“A Systems Approach to Establishing Effectiveness for Command and Control”

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Abstract

Establishing the effectiveness of Command and Control (C2) is considered to be a difficult task and the lack of understanding of the meaning of C2 only adds to this difficulty. It can be shown from a literature study that references to C2 mean one of three things, namely: Command Arrangements, Command, or Command Support Systems. An appreciation of this and an understanding of the nature of these three meanings is a pre-requisite to establishing C2 effectiveness. Treating a military organisation as a system enables each of these elements to be considered as a component of the military system with the role of contributing to the achievement of the operational mission. The systems approach enables the use of the emergent properties of the system to form the basis for the formulation of Measures of Effectiveness (MOE). It also permits a distinction to be made between MOE and Measures of Performance (MOP). The ideal situation would be to establish the contribution that C2 makes to achieving the success of the mission but, when this is not possible, resort must be made to either a reductionist or even an interpretive approach. Although not an ideal situation, it can provide a useable answer.

Introduction

Command and Control (C2) is an essential component of any military organisation. It is a topic that is discussed, defined, and practiced in every military force in the world but it is also one that is often surrounded by confusion and debate. An outcome of this confusion is the perceived difficulty of establishing measures to demonstrate the level of effectiveness of C2. The costs, both human and material, associated with C2 make the determination of effectiveness a significant matter and one worthy of resolution. This paper argues that these difficulties are brought about by confusion surrounding the meaning of C2 itself and of measures generally. It is suggested that there are several underlaying reasons for this.

Firstly, there has been no clear conceptual model for C2 *per se*. The literature generally presents the model of C2 both as '… the process and…the system by which the commander decides what must be done and sees that his decisions are carried out' (NDP6, 1995, p6). The systems are usually denoted under various acronyms such as C3I, C4ISR etc. This model is hard to come to grips with especially when trying to establish metrics for 'process' as process is a means to an end and not an end in itself. When dealing with effectiveness issues, it is the end that needs to be addressed and not the means. The situation has been aggravated by the confusion over the combination of the nouns 'command' and 'control', and much effort is expended in trying to discriminate one from the other. Without a clear model, it is easy to confuse equipment with process, ends with means.

Secondly, there seems to be little agreement on the nature of Measures of Effectiveness (MOE) and Measures of Performance (MOP). Both terms suffer from the lack of a universal definition and the subsequent confusing set of meanings applied to them. This is exacerbated by the confusion in distinguishing between effectiveness and performance. Those responsible for establishing requirements may specify performance when they should be addressing effectiveness and *vice versa*. The terms 'MOE' and MOP' are used indiscriminately and without definition, resulting in differing interpretations as to what each means or even acknowledgment that there is a distinction to be drawn.

A study of the literature offers insights into how the term 'C2' is being used. Without having to introduce new definitions or other new material, it can be shown that there are several generic groups into which the meanings given for the term 'C2' can be categorised. It will then become evident that it is the manner in which the terms are being employed that is bringing about much of the present confusion in meaning. Mapping them onto a systems model of the military organisation can enhance the simple model provided by these generic meanings. This will provide a powerful insight into how the term 'C2' is being used at any particular time. It also provides equally significant insights into the use of metrics with C2 and the effect that the choice of model can have on levels of confidence in test results. .

The aim of this paper is to explain why there has been difficulty to date in establishing metrics for C2 and to offer, in outline, a methodology to address the problem. The argument will be developed by a discussion of the reasons why there is confusion in the use of the terms 'C2', MOE, and MOP. It will be shown that a military organisation is a system and how the various elements in the C2 groupings may be considered components of a System of Interest (SOI). The application of the understanding gained by the use of the three generic meanings of C2 and of MOE and MOP will offer a way out of the difficulties in assessing C2, along with an awareness of the associated level of confidence.

What is meant by 'Command and Control'

The simple three element model

C2 has its own body of literature but extensive reference to C2 is also to be found in military history texts. From a study of this literature, the confusion surrounding the use of the term C2 becomes very evident. Roman (1996) confirms this state of affairs when he states:

We are so familiar with the words "command and control" that one may believe no problem exists. After all, these two words sound like a perfect marriage, giving the impression of equal weighting, value, and importance. While few would challenge this observation, there is little consensus on what "command and control" really means

This confusion is brought about by a lack of a simple model that would enable practitioners to develop a mutually agreed picture of C2. The absence of such a model is a root cause of this confusion. It is often difficult to discern exactly what issues the authors of articles are addressing when they write about C2 because their paradigm of C2 differs from that of the reader. Definitions of C2 differ one from the other because views of what should be the scope of C2 may vary. This lack of an agreed model and lack of distinction about the subject matter at hand makes C2 the confusing topic that it has become. Paradoxically, the solution lies in the literature itself for, if a slightly abstract view is taken, it will be recognised that writers are associating three different meanings to C2. The generic meanings being attributed variously to C2 are:

- command arrangements;
- command; and
- command support systems.

The use of these three groups provides a valuable insight into how practitioners use and refer to the term ‘C2’. Once it is accepted that these are the three groups constantly referred to as ‘C2’, it soon becomes apparent which of the terms is being used at any particular instance. It also becomes apparent that groups are often used in combination, not only in conversation but also in definitions and in the literature. At times, a combination of several meanings may be used without necessarily distinguishing one from the other. This realisation removes a significant amount of misunderstanding and resultant confusion when the topic of C2 is discussed. The separate groupings are discussed below in greater detail to better explain what each group means.

Command Arrangements

Command arrangements provide for the need for unity of purpose and/or unity of command. Command arrangements describe ‘…the degree of operational authority between headquarters, formations, and units’ and is concerned with ‘…assigning missions and tasks for particular circumstances’ (ADFP 6, 1998, p 5-7). The NATO Code of Best Practice (COBP, 1998, p 35) refers to these as organisational issues such as the number of echelons or layers in an organisation; the span of control; pattern of linkages; and whether relationships are transitory or permanent. In an effort to assist mutual understanding, military organisations define what they consider to be suitable categories of command arrangements. It is not intended to discuss these in this paper as it is their existence not their definition that is of interest. One such set is described in ADFP6 (1998, p 5-7) as:

- Full Command;
- Operational Command;
- Operational Control;
- Tactical Command;
- Tactical Control;
- Direct Support; and
- In Support Of.

Such arrangements are sometimes referred to as ‘Command Status’. In a discussion of peace operations, Alberts et al. (1995), although not specifically mentioning ‘command status’, give the impression that ‘command arrangements’ may be a more encompassing term. In other places, ‘command arrangements’ seems to be given a meaning similar to ‘command status’ so, in the absence of anything more authoritative, command arrangements will be used in this paper in preference to command status.

A study of the Allied and German command arrangements just prior to the invasion of Europe in 1944 demonstrates their importance to the outcome of a mission. General Eisenhower was appointed the Supreme Commander for the Allied Expeditionary Force that was to make the landing. Under his command were all the soldiers, sailors, airmen and women involved in any way in the invasion regardless of nationality. Also under his command were the US and British strategic air forces. All responsibility for logistics was given to the US Army European Theatre command. Thus Eisenhower had six officers reporting to him and they, in turn, commanded everything that was needed for the invasion. In France, preparing to repel the Allied invasion, Field Marshal von Runstedt’s air and naval forces did not report to him but to their own service High Commands. His theatre reserves were not only under the control of the German High Command (OKW) but also needed Hitler’s personal approval to be deployed. His land forces, the 30 divisions of Army Group West, were commanded by Rommel who, as a field marshal, had direct access to Hitler. On occasions, Rommel exercised that option. Eisenhower’s command arrangements gave him great control; von Runstedt’s command arrangements reduced his control.

Command

A military force is generally a large and complex organisation with many individuals carrying out disparate functions over a wide geographical area. The management, leadership, and/or coordination of all this activity is what is often considered to be ‘Command’ leading to the second generic use of the term C2. Command, in a military context, means ‘…to have authority over, be in charge of (a unit)’ (New Oxford Dictionary of English). JP 1-02 defines it as:
‘…*the authority and responsibility for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel’*.

Command focuses on the person of the commander, as military operations are not run on a committee basis. The job of commanders is to ‘…lead, guide, and motivate their soldiers and organisations to accomplish missions and to win decisively. Command is the commander’s business’ (Alberts et al., 1995, pp 1-2). C2 is ‘…fundamentally the business of the commander’ and it is the means ‘…by which a commander recognises what needs to be done and sees to it that appropriate actions are taken’ (DP6, 1997, p 2)

Alberts and Hayes (1995, p 1) state that C2 ‘…is the military term for management of personnel and resources’. Hitchins (1997b) takes a similar approach in saying that C2 is the ‘management of conflict’ although Falk (1976, p 47) would qualify this by saying that ‘Command is leadership as well as management’. A recurring theme in Van Crevald (1985) is that Command is both an art and management[1]. Alberts et al., (1995, p1) also refer to command as being primarily an art where commanders '…formulate concepts, visualize a future state, assign missions, allocate resources for those missions, assess risk, and make decisions. It is this characteristic of decision making that seems to be of particular interest to those concerned with C2. This is apparent in the significant proportion of the C2 literature that is taken up with what the commander needs to make decisions, the process of making decisions, the quality of such decisions, and how the decision is communicated throughout the force. This concern with decisions is seen through direct references to decision making as well as to associated topics such as overcoming uncertainty and time, communication of the commander's intent, and achieving situational awareness. The frequent references to the cycle of Orientation, Observation, Decision, and Action, often referred to as the OODA Loop or Boyd cycle, is an illustration of this interest.

Command Support Systems

Command Support Systems include entities such as headquarters staffs, communications networks, doctrine, messaging systems, computers, maps and geographic information systems, software to solve algorithmic problems, standardisation agreements, and data bases. The US Marines draft concept document on C2 for the Marine Air Ground Task Force, in making it clear that equipment is but a means to an end, identifies equipment as a separate entity under the broad umbrella term of C2:

Marines know that equipment is but a means to an end and not the end itself, our concept for command and control is not associated with any particular communications, data processing, or other technology. Rather, it provides a framework within which these technologies, as well as the other components of command and control support, will be judged.(Concept paper, 2000)

Van Crevald (1985, p 275) notes the separation of equipment from the notion of Command when he says 'Far from determining the essence of command, then, communications and information processing technology merely constitutes one part of the general environment in which command operates'. The US definition of command and control (JP1-02) refers specifically to command support systems by noting that:

Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

A case in point

To illustrate how these three topics are being used in combination, one need only consider the definition of C2 provided by JP1-02, namely:

The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, coordinating, and controlling forces and operations in the accomplishment of the mission. (JP1-02)

In this definition all three elements of the model can be identified, namely:

- Command Arrangements (Assigned forces);

[1] Some commentators consider management to be an art! Drucker (1977, p 26) states that it is not a science but is a practice '…comparable to medicine, law, and engineering. It is not knowledge but performance'.

- Command (the commander); and
- Command Support Systems (that which is necessary to perform the C2 functions).

This pattern becomes evident when any reference is made to C2

Enhancing the model

Mapping C2 onto a model of the parent military organisation may enhance this simple model. By doing this, C2 can be put into context as a component of the overall military enterprise. One approach to extending this paradigm is to consider the military organisation as a system. Such an approach offers the added advantage of explaining the use of metrics such as MOEs and MOPs.

Measures and Systems, Effectiveness and Performance

What is a system?

While there are a variety of definitions for the word 'system', Webster's primary definition states that a system is a '…regularly interacting or interdependent group of items forming a unified whole… or '…a group of interacting bodies under the influence of related forces <a gravitational system>'. Blanchard and Fabrycky (1998, p1) defines systems as '…an assemblage or combination of elements or parts forming a complex or unitary whole…any assemblage or set of correlated members…'.

Kline (1995, p 15) proposes that a system can have one of three meanings. It can be:

- Any object of study that we care to define and delineate;
- A representation of such a system just as a map is a representation of a piece of ground. When used in this manner, Kline coined the term 'sysrep' to describe the representation; or
- '…an integrated entity of heterogeneous parts which act in a coordinated way' and when referring to a system in this context, Kline uses the term 'systemic'. Checkland and Scholes (1990, p 18) use also use 'systemic' in a similar manner.

These and similar definitions convey the impression of a collection of components, acting together in such a manner so as to present a whole that is greater than the sum of the components. The whole generates properties that the components, by themselves, could not produce. An aeroplane comprises a power plant; fuselage; lift surfaces; pilot; fuel; etc. By themselves, none of these components can fly. Put them together and they interact with each other to produce what are called emergent properties, eg. powered flight in this instance. The importance of viewing a system as a whole is developed in systems theory.

Systems theory originated in the 1940s with the work of the biologist, Ludwig von Bertalanffy. It was a reaction against reductionism and an attempt to unify science. Kline (1995, p. 15) notes that the system concept '…most sharply differentiates ancient from post-Newtonian modes of science'. Hitchins (1992, p 4) notes the development of a systems discipline as the successor of established disciplines such as engineering, science, etc. and he considers it to be a 'meta discipline'. This meta discipline provides a different way of looking at things with the introduction of the concept of looking at wholes instead of components and the understanding of complexity.

Using systems thinking, systems theory, and dictionary definitions it can be established that a system:

- Is hierarchical
- considers the entity as a whole or must provide a holistic view;
- Is made up of components that can be identified as separate entities;
- Has communication and control between its separate components;
- Is complex as a result of its interactions and the synergy between its components; and
- Is greater than the sum of its parts and so exhibits a property called 'emergence'.

Measures of Effectiveness and emergence

Simon (1984) and Champy (1995) place the end user(s) of a system outside the system. The end users are not so much interested in the system itself as in what the system can do for them. A commander wishing to communicate with a subordinate 100 km away is not concerned if the means to be employed are voice radio, satellite communications, or a videoconference link so much as being able to communicate. The commander views any communications arrangement as a system and views it in a holistic manner by identifying with the end result rather than the means. In reality, the commander should only be interested in the emergent properties of this system, namely in the capability of the system to provide communications when and as needed.

Viewing a system only from the outside in order to judge effectiveness indicates that it is the emergent properties of a system that are of primary interest to the user. This is opposed to the views of, say, the developer of the system who will be interested in internal properties. Emergence is the property (or properties) that MOEs are based on. Although a system may have a range of emergent properties, only a select set of them will be of interest to a particular user. It is these emergent properties that are the subject of MOEs.

Defining Measures of Effectiveness

There is no universal agreement on the meaning of MOE although Sproles (2000a, p 54) has suggested a definition for Measures of Effectiveness. This was arrived at by not only using dictionary definitions of the components of the expression but by drawing upon the thread of agreement that can be found in the literature when the term is used. The suggested definition is that MOEs are

'*…standards against which the capability of a solution to meet the needs of a problem may be judged. The standards are specific properties that any potential solution must exhibit to some extent. MOEs are independent of any solution and do not specify performance or criteria.*'

Measures of Performance

Measure(s) of Performance is another common term and confusion often arises between it and MOE. The distinction between 'effectiveness' and 'performance' shows that MOEs and MOPs are formulated from different viewpoints. An MOE refers to the effectiveness of a solution and is independent of any particular solution; an MOP refers to the actual performance of an entity. An MOE will indicate a property which a potential solution must possess in order to meet a need: An MOP will tell what something is capable of doing even if this is not necessarily what the end users may want it to do. An MOE is a measure against which we judge how well we achieved what we intended or wanted to achieve; an MOP is a measure of what was actually achieved.

Illustrating the difference

In the 17th century, the British government offered a prize for anyone able to solve the problem of calculating longitude at sea. A possible MOE could have been 'Ability to establish longitude on an open ocean voyage'. Note that there is no reference to any particular solution and the interest is only in the end result. One proposed solution was to develop a chronometer and an MOP may have been 'ability to keep a constant rate'. This MOP is directly associated with a particular solution and uses an internal view. Another proposed solution was for a set of astronomical observations called 'lunars' and an MOP for them could have been 'Probability of obtaining suitable star observations at sea'. The MOP concerning constant rate, although appropriate to a chronometer type solution, is irrelevant to the 'lunar' solution. While the MOPs for one solution may have no relevance to the MOPs of another solution, the MOEs will be relevant to both.

Which measure to use?

MOEs and MOPs provide information on what was achieved but do not necessarily explain why something was or was not achieved. In general terms, effectiveness is the domain of the end user who wishes to know if some system is able to meet a need. To establish effectiveness, MOEs are formulated to identify the desired emergent properties. On the other hand, MOPs are the domain of the developer who is trying to produce a system that will exhibit the emergent properties sought. Both MOEs and MOPs assist in answering questions such as 'Does this system do what I expect of it?' If, however, the question is along the lines 'Why does the system do this or not achieve that?' then other techniques such as Operations Research (OR) or Operations Analysis (OA) are required. It is suggested that the military end user is interested in the application of MOEs more than MOPs or OA. The latter two areas are more in the realm of developers and designers.

Military Forces are Systems

Van Crevald (1989, pp 153-166) describes how, after 1830, men and technological devices were integrated into systems in order to wage war. This started with the introduction of the telegraph as an instrument of war, followed by the railways, and mass mobilisation as the industrial revolution developed. He notes that the revolution in technology that occurred in this period '…very largely turned war itself into a question of managing complex systems'. This approach enabled the assembly, focussing, and commitment of ever-greater military forces. He observes that World War II was not won by the side with the best soldiers and plans. Instead those able to establish the technological systems and the means to run these systems efficiently won the war. Total war, as experienced in World Wars I, and II required the management of national military efforts as a whole. It was not enough to concentrate on operational matters alone: it required the correct distribution of '…one's total resources, both human and material, between the fighting front and the rear.' As a result of this progressive integration, any military force can be shown to meet the requirements of a system.

A 'Sysrep' for Military Forces

Kline (1995, pp16-19) discusses the limitations of human cognition. He states that we make 'sysreps' (for 'system representation') in the form of models, or representations of systems, to better support our reasoning about systems. A sysrep permits the study of characteristics of a system. It enables the study of entire classes of systems and '…provides us with important principles for organizing and improving our thinking about a sector of the world.' Such representations can be considered as a means to clarify thoughts and concepts.

Hitchins (1997) developed a five-layer model that can be adapted to describe any business enterprise from the level of individual product up to government level. Intuitively, it feels 'right' and, as a partial result of discussions with Prof. Hitchins (pers.com., Apr 2000) it was used as the basis for the defence system model illustrated at Table 1. This model fits Burke's (2000) notion of a synoptic model as it provides an overview of sequence of events in raising and employing a military force in accordance with established government policy.

Level	Name
5	Socio-economic
4	Governance or higher direction
3	Mission
2	Capability
1	Human and material resources

Table 1: A five-layer model for a national military organisation

Explanation of model for a national military organisation

The levels in the model, commencing at level 5, refer to:

- The socio – economic responsibilities of government to establish policy and provide the means for the military to execute that policy;
- The establishment of the higher direction by which a commander is provided with a mission and resources to accomplish the mission;
- The actual execution of the mission. Traditionally, this involves engagement with an enemy;
- The force structure necessary to provide the force with a range of capabilities necessary to meet the obligations established by government policy;
- The national resources, human and material, from which a military force is built up

Mapping generic command and control groups to the model

The purpose of generating the five-layer model was to map C2 onto it to achieve a holistic view of C2. Having established which meaning is intended for the use of the term 'C2' at any particular instance, it is possible to place that intended meaning of the term 'C2'at the appropriate level in a 'sysrep' of the system. This can be illustrated to show how the three groupings fit into a national military system by using the sysrep shown at Table 2.

Level	Level Name	Generic C2 Group
5	Socio-economic	Command arrangements
4	Governance or higher direction	Command arrangements
3	Mission	Command
2	Capability	Command support systems
1	Human and material resources	Command support systems

Table 2: Generic C2 groups mapped onto the 5-layer model of a military organisation.

Command arrangements were placed at Levels 4 and 5 as they are produced by governments or by the higher echelons of the military. They are products of institutions such as parliament or high-level military headquarters such as the Pentagon. The nexus between Command and the mission given to the commander makes Level 3 an obvious choice for Command. The various components of Command Support Systems are assembled or developed at Levels 1 and 2 such as military training establishments, centres devoted to the development of doctrine, and to acquisition and trials of equipment.

A Way Around the Difficulties

Command and Control, and effectiveness

When attempting to establish effectiveness for C2, it is essential to define exactly what is intended to be tested. The C2 practitioner may have to decide which of the three areas, or which combination of these three areas of C2, is to be evaluated. As any one area may interact and influence one or more other areas, it can sometimes be difficult to decide where to establish the limits of the system to be tested. This is a common dilemma not restricted to C2, as the world is full of systems interacting one with the other. Some systems may be considered components of bigger systems that in turn are components of even larger systems. The English poet, Jonathan Swift (1667-1745, from 'Poetry, a Rhapsody') described the situation succinctly when he wrote:

So, naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller still to bite 'em;
And so proceed ad infinitum.

As well, some of these sub-systems interact with multiple larger systems. For example, an individual human may be a component of the nation system, of their religious beliefs system, of the local school's transport system, of their employment system, etc. Hitchins (2000, p 1) describes this as a '…nesting model, of systems within systems, within systems…' Having determined the limits of the system to be tested, it can now be said to be what Hitchins (2000, p 2) describes as a System of Interest (SOI).

System of Interest and Measures of Effectiveness

In order to establish the effectiveness of C2 and to formulate MOEs, a SOI must be agreed. This involves establishing the need for which the SOI is being offered as a solution and the formulation of MOEs to enable the testing of the SOI. The ideal sequence of events is to

- Identify the need;

- Identify the essential emergent properties;
- Formulate MOEs;
- Design solutions; and
- Test the solution(s) using the MOEs to establish if the SOI is effective or not.

In the case of C2, it is possible to establish several potential SOIs. A holistic view of the military organisation would require viewing C2 as a contributor to force effectiveness rather than being a SOI in its own right. There are other possible SOI such as the three generic elements of command arrangements, command, and command support control systems. These could be considered individually or combined. Each of these views will be discussed separately.

The operational force as the System of Interest

The operational force (ie. the commander's command) can be considered a SOI as it can be bounded and it exhibits emergent properties in being able to achieve a mission. As far as military organisations are concerned, it may well be the ultimate SOI. It is the military force that achieves in the field the very purpose of the organisation and all other elements of the military, including C2, exist to contribute to this force and its very purpose.

Drucker (1977, p 68) stresses the necessity for asking the question 'What is our business and what should it be?' While not proposing that the military is a business, indeed he is adamant that it is not, he does note that all institutions exist for a specific purpose and to fulfil a mission. '…any institution-is defined by its contribution; everything else is effort rather than result' (*ibid*, p 78). The business of any military organisation is to engage and impose the national will on an enemy and its contribution is the security of society. It does this by fighting and winning battles and wars. General Colin Powell (1995, p 135) states that '…operations are the reason why armies exist' and 'if you are considering getting into Vietnam, Kuwait, Somalia, Bosnia, Panama, Haiti, or wherever, go in with a clear purpose, prepared to win – or don't go' (*ibid*, p 198). 'Our society and the institution look to commanders to make sure that missions succeed…' (FM 22-100, 1999).

The sole justification for the existence of C2, whatever meaning is attributed to it, can be seen as a component of this SOI in the same sense that naval fleets, bomber squadrons, brigades, logistics systems, training establishments, field hospitals, etc. are components of the military system. The elements of a system, in this case a military system, interact and produce emergent properties that cannot be explained by the individual contribution of any component element. The military organisation is a 'meta system' from the view of C2 and it is suggested that the ultimate SOI associated with a military organisation is the force assigned an operational mission

The emergent property of the military organisation is the ability to succeed in achieving the mission for this is the sole purpose of the military. As a component of the military system, the effectiveness of the C2 system, when viewed in this manner can only be judged by whatever contribution it makes to the mission of the military meta-system. This requires an analysis of how well the military system achieved its mission. From amongst the myriad of interacting elements that make up the system, it is necessary to try and identify how the various generic groups of C2 contributed. Sometimes this is relatively easy and this contribution, or the lack of contribution, is so obvious that it can be identified.

The disadvantage of this approach is that instances where the contribution is so obvious are exceptional because the contribution of C2 is generally lost amongst the synergy that occurs when all the components of a complex system combine to provide the emergent properties of the meta-system. If the contribution that C2 makes was always obvious then an MOE such as 'Contribution to mission accomplishment' would be simple to establish and, more importantly, to test. But the contribution is rarely obvious and formulating an MOE to capture qualities that will indicate contribution is difficult. This is more so when it is remembered that the MOE must be capable of being evaluated and that an MOE that cannot be evaluated in some manner is of little use.

An advantage is that, given appropriate scenarios, the 'unknown unknowns' will have come into play giving rise to a greater level of confidence in the results. For example, the introduction of computer based information systems has demonstrated the need for personnel to remain current with the use of software even though they may only use it when in the field. It is a skill easily forgotten. While the member's records may show proficiency in the use of the equipment, only actual operations in the field will demonstrate the real degree of knowledge.

Approaching the establishment of C2 effectiveness via a holistic approach using the force as the SOI has the advantage of providing good levels of confidence in the results, dependent on the quality of the methodology used. However, it is not always a practical approach. Not every military force has the resources to carry out suitable tests under controlled conditions due to the need to achieve other aims such as training, the effect on operational readiness, and cost. It may be possible for the largest military forces to attempt this but it would be beyond the resources of most countries. An MOE is useless unless it can be the basis of a test and at some point a decision has to be made as to what is practical and what is not. This is what Simon (1984, p. 138) calls 'satisficing' or the acceptance of a satisfactory as against an optimal solution. This is a term used frequently in the literature, for example Krosnick and Alwin (1987) wrote about it as a general phenomenon amongst people answering opinion surveys. Principia-Cybernetica says when 'a decision maker who settles for a less ambitious result and obtains the optimum he can compute under given time or resource constraints (he) is said to satisfice'. The implication is that if the SOI chosen cannot be tested for effectiveness, then another SOI must be chosen even though it may not give an optimal solution. It is applying the principle that some information will be better than no information. Candidates for the less holistic SOI of the force are the three elements of C2 previously identified.

Consideration of these elements in isolation requires a deliberate decision to ignore the effects of other variables on the isolated component and to put aside the emergent properties of the force as a whole. The system boundary has been re-drawn from including the entire military system to just include a particular component of the system. This reductionist approach has the advantage of being easier to achieve but has the disadvantage of providing a reduced level of confidence in the results. Van Crevald (1985, p 265) illustrates why this lowering of confidence in the results occurs when he observes that '…command cannot be understood in isolation'. Treating each element in isolation without the interaction of the other elements makes no concession to the existence of 'unknown unknowns' or the effect of the interaction of the other components on each other.

Command Arrangements as the System of Interest

Command arrangements can be considered a system as they provide for the need for unity of purpose and/or unity of command. Within the system there is emergence in the form of unity of command or of purpose as well as interaction between the various headquarters and commanders involved.

It is possible to test command arrangements for their effectiveness in achieving unity of command or of purpose by qualitative means. In fact, military historians are consistently doing this. It is a process that engenders considerable and lengthy debate on aspects of the arrangements that sometimes is never fully resolved. For example, agreement on the effectiveness of the Allied Combined Bomber Offensive in Europe from 1942-45 is yet to be achieved over 50 years later. However, it is possible to obtain some result.

Command as the System of Interest

If command is viewed as being vested solely in the person of the commander, then it can be said to be a system providing for the management and coordination of the force. The commander is a system with various factors such as past experience, training, moral values, courage, etc. interacting.

The effectiveness of a commander can be tested using techniques such as analysis of performance during operations and exercises, from Command Post Exercises (CPX), Tactical Exercises Without Troops (TEWT), and by modelling and simulation. The means employed are often subjective and results can be subject to dispute. For example, will the innovative and unconventional – even radical - approach be appreciated and be recognised for its real potential?

Command Support Systems as the System of Interest

It is suggested that there is no command support system *per se*. Rather there is a group of entities that are systems in their own right that collectively support the commander in the pursuance of the commander's mission. They do not necessarily form a hierarchy nor have communications and control between each other. Emergent properties are a characteristic of individual systems rather than as a characteristic of the collection of all systems in this category. The emergent properties of command support systems, when chosen as SOI, may have little apparent influence on mission effectiveness.

Thus, the more this SOI varies from the primary SOI, the more difficult it is to establish the amount of contribution that it makes to mission success. One could say with a high level of confidence that a commander, shown to have good situational awareness, will contribute significantly to mission success. On the other hand, while it is possible to establish the effectiveness of a SOI encompassing a mobile bath unit, one could not establish its contribution to mission success with any great level of confidence. It contributes but to what extent? In principle, a similar situation applies to assessing the effectiveness of command support systems.

Attempts to establish the effectiveness of such SOI by quantitative methods is more likely to establish performance rather than effectiveness. If this occurs, then it becomes a futile exercise. Qualitative techniques, especially those developed by the behavioural sciences may offer a means to at least provide an indication of the level of effectiveness of elements of the command support system. There is scope for the use of interpretive methods to establish at least an idea of the contribution of such SOIs to mission effectiveness. Such an approach is described by Sproles (2000b) in the evaluation of the effectiveness of the Australian Army Battlefield Command Support System (BCSS).

Using interpretative methods to establish effectiveness

The difficulty in carrying out such a task is the problem of establishing if the SOI has or has not made a contribution to the accomplishment of the operational mission. The approach taken in this case was much along the lines suggested by Dey (1993) in Chapter 3. Due to a lack of opportunity, a snapshot was taken of an Army formation that had experience in the field with the use of BCSS. The process, as described by Dey(1993) was to collect data, sort it, categorise it, and to make connections enabling a conclusion. The data collection was achieved by interviewing a cross section of members of the formation from the commander down to private soldiers. In this manner it was possible to obtain the views of professionals on a professional matter.

Interviews were carried out face-to-face with the interviewees at their workplace. The questions were prepared beforehand and were categorised based on existing knowledge of how an effective C2 support system was likely to contribute to mission effectiveness. On completion of the interviews the data was entered into Nvivo, a computer based qualitative analysis tool. This permitted the responses to be categorised either into the existing categories or for new categories to be established. At all times, the aim was to funnel data into relevant categories for analysis to enable a conclusion to be made on the contribution of BCSS to mission effectiveness. In the process, some existing categories were amended in scope, new categories were established, and some categories were allowed to overlap. When this was completed, it was possible to make comparisons between the responses and to make connections between the different pieces of data. A search was made to establish regularities, exceptions to these regularities, and even singularities ie. when comments were made that no one else had made.

It was possible from this to develop a picture of how effective BCSS was at this stage and to draw some conclusions on its future effectiveness. Admittedly this was not a rigorous process due to the limited opportunity and the taking of samples at one point of time only. On the other hand, the data is still available for future use. Given opportunities in the future to carry out a similar exercise, the results can be compared to build up a richer picture. The existing data can be combined with the new data and even be re-categorised if so desired. This exercise demonstrated that qualitative (interpretative) techniques were feasible in establishing the effectiveness of a command support system.

Conclusions

The difficulty in establishing metrics for C2 is largely due to the confusion in what is meant not only by C2, but also by terms such as MOE and MOP. The confusion surrounding C2 is dispelled when it is realised that discussion centres around one of three generic meanings. For want of better terminology, these can be called command arrangements, command, and command support systems. These terms can easily be mapped onto a model of the military organisation.

Using the systems approach, it can be shown that MOEs are appropriate when a system is being viewed in a holistic manner, ie. externally, and where the emergent properties of the system are of interest. If, on the other hand, it is the internal properties of the system that are considered to be of interest, then MOPs are the appropriate measure. A SOI determines the boundaries of the system that will be subjected to testing based upon the MOEs. The SOI that offers the best chance of establishing the effectiveness of C2 is that of a force being tested against a range of scenarios. In the absence of such an SOI, generally for practical reasons of opportunity or cost, other SOIs must be determined. These will provide data from which a conclusion may be reached but only with a reduced level of confidence.

The realisation of the three meanings applied to C2 and an understanding of the nature of MOEs and MOPs will reduce significantly the difficulties associated with formulating measures for C2. An understanding of the systems approach to the problem of evaluating C2 establishes the ultimate test for C2 as lying in an analysis of the effectiveness of the commander's force. It also enables a less than perfect reductionist approach to be made with the full realisation of the limits of such an approach. The result of this is a framework upon which C2 assessment can be built while providing rigour to the process.

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