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Archetypical C2 Organization Design for Ever Increasing Technological Autonomy: An Unmanned Aircraft System Illustration[1]

Autonomy Track – Paper 012

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14. ABSTRACT
According to US doctrine, command and control (C2) represents the most important military activity of all, and it recognizes people as the central element. Given the complementary importance of technology, however, it is insightful to view C2 in terms of socio-technical system design. In such context, it is important for any such design to balance its socio and technical subsystems. Unfortunately, the rapidly advancing technologies associated with autonomous systems are pulling C2 designs out of balance, particularly where autonomous agents, robots, unmanned vehicles and other machines are increasingly replacing people in organizations. This raises the important, open, research question of how socio-technical C2 systems should be (re)designed to (re)balance such rapid technological advance and broad proliferation of autonomous systems. Borrowing from success in engineering and the physical sciences, we seek to leverage known and well-understood principles to approach this design problem, and we draw specifically from Organization Design (OD) to address this open question. In particular, we build upon OD to characterize a principled, socio-technical system design method, the use and utility of which we illustrate through application to unmanned aircraft systems.

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Abstract

According to US doctrine, command and control (C2) represents the most important military activity of all, and it recognizes *people* as the central element. Given the complementary importance of technology, however, it is insightful to view C2 in terms of socio-technical system design. In such context, it is important for any such design to balance its socio and technical subsystems. Unfortunately, the rapidly advancing technologies associated with autonomous systems are pulling C2 designs out of balance, particularly where autonomous agents, robots, unmanned vehicles and other machines are increasingly *replacing people* in organizations. This raises the important, open, research question of how socio-technical C2 systems should be (re)designed to (re)balance such rapid technological advance and broad proliferation of autonomous systems. Borrowing from success in engineering and the physical sciences, we seek to leverage known and well-understood principles to approach this design problem, and we draw specifically from Organization Design (OD) to address this open question. In particular, we build upon OD to characterize a principled, socio-technical system design method, the use and utility of which we illustrate through application to unmanned aircraft systems.

Introduction

According to US doctrine, command and control (C2) represents the most important military activity of all: "… no single activity in military operations is more important than C2. Alone, C2 will not destroy a single adversary target or affect a single emergency resupply. Yet, none of these essential joint force activities, or any others, would be possible without effective C2" (JP6-0 2006, I-1). Within this context, *command* is viewed broadly as "the authoritative act of making decisions and ordering action," whereas *control* pertains to "the act of monitoring and influencing this action" (NDP6 1995, ii). Together, command and control enable people in an organization to understand "what needs to be done," ensure "that appropriate actions are taken," and conduct effective "planning, directing and controlling operations of assigned forces pursuant to the missions assigned" (JP6-0 2006, I-1).

Much more than the computers, networks, satellites, radios, technical systems and other equipment used for communication and coordination, this same doctrine recognizes *people* as the central element of C2 (JP6-0 2006, I-1). Moreover, much more than the decisions and actions of some specific military commander, C2 is viewed best as a shared responsibility (Alberts & Hayes 2003, p. 14), a *process* with functions that must be carried out even when no one is "in charge" (e.g., multinational and multi-organizational coalitions for humanitarian assistance and disaster relief [HADR]). Indeed, US doctrine recognizes such shared responsibility also, articulating how people, at all organizational levels, are central to C2: "Human beings—from the senior commander framing a strategic concept to a junior Service member calling in a situation report—are integral components of the C2 system and not merely users of it" (JP6-0 2006, I-1).

Nonetheless, the people at every hierarchical level must be organized to accomplish (at least partially) shared goals (Scott 2003). Hence C2 is largely about *organizing* people—spanning all organizational levels and sometimes crossing myriad organizational boundaries—who coordinate efforts via organizational processes and leverage capabilities through *technologies* (Van Creveld 1985, p. 10). This all suggests that C2 may be examined fruitfully as a teleological, socio-technical system, comprised of people, processes, organizations and technologies (Nissen 2011).

As with most designed systems—including artificial ones (Simon 1999)—balance across system elements is important; whenever one element in a balanced design is changed, one or more other elements must change generally as well. A well-designed car being equipped with a huge new engine, for instance, will require substantial redesign (e.g., to suspension, structure, body, transmission, cabin) to maintain handling, structural integrity, aerodynamics, reliability, comfort and like, important performance characteristics. Likewise, even a well-designed C2 system being equipped with radical new technology, for instance, will require substantial redesign to maintain its important performance characteristics too.

Today, the technologies associated with autonomous systems (e.g., "intelligent" agents, robots, unmanned vehicles) are changing very rapidly and dramatically, and such systems are proliferating broadly and deeply throughout military organizations. Much more than simply advanced tools and equipment to be used or operated by people in organizations, autonomous systems are increasingly *replacing people* and performing jobs and duties that have been reserved for humans from time immemorial.

Moreover, this trend appears to be accelerating. As autonomous systems take on an ever increasing fraction of organizational work, their presence will pervade an ever increasing degree of organizational processes, and current trends suggest that C2 will be as much about commanding and controlling autonomous systems as people in organizations. Indeed, the limits experienced by autonomous systems in many organizations and mission-environmental contexts today are not technologically imposed; rather, such limits stem from organizational policies, procedures, perceived risks, ethical considerations, and like restrictions imposed by people, not technology. The people, processes and organizations associated with contemporary C2 are not keeping pace with technological change in the domain of autonomous systems, and the design balance is being lost.

How should teleological, socio-technical C2 systems be (re)designed to (re)balance such rapid technological advance and broad proliferation of autonomous systems in order to maintain important performance characteristics? Should robots report to other robots in organizations? Should every C2 organization involving autonomous systems reflect the same design? How will C2 organizations adjust to maintain the "best" designs across changes in their specific people, technologies and mission-environmental contexts? These represent open research questions, which—given the fundamental role of C2—are taking on critical importance and urgency at present. All of the technological attention to and advance of autonomous systems in the world will not restore or preserve the important design balance necessary for C2 efficacy. Rather, given technological change as a driver, such balance will be principally in terms of the people, processes and organizations associated with agents, robots, unmanned vehicles, and other autonomous systems.

One promising approach—borrowing from success in engineering and the physical sciences—is to leverage known and well-understood principles to approach a design problem. Of course principles from engineering and the physical sciences are much more precise and analytically tractable than are those pertaining to C2, but the C2 field is imbued with many principles, some dating back to the beginning of people organizing work together and including military endeavors. Indeed, the "problem of commanding and controlling armed forces … is as old as war itself" (Van Creveld 1985, 1). Many enduring principles have been induced through the study of C2 history, principles which can be integrated into coherent and useful models or theories (Alberts & Hayes, 2003; Builder et al. 1999; Van Creveld 1985). Further, many useful C2 principles are also being adapted from parallel fields (e.g., Complex Adaptive Systems, Information Science, Organization and Management), and work to articulate metaphorical Rosetta Stones (Alberts & Nissen 2009) to translate promising techniques directly are being discovered and employed now.

In this article we build upon well-understood principles from Organization Design (OD) to address the question of how a socio-technical C2 system can be redesigned to incorporate ever increasing technological change. We begin by characterizing OD in the context of socio-technical systems. Then we follow with close examination of a systematic organization design method, after which we illustrate the use and utility of this approach through application to unmanned aircraft systems.

Background

Organization Design centers on socio-technical knowledge developed through a large body of theoretical and empirical research over the past half century, and it interrelates very closely with C2 (Nissen 2007). This is the case in particular where the mission-environmental context of C2 is changing and requires rebalancing: OD involves purposeful design and change of organizations to fit their missions, environments and other contingencies (e.g., strategies, technologies, people). Such purposeful design and change reflect a fundamentally rational, teleological view of organizing, a view which is ascribed widely to those involved with C2. Central to OD is the longstanding maxim that there is no single "best" way to organize across all contingencies (Burns & Stalker 1961, Woodward 1965, Lawrence & Lorsch 1967); rather, designs must be balanced and tailored to *fit* each contingency set (Donaldson 2001).

Moreover, the term *organization* refers to any collectivity of people with at least partially shared goals (Nissen 2007). This can range from individual families, bowling clubs and sole proprietorships (e.g., "mom and pop stores") on the small side to the largest corporations, military forces and government agencies on the large side, in addition to organizations of organizations (e.g., the North Atlantic Treaty Organization, the United Nations, corporate supply chains and webs). Hence the term is quite broad and far, far more encompassing than the simple box and wiring diagrams used often to depict managerial areas of responsibility and reporting relationships (e.g., standard organization chart).

Within this context of OD, we leverage the relatively recent "Rosetta Stone" by Alberts and Nissen (2009) to identify key variables and to interrelate them between OD and C2. For instance, the C2 Approach Space (Alberts & Hayes 2006) identifies three principal dimensions useful for organizing C2: *allocation of decision rights (ADR), patterns of interaction (POI)* and *distribution of information (DOI)*. By combining these three dimensions graphically, one can visualize a voluminous space of possible C2 organization designs as depicted in Figure 1.

For instance, the space includes two broad design classes of C2 organization: 1) Most Military Organizations, and 2) Edge Organizations. The former class is characterized by hierarchical organization, unity of command, centralized decision making, bureaucratic processes, and like aspects of most military organizations in practice today. In Approach Space terms, such organizations reflect negligible ADR from Commanders, limited POI across functional organizations, and limited DOI down or across hierarchical channels. The default C2 approach corresponding to this design class is termed *De-Confliction* (SAS 2010). Leaders seek to prevent different organizations, units and elements from interfering with one another (e.g., via collisions, fratricide, contention for limited assets).

Such de-confliction does not obtain always, however, and many circumstances find organizations in conflict with one another (esp. in multi-organization, joint, coalition and humanitarian operations).

Although *Conflicted* does not represent a C2 “approach” per se, we recognize it here to characterize the corresponding situation that is unfortunately common and potentially perilous. By analogy, most roadway systems utilize a de-confliction approach that separates cars travelling in different directions on opposite sides of the road. Roadway planners seek to prevent different cars from occupying the same roadway space at the same time (i.e., common roadway space-time), which is particularly important for avoiding head-on collisions. However, some circumstances find cars in conflict with one another, and it takes only a single car violating the de-confliction scheme (e.g., driving on the wrong side of the road, weaving back and forth across lanes, driving much faster or slower than other cars) to cause the entire system to fail and shut down.

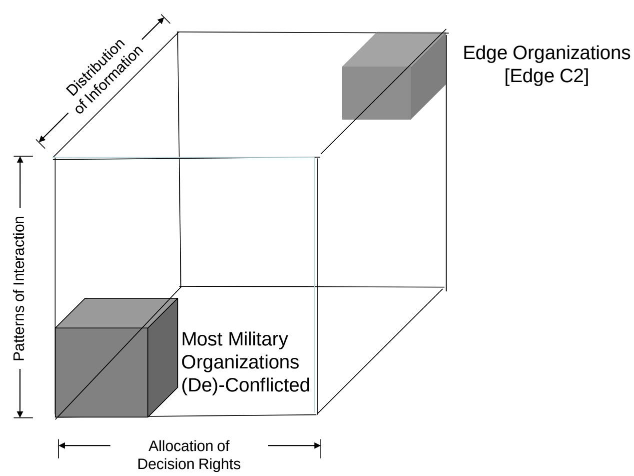

Figure 1 C2 Approach Space (Adapted from Alberts & Hayes, 2006)

Alternatively, the latter design class (Alberts & Hayes 2003) is characterized instead by flat organization, emergent leadership, meritocracy, and self-synchronization. In Approach Space terms, such organizations reflect complete ADR from Commanders, extensive POI across functional organizations, and unlimited DOI down and across hierarchical channels. The corresponding C2 approach—termed *Edge C2*—is dramatically different than De-Confliction: it centers on self-organization and self-synchronization, and it facilitates greater agility (Alberts & Hayes 2006). Notice that these two classes—and their corresponding C2 approaches—are plotted at opposite corners of the Approach Space, signaling radically different C2 organization designs. Neither is universally “better” than the other: each has its own circumstances of best fit. Generally, C2 approaches closer to De-Conflicted tend to be quite stable, reliable, efficient and simple to coordinate—but they are very limited and rated at lower levels of *C2 maturity* (SAS 2010)—whereas those closer to Edge tend to offer greater inter-department, -unit or -organizational synergies but involve much greater coordination costs—and they reflect higher maturity.

Theoretically, a C2 organization can be designed anywhere within this approach space. For instance, some recent work on C2 co-evolution (Alberts et al. 2013) suggests that a main diagonal connecting these two design classes represents the most appropriate region for alternate C2 organizations. However, this suggestion effectively discounts the potential of off-diagonal designs (esp. for unusual contingency sets) and may limit our OD flexibility unnecessarily. This represents a ripe area of continued research.

The diagram above belies the immense size of the C2 Approach Space: unlike the relatively large cubic shapes used to depict these two organization *classes*, any specific C2 organization design would be represented more accurately as a *point*, and many different yet similar design points would fill the volume of Approach Space represented by any single design class. In other words, the class represents a large collection of similar design points.

Of course we understand from above that different organization designs will be appropriate to fit different sets of mission-environmental contexts and like contingencies, and it is likely that only a relatively small subset of all possible design points will turn out to provide good contingent fit. The challenge of course is in searching through the relatively huge number of *potential* design points and identifying the comparatively tiny number of those providing *good fit.* As elaborated below, this represents a very challenging—and sometimes intractable—search problem, for which we turn to archetypical design.

Archetypical Design

We understand well how the use of archetypes can be effective in terms of reducing the kinds of otherwise intractable search spaces associated with design (Senge 1990). The heuristic classification approach, for instance, has been employed with great success via diagnostic artificial intelligence (AI) applications in medicine (e.g., MYCIN; see Shortliffe & Buchanan 1975), electronics (e.g., SOPHIE; see Brown et al. 1982), business (e.g., KOPeR; see Nissen 1998) and other, diverse domains. As such, the approach is quite general, and it offers good potential for application to C2 organization design.

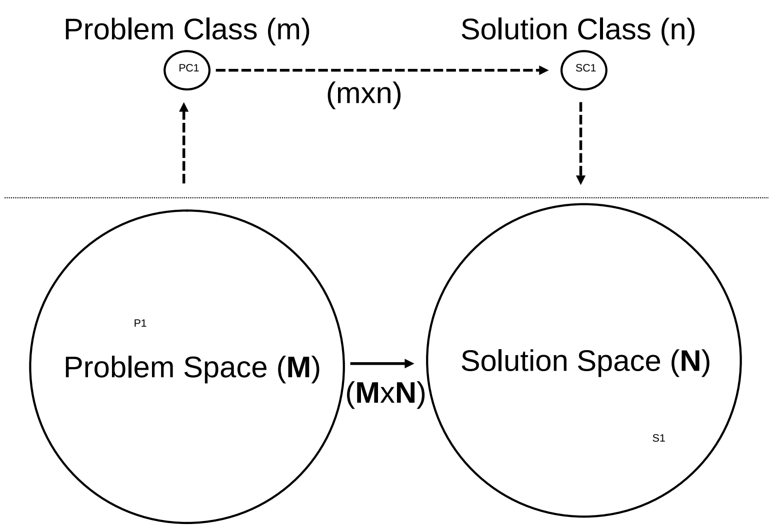

Figure 2 Heuristic Classification

Figure 2 illustrates the approach. At the bottom-left we show a large problem space with M possible problems to be diagnosed. Depending upon the domain, such problems could pertain to human disease, electronic circuits, business issues or others, and the number of possible problems (e.g., mild to severe, individual or in combination, singular to recurring) that could potentially occur for a complex domain is immense. Hence we show the problem space as a large circle in the figure, and we denote the immense size of such space with a bold-capital "**M**." Similarly at the bottom-right we show a corresponding solution space with N possible solutions to problems that could be diagnosed. Likewise the number of possible solutions (e.g., poor to excellent fit, individual or in combination, short to long term) that could potentially exist for a complex domain is immense also. Hence we show the solution space as a large circle in the figure, and we denote the immense size of such space with a bold-capital "**N**."

Once a particular problem has been diagnosed—which is a very challenging search task in many complex domains—it represents a specific point within the problem space. We denote one such point with a comparatively tiny symbol "P1" in the figure. In design terms, this point P1 could represent a specific set of performance shortfalls and interacting constraints (e.g., technical, physical, economic, organizational, ethical). A particular solution to such specific problem lies somewhere as a point in the solution space, which must be found through search also. We denote one such point with an equivalently tiny symbol "S1" in the figure. In design terms, this point S1 could represent a particular configuration of system elements (e.g., computational, structural, financial, procedural, decisional) specified through design to address the specific problem P1. When attempting to diagnose problems (e.g., performance shortfalls and interacting constraints) and identify solutions (e.g., system design configurations), one is searching the combined spaces with a huge number (MxN) of possibilities. For complex domains, such search can be highly inefficient, ineffective or even infeasible within practical time and computational constraints.

Alternatively, heuristic classification involves abstracting up from the immense problem space to a comparatively much, much smaller space of problem *classes* or *archetypes*. We denote the size of such space with a small "m" (m << M). A specific problem class or archetype (e.g., labeled "PC1" in the figure) represents more than just a single point: it represents a class or collection of many similar points, which is much easier to diagnose via search within a comparatively small space. Similarly with the space of solution *classes* or *archetypes*, the solution class space is much, much smaller than the solution space as a whole. We denote the size of such space with a small "n" (n << N); and a particular solution class or archetype (e.g., labeled "SC1" in the figure) is much easier to identify via search within a comparatively small space. In contrast to the huge number (MxN) of possibilities as above, the search problem becomes much easier (mxn).

In our domain of C2 organization design, the problem and solution spaces are huge. Even when an organization's problems have been diagnosed already (i.e., problem space search is complete), identifying the best-fitting organization design (i.e., via solution space search) remains a daunting task. Drawing from Burton et al. (2006), for instance, conservatively a quarter-billion[2] unique design points (i.e., solutions) can be identified even for a relatively small, common and well-understood subset of organization problems. Instead of searching such a large space directly (e.g., evaluating a quarter-billion different design alternatives), we seek to identify an organization *class* or *archetype* that meets the design objectives generally. Then we refine the design to fit the specific organization under examination (Nissen 1997). We refer to this approach as *archetypical organization design*, and we draw initially from Mintzberg (1979) and then Alberts and Nissen (2009) to articulate the approach.

Organization Archetypes

Mintzberg (1979) proposes that almost all organizations can be described by only five[3] organization archetypes: 1) Machine Bureaucracy, 2) Simple Structure, 3) Professional Bureaucracy, 4) Divisionalized Form[4] and 5) Adhocracy. Alberts and Nissen (2009) also discuss the No Organization "archetype," which

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[2] Based upon 14 organization design factors each with 4 alternate values: 4^{14} = 268,435,456; this number of alternate values is *very* conservative.

[3] In later work Mintzberg expands the set to include a couple of additional archetypes.

[4] We ignore the Divisionalized Form here, for it is simply a collection of other archetypes.

involves collections of independent people or organizations pursuing at least partially shared goals without organization structure or coordination mechanism. Each archetype can be characterized in terms of five organizational elements: 1) strategic apex, 2) middle line, 3) operating core, 4) technostructure and 5) support staff. Each archetype can be characterized also in terms of five coordination mechanisms: 1) mutual adjustment, 2) direct supervision, and standardization of 3) work processes, 4) outputs and 5) skills.

Drawing heavily from Nissen (2005), Figure 3 summarizes these organizational elements in the upper-left quadrant. The *strategic apex* is shown as a circle at the top of the organization. This is where strategic organization, management and leadership are accomplished in most views of organizing. The *middle line* is shown as a square below the apex. This is where line organization, management and leadership take place, often through functional departments or like approaches to division of labor. The *operating core* is shown immediately below the middle. This is where the basic product and service outputs of the organization are accomplished. On either side of the middle line is the *technostructure* and *support staff*. Like the middle line, these two elements both sit between the strategic apex and the operating core, but as staff organizations they are not part of the direct line between the apex and core. The technostructure is responsible for direct support such as planning, analysis and technology. The support staff is responsible for indirect functions such as accounting, legal counsel and building maintenance.

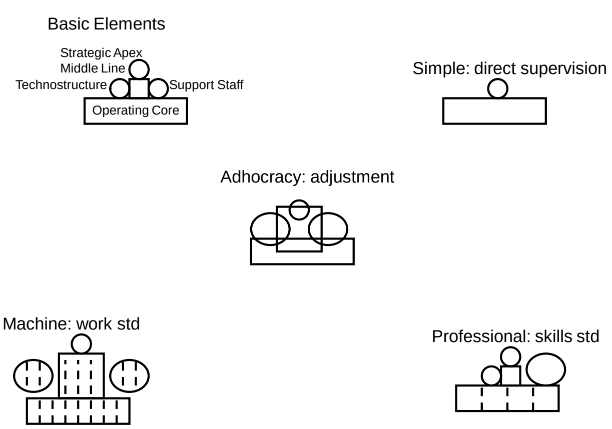

Figure 3 Organizational Elements and Coordination Mechanisms (Adapted from Nissen 2005)

Using these elements arranged as such, different organization archetypes can be depicted and differentiated analytically and graphically. For instance, the Machine Bureaucracy (labeled "Machine: work std") is depicted in the lower-left quadrant. It includes all five elements, with three elements emphasized in terms of large prominence. Specifically, the middle line is depicted using a relatively large square, and both the technostructure and support staff are depicted similarly using relatively large circles. This depiction represents the relatively many layers of middle management and relatively large size and influence of technical and support staffs. Coordination is attained largely through standardization of work processes (e.g., standard operating procedures [SOPs]). We include several vertical lines in most of the elements to represent the manner in which people are organized often via functional departments, where authority, communication, work and information flow vertically via "stovepipes," and where people are highly specialized in the jobs that they perform. Most large firms, military commands and government agencies organize along these lines, and the C2 term *Hierarchy* corresponds very closely with this Machine Bureaucracy archetype (Nissen 2005). The Machine Bureaucracy fits well with relatively complex tasks and environments that are stable and predictable, particularly where output reliability and coordination efficiency represent driving concerns. Alternatively, this form does not change rapidly or perform novel tasks well, as the organization resists change even when it is desired by the apex and necessary for survival. It does not fit well with environments that are dynamic and unpredictable or where extensive cross-functional interaction is important. The Machine can become unbalanced quickly by technological change.

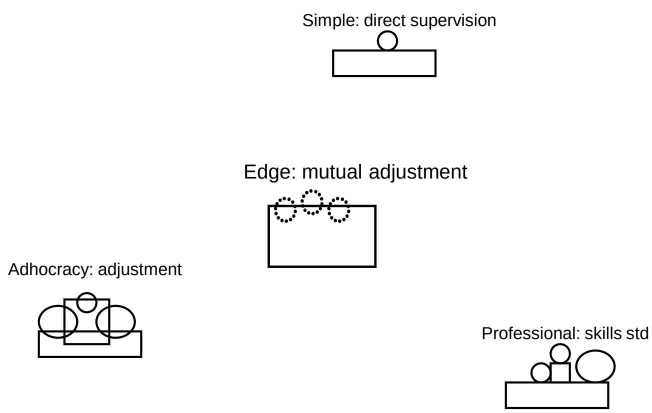

Figure 4 Edge Organization (Adapted from Nissen 2005)

In contrast, the Simple Structure (labeled “Simple: direct supervision”) is depicted in the upper-right quadrant. It includes only two of the five elements: 1) strategic apex, and 2) operating core. The strategic apex is emphasized in terms of large prominence, and coordination is attained principally through direct supervision (e.g., giving orders), often to a pool of people who are largely unspecialized in the breadth of jobs that they perform. Most small businesses are organized as such. The Simple Structure fits well with relatively simple environments and small numbers of people. It can adjust very quickly to goal shifts and other changes from the strategic apex, and this archetype is appropriate where coordination cost and simplicity represent key concerns. Alternatively, this archetype is not suited well for complex tasks and environments, nor does it scale well: the organization can break down and fail quickly when it becomes too large for a single person or small staff to manage effectively from the apex.

The Professional Bureaucracy (labeled “Professional: skills std”) is depicted in the lower-right quadrant. It includes all five elements also, but both the operating core and support staff are emphasized in terms of large prominence. Here standardization of skills provides the principal means of coordination among professionals in the operating core (e.g., professional certifications). We include a few vertical lines in the operating core element to represent the manner in which professionals specialize in distinct areas of expertise: people share common backgrounds (e.g., medicine, engineering, consulting) but pursue unique specializations (e.g., Gynecology, Oncology, Hematology). Most professional corporations (e.g., legal firms, medical offices, consultancies) organize in these terms. The Professional Bureaucracy fits well with environments requiring deep technical expertise and specialization. It can address exceedingly difficult problems within a particular area of expertise, and this archetype is appropriate where efficacy is a central concern. Alternatively, it does not respond well to changes driven from the apex—the *herding cats* metaphor is apt with this organization archetype—and extensive cross-functional interaction across specialties can be a challenge.

Table 1 Organization Archetypes – Comparative Fit

Archetype	Good Fit	Poor Fit
Machine Bureaucracy	Complex tasks required Stable & predictable environments Reliability & efficiency concerns	Quick change & novel tasks required Dynamic & unpredictable environments Cross-functional interaction
Simple Structure	Simple environments & few people Quick change required Cost & simplicity concerns	Complex tasks & environments Does not scale well
Professional Bureaucracy	Deep technical expertise required Highly difficult problems Efficacy concerns	Quick change required Cross-functional interaction
Adhocracy	Dynamic & unpredictable environments Quick change & novel tasks required Cross-functional interaction	Reliability & efficiency concerns Control important
Edge	Same as Adhocracy Unfamiliar people & no one in charge	Same as Adhocracy Risk concerns

The Adhocracy (labeled "Adhocracy: adjustment") is depicted in the center. It includes all five elements also, but they are blended together to delineate much less structure and differentiation than is present in the other archetypes. Here mutual adjustment provides the principal means of coordination among people in all areas of the organization (e.g., close interaction, often of an unscripted or non-procedural nature), and although people may be quite specialized individually in the jobs that they perform, extensive interaction across functions and specialties is involved generally. Many new firms, agencies and organizations (e.g., business startups, innovative companies, non-profit groups) reflect the loosely structured Adhocracy. The Adhocracy fits well with dynamic and unpredictable environments, particularly those that require rapid reconfiguration and adjustment to novel tasks, and where cross-functional interaction is essential. Alternatively, outputs can suffer in terms of reliability; this organization archetype is notably inefficient (yet potentially uniquely effective) due to high coordination costs; and organization leaders may sense a loss of control.

It is important to understand that these organizational elements and coordination mechanisms can be put together in many different manners and that they can change dynamically. For instance, the Edge organization (Alberts & Hayes 2003) integrates aspects of multiple archetypes. Like the Simple Structure, it reflects low specialization; like the Professional Bureaucracy, it reflects a prominent operating core; and like the Adhocracy, it involves coordination via mutual adjustment; but it lacks the other organizational elements. Indeed, the Edge can be viewed as a hybrid archetype, yet it is distinct (Gateau et al. 2007, Orr & Nissen 2006) in that *only* an operating core is involved. Leadership is emergent in the Edge meritocracy environment, which we depict by different dotted circles (e.g., corresponding to different leaders emerging at various times) extending only partially from the operating core in Figure 4. This figure includes the three archetypes from which it draws also. The Edge provides good fit in the same situations noted for the Adhocracy above, and it can be uniquely effective in circumstances where people or organizations share some common goals (e.g., humanitarian assistance) but are unfamiliar with one another and no one is in charge. Alternatively, it suffers from the same limitations as the Adhocracy, and the Edge raises large concerns in terms of risk stemming from mistakes. Table 1 summarizes these five organization archetypes in terms of circumstances corresponding to their comparatively good and poor fit.

Additionally, Mintzberg introduces ten OD variables associated with organization design—what he terms *design factors*—to specify and contrast the archetypes in considerable detail. Such variables enable us to get more precise in terms of specifying the different archetype (and point) designs. Experience suggests that *all ten factors* will play a role in any organization redesign (e.g., to restore balance).

Table 2 summarizes the archetype variables. *Centralization* pertains to the breadth of decision rights. *Specialization* refers to the division of labor and includes two dimensions: *vertical* refers to the extent of job control; *horizontal* refers to the breadth of job duties. *Formalization* represents the extent to which work processes are specified formally (e.g., via rules, policy manuals, written procedures, job instructions). *Liaison devices* involve means of horizontal interaction (esp. across different functions, specialties and organizations); this can include approaches such as informal exchanges, liaisons, task teams and matrix organizations. *Planning and control* refers to how outputs are managed; this can be by (advance) action planning or (ongoing) performance control.

Table 2 Archetype Variables (Adapted from Alberts & Nissen 2009)

Design Factor	**Meaning**
Centralization	Breadth of decision rights
Vertical specialization	Limitedness of job control
Horizontal specialization	Narrowness of job breadth
Formalization	Formalization of work processes
Liaison devices	Means of horizontal interaction
Planning & control	Management of outputs
Training	Formal education & training
Indoctrination	Intensity of acculturation & norming
Unit grouping	Composition of organization units
Unit size	Span of control

Training involves the degree of formal education of and training provided to organizational participants, usually in advance of beginning a job. *Indoctrination* involves the intensity of acculturation and norming forces associated with an organization. *Unit grouping* refers to how organizational units are composed; this is most commonly by function (e.g., skill, knowledge, business process) or market (e.g., product, geography, demographic). Finally, *unit size* refers to managerial span of control. With this set of ten design factors, we have the ability to characterize a broad diversity of organization archetypes and specific design points, and we have a set of variables to both specify and contrast them analytically and graphically.

Indeed, using the concepts and variables from above, we can specify each of the five organization archetypes discussed above (i.e., Machine Bureaucracy, Simple Structure, Professional Bureaucracy, Adhocracy, Edge). This provides a vivid example of reduced solution space size: a solution space with over a quarter-billion alternate design points can be condensed to only *five* OD archetypes (i.e., that can be counted on one hand).

Table 3 summarizes design specifications for each of the five archetypes. The first column refers to six of the most relevant design factors summarized in Table 2 above. The other five columns reflect OD variable values for each archetype. For instance, Column 2 summarizes specification of the Machine Bureaucracy in terms of this variable set, which reflects high centralization, specialization and formalization levels. The other variables and levels follow accordingly for the Machine Bureaucracy and counterpart archetypes. In addition to relatively extreme labels (esp. "High" and "Low"), we include some intermediate values (e.g., "Some" and "Little") to suggest that not all archetypes and variables reflect such extremes. At this point in our conceptual development, archetypical design specifications remain limited to such use of ordinal scales. We leave to future research the continued refinement to develop ratio measures.

Table 3 Archetype Specifications (Adapted from Alberts & Nissen 2009)

OD Variable	Machine Bureacracy	Simple Structure	Prof. Bureacracy	Adhocracy	Edge
Centralization	High	High	Low	Low	Low
Vertical specialization	High	High	Low	Low	Low
Horizontal specialization	High	Low	High	High	Low
Formalization	High	Low	Low	Low	Low
Liaison Devices	Few	Few	Some	Many	Many
Planning & Control Systems	Action planning	Little	Little	Some action	Performance control

C2 Integration

Alberts and Nissen (2009) build upon this work to integrate OD and the C2 Approach Space. Specifically, each of the organization archetypes and design factors is mapped to corresponding C2 approach space elements through what they refer to as a metaphorical "Rosetta Stone" (p. 39) that interrelates OD-C2 concepts and variables across domains.

Table 4 Mapping Variables across Domains (Adapted from Alberts & Nissen 2009)

C2 Dimension	**OD Variable**
Allocation of Decision Rights (ADR)	Centralization Vertical Specialization Horizontal Specialization
Patterns of Interaction (POI)	Formalization Liaison Devices Planning & Control Systems
Distribution of Information (DOI)	Liaison Devices Planning & Control Systems

Table 4 summarizes this interrelating. Within the C2 column we have the now familiar *ADR, POI* and *DOI* dimensions, with corresponding OD variables in the next column. For instance, the C2 Approach Space dimension *ADR* corresponds best with three OD variables: *centralization, vertical specialization* and *horizontal specialization*. The same applies to the other two C2 dimensions. Notice some overlap of OD variables across the POI and DOI dimensions; this suggests that such dimensions are not orthogonal, and indeed they appear to be somewhat related (Alberts & Hayes 2006). The interested reader can refer to Alberts and Nissen (2009) for details. Notice that not all of the OD variables from Table 2 are included. Only a subset of the OD variables is required for mapping to the C2 Approach Space; this suggests that the C2 Approach Space offers potential for further dimensional expansion.

Table 5 C2-OD Archetype: Detail Specification (Adapted from Alberts & Nissen 2009)

C2 Dimension	OD Variable	Machine Bureacracy	Simple Structure	Prof. Bureacracy	Adhocracy	Edge
Allocation of Decision Rights	Centralization	High	High	Low	Low	Low
	Vertical specialization	High	High	Low	Low	Low
	Horizontal specialization	High	Low	High	High	Low
Patterns of Interaction	Formalization	High	Low	Low	Low	Low
	Liaison Devices	Few	Few	Some	Many	Many
	Planning & Control Systems	Action planning	Little	Little	Some action	Performance control
Distribution of Information	Liaison Devices	Few	Few	Some	Many	Many
	Planning & Control Systems	Action planning	Little	Little	Some action	Performance control

Table 5 maps these C2 approach dimensions to corresponding OD variables and organization archetypes according to this scheme. Looking at the Machine Bureaucracy archetype, for instance, we have high centralization, vertical specialization and horizontal specialization: together, these three high levels suggest unitary ADR. Likewise for POI: high formalization, few liaison devices and focus on action planning suggest constrained interaction patterns. Similarly for DOI: few liaison devices and focus on action planning suggest controlled information distribution. The same kind of reasoning applies to OD specification of the other four archetypes. Notice the considerable contrast between Machine Bureaucracy and Edge; this is consistent with prior research in both C2 (Alberts & Hayes 2006) and OD (Nissen 2005).

Table 6 condenses this specification into the three dimensions comprising the C2 Approach Space, and it identifies the principal C2 approaches corresponding to each organization archetype. The Machine Bureaucracy, for instance, is specified as Unitary ADR, Constrained POI and Controlled DOI. At the bottom of Table 6 we also highlight **De-Conflicted** in bold font as the primary C2 approach employed by the Machine Bureaucracy. We note Coordination as a secondary approach here also. The other four organization archetypes are specified similarly and related to their primary and secondary C2 approaches in like manner.

Table 6 C2-OD Archetype: Condensed Specifications and C2 Approaches

C2 Dimension	Machine Bureaucracy	Simple Structure	Prof. Bureaucracy	Adhocracy	Edge
Allocation of Decision Rights	Unitary	Mostly unitary	Mostly P2P	Mostly P2P	P2P
Patterns of Interaction	Constrained	Partially constrained	Balanced	Mostly unconstrained	Unconstrained
Distribution of Information	Controlled	Mostly controlled	Balanced	Mostly broad	Broad
C2 Approach	**De-Conflicted**	De-Conflicted			
	Coordinated	**Coordinated**	Coordinated		
			Collaborative	**Collaborative**	
				Edge	**Edge**

Figure 5 shows each of the five archetypes positioned within the C2 Approach Space. As a point of reference, Machine Bureaucracy is plotted in the lower-left-front area of the diagram, reflecting unitary ADR, constrained POI, and controlled DOI; the primary C2 approach *De-Conflicted* is shown in the figure, and we delineate some overlap with *Coordinated* also. The other organization archetypes are plotted similarly, and aside from the Edge archetype, they reflect overlapping C2 approaches too. As depicted here and discussed above, in contrast, the Edge organization archetype corresponds solely with the Edge C2 approach. This provides us with visual representation of alternate organization archetypes and how they relate to different C2 approaches. For simplicity and clarity of illustration, each of the five organization archetypes is delineated by a box shape of roughly the same size, and all five box regions are plotted along a main diagonal of the Approach Space. We leave for future research the more precise scaling and plotting of such box regions.

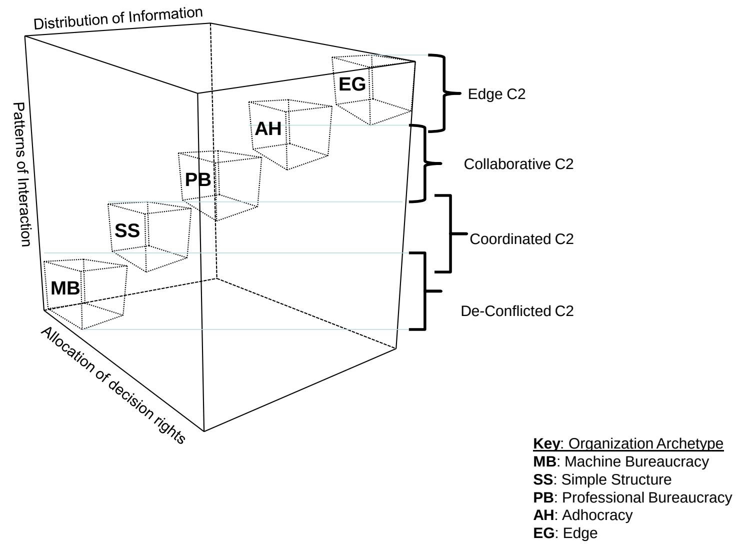

Figure 5 OD Archetypes in C2 Approach Space (Adapted from Alberts & Nissen 2009)

Archetypical Organization (Re)Design Summary

The first step in terms of archetypical organization (re)design is to recognize one's current circumstances. Because very few of us have an occasion to design a whole new organization from a metaphorical blank sheet of paper, we emphasize *redesign* here; hence the first step is to understand one's current organization archetype—and corresponding C2 approach—then to assess its contingency fit. The discussion of organization archetypes, elements and design factors can guide this step, and the summary presented in Table 1 above is central to diagnosing current problems *at the class level*. Most people in military, government or large corporate organizations, for instance, will find themselves in the Machine Bureaucracy archetype and employing De-Conflicted C2.

Presuming[5] that one or more problems with the contingency fit are identified—again, at the class level—the second step is to identify the organization archetype that provides the best fit with either the current or anticipated contingency context, and as above, Table 1 above is central to identifying the best fitting *archetype*. Many people in military, government or large corporate organizations, for instance, will find themselves interested in more rapid organizational change (esp. to rebalance with technological advance), the ability to perform novel tasks (e.g., pertaining to relatively unfamiliar or unpracticed missions), agility in dynamic and unpredictable environments (e.g., not being inhibited by one's own rigid organization structure and processes), and increased cross-functional and interorganizational interactions (esp. where multiple functions and organizations are required to work together), potentially with unfamiliar organizational partners (e.g., that do not participate in common training exercises), and occasionally where no one person or organization is in charge (e.g., HADR).

Step three involves examining the organization design factors and associated C2 approaches that correspond with the archetype identified in Step 2. Organizational leaders must then compare such factors and approaches with those corresponding with the current organization design (i.e., compare

[5] If there are no (perceived) problems with fit, then the extant archetype is (apparently) fine, and one can skip to Step 4.

the “to be” design factors and C2 approaches with their “as is” counterparts). When a list of changes has been formulated and finalized, the organization can refine the archetypical design to suit its specific needs and idiosyncrasies in Step 4. This completes the organization *design* activity.

Leaders then initiate a program of organizational *change* in Step 5 to transition from one design point to another. Of course this succinct summary belies the considerable challenge inherent in the details. The four organization design steps are largely analytical and can be accomplished principally in the strategic apex and technostructure. Step 5 involves organizational change, in contrast, which must permeate through the middle line and operating core. This is a notably difficult undertaking in all but the smallest and simplest organizations and environments. We include this fifth step for reference in Table 7 nonetheless. Note that this process is ongoing; sharing some similarities with the OODA Loop[6], one repeats these steps with each new mission, environment, technology, and like change that can push the socio-technical C2 system out of balance.

Table 7 Summary – Archetypical OD Process

Step	Activity
1	Understand current organization and assess contingency fit (“as is”)
2	Identify the organization archetype that provides the best fit (“to be”)
3	Compare organization design factors and associated C2 approaches
4	Refine archetypical design to suit specific needs and idiosyncrasies
5	Initiate program of organizational change (“as is” → “to be”)

Autonomy C2 Application

In this section we illustrate the use and utility of the archetypical OD approach through application to unmanned aircraft systems (UAS). We begin by outlining two, contrasting use cases in the context of maritime interdiction operations (MIO): 1) a single, organically operated unmanned aerial vehicle (UAV) in sparse, locally controlled airspace; and 2) a large number of manned and unmanned aircraft operated by non-allied nations in dense, uncontrolled airspace.

Case 1 – single organic UAV in sparse, locally controlled airspace

In this first case, consider a US Navy vessel operating somewhat independently at sea to conduct anti-piracy operations. The vessel and crew are clearly part of an established US Military organization and command structure (e.g., fleet, task force, combatant command), but it is operating with minimal contact, oversight or interaction. The ship’s crew relies heavily upon intelligence, surveillance and reconnaissance (ISR) to locate piracy suspects, and it utilizes the visit, board, search and seizure (VBSS) process when such suspects are found. These processes have become very routine, formal and procedural, and where manned aircraft are employed to extend ISR, the operational airspace is controlled locally (when possible) through planning associated with the Air Tasking Order (ATO). Say that the C2 organization—with respect to ISR, VBSS and the ATO—is in good balance. This does not imply

[6] Observe; Orient; Decide; Act; see Boyd.

that the organization is "optimal[7]," "effective," "efficient" or beyond the need for redesign; rather, the various system elements (i.e., people, process, organization, technology) are in balance with one another.

Now we introduce an organic Scan Eagle for remote ISR and VBSS support. Like many UAS today, Scan Eagle operations involve people with different skills (e.g., Air Vehicle Operator, Mission Payload Operator, Mission Coordinator), involve unique processes (e.g., shipboard UAV launch and recovery, remote control), and can insert contractor personnel and like non-military organizations into the C2 socio-technical system (C3F 2012), in addition to unique technological implications (e.g., UAVs lacking the ability to sense and avoid other aircraft in flight). This UAS technology introduction can tip the C2 organization out of balance (e.g., requiring new SOPs, tactics, processes, training, communication patterns, reporting relationships), particularly where the crew begins relying upon the UAS and using it in lieu of manned aircraft support to some missions.

Following the five steps summarized above, we begin by recognizing the current organization as a Machine Bureaucracy typical of Navy ships and crews. One could make the case for the organization within this specific ship reflecting many aspects of Simple Structure (esp. stemming from the extensive use of direct supervision for coordination), but the high degrees of centralization, specialization, formalization and departmentalization suggest that the Machine Bureaucracy archetype provides a better characterization.

The C2 approach associated most generally with such machine archetype is De-Conflicted, which matches the approach in current use. Indeed, according to the ATO, various (manned, and now unmanned) aircraft perform their missions generally at different times and/or in different operational areas. The organization controls its local airspace and works to determine via advance planning—except in emergent situations—which aircraft will fly where and when; the plan helps to ensure that multiple aircraft do not encounter airspace-time conflicts with one another.

In terms of the C2 Approach Space delineated in Figure 6, unitary decision rights are fixed within the strategic apex and middle line (i.e., low ADR), and different aircraft operating units are constrained generally so as to not share common airspace-time (i.e., low POI). These characteristics correspond well to the Machine Bureaucracy archetype. The DOI, however, reflects greater balance yet remains mostly controlled. Data analyzed within intelligence centers are disseminated Fleet-wide via Common Operational Picture or Recognized Maritime Picture, but future aircraft operational information is mostly controlled through ATO distribution, and current operational information associated with each aircraft (e.g., specific geographical location and velocity, sensor feeds, in-flight decisions) remains comparatively local. These characteristics correspond more closely with the Simple Structure archetype. As plotted within the C2 Approach Space here, the corresponding "Case 1 OD" point plots well at the outside corner of the Machine Bureaucracy archetype ("MB"), reflecting some overlap with the Simple Structure ("SS"), and it sits within the De-Conflicted C2 approach band shown in the figure.

[7] We place these terms in quotation marks to indicate that socio-technical systems can be difficult to assess with precision and reliability. This also suggests that nearly every organization has room for some improvement; the question is generally whether it comes via minor refinement or major redesign.

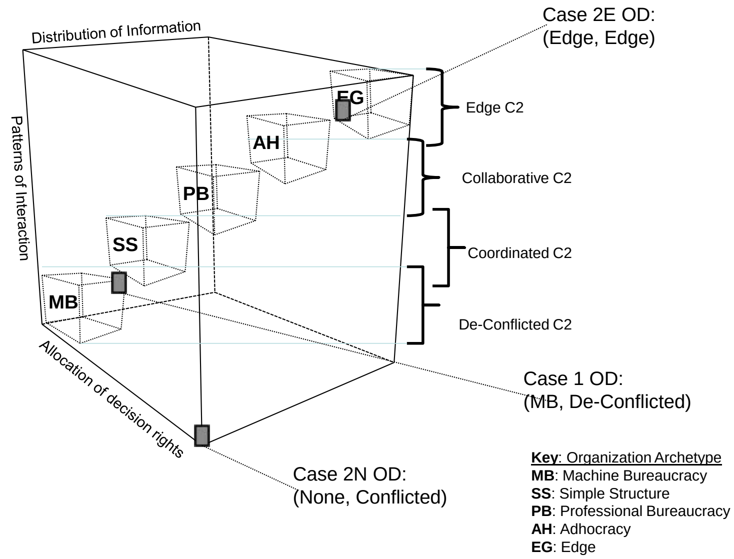

Figure 6 UAS C2 OD

The next step involves understanding the need for change and identifying the best fitting archetype for preserving or restoring socio-technical balance[8] to the C2 organization. In this first use case, it's unclear why the organization as configured would require change *at the archetype level*. With the ATO in place to prevent airspace-time conflicts, and the vessel operating only a single Scan Eagle, the C2 organization appears as though it can integrate the new UAS personnel and skills (e.g., within the Operations Department onboard ship; this could integrate in turn into the JAOC and JFACC[9] organizations when the vessel rejoins its task force), modify processes (e.g., fly only one manned or unmanned aircraft at a time in a particular region of airspace), create new positions (e.g., Mission Coordinator to interface between UAS and ship personnel), and make like, relatively minor changes to accommodate UAS operations without affecting C2 organization in a major way. Moreover, the organizational environment is relatively stable and predictable; operational reliability is a key concern; and UAS integration does not affect cross-functional interaction extensively. Provided that organizational leaders are content with De-Conflicted C2 (i.e., efficient and simple to coordinate but not agile or synergy promoting), we see no need for archetypical redesign in this case. Our message to the organizational leaders and managers: carry on—until the next new mission, environment, technology, or like change that can push the socio-technical C2 system out of balance comes along.

Case 2 – many non-allied UAVs in dense, uncontrolled airspace

In this second case, consider the same US Navy vessel, crew, Scan Eagle and VBSS support role noted above. Consider further that this vessel is operating now as part of a task force (e.g. Joint Task Force or Coalition Task Force) or like, multi-unit, hierarchical organization. Additionally, consider that there are other, non-allied vessels (e.g., from a variety of different nations) conducting anti-piracy operations in proximity to the task force. However, these foreign ships may not all be willing "partners" to the joint or coalition task force structure. Indeed, in some cases they may be unable—even if willing—to operate as part of a unified coalition or like approach suggesting common or predetermined command structure, operating procedures and information exchange across organizations. Moreover, several of the

[8] At this point we lack a good metric for *balance*. This represents a fruitful research topic.
[9] JAOC: Joint Air Operations Center; JFACC: Joint Force Air Component Commander

participants may even be inherently mistrustful of one another (e.g., consider American, Chinese and Russian ships operating in a common area; imagine Iranian, North Korean and Somalian mercenary ships joining in; how about extraterrestrials and pre-apocalyptic Zombies?) and lack prior cooperative training or experience.

Additionally, say that most participating organizations operate their own organic aircraft, manned and unmanned alike, and that there is no process for integrated planning of ATOs across the diverse participant organizations. Nonetheless, these organizations are all working toward a partially shared set of goals (esp. anti-piracy, non-escalation of tension between international participants, safe maneuver), and they all value the ISR and VBSS support capabilities of their UAVs. Say further that the ships all tend to swarm toward areas where acts of piracy are common, suspected or reported—in which case the airspace could be dense with a large number of manned and unmanned aircraft—and there are no established or customary means to deconflict UAS operations across *all* organizations.

As above, Step 1 starts by recognizing the current organization as a Machine Bureaucracy *within the US Navy vessel and joint/coalition task force*. However, as we extend our analysis across the multiple anti-piracy participants operating in a common area, they are all very clearly not part of a common machine or like organization. Without some means of organizing across the various participants—and despite the joint/coalition ATO process—the de-facto C2 approach defaults to *Conflicted* in this case, and no apparent organization is in place across all participants (i.e., the "archetype" *No Organization*). Not only do we observe the same, UAS-driven design issue discussed above, the lack of multiparticipant organization renders C2 pertaining to operations in dense airspace relatively ineffective and potentially dangerous. Moreover, the kinds of relatively minor organizational adjustments noted above appear to be inadequate here, and the associated search space appears to be huge. Archetypical OD seems appropriate in this second use case.

Indeed, Step 2 suggests that one begin by examining the contingencies in place and identifying the best fitting organization archetype. Even from the short description above, quick change will likely be required to work effectively with the other anti-piracy participants; the corresponding multi-organization environment is likely to remain relatively dynamic and unpredictable so long as multiple participants' ships and planes co-operate in common areas; and cross-organizational interaction seems essential. Referring back to Table 1, these are all considerations suggesting that a typical military Machine Bureaucracy—even if feasible—would not represent a good fit. Nor would a Simple Structure (e.g., due to the complex task environment and large number of people involved) or Professional Bureaucracy (e.g., due to requirements for quick change and cross-organizational interaction) appear to fit well.

Alternatively, both the Adhocracy and Edge archetypes offer potential for good fit in these same respects (i.e., they fit well in circumstances where these other archetypes do not), but they present their own set of issues (esp. concerns with reliability, control and risk). Regardless of such issues, it is relatively clear that no one is in charge *of the multi-organization collective*. Hence the archetypical choice reduces to Edge organization or no organization at all; this corresponds to a choice between Edge C2—which implies considerable C2 maturity and agility—and Conflicted C2. We note this choice as "Case 2E" (Edge Organization, Edge C2) and "Case 2N" (No Organization, Conflicted C2), respectively, in Figure 6.

In the former case of Edge organization, we plot the design very near the Adhocracy archetype, suggesting that US Navy leadership may wish to limit ADR, POI and DOI as much as would remain consistent with Edge C2 (e.g., self-organization and self-synchronization). In the latter case of no organization, notice the positioning of this organization design at the bottom-right-front corner of the C2 Approach Space diagram. This suggests complete ADR (e.g., non-allied participants can do whatever they please) and no POI or DOI (i.e., no deliberate interaction or sharing with *all participants*). Presuming that Edge represents the better choice, this completes Step 2 of the archetypical OD process.

It is important to understand the focus of this choice, however. We are not expecting all of the multinational participants to abandon their internal organizations and move in whole to the Edge. There is probably insufficient trust, knowledge and learning capability (or desire) to enable the Edge as a whole. Alternatively, if we focus this analysis solely on C2 organization *pertaining to manned and unmanned aircraft*, then it becomes a more feasible, understandable and practical approach, one which is presumed in the remainder of our discussion.

Step 3 entails examining the OD factors and associated C2 approaches. The change required for the US Navy vessel and task force is to transition from its Machine Bureaucracy organization *internally* (i.e., within the ships and task force) and enable Edge organization *externally* (i.e., across multinational ships and organizations)—again, with respect to UAS C2 organization. The de-facto ADR is complete already (i.e., no one organization asserts control over another's assets), but it is important for the organizational leaders to understand the implications. In particular, the high levels of centralization, vertical and horizontal specialization in force within the task force organization would give way to lower levels across the non-allied participants' organizations. Centralized command, control and communication would continue within the task force of course (e.g., Skippers would communicate with commanders and counterpart Skippers), but Lieutenants, Chiefs, UAV operators and others *within the task force organization* may begin making UAS-related decisions and communicating directly with their counterparts on non-allied ships. Such added decision making would decrease the vertical specialization associated with these people, and the corresponding cross-organizational interface activities would reduce horizontal specialization also. As summarized in Table 1, leaders across all organizations will likely have concerns regarding reliability of operations, risk of mistakes, and loss of control (esp. regarding the airspace-time), but no one is in charge, and the alternative is *no organization*. If other participating organizations are flying UAVs in the airspace-time on a local organization's ATO plan, for instance, then one could consider just accepting that the other organization's UAVs got there first and asking for them to share sensor feeds (and offer to reciprocate of course). This reflects a more Edge-like (and agile yet perhaps uncomfortable) C2 approach.

The same thought process applies to the POI and DOI dimensions. In particular, recall that *formalization, liaison devices* and *planning and control systems* represent the key OD variables influencing POI. For unconstrained POI—and again, with respect to UAS C2 organization—a shift from few to many liaison devices and a change from action planning to performance control would be particularly important here. These same changes would enable broader DOI as well. In addition to the cross-ship communications suggested above (e.g., Lieutenant-to-Lieutenant), the task force participants could establish rich means of communication, observation and interaction with the non-allied organizations. Indeed, with access and discussions restricted to UAS operations, the various participants may benefit by exchanging liaison officers across ships. This would decrease formalization levels, as all UAS participants begin this new organizational approach, and it would highlight the need for additional training (e.g., in Russian and Chinese language) and indoctrination (e.g., working closely with potentially low-trust "partners"), in addition to a notable shift from advance planning to ongoing situation monitoring as means of control. Further, it would probably make sense to distribute abundantly the information pertaining to aircraft operations (e.g., share ATOs and UAV sensor feeds). Notice, again, we're not discussing an extension of interactions and shared information about *all operations*; rather, we're focused solely on patterns of interaction and distribution of information pertaining to *UAS organization and C2*.

The shift from action planning to performance control will require considerable mutual adjustment between participants, and coordination loads will exponentiate accordingly. Each organization may continue to produce and even share its (action planning) ATOs, for instance, but there are bound to be many conflicts. When multiple participants' UAVs become dense within a given airspace, the corresponding crews will need to maintain real-time situational awareness (to the extent supported by technology), adjust to potential airspace-time conflicts as they arise, and seek to synchronize UAV operations in flight. Moreover, notice how unit grouping will likely exhibit a shift from functional (esp. departments and "J-codes") to processual (e.g., UAS operations), and people in the middle line across all participants' organizations (e.g., Lieutenants, Chiefs, Mission Coordinators) will probably experience increased spans of control. Indeed, all ten of the organization design factors listed in Table 2 above should see change, and each of these OD decisions will need to be made in the context of the UAS with respect to individual ships, commands, organizations and other local circumstances. This is the essence of Step 4. The diverse people, processes, organizations and technologies would appear to regain some balance through this archetypical organization (re)design process.

Step 5 of course involves organizational change to effect the Edge archetype and C2 approach—pertaining to UAS organization. Of course such change is neither straightforward nor easy. Again, however, the immediate alternative is *no organization*. Over considerable time (and trust development), the various multinational participants may seek to establish mechanisms for coordinated or even collaborative C2 (e.g., consider the different nations sharing and adjusting—or possibly integrating—their ATOs with one another), in which case the Edge organization and C2 approach would likely fall out of fit; C2 agility would decline, but it would be offset by increases in reliability, efficiency and control. If so, then these same five archetypical OD steps can be completed again (OODA), and the multinational, multi-organization collective may find itself transitioning to more of a Professional Bureaucracy (e.g., where each nation's ship performs the tasks that it does best) or even Simple Structure (e.g., one nation's organization takes—and is accepted as—the lead).

In any case, archetypical C2 organization design provides a principled and structured approach to an otherwise unwieldy multi-organization problem. It can also help to guide the restoration of C2 balance across socio-technical elements of people, process, organization and technology, and it can obviate or mitigate the time and risk associated with searching an enormous solution space of OD alternatives. This approach is no panacea of course, as it requires OD expertise—which is not part of most military officers' education, training or experiential portfolios—and repeated redesign and change will introduce considerable turbulence within the affected organizations—which could potentially detract from mission accomplishment itself. Further, this archetypical OD approach is experiencing its own continuing development and change at present—as we work to refine the integration of heuristic classification and like class-level search techniques with organization design—and many of our long-held OD and C2 principles will need to be revisited and refined as autonomous systems continue their proliferation throughout routine as well as exceptional organizational life. This all makes for an exciting and relatively open-ended research agenda, one that can induce whole new conversations between organization designers, system engineers, UAS technologists, military commanders and others. Indeed, a major goal of this research project and corresponding article is to help to facilitate just such conversations.

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