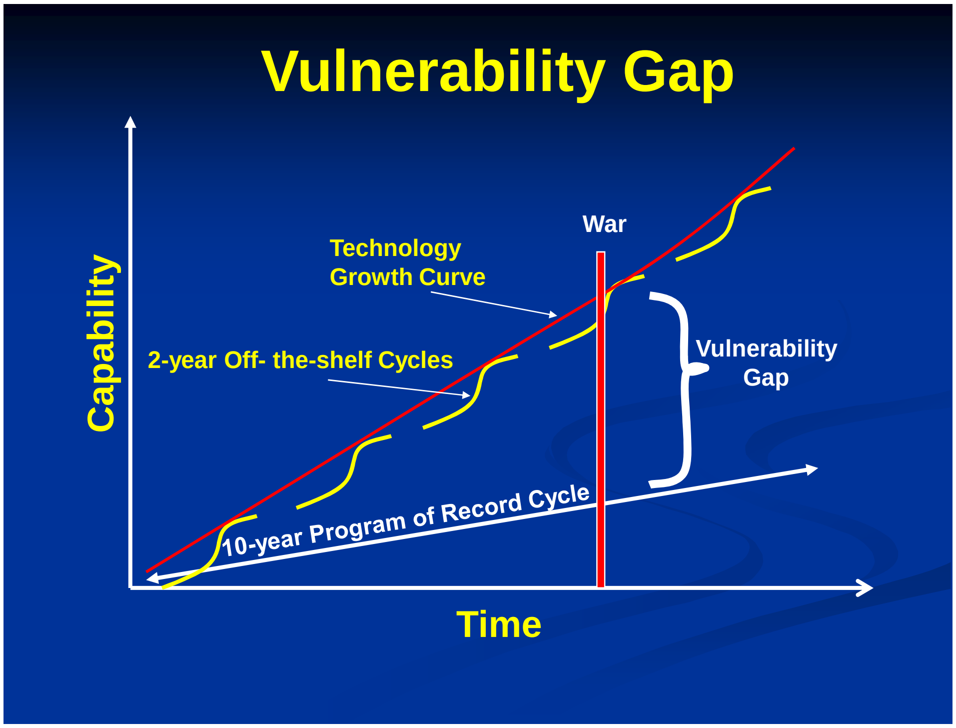


Figure 7. Off-the-shelf capability vs. 10-year programs of record

American computer scientist Alan Kay said it well - “The best way to predict the future is to invent it.”[9] The agile organization must not only know how to reorganize itself in the present to confront current adversaries, but it must also have a vision of how the future will look and to invent itself for that future. Our common experience reveals that this is not always easy. We scarcely buy a new personal technology for ourselves today and then we soon find out that it is being replaced by a better model, or worse, a new method altogether. We observe this when we track the evolution of music devices from records, cassettes, CDs, and MP3 players. How do we choose in advance of their invention? When do we make our investment in one or wait for the next? And yet it is intuitively obvious to most observers that the future will not be the same as today. Further, the future will come faster from the present than the present came from the past, or put another way, growth is accelerating exponentially. Because of exponential growth, the amount of progress made in the last twenty-years will be experienced in the next five to seven years. How do we prepare for the battlefield after next and how do we expect to counter and exploit the enemy after next? We represent the “after next” in Figure 8 where the contribution of S-curve paradigm shifts plots a curve of exponential acceleration.

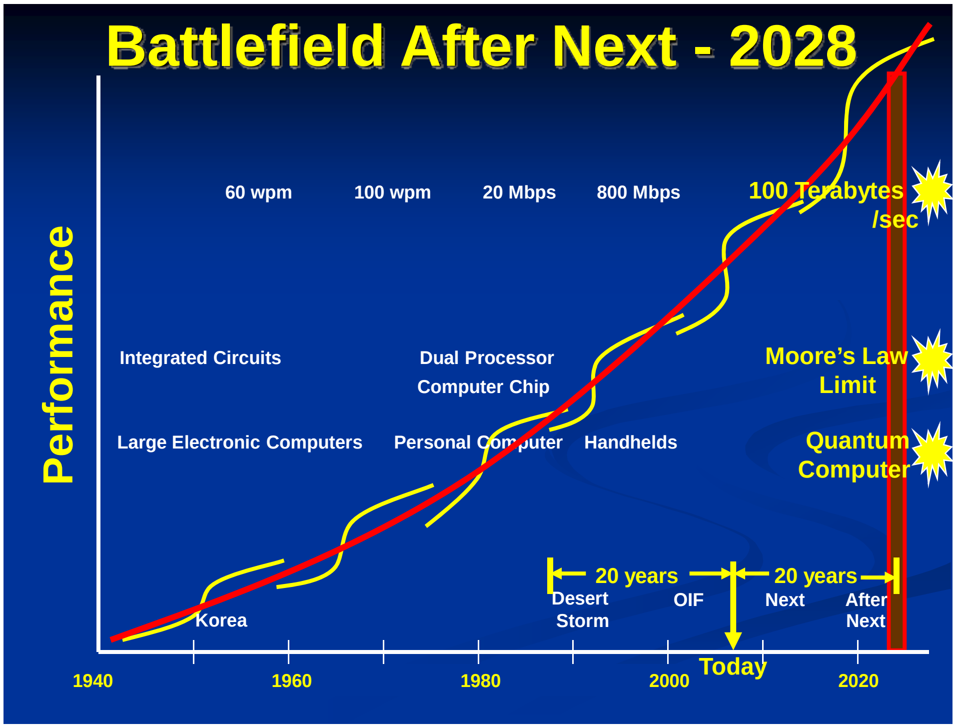


Figure 8. Future battlefield technologies arrive faster than in the past

Predicting the future battlefield of 2028, for example, is sometimes left to science fiction. When we conduct real wargames with future scenarios, we usually constrain ourselves with the weapons and technologies of the present. Similarly, we apply current command and control constructs of the present which are still too rooted in the past to effectively utilize the robustness, complexity, and adaptability of a truly learning organization. The key again lies in agility, the ability to quickly adapt a current organization into a new form; an isomeric organization capable of rearranging its constituent parts to confront the challenge of a yet unknown adversary.

Shrinking the OODA Loop

Much has been said of Colonel John Boyd's OODA loop. The Observe, Orient, Decide, and Act (OODA) cycle has withstood fifty years of scrutiny and application. It professes that if this cycle (embedded in Figure 9) is faster than the adversary's decision-response cycle, then the faster cycle will prevail. This tenet seems plausible, and in fact, has been tested in a number of ways. Clearly in tank-on-tank warfare, the faster tank team wins. Similarly, shortening the sensor to shooter cycle time gives less time for the adversary to hit and run. A good example of this is the shrinking of the OODA loop targeting cycle in Kosovo (1999) from six hours to targeting in Iraq (2003) to ten minutes.[10] This 97% reduction in time-on-target capability is due largely to global communications and unmanned aerial vehicles as depicted in Figure 9.

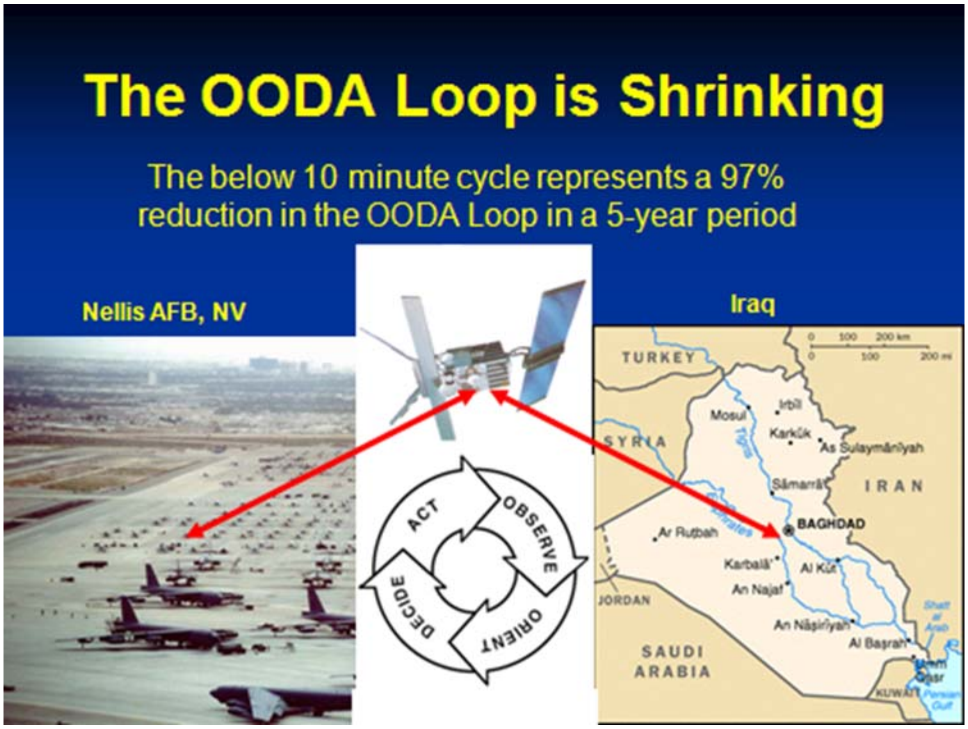


Figure 9. Real-time targeting cycle contracted 97% in five years.

This seems to be a natural outgrowth from technological advances over a five year span of time, but in many ways this OODA loop cycle is transformational, adaptive, and agile. Reductions from 6-hours processing targets in Kosovo in theater to 10 minutes time from Nellis AFB to Baghdad also presupposes relinquishing some human-in-the-loop activities between the two scenarios. Some functions became rote, some decisions were now *a priori*, and some processes no longer needed humans at all. This is transformational C2. This is agile C2 for a specified domain, in a specific timeframe. To delegate some command authority and to forgo some human control processes is in fact a movement towards decentralization. Indeed, the initial resistance of the U.S. Air Force to use unmanned aerial vehicles instead of fighter pilots is a study of a transformational process.[11] Decentralization is a shift in organizational structure which enhances agility through the attributes of robustness, resilience, responsiveness, flexibility, innovation, and adaptation.[12]

Shrinking the OODA loop with new technology is only truly enabled by moving from a classic C2 organization to an edge organization. Why? Because countering the adversarial capabilities will require it, with reference again to the preceding diagrams for the Vulnerability Gap and the Battlefield After Next technology capabilities. The current speed of C2 in the OODA Loop, represented by its Orient and Decide functions, may be too slow in the future for some engagement scenarios across the spectrum of conflict. Human perception-reaction biology is measured in about 300 milliseconds. Add to that the human orientation factors such as culture, experience, and genetic heritage which weigh in on the decision process, and then we have about a 500 millisecond human delay in the sensor to shooter cycle (Figure 10).

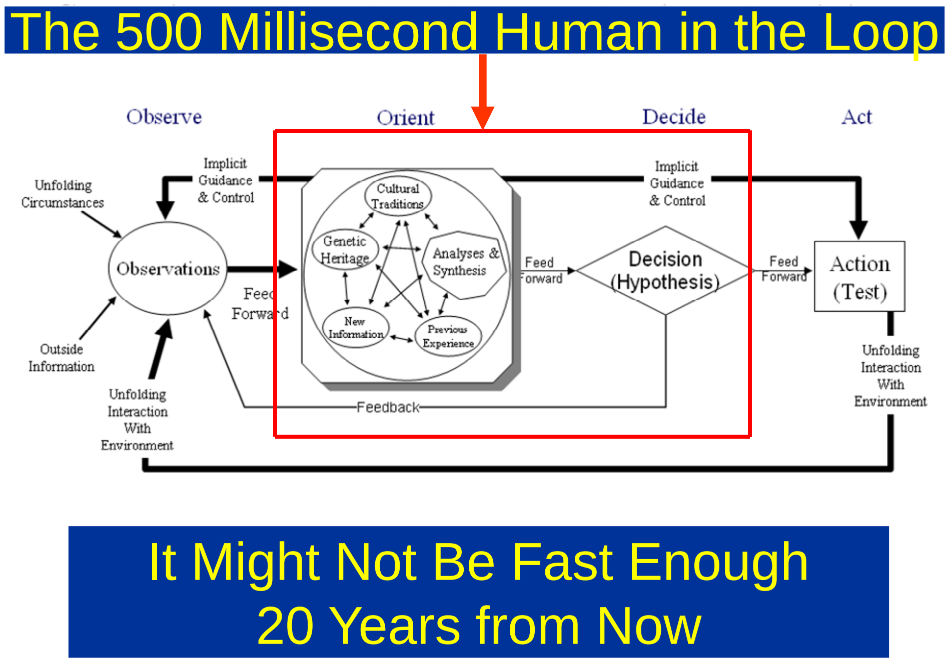


Figure 10. John Boyd's OODA Loop highlighting the human Orient-Decide functions (adapted with permission from the Kettle Creek Corporation).

On the battlefield after next, the human processing speed may be too slow to be effective in the most demanding scenarios. It may give rise to shifting human C2 out of the loop directly and replacing it with decision support systems. Rules of engagement and the commander's intent will be factored into automated systems *a priori*, depicted in the next figure. This notion may be hard to accept presently, but then so were drone aircraft shooting Hellfire missiles unacceptable in the early 1990's, not to mention the application of the tank at the Battle of Cambrai in WWI and the introduction of the aircraft carrier in the 1930's. Ultimately, in a truly learning organization, change wins when its effectiveness is proven despite entrenchment and tradition. When near omniscience on the battlefield is fed to a quantum computer half-way around the world to on-call shooter systems with half-meter circle error probable accuracy is a reality (sooner than we may think) without a human in the loop, then C2 may take on a different meaning from how we semantically perceive it today. The commanding may no longer be commander centric (Alberts[13]) and the notion of control may no longer be solely a human attribute and could be devoid of humans altogether. In the limit, the demands for a shrinking OODA loop may give way to the new OODA Loop After Next where Sense-Compute-Shoot is a purely automated chain of events with human override where command and control are a tangential attributes as shown in the Figure 11.

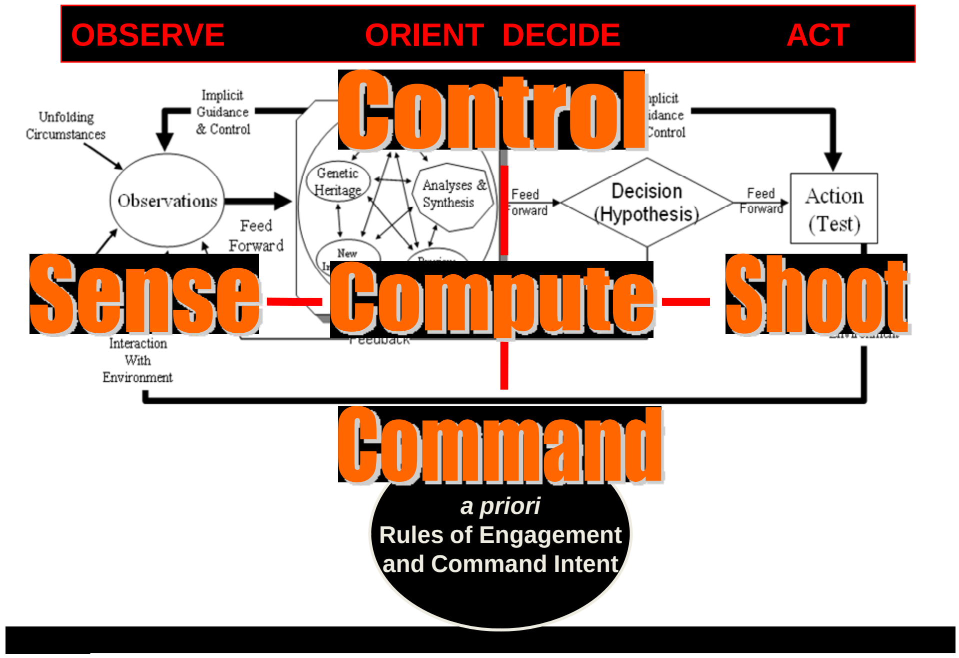


Figure 11. The OODA Loop After Next

The OODA Loop After Next takes on the form of neopentane (Figure 12) in some ways, with the Sense-Compute-Shoot chain designed as a fully automated function. The Command and Control functions are not directly in this loop, but rather are incorporated as preset functions for the rules of engagement and command intent. They set the initial conditions and then the edge organizations are liberated to respond to the emerging threat.[14]

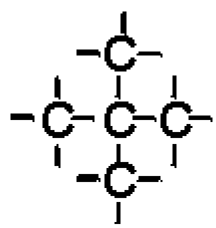


Figure 12. Molecular structure for neopentane

We can imagine this configuration for applications which are too fast for human intervention. The Navy's Phalanx[15] system is one application and the airbag deployment system in modern automobiles is another where humans in the loop are not responsive enough to make real-time activation decisions. Innovation and necessity will be the forcing functions which transform military organizations into an altered C2 state where human command and control are indirect functions. Organizations adopting this configuration will be guarded at first just as it was illegal in some states in the early 1900's to drive a motor vehicle on a city street unless a man with a lantern preceded it. As we turn back to our organic chemistry isomer model, we understand the skepticism and resistance to new concoctions said to improve our lives, make our clothes whiter, and augment our biological functions through better chemistry. We recall recent outcry protesting genetically altered or radiated foods. Rearranging the elements in the compound or adding yet another carbon to produce a new compound with enhanced properties supports our analogous human organizational adaptability model well. It remains to be seen if we are agile enough to accept new technologies and apply these adaptations soon enough.

Adapting to the Spectrum of Conflict

To be sure, the United States and its allies have been learning and adapting organizations. Only a decade ago, the U.S. Department of Defense (DoD) questioned whether it had a legitimate role and responsibility in operations other than war (OOTW). Today, considering the Army's recent promulgation of FM 3-0 (Operations), the mission to engage across the full spectrum of conflict is now accepted. This spectrum runs from humanitarian missions to total war as shown in Figure 13.[16]

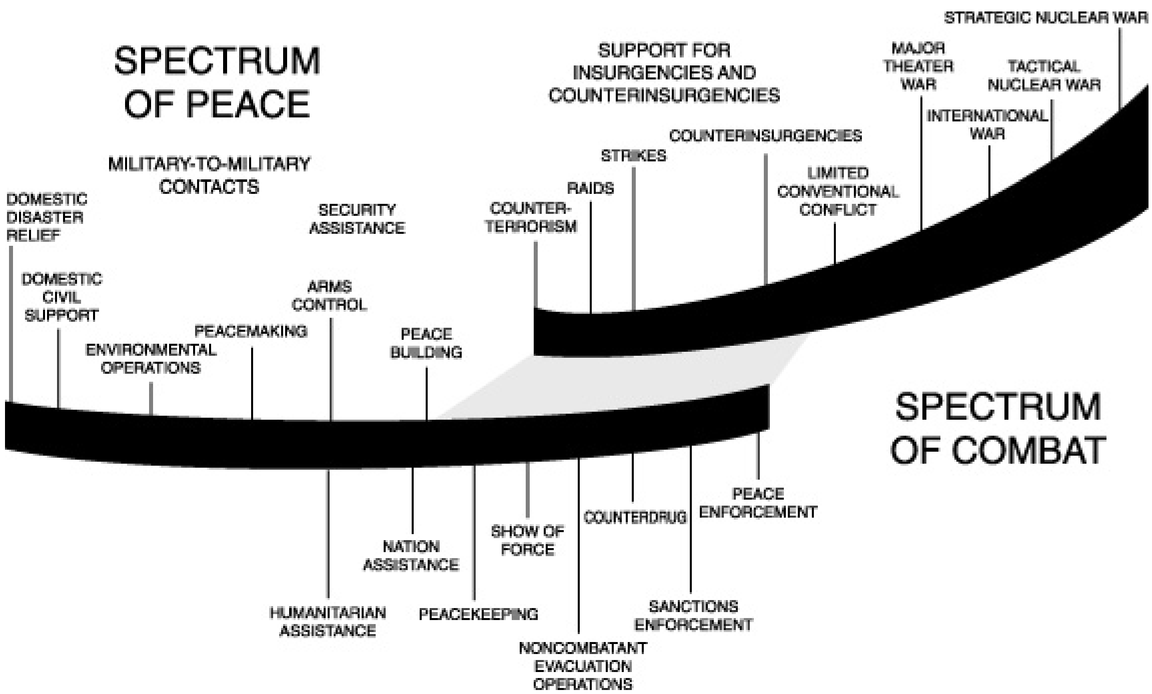


Figure 13. The Military Spectrum of Conflict

The variety of mission requirements places significant challenges on the shoulders of an organization which must, sometimes within hours, shift from one condition to another across a wide spectrum of operational capabilities.

To continue our isomer analogy, we first introduce the Rubik's Cube, a six-sided puzzle introduced by Hungarian inventor Erno Rubik. Each cube face consists of a unique color and consists of nine "cubies" on each face. As many people know, the initial state of the cube has a different homogeneous color on each of the six faces. As each row or column of cubies is rotated, a different color is introduced to the faces, such that in short order any face may consist of as many as six colors. There are many combinations and configurations of cubie colors and positions on each face. The difficulty, and object of the puzzle, is getting the cube back to its initial state through a series of rotations of rows and columns. We will return to this problem later.

In our earlier discussion about isomers, we stated that methane, ethane, and propane were trivial cases since there are no possible rearrangements in their respective one, two and three carbon chain structures to produce different structures. We moved to butane, pentane, and hexane (four, five, and six carbon atoms respectively) to introduce complexity and variability into our understanding about the different forms that a given compound could take. It was suggested that that human organizations (as in matrix organizations) could take on new forms and properties by rearranging without adding or subtracting in the same way that isomers are constructed for a specific size carbon compound. We conveniently ended our early isomer representations with hexane (six carbon atoms) to align ourselves here to the six-sided Rubik's Cube. (We leave to the reader's imagination how to devise a heptane (7-sided) or octane (8-sided) puzzle and name it for his or herself in the manner Erno Rubik did for his structure).

The rationale for using isomers, the Rubik's Cube, and the Spectrum of Conflict to this point now focus and converge on the conclusion of this paper. Initially, the facing three sides of the Rubik's Cube are homogenous as depicted in Figure 14. This represents earlier era C3 (command, control, and computers) human organizations in a static configuration.

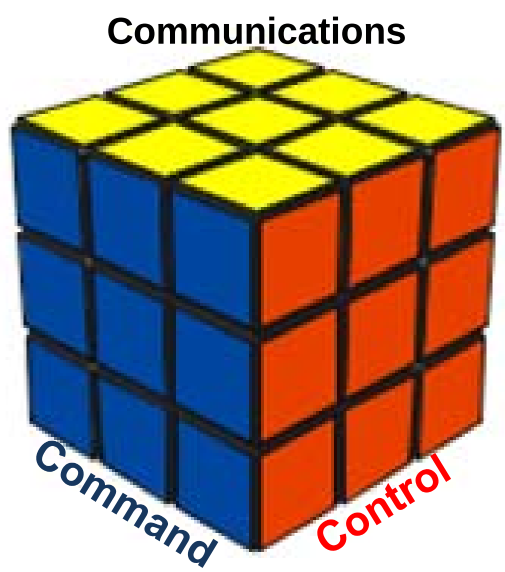
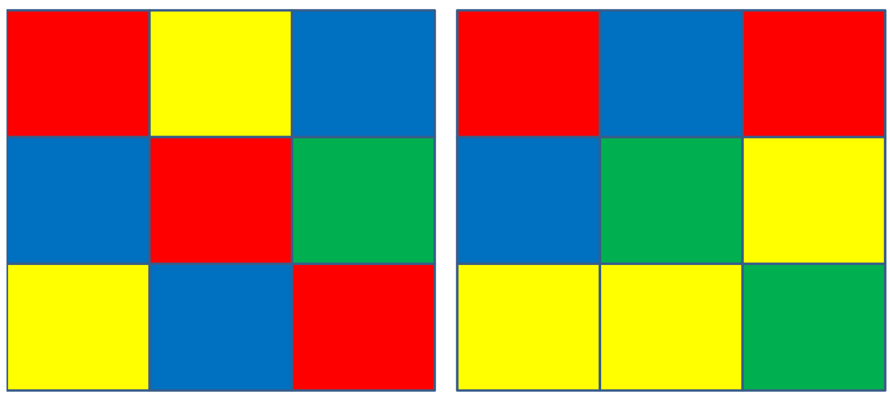


Figure 14. Representation of a static C3 organization

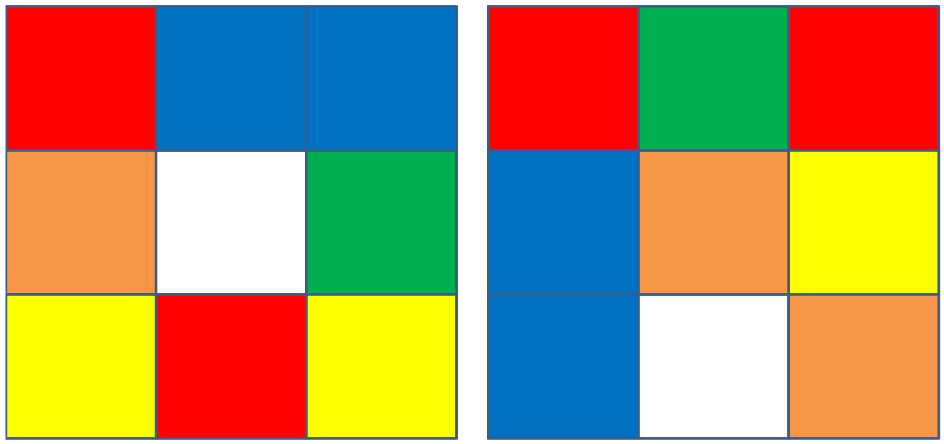
It was simple, had no isomer analogy, and was either applied in the conduct of war or was dormant in peace. Command and control (C2) in military organizations, although always adapting with new weapons and formations, were more or less static at least when measured generationally throughout history. In the past, inventions were slow to evolve, communications were constrained by line of site, and movement was at the speed of foot and hoof until about the dawn of the 20th century. At that point, someone started to “rotate the cube” of military organizational change. The telegraph, the radio, and observation planes added a new dimension, a C for communications (yellow) in the C2 chain to produce a C3 paradigm. It lasted for more than a half-century. Not until the 1970’s did computers in primitive form and limited application cause yet another cube rotation (green) and produce an adapting organization with a four color (C4) construction. We can visualize this evolution from a C2 to a C4 structure using four random colors to represent two versions (isomers) of the C4 organization, shown in Figure 15, as uniquely different configurations of a Rubik’s Cube.



C4 organization, version 1 **C4 organization, version 2**

Figure 15. Two different configurations of a C4 organization.

At this stage complexity and variability are evident. Military organizations begin to learn how to best use the new capabilities of computation and information. For example, the U.S. Army experimented with the 4th Infantry Division at Fort Hood in the 1990’s to learn how to capitalize on digitization as an element of combat power. It put this learning to first real use in 2003 in Iraq, but came up short in fielding enough systems in time for maximum effectiveness. By introducing two more organizational challenges, Complexity and Chaos Theory for example, we now have one of several arrangements of six colors on the facing side of the cube to apply to a given environment. There are many other arrangements possible. Let each arrangement of possible cubies represent an isomer of the same organization. Each isomer represents a different construct of the same organization, each with different strengths and attributes for a different application, just as 2-methylpentane had different boiling and melting points than 2,3-dimethylbutane did as discussed earlier. Each, however, had the same number of carbon atoms, but one chain rooted in pentane and the latter rooted in butane to enhance their given attributes.. We show two hexane isomers represented by nine color cubies from 6 distinct colors here in Figure 16.



Two different configurations (isomers) of a C6 size organization (hexane)

Figure 16. Two configurations for a C6 organization

The question at hand is which configuration, which organizational arrangement is most effective for a given application? How do you organize the same fighting force effectively at each stage across the spectrum of conflict? Figure 17 depicts various configurations for specific locations on the spectrum of conflict although no interpretation or solution to the questions posed is insinuated here.

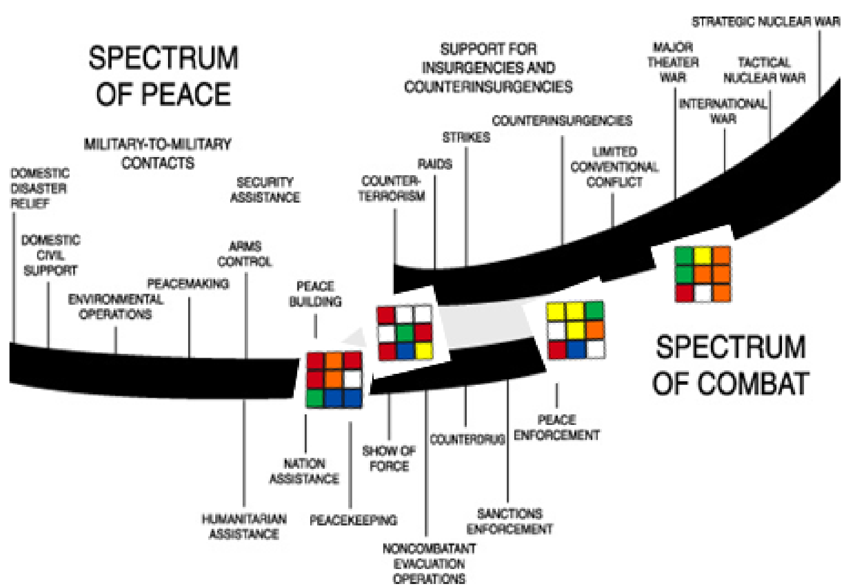


Figure 17. Four configurations on the spectrum of conflict

Note that not all configurations make use of all six colors. Some attributes may not be applicable to a given situation. The true learning organization will understand and develop ways to transform itself across the spectrum to be dominant against its competition at any point in that spectrum. Doing so rapidly gives it the agility, the competitive advantage needed to win and to get inside the adversaries OODA loop. The authors know someone who can solve the Rubik's Cube in less than two minutes, they themselves would take hours. Agility is a competitive advantage and usually wins every time. It is not sufficient to simply adapt, because adaptation may come too late. So too must military organizations, in the new era of complexity, convergence, edge technologies, and chaos theory, learn how to adapt with agility to win every time. It may be necessary to reduce the amount of command in some cases and in other cases diminish the influence of direct control.[17] On some chaotic battlefield of the future, command and control might only be vestiges in name only, where the situation dictates no locus for a commander and no realizable sense of controlling the activities that occur too fast for human reaction to have any measureable or meaningful effect. Thus we may craft our "isomeric organization" with attributes devoid of the old notions of command and control for more potent constructs for the demands of future and even unknown situations.

Back to the Methodological Model

The notion of reorganizing military units to confront a new threat is not new. Indeed the Army's Pentomic Division in 1957 was just such a unit based on the number five to try to effectively confront the new threat of atomic weapons on the battlefield.[18] Four years later, the Army took on another division level reorganization known as Reorganization Objective Army Divisions or ROAD. ROAD divisions incorporated the need for air mobility which later gave rise to the 1st Cavalry Division (Airmobile).[19] The point here is that military organizations have historically tried to reorganize in the face of new threats or to insert new technological capabilities such as the helicopter in ROAD Divisions. Today, Army Transformation is rearranging combat units as Units of Action (UAs) which are integral to the Future Combat Systems formations. The UAs may bring about the demise of historic echelons such as Division and Corps in the same way that the Pentomic Division sought to eliminate the Regiment. The latter elimination was a significant factor in the failure of the Pentomic Division, however. The loss of the regimental tradition reduced unit cohesion. Adherence to tradition still persists in the Army today. This is the heart of the case being presented in this paper. True learning organizations must be careful and introspective if they insist that tradition and heraldry must trump innovation and effectiveness. Heraldry should only go so far if adaptability and agility are to be the new order for the 21st century meaning of competing and winning.

Thus we refer back to the initial premise of this paper which was that the semantics of language are no longer sufficient to aptly describe complex organizations. In 21st century warfare, command and control (C2) may no longer have the same connotation as it once did and may in fact have to be either redefined or split and defined only as separate terms. Command may be viewed as an art, and control (because of increased technology in the conduct of war) may be viewed as a science.[20] Understanding the complexity of military organizations that were level C3 and below could be described using the Art of War vocabulary. Moving to C4 organizations in which isomeric configurations are now possible, requires a science to fully comprehend their variability, adaptability, and capability. Adding new elements to isomers such as bromine or chlorine in place of a hydrogen atom can radically alter the strength or application of the isomer. We can use our organic chemistry metaphor 2-bromo-2-methylpropane (Figure 18) to represent a human organization that can deftly insert a new technology in 2019, for example, with agility.

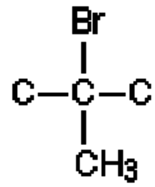


Figure 18. A representation for an agile adaptation to new technology

How does it do it? How does this affect DOTLM-PF[21] requirements? Does DOTLM-PF need to be reinvented to accommodate future technological innovation and enhanced procurement cycles to preclude a vulnerability gap? Perhaps it is time to inaugurate a science of war for the future spectrum of conflicts in much the same way that NASA uses science for the conquest of outer space. The spectrum of conflict has become as complex as space exploration if not more so.

For industry, inventing the new products for medicine, cleaning, and new materials requires serious investment in basic science, research, and development in order to remain competitive. Marketing has its place, but unless innovation and new products can be generated, there is not a happy prospect for the industry’s future. Marketing an old idea has its limits. Polaroid recently announced discontinuance of its instant film product line. What is the meaning of a Kodak moment when we have almost universally moved to digital photography? Making the products of the future relies heavily on scientific discovery and then engineering. The demands on complex organizations in the future cannot be left to rely on earlier methods and outmoded models. Just as we craft numerous new chemical products for applications in medicines, fuels, and synthetics, the isomer methodological model stands up well for the formulation of new designs needed for the insertion of countless technologies and inventions that will become integral to organizational survival. These adaptations will be necessary and demanded. They will come fast as the exponential acceleration curves have shown. The agile, learning organization will accommodate these adaptations quickly and perhaps even with precognition. It may be possible to invent an Isomeric Division of any arbitrary complexity level of C, such that insertions of capability are the equivalent of today’s computer Plug & Play applications. Observe the complexity and richness of the some octane (C8) isomers in Figure 19 below.

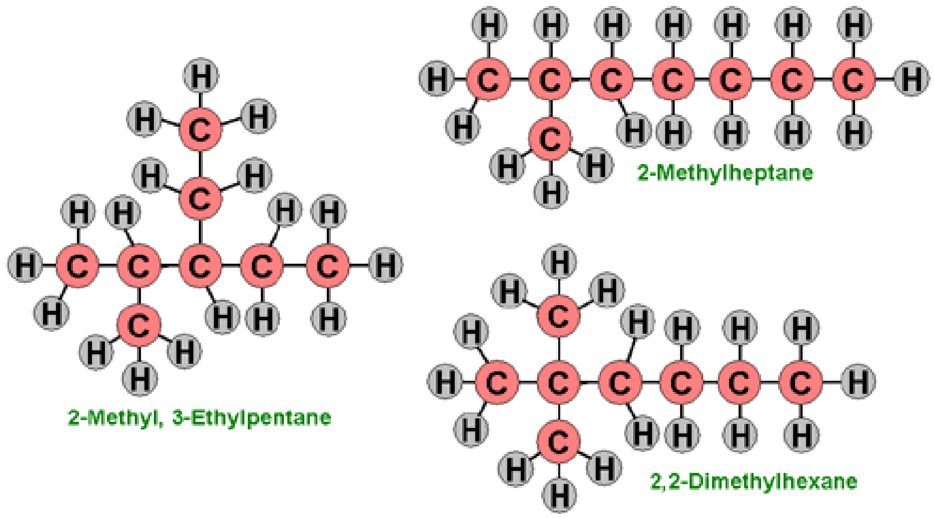


Figure 19. A representation for a notional Isomeric Division of size C8

We suggest here that the traditional notion of Command and Control cannot be found at the locus of one of these isomeric arrangements. There may be no such locus on the highly dynamic, complex, and chaotic battlefield of some future. We may need new terminology for "command" and "control" to better describe organizational behavior for these new constructs just as chemistry knows how to construct, target, and name compounds for products that it creates. Our model for the new chemistry of C2 is designed to help understand what will be necessary to construct an agile Future Force.

Conclusion

Military operations, capabilities, and the speed of events have been changing with great intensity for the last decade. The availability of additional capabilities through the insertion of new technology seems endless as new software and hardware like collaboration, data access and processing, planning tools, and the speed and lethality of kinetic systems emerge. With this rapid change in military capabilities, we need a new way of considering the "command and control" of units and systems in order to effectively meet the opponent and have an advantage in the conflict. Old ways of conducting business and being constrained semantically have no place in current and future warfare and will negatively influence the potential of success. Those in "command" must understand what equips their organizations for success. The Cold War concepts of "commander centric" organizational structure must be shelved and replaced. Additionally, the focus of the organization must be on the unity of effort in the operation vice the unity of command. This must be established early in any operation, especially those that are combined (international) in make-up.

The one in command must understand that the speed of decision making will be a critical factor in success and therefore must prepare the organization for that type of operation. The commander will have to realize that, for the old concepts of hierarchy, the commander making all the decisions during the fight must transition to new concepts with which to speed up that decision-making process. Of necessity, commanders will need to focus on the full gamut of intent, perhaps command intent but most likely the operational intent. Included are the establishment of the rules of engagement, the setting of initial conditions (to include infrastructure, agility preparations, and training), and consideration of future requirements. In this regard, the analogy of the chemical isomer is most pertinent; the commander will decide which isomer will be appropriate for the location of the intensity of the event on the spectrum of conflict and lead the organization in the preparation for operations in that isomeric configuration. Added to these commander requirements will be the establishment of a command environment that provides for the speed of decision making required (either human or otherwise), the establishment of the technical and communications infrastructure with which to provide the necessary agility and information sharing, and the dedicated preparation for all potential isomeric configurations in the spectrum of conflict, even those that would not be anticipated by world events today.

The analogy of organic chemistry seems to be an excellent fit for the concepts of organizational configuration, especially when agility is required to meet emerging operational concepts. The commander must have established an isomeric configuration to adapt to the current level on the spectrum of conflict. However, it must be emphasized that using the isomeric notation for organizational configuration is not a panacea; in fact the improper choice of isomer to fit a specific environment could be met with significant pitfalls. Surely the properties of each "isomer" must be evaluated and tested to ensure it is the correct fit for the point on the spectrum of conflict that it is being addressed.

Just as the chemical industry strives to provide the best performing product for the consumer, so too the commander of a military organization, especially one dealing with national or theater events, must be able to reorganize available assets to best meet the threat, prepare for future threats, and allow for the application of new technology to achieve the optimal results. Being open to and skilled in the agile adaptations of complex organizations will best accommodate the next challenges presented to future commanders. The ability to focus the organization towards the objective and to enable all essential elements of power to converge on the opponent with agility will be the "New Chemistry" of C2.

[1] Alberts, David S., Hayes, Richard E., "Understanding Command and Control," Command and Control Research Program, U.S Department of Defense, 2006.

[2] Alberts, David, S., "Agility, Focus, and Convergence: The Future of Command and Control," The International C2 Journal, Vol 1, No. 1, 2007.

[3] "The Basic Writings of Bertrand Russell," Routledge Publishing, 1992, p. 133.

[4] Laws of Science definition: "Independently and sufficiently verified description of a direct link between cause and effect of a phenomenon, deduced from experiments and/or observations. Also called laws of science, scientific laws are considered established and universally applicable (to certain class of things or phenomenon under appropriate conditions) but not necessarily definitive." Found at http://www.businessdictionary.com/definition/scientific-law.html

[5] Omar N. Bradley, "A Soldier's Story," (New York: Henry Holt and Company, 1951), p. 474.

[6] Alberts, David, S., "Agility, Focus, and Convergence: The Future of Command and Control," The International C2 Journal, Vol 1, No. 1, 2007, p. 16.

[7] The term "disruptive technology" was coined by Clayton M. Christensen in *The Innovator's Dilemma* to describe technologies which produce new products in new ways. Initially they cost more, but eventually they become much cheaper and drive older technologies out of the market.

[8] Found at http://www.brainyquote.com/quotes/authors/j/jack_welch.html

[9] Found at http://www.quotationspage.com/quotes/Alan_Kay/

[10] Time sensitive target execution has gone from 6 hours in Kosovo (1999) to 10 minutes in Iraq (2003), as stated by Lt General Michael Peterson, Chief Information Officer, USAF, MILCOM conference presentation, Orlando, FL, Oct 2007.

[11] Major James C. Hoffman, USAF and Charles Tustin Kamps, "At the Crossroads: Future Manning for Unmanned Aerial Vehicles," Air & Space Power Journal, Air Command and Staff College, Maxwell AFB, Alabama, Spring 2005, found at http://www.airpower.maxwell.af.mil/airchronicles/apj/apj05/spr05/hoffman.html

[12] Alberts, David S., Hayes, Richard E., "Power to the Edge: Command and Control in the Information Age," CCRP Information Age Transformation Series, U.S Department of Defense, April 2005, p126.

[13] Alberts, David, S., "Agility, Focus, and Convergence: The Future of Command and Control," The International C2 Journal, Vol 1, No. 1, 2007, p. 16.

[14] Alberts, David S., Hayes, Richard E., "Power to the Edge: Command and Control in the Information Age," CCRP Information Age Transformation Series, U.S Department of Defense, April 2005.

[15] *Phalanx* is the only deployed close-in weapon system capable of autonomously performing its own search, detect, evaluation, track, engage and kill assessment functions. *Phalanx* also can be integrated into existing Combat Systems to provide additional sensor and fire-control capability. Found at http://usmilitary.about.com/library/milinfo/navyfacts/blphalanx.htm

[16] Hillen, John, Peacekeeping at the Speed of Sound, Airpower Journal, Winter, 1998 and as adapted from *Army Vision 2010* (Washington, D.C.: Headquarters, Department of the Army, November 1996) found at http://www.airpower.maxwell.af.mil/airchronicles/apj/apj98/win98/hillen.html

[17] The definitions for the terms “command” and “control” are varied. Simply put here, command means direct application of authority and control refers to direct involvement in an operation under the authority. Taken together “command and control” can mean something other than the sum of the parts and the reader can refer to the NATO Glossary of Terms found at http://www.dtic.mil/doctrine/jel/other_pubs/aap_6v.pdf Command: The authority vested in an individual of the armed forces for the direction, coordination, and control of military forces. Control: That authority exercised by a commander over part of the activities of subordinate organizations, or other organizations not normally under his command, which encompasses the responsibility for implementing orders or directives. All or part of this authority may be transferred or delegated.

[18] Pentomic Division. The official name of this structure was ROCID- Reorganization of the Current Infantry Division. However, it was generally known as the Pentomic Division. The Pentomic structure was a reaction to the perceived threat of atomic weapons on the modern battlefield and a chance for the Army to secure additional funding. The standard infantry division was seen as being too clumsy in its fixed organization. Units were organized in a system of "5's". A division was organized with 5 "Battle Groups", each commanded by a colonel. Each Battle Group consisted of five line (rifle) companies, a combat support company, and a Headquarters & Headquarters company. Each company was commanded by a captain. Artillery units were organized with 5 batteries - 4 were howitzers, the fifth was a mortar battery. The addition of "Davy Crockett" rockets with atomic warheads brought the Army into the atomic age. Found at http://en.wikipedia.org/wiki/Pentomic

[19] For an authoritative history of Pentomic, ROAD and other Army unit reorganizations, see John B. Wilson, The Army Lineage Series, Maneuver and Firepower, The Evolution of Divisions and Separate Brigades, center of Military History, United States Army, Washington, DC, 1988, found at http://www.history.army.mil/books/Lineage/M-F/index.htm

[20] The authors’ view stems from the presentation by General James N. Mattis, Supreme Allied Commander Transformation, entitled “SACT C2 Vision: The Art of Command and the Science of Control,” 6th NATO Network Enabled Capability Conference, Chantilly, VA, 17 March 09.

[21] DOTLM-PF is an acronym for Doctrine, Organization, Training, Leadership, Materiel, Personnel, and Facilities.