17th ICCRTS: Operationalizing C2 Agility

"Achieving Agile C2 by
Adopting Higher Levels of C2 Maturity"

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Abstract

Alberts (2007) has identified three concepts that form the core of the conceptual basis for command and control of complex endeavors in an uncertain environment: agility, focus and convergence. "*In brief, agility is the critical capability that organizations need to meet the challenges of complexity and uncertainty; focus provides the context and defines the purpose of the endeavor; convergence is the goal seeking process that guides actions and effects*".

These concepts are captured by the NATO Network-Enabled Command and Control (C2) Maturity Model (N2C2M2 which is discussed in this paper. The N2C2M2 is particularly apt at the present time since both the US and European nations are facing complex and uncertain futures, with the emphasis on coalition-based defense.

The N2C2M2 defines a set of variables that characterize the inter-organizational structure, namely patterns of interactions and information flows between and among a disparate set of entities (which we term a 'collective') that are participating in a Complex Endeavor, and delegation of decision rights by entities to the collective. The N2C2M2 defines five C2 approaches that may be practiced by the Collective (conflicted, deconflicted, coordinated, collaborative, edge) and describes the C2 Maturity and Agility of the Collective in terms of its ability to select, adapt, and employ an appropriate C2 approach to meet the challenges posed by the complexity and uncertainty of the operational environment and the nature of the response required.

Complex Endeavors are typically characterized by diverse multinational coalitions of military and non-military organizations and entities. Case studies and experiments undertaken to validate the N2C2M2 have shown (inter alia) that the C2 Agility of the Collective is more or less limited by the approaches to C2 practiced by the various participants and the capabilities of the systems that support them. These studies and experiments also provide evidence that improving Collective C2 Agility requires that the participating entities have the ability to choose from and adopt a wider range of potential C2 approaches so that they may change their C2 approach as operational circumstances change. This capability is what we refer to as C2 Maturity. Two case studies on the response to complex natural disasters (hurricane Katrina and the Indian Ocean Tsunami 2004) are revisited at the end of the paper. They support the hypothesis that C2 Maturity and C2 Agility go hand in hand.

Keywords: Agile C2, Network-enabled capability (NEC), Networked-enabled C2 (NEC2), NEC value chain, operational uncertainty, complex endeavors, complex adaptive systems, adaptive campaigning, C2 maturity and agility,

Introduction

Command and Control (C2) Agility is the ability to effect, cope with and/or exploit, either reactively or proactively, changes in circumstances.[1] In an uncertain and dynamic operational environment, C2 Agility is the critical component of operational agility. The operational agility of an organization is, itself a well-defined and much desired existential capability[2]. Whatever potential agility an organization may have cannot be brought fully to bear in a Complex Endeavor[3] unless C2 is itself agile. Most 21st century mission challenges are thought to involve Complex Endeavors for addressing diverse security threats originating, for example, from weak or failed states, large-scale natural disasters, population growth, insurgency and stabilization, and dwindling natural resources.

The importance of and ways to improve C2 Agility have emerged from the insights gained from a set of case studies and experiments that were carried out by the members of NATO RTO Task Group SAS-065 as part of their efforts to validate the assumptions underlying the NATO Network-enabled C2 Maturity Model (N2C2M2) developed by them.[4] These suggested that, from a viewpoint of efficiency, it is not necessarily the most networked-enabled C2 approach that is appropriate in a given situation. Rather, the appropriate C2 approach is a function of the degree of complexity and dynamics of the mission environment. Thus, C2 Agility encompasses the ability of an organization or a Collective to select an appropriate C2 approach and, if necessary, adaptively change its C2 approach to effectively and efficiently meet the challenges of a dynamic operational environment. In its initial selection of a C2 approach, SAS-065 found that an entity should take into consideration not only current conditions but also factor in the frequency and significance of anticipated changes in circumstances. In other words, an entity's C2 Agility reflects an organization's or a Collective's ability to adapt its C2 or management approach to efficiently cope with or exploit changes in operational circumstances.

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[1] See also Alberts (2011), p. 189,

[2] Operational agility has traditionally been defined in term of a synergistic combination of six attributes of an organization: robustness, resilience, responsiveness, flexibility, innovation, and adaptability (Alberts and Hayes, 2003).

[3] NATO RTO-SAS-065, 2010, Chapter 2 pages 8-11

[4] Co-chaired by these authors, SAS-065 comprised some 40 experts from 15 nations and NATO organizations who contributed to its product as documented in the report (see ibid, p. xii, Table i.)

In what follows, we will briefly explain the N2C2M2 as the conceptual underpinning of C2 Agility and discuss selected results from SAS-065 case studies that support the assumptions underlying the N2C2M2. Theory suggests that an entity's (in this case a Collective's) degree of C2 Agility is limited by the C2 Approaches available to it (these range from De-conflicted C2 to Coordinated C2, Collaborative C2 and Edge C2). For example, a significant degree of Collective C2 Agility may be achievable from '*adaptive campaigning'* which assumes that all of the involved entities agree to practice a form of Collaborative C2 based on a common, shared and adaptable campaign plan.[5] Maintaining mission effectiveness however, may require that Collectives have the ability to transition from Collaborative C2 to Edge C2. Such a transition involves enabling embedded organizations and/or participating entities to practice "emergent" self-synchronization based on "Power to the Edge" principles (Alberts and Hayes, 2003). This is most likely to apply to small, 'hardened' groups with high levels of trust and a rich shared understanding of both their capabilities and the context. In fact, Collectives practicing such Edge C2 in Complex Endeavors can be thought of as *Complex Adaptive Systems*.

In summary, it is argued that building agile operational capabilities is an essential response to the complexity and uncertainty of the future operational environment, and that C2 Agility is a necessary enabler.

The Basic Idea: the Network-Centric Operations Value Chain

Complex endeavors are characterized by a set of diverse participating entities that are connected, or networked, and thus principally capable of collectively generating coherent effects and improved mission effectiveness through leveraging their connectedness. The basic mechanism for taking advantage of such connectedness is captured by the value chain of network-centric operations that stretches over the four domains as illustrated in Figure 1:

[5] Tatham (2008) points out that a core issue of adaptive campaign planning "will be the ability to effectively orchestrate, innovate and adapt effort across all arms of government to achieve effect at the right time".

- The physical domain where effects take place;
- The information domain where information is created, processed and shared;
- The cognitive domain where beliefs, values, perceptions, awareness and understanding reside and where, as a result of sense making, decisions are made;
- The social domain where entities interact by sharing resources, awareness and understanding.

Mission effectiveness in the physical domain depends on the quality of and the degree to which the activities in the information, cognitive, and social domains may unfold, given the constraints of the C2 approaches practiced by the participating entities (Alberts and Hayes, 2003).

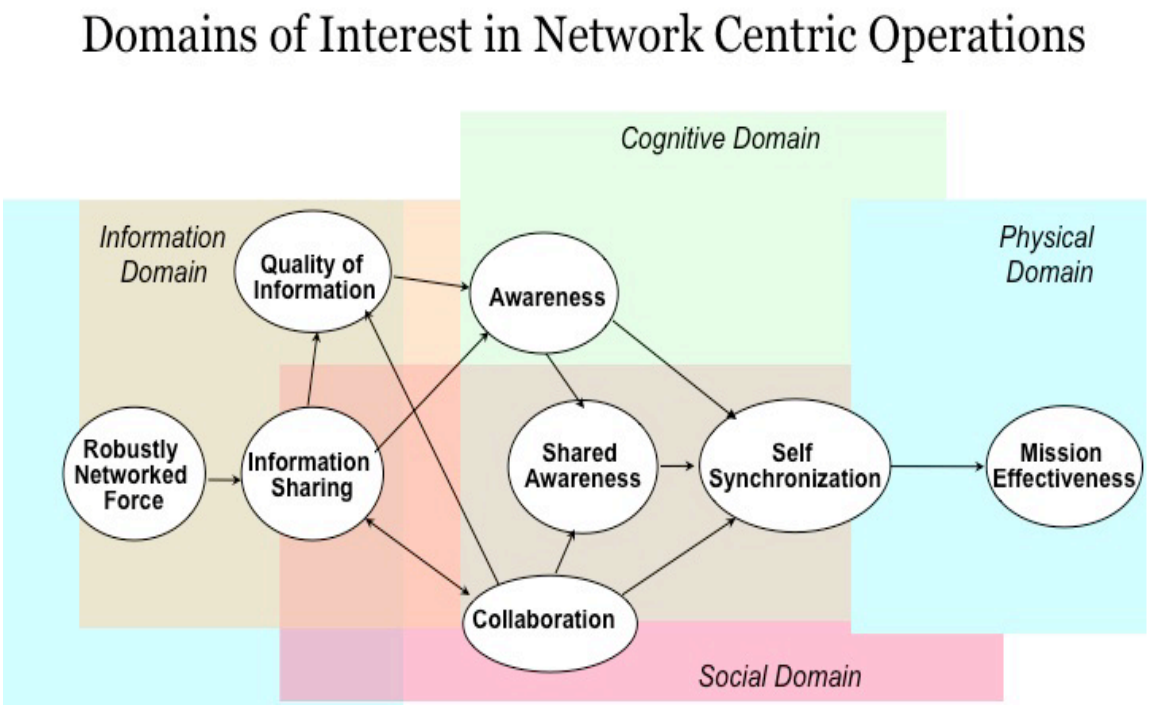

Figure 1: Network-Centric Operations Value Chain (Alberts and Hayes; 2003)

C2 Approaches and the C2 Approach Space

Consistent with the five levels of operational capability defined by the NATO Network-Enabled Capability (NEC) Feasibility Study (NC3A, 2005) and depending on their objectives[6], the N2C2M2 has grouped the set of available C2 Approaches into five classes each characterized by three variables:

1) The degree to which information is distributed among entities;[7]

2) The patterns of interactions among entities (see Figure 4 below);

3) The degree to which decision rights are delegated by entities to the Collective (the nature and extent to which decisions rights held by individual entities are transferred to the Collective).

The regions in the three dimensional Approach Space within which these five classes of C2 Approaches are located are shown in Figure 2. These regions lie sequentially along the diagonal vector of this C2 Approach space, with Conflicted C2 at the origin and Edge C2 in the upper, rear, right hand corner. Readers should note that the axes are not independent of each other. As an entity moves along this vector, its approach to C2 becomes more network-enabled and the domain focus changes (NATO-RTO-SAS-065, 2010).

For example, as one moves up the left hand side of Fig.2, the frequency of interactions among entities increases and thus their focus shifts from the Information domain (from sparse to rich exchange of information) to the Cognitive domain (toward higher degrees of situational awareness) and to the Social domain (toward higher degrees of shared awareness and understanding and increased sharing of resources).

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[6] In ascending order of capability, the five levels of NATO operational capability (and corresponding C2 approaches) are 1) Disjointed Operations (Conflicted C2); 2) De-conflicted Operations (De-conflicted C2); 3) Coordinated Operations (Coordinated C2); 4) Integrated Operations Collaborative C2); 5) Transformed Operations (Edge C2).

[7] In large part, information distribution determines their respective Entity Information Positions in terms of their relevance, timeliness, and accuracy of information vis-à-vis an adversary, For an a detailed explanation of the term *Information Position* please see Alberts et al. (1999), p.56.

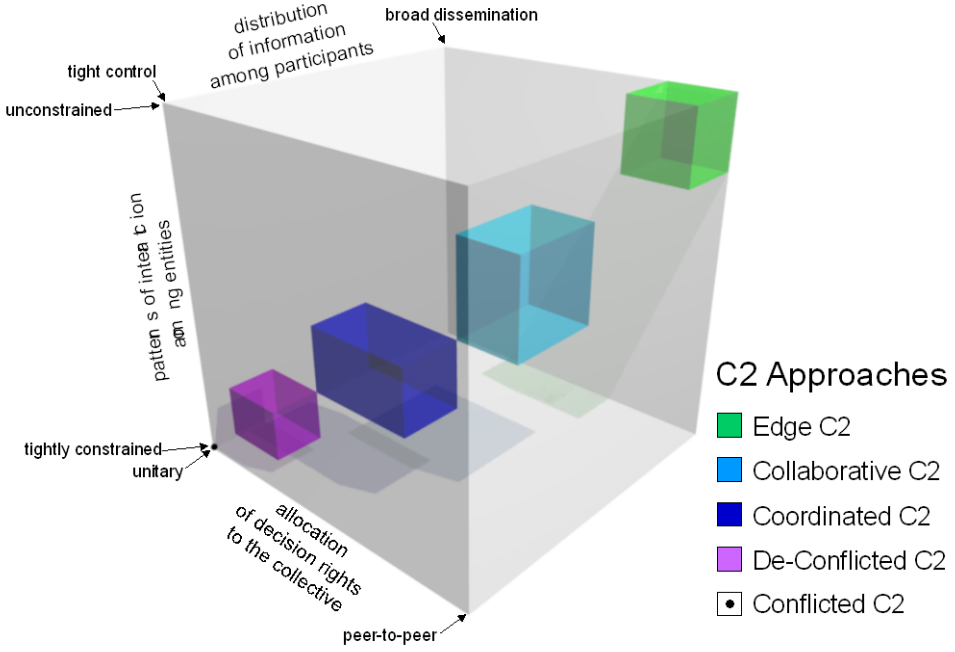


Figure 2: C2 Approaches and the C2 Approach Space (SAS-065)

The regions occupied by each of the C2 Approaches are summarized in Figure 3 in terms of the values of the three defining variables listed across the top. The gaps between Conflicted and De-conflicted C2, and between Collaborative and Edge C2, indicate that there is a qualitative difference between them with regard to allocation of decision rights to the Collective. In the case of Conflicted C2, there is no interaction among participating entities and no delegation of decision rights at all from individual entities to the Collective. The entities operate in a stand-alone mode based on their organic information only. Thus, in practical terms there is no Collective established in case of Conflicted C2. In case of Edge C2, an emergent, tailored and dynamic process is expected, as opposed to the well-defined allocation processes seen in De-conflicted, Coordinated, and Collaborative C2. The dashed lines between the latter indicates that the exact boundaries between them are difficult to define precisely, and the two-headed arrows signify that the transition between

them can be affected by changing constraints regarding patterns of interaction and distribution of information.

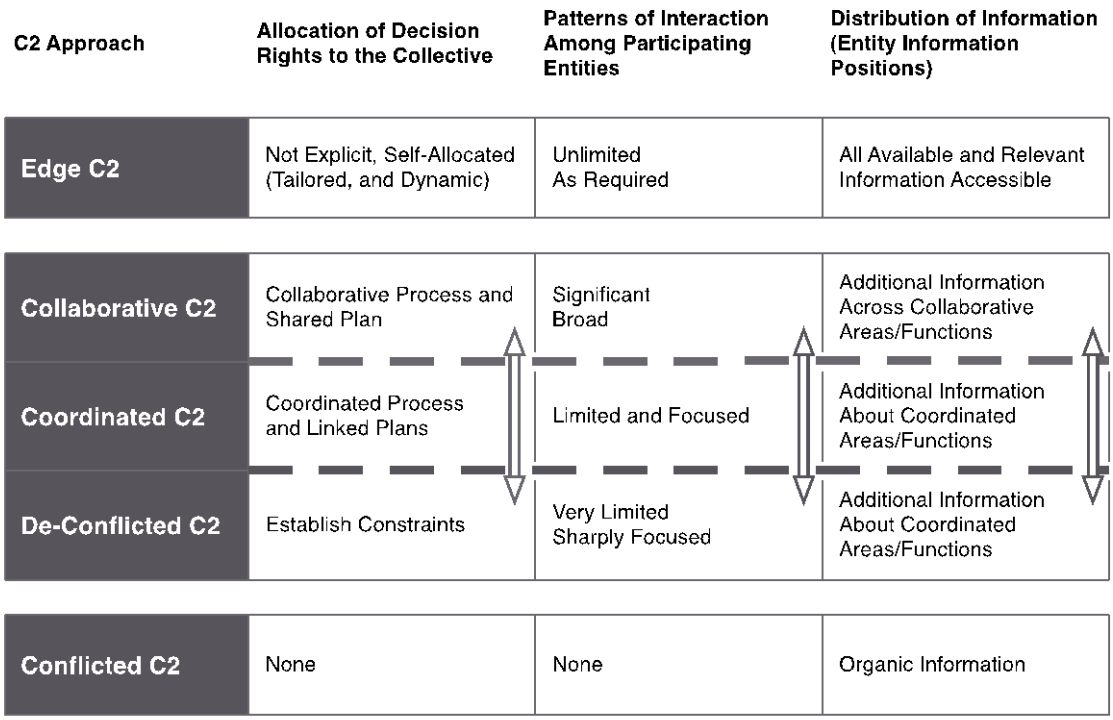


Figure 3: Variables defining collective C2 Approach (SAS-065)

In addition to the three characteristic variables, there are a number of other entity properties enabled by the characteristics of a C2 approach that can be used to distinguish between and among C2 approaches. These include the degree of the shared awareness[8] and the degree of task-based organization across the Collective, both of which increase as C2 approaches become more network-enabled.

C2 Maturity and C2 Agility

The Network-Centric Maturity Model proposed by Alberts et al. (1999) was about entities becoming more network-centric with the term "C2 maturity" reflecting the ability of

[8] The degree of shared awareness across the Collective is – together with degree of shared understanding and the adaptability of the Collective C2 process – a measure of C2 effectiveness.

C2 approaches to develop more shared awareness and then ultimately to exhibit increasing ability to manifest self-synchronizing behaviors. Based on the insights from validation case studies and experiments conducted by SAS-065, it was apparent that the terms "more net-worked enabled" and "more mature" were being used synonymously. Therefore, the members of SAS-065 reserved the use of the term C2 Maturity to describe the capability of an entity to move around in the C2 Approach space in an appropriate manner. Thus, C2 Maturity includes the ability of a C2 or management system to recognize the situation-dependent appropriateness of different C2 approaches, and the ability to transition between them.[9]

To this end, NATO SAS-065 introduced the toolkit analogy that views each C2 'maturity level' having a toolkit at its disposal that has a number of C2 approaches in it, and the ability to transit between the available approaches. As shown in Figure 7, Level 1 of the C2 maturity toolkit has only the Conflicted C2 approach in it; for C2 maturity level 2 only De-conflicted C2; for C2 maturity level 3 De-conflicted and Coordinated C2; for C2 maturity level 4 De-conflicted, Coordinated, and Collaborative C2; and C2 maturity level 5 has all four approaches in its toolkit. C2 agility requires an ability to match the right tool to the task. Alberts (2011) proposes using Agility Maps to visualize and compare the relative agility of two or more approaches to C2 (called C2 Approach Agility) or two or more "C2 tool kits" (called C2 Agility) and two metrics to measure the degree of agility. The first of these simply looks at the percentage of Endeavor Space where the entity's selected C2 Approach is successful. A failure could be a result of not having any appropriate C2 Approach in one's toolkit for the situation in question or from an inability to recognize the situation and adopt the appropriate approach.

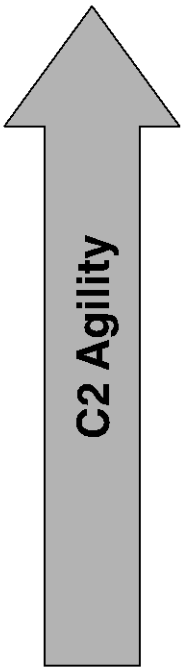
Thus, having the requisite classes of C2 approach in an entity's or Collective's C2 system repertoire is necessary but not sufficient for being able to respond in a timely manner or exploit situational change involving one's own coalition (self), the mission and/or the en-

[9] Based on a comparison of the results of two case studies of natural disaster relief endeavors (Elbe Flood of 2002 in the eastern part of Germany and the Tsunami 2204 in Aceh), it was concluded that whether or not a given C2 approach is sufficient or appropriate to handle a situation depends on the situational complexity and the dynamics of the operational environment. Thus the terms requisite maturity and requisite agility were proposed to describe the capability of a C2 or management system to transit between "appropriate" C2 approaches in dynamic operational environments characterized by more or less frequent changes of situation (Huber et al, 2008).

vironment. To this end, entities must also able to recognize which of the C2 approaches in their toolkit is appropriate to cope with changes as they are recognized, emerging, or anticipated, and they must have the ability to transition to the appropriate approach.

Deep shared situational understanding is required in order to anticipate situational changes that may overwhelm a Collective's operational capabilities unless counteracted in time to cope with them, or to preclude or elude situational changes altogether.

As shown in Figure 4, SAS-065 hypothesized that as an entity possesses a more mature C2 capability, it will become more agile. Thus, SAS-065 concluded that as C2 maturity increased it would result in increased C2 Agility.



C2 Capability Levels	Contents of C2 Toolkit	C2 Approach Decision Requirement	Transition Requirements
Level 5	Edge C2 Collaborative C2 Coordinated C2 De-Conflicted C2	Emergent	Edge C2 ↔ Collaborative C2 ↔ Coordinated C2 ↔ De-Conflicted C2
Level 4	Collaborative C2 Coordinated C2 De-Conflicted C2	Recognize 3 situations and match to appropriate C2 approach	Collaborative C2 ↔ Coordinated C2 ↔ De-Conflicted C2
Level 3	Coordinated C2 De-Conflicted C2	Recognize 2 situations and match to appropriate C2 approach	Coordinated C2 ↔ De-Conflicted C2
Level 2	De-Conflicted C2	N/A	None
Level 1	Conflicted C2	N/A	None

Figure 4: C2 Maturity Levels and C2 Agility (SAS-065)

Complex Endeavors and Complex Adaptive Systems

The term "Complex Endeavors" has been used here to refer to undertakings that have one or more of the following characteristics.

1. The number and diversity of the participants is such that;
    a. there are multiple interdependent 'chains of command',
    b. objective functions (goals) of the participants conflict with one another or their components have significantly different weights, or,
    c. participants' perceptions of the situation differ in important ways.
2. The effects space (situations) spans multiple domains (Physical, Information, Cognitive and Social) and there is
    a. a poor understanding of networked cause-and-effect relationships, and
    b. difficulty in predicting the precise effects that are likely to arise from alternative courses of action.

These characteristics reflect six principal characteristics of Complex Adaptive Systems and their relationship to Information Age warfare as described in (Moffat, 2003):.

1. **Non-Linear Interaction**. This can give rise to surprising and non-intuitive behaviour, on the basis of simple local co-evolution as in combat forces consisting of a large number of nonlinearly interacting entities.
2. **Decentralised control**. Natural systems, such as the co-evolution of an ecosystem, or the movement of a fluid front through a crystalline structure, are not controlled centrally. The emergent behaviour is generated through local co-evolution. There is no master "oracle" dictating the actions of each and every combatant.
3. **Self-Organization**. Such natural systems can evolve over time to an attractor corresponding to a special state of the system, without the need for guidance from outside the system. Local military action, which often appears "chaotic", induces long-range order.

4. **Non-Equilibrium Order**. This refers to the order (for example the space and time correlations) inherent in an open, dissipative system which is far from equilibrium. Military conflicts, by their nature, proceed far from equilibrium. Correlation of local effects is a key factor.
5. **Adaptation.** Such systems are constantly adapting – clusters or avalanches of local interaction are constantly being created and dissolved across the system. These correspond to correlation effects in space and time, rather than a top down imposition of large scale coincidences in space and time. Combat forces must continually adapt and co-evolve in a changing environment.
6. **Collectivist Dynamics.** The ability of elements to locally influence each other, and for these effects to ripple through the system, allows continual feedback between the evolving states of the elements of the system. There is continual feedback between the behaviour of combatants and the command structure.

Interpreting these observations we arrive at the following conclusions regarding Complex Endeavors and the agility of their Collective C2 or management:

- The number and diversity of participants result in a correspondingly large number of 'degrees of freedom' that, in turn, can generate a large number of different ways in which participants could interact.

- The interactions that can and are likely to take place among participants (one of the three dimensions of the C2 approach space) are directly affected by the other dimension of the C2 approach that has been adopted (distribution of decision rights, distribution of information). These interactions are affected by the nature of the perspectives of the individual participants, the amount of information that is shared, their individual qualities of awareness, and the extent of their shared awareness. Given the large number of factors that influence the nature of each interaction, it is reasonable to assume that these interactions will not be linear (thus small differences in initial conditions may lead to large changes in outcome).

- Multiple, interdependent chains of command mean that there is no single person in command, hence no "master oracle" dictating the actions of each and every combatant.

- An agile C2 capability requires that there be feedback between the behavior of the combatants (the circumstances and context) and the command approach adopted.

- Networked cause-and-effect relationships are likely to result in cascades of effects that ripple through the Physical and Cognitive domains (Smith, 2003). Our ability to predict these circumstances and the resulting effects is, at best, limited. However, we may be able to bound the range of values that could occur, or are likely to occur (Smith, 2003).

Case Study Examples

For the purpose of this paper we selected – from the 17 validation case studies performed by SAS-065[10] – two cases of major disaster responses that required truly complex endeavors: the impact of Hurricane Katrina on New Orleans and the surrounding area of the gulf coast of USA in 2005 and the effect of the Indian Ocean Tsunami of 2004, focusing particularly on the coastal province of Aceh in Sumatra and the medical response in Thailand. As the authors of the available reference materials on these events had not developed a data collection plan with C2 maturity in mind, the members of the respective SAS-065 working groups had to rely on their experience and exercise judgment in order to perform assessments of the factors characterizing the C2 Maturity of the Collective and entities participating in the endeavors. In order to facilitate comparisons between cases, a common template of factors was used that described their values in qualitative form for each of the five classes of C2 approach specified in Figure 2.

In addition to the three characteristic variables defining Collective C2 Approaches (see Figure 3), the common template included the following three groups of variables:

[10] They included five cases of combat and military exercises, six cases of peace operations in the Balkans, and three each of simple and complex disaster responses.

- Required Patterns of Interaction described in terms of 1) the degree of task-based organization across the Collective (tasks-oriented versus entity clusters); 2) the degree of inter-cluster connectivity; 3) the frequency/continuity of interactions.
- Measures of C2 Effectiveness across the Collective captured by 1) the degree of shared awareness; 2) the degree of shared understanding; 3) the adaptability of the Collective C2 process.
- Measures of Endeavor Effectiveness described in terms of 1) the relative effectiveness (synergies / negative cross impacts); 2) efficiency given effectiveness (efficient use of resources); 3) agility of the collective C2 process (constraints, timeliness).

Both of the cases presented below have shown that 1) Collective C2 maturity and agility go hand in hand, 2) the C2 Maturity and hence, C2 Agility, is more or less limited by the C2 maturity of the participating entities, 3) entity C2 Maturity is limited by the capabilities of entity C2 systems; and 4) observed instances of agile behavior, in both cases, were restricted to situations where the respective participants had, or were able to generate, the connectivity necessary to adapt their command and management systems and processes to the dynamic changes of the operational environment.

The Response to Hurricane Katrina

The Federal Planning Process

The National Response Plan (NRP) resulting from DHS Presidential Directive No. 5 in 2004 recognizes that planning, preparing for and responding to natural and other disasters are primarily responsibilities of the States. This reflects the US constitutional perspective, and results in a *pull* response assumption, with local authorities having the lead at the start, escalating to State level and then to Federal level, if necessary and if requested.

The ‘Stafford Act’ reiterates the philosophy that, in a disaster, local resources should be used first, then State and finally Federal resources. The Stafford Act also outlines the process by which State governors can request assistance from the Federal government when the event becomes one of ‘National Significance’. The US President then has to

decide whether this merits designation as an 'emergency' (releasing limited resources to the States), a 'Major Disaster' (releasing much greater resource to the States) or a 'Catastrophe'. The first two of these result in a 'pull' response; the States requesting and drawing down from these Federal resources as they see the event unfolding. The third category of 'catastrophe' was only being formulated at the time of Katrina, and had not been fully implemented. If called for by the President, it would have resulted in a proactive 'push' of resources to the region without waiting for requests from State authorities.

Under the NRP, a comprehensive framework is set up of response to major incidents. At the Federal level, the Homeland Security Operations Centre, the FEMA (Federal Emergency Management Agency) National Response Centre and the Interagency Incident Management Group jointly coordinate the response across Government Departments. The Federal Coordinating Officer (FCO), a representative of the Secretary for Homeland Security, is authorized to lead a Joint Field Office (JFO). This is a temporary Federal facility established locally at the time of a disaster to coordinate the local, State and Federal response. It consists of senior representatives from all of the agencies and responders involved, and develop objectives, strategies, plans and priorities. The membership of this office is envisaged as growing and adapting over time as the incident escalates or diminishes.

The **Timeline and Response to Hurricane Katrina**

Table 1 below describes the evolution of the disaster over time and how the C2 approach adapted in response to these changing events.[11]

Table 1: The adaptation of the C2 Approach over time, in response to Hurricane Katrina

Date **Year: 2005**	**Activities**	**NNEC C2 Approach**
Wed Aug 24	• FEMA activates Hurricane Liaison Team –FEMA, National Weather Service, State, Local • DoD NORTHCOM issues Warning Order for supporting commands to prepare	**De-Conflicted/Conflicted C2** De-conflicted C2 between FEMA, National Weather Service and National Hurricane Center.

[11] A detailed account, is given in the working group paper by Moffat et al. (2008)

	• Planning Perception –"Adequate and Exemplary"	Conflicted C2 at the local level due to separate initial local responses.
Thurs Aug 25	• Local emergency preliminary responses within each State • First FEMA teleconference – Federal/State/local • Plans for evacuation and shelter • FEMA initial pre-positioning • Rapid needs and emergency response teams on alert • Local private sector entities respond	
Fri Aug 26	• Louisiana (LA) and Mississippi (MS) Governors declare states of emergency • Alabama (AL), LA and MS – Emergency Operational Centers expanded to highest readiness levels • LA Joint Operations (OP) Centre activated –LA, MS National Guard mobilized • FEMA daily video conferencing – Regions, Nat. Hurricane Center, Federal Agencies and Depts. – Exchange information; reconcile responses	**De-Conflicted C2** Limited interactions in the information domain
Sat Aug 27	• Phase 1 of LA Emergency Evacuation Plan –implemented and MS informed • LA and MS Departments of transportation linked –Evacuation transportation plans coordinated • FEMA activates National Disaster Medical Systems teams • FEMA and FEMA regional HQs in Texas (TX) and Georgia (GA) go to level 1 • FEMA Mobile Emergency Response Support Detachment deploys to LA from TX • Fed CO appointed (heads Joint Field Office) • LA and MS implement contra-flow plans • LA and MS deploy personnel and pre-position resources • Fed emergency declared by President after request from Governor LA • Governor AL offers assistance to LA and MS	**Coordinated C2** Limited linking of plans and actions

Sun Aug 28	• President calls LA Governor – Urges mandatory evacuation of New Orleans • FEMA video conference –President –Secretary, Homeland Security (DHS) –FEMA –National Hurricane Center –State Representatives	**De-conflicted C2** Periodic information exchange **De-conflicted C2** at President/State level

	• Regular briefings to President • "DoD fully engaged" (FEMA reports) • National Weather Service issues accurate warning of severity of impact (to all parties)	**Coordinated** C2 at the local/State level
Mon Aug 29	• Storm hits – Huge damage to power, communications – Damage to infrastructure, transport, healthcare – Mayor of New Orleans could not communicate for 48-hrs • LA and MS request National Guard assets from other States • Conflicting reports to local/State/Federal level – Inaccurate and incomplete information • Lack of situation awareness and Common Operational Picture (COP) – Breaching of levees unclear • Impossible to establish functioning incident command centers • Some emergency responders did not respond • Search and Rescue begins • Command structure broke down for local emergency response	**Conflicted C2** Search and Rescue begins
Tues Aug 30	• DoD Joint Task Force Katrina established • State and local officials begin to organize mass evacuation of New Orleans • FEMA organizes bus transportation – Buses arrived eve of Aug 31 • Search and Rescue fully committed	**Conflicted C2** Search and Rescue **De-Conflicted C2** for FEMA/State • Some plans and actions starting to be linked • Low level of coordination being established

Wed Aug 31	• LA and Federal level working together to plan evacuation to other States • DoD, DoT, DoS activities: – local delivery of food, water – plan further evacuation activities from New Orleans • No Federal active duty forces in the area – due to incorrect situational awareness • Large crowds at Convention Centre –no food or water • Federal Search and Rescue – Evacuees deposited on high ground with no coordination or unified command structure	**Conflicted C2** at local level and with DoD **Conflicted C2** for Search and Rescue **Coordinated C2** planning in parts of Federal/State levels

Fri Sept 2	• Superdome evacuation continues – 15,000 evacuated – 5,500 remaining	**Conflicted C2** for National Guard and Active Duty Force Beginnings of **De-Confliction** • using local liaison officers **Coordinated** planning in parts of Federal/State levels
Sat Sept 3	• Evacuation of Convention Centre starts – Food, water and medicine now available – 25,000 to be evacuated • Superdome evacuation continuing	**De-Conflicted C2** • for evacuations • between National Guard and Active Duty Forces via JTF Katrina
Sun Sept 4	• Evacuation mostly complete – Superdome and Convention Center	**Coordinated C2** between National Guard and Active Duty Force • via Joint Task Force Katrina
Mon Sept 5	• Vice Admiral Allen (Coast Guard) – Designated Deputy Primary Federal Officer	**Coordinated C2** Higher levels emerging
Tue Sept 6	• Establishment of Law Enforcement Coordination Center – Unified Command for Law Enforcement – New Orleans (NO) Police, LA State Police, National Guard, Federal Law Enforcement	**Collaborative C2** emerging

From Table 1 we can see that the initial planning and implementation prior to landfall of the hurricane worked fairly well. However the size and scale of the hurricane overwhelmed those facilities and forced the C2 Approach back down to the Conflicted C2 level. It then took some time to build back up again, reaching Collaborative C2 level by Sept 6, 2005. Thus, while over the course of the crisis response, entities were able to adopt different approaches to C2, the approach adopted was dictated by constraints and not by choice. Thus, C2 Maturity was limited and, as a result, limited C2 Agility was manifested.

The Indian Ocean Tsunami of 2004

The Indian Ocean Tsunami of 2004 is believed to have been the deadliest natural disaster in modern history. Fanning out across the Indian Ocean, the tsunami was triggered by a massive undersea earthquake that occurred in the morning of 26 December 2004 off the western coast of Northern Sumatra. It flooded coastal areas wiping away local infrastructures and killing over 227,000 and displacing some 1.7 million people in 14 countries around the Indian Ocean. A massive media-fueled response generated an unprecedented US$ 13.5 Billion in international aid. On the ground, the Tsunami disaster response was a truly complex endeavor involving military assets from 21 countries, numerous UN and foreign government aid agencies and hundreds of national and international non-government organizations (NGO). The SAS-065 Tsunami case study had its focus on the Indonesian province of Aceh and Thailand, both of which were among the countries hardest hit (Huber et al., 2007).

The International Disaster Response Process

International disaster response is coordinated by the Geneva-based UN Office of Humanitarian Affairs (OCHA) through the Interagency Standing Committee (IASC) chaired by the UN Emergency Relief Coordinator (ERC). IASC participants include all humanitarian partners from UN agencies, funds and program to the Red Cross Movement and non-governmental organizations (NGO). IASC ensures interagency decision making in response to complex emergencies including, among others, needs assessments, consolidated appeals for financial support of response plans as a basis for voluntary commitments by UN member countries, field coordination.

At the time of the Tsunami, OCHA disposed of about 1,100 staff members in New York, Geneva and some 20 field offices. In case of a disaster, OCHA dispatches UN Disaster Assessment and Coordination (UNDAC) teams to the countries hit to establish and prioritize the needs for aid and allocate arriving aid organizations to efficiently meet established needs consistent with the organizations' capabilities and support requirements.

Thus, UN disaster response management is designed as a process corresponding to Coordinated C2 that turned out, however, to be largely inadequate to efficiently manage a

complex endeavor such as the response to the Indian Ocean (Telford and Cosgrave, 2006; Schulze, 2005).

The Response to the Tsunami in Aceh

The case study undertaken by SAS-065 focused primarily on the three overlapping phases of the national and international response up to about six months after disaster had struck without warning in the morning of December 26, 2004. These Phases were 1) Search and Rescue, 2) Relief, and 3) Reconstruction. In the initial SAR phase, the first response mainly involved both Indonesian civilian and military entities followed, in the Relief phase, by a large number and variety of foreign actors, military forces, NGOs, and international organizations. By the end of December, 430 local and 124 international NGOs had registered in Aceh, by the end of March more than 380 humanitarian organizations in addition to numerous UN and foreign aid agencies.

For sake of simplification, the SAS-065 case study team on Aceh grouped the some 900 organizations participating in the response into eight clusters comprised of 1) local individuals and agencies and local NGOs (LIAN); 2) Regional and provincial agencies, national NGOs (RAPN); 3) National military forces (NMF); 4) International military forces (IMF); 5) United Nations and Red Cross/Red Crescent (UNRC); 6) International governments and government agencies (IGGA); 7) International NGOs; 8) National government and government agencies (NGGA). The approximate arrival and exit times of these responder clusters are shown in Figure 5. By agreement with the respective governments, the presence of international military forces (IMF) ended by 26 March 2005.

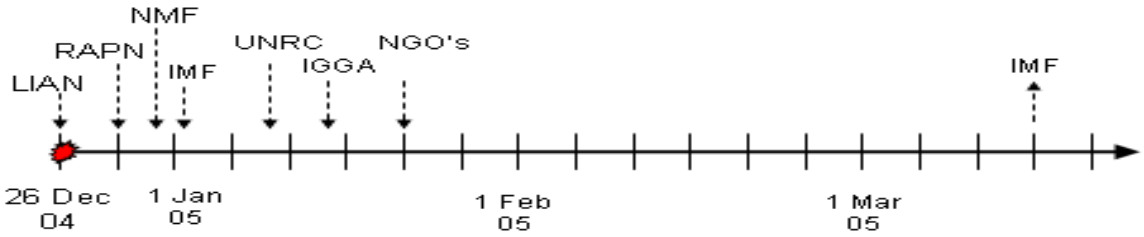


Figure 5: Arrival of Disaster Aid Organizations in Aceh

Based on the facts identified in the reference materials for each phase of the disaster response, detailed assessments of the C2-relevant relationships between these groups of participants were made indicating that relationships between military and non-military entities were generally conflicted.[12] Therefore, assessment results were summarized separately looking at civilian and military actors as units of analysis in phases 1 and 2.

Phase 1 - Search and Rescue (S&R): Since lines of communications were destroyed or dysfunctional, surviving[13] local officials in Aceh were isolated. Nevertheless, the high degree of collaboration in and among S&R teams, self-organized ad hoc by locals, suggested that, within the reach of whatever means of C2 were left locally, C2 was Collaborative on all three of the variables defining the Collective C2 approach as well as those describing the required pattern of interaction. However, measured across the impacted area, the relative effectiveness and efficiency given effectiveness was assessed to correspond to Conflicted C2.[14]

The responding Indonesian military's C2 approach was judged to correspond to Coordinated C2 except for the variable describing their performance (efficiency given effectiveness). Its rating as De-conflicted C2 reflects their segmentation of effort.

All other actors present during Phase 1 (mainly NGOs) were functioning on a level corresponding to Conflicted C2 because they had no capability to organize their efforts, no reliable means to share information, and no coherent approach to allocating decision rights.

Phase 2 - Relief: Independent activity by local councils all but disappeared under the weight of civil authority from national and regional government and a massive international NGO presence.[15] Considering all civilian activity as a unit of analysis, SAS-065

[12] This was especially the case for the relationships between international NGOs and the military. Due to the longstanding separatist conflict between the Free Aceh Movement (GAM) and the Indonesian government, the Indonesian military (TNI) considered international NGOs as potential supporters of GAM. Vice versa, the NGOs did not approve the TNI's involvement in the relief effort claiming that TNI was directing aid away from GAM areas (Telford and Cosgrave, 2006).

[13] In Aceh, about 60 senior leaders of civil society and 5,200 staff from local authorities had died and another 2,300 were missing (Schulze, 2005).

[14] It took a week to get the first phone lines working again. This left only the military which had its headquarters in the capital Banda Aceh and were themselves hard hit (Comfort, 2007).

[15] On December 28, two days after disaster had struck, a United Nations Disaster Assessment and Coordination (UNDAC) team arrived in Aceh to deploy and coordinate international aid. It was quickly overwhelmed by the sheer number of unsolicited international aid triggered by a massive media

concluded that on the variables defining Collective C2 approaches these efforts remained at Conflicted C2, various efforts to coordinate work on a functional level (food, housing, etc.) notwithstanding.[16] However, the interactions between the clusters / actors involved were sporadic and only frequent enough to allow De-conflicted C2. Since the variables measuring C2 effectiveness (shared awareness and understanding, adaptability of the Collective C2 process) were rated to reflect Conflicted C2 as well, SAS-065 concluded that the entire civilian Tsunami relief endeavor in Aceh was at the level of Conflicted C2.[17]

By contrast, the military actors, which eventually included forces from 13 countries, were able to establish Collaborative C2 at the senior level across the three variables defining Collective C2 approaches.[18] The reported top level interactions were rated to have been on the level of Collaborative C2 on both shared awareness and understanding, and adaptability of the Collective C2 process. However, because of structural and cultural differences between the militaries involved, the patterns of interaction were mainly limited to the level of Coordinated C2 as collaborations were implemented in the field.[19] Thus, in terms of both the measures of C2 effectiveness and endeavor effectiveness, the overall the effectiveness of the multinational military relief effort in Aceh was rated as corresponding to the Coordinated C2 approach.

Phase 3 - Reconstruction: In the SAS-065 case study, the term 'Reconstruction' includes the activities related to local recovery aimed at saving, protecting and generating livelihoods and communities. Building on recovery projects, reconstruction is often re-

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campaign proclaiming that any hand is needed. UN figures show that more than 50 aid organizations and 11 military task forces had flooded into Aceh by January 12 and more than 100 international NGOs by January 19, 2005. Many of the civilian volunteers showed up without supplies and transportation and thus became a burden on the infrastructure. Also, there were turf wars between NGOs competing for projects and local human support (Oloruntoba, 2005).

[16] In fact, the proliferation of international actors to be coordinated combined with deep pockets of money meant that they had little interest in common services which made coordination difficulty, not to speak of the lack of continuity, skills and experience among some of the UN coordinators (Telford, 2006; Schulze, 2005).

[17] This is also true for interaction between military and non-military actors, especially international NGOs. Their relationships to both Indonesian and international military bordered on out-right hostility

[18] A military contingent from Singapore was the first arriving on December 28, 2004, followed by US, UK and some other countries beginning in January 1, 2005. Initially they had their tasks allocated by the Indonesian military that had the detailed local knowledge required for an efficient needs-based assistance (Schulze, 2005).

[19] The collaborations focused on aiding the Indonesian military with helicopters, field hospitals, and logistics assets.

ferred to as the long-term effort of "building back better" that started in May 2005 shortly after the Aceh and Nias Rehabilitation and Reconstruction Board (BRR) was established.[20] Reconstruction was carried out under the leadership of the Indonesian government, with NGOs and international organizations following its lead. Foreign militaries had departed by the end of February. Virtually all of the Variables for this phase were scored as reaching Coordinated C2. This clearly reflected the experience in the prior phases and the opportunity to learn how to work with one another. However, both relative effectiveness and efficiency were seen as De-Conflicted C2, indicating that the actions on the ground did not take full advantage of the C2 capability present.

Assessment of Agility of the Tsunami Response in Aceh

The agility of the Collective C2 process in the military area, i.e. the effectiveness of changes to the C2 approach over the three phases, was constrained by the established doctrine and training of the various militaries involved that, in turn, limited their operational agility (see footnote 2). While the value of Collaborative C2 was seen in some ways, it could not be carried over to the full suite of C2, both because of the relatively weak communication capabilities between the militaries of different nations, and because of an unwillingness or inability to become more interdependent.

The civilian entities involved across the three phases were rated as capable only of De-Conflicted C2 because it seemed that they had serious problems on agreeing on a goal structure that would allow them to implement a more network-centric C2 approach.

Emergent Self-Synchronization: Thai medical response to the Tsunami 2004

The response of the Thai medical system to the Tsunami that hit the beaches in southern Thailand (Phuket and Khao Lak) causing thousands of casualties is an example where the embedded entities were able to transition from initially Coordinated C2 to Collaborative C2 and ultimately Edge C2. The hierarchically organized system – consisting of local

[20] Reconstruction planning began as early as January 7, 2005, when World Bank President Wolfenson visited Aceh and launched the planning for a 'rapid and comprehensive' recovery program .In April, the Indonesian government released its blueprint. In May 2005, the Indonesian government established the inter-departmental Aceh and Nias Rehabilitation and Reconstruction Board (BRR) acting as the government's agency through which donor money was to be channeled. Shortly thereafter, the first housing projects were approved (Schulze, 2005; Comfort, 2007).

primary clinics for outpatient care (no hospitalization capability), district hospitals (30-90 beds), and provincial hospital (250-500 beds) – stood out in terms of its capability to adapt ad hoc to a situation it had never practiced before.[21] Most casualties were treated in the field or in primary clinics. To this end, mattresses and beds were rapidly organized to hospitalize patients until primary care was completed and secondary triage could be performed at a district or provincial hospital that had not been destroyed or severely damaged. District and provincial hospitals sent personnel and medical supplies to reinforce primary clinics. These "outreach teams" provided advanced life support, triaged casualties, informed the surgical center at their hospitals, and self-synchronized to selectively evacuate patients, in cooperation with Thai military ground and air transportation entities, to avoid overwhelming surgeons who simultaneously operated on two patients at a time for 48 hours without rest (Laiba et al.[22] 2006). This example supports the observation, that self-synchronization based on 'Power to the Edge' principles is most likely to apply to small 'hardened' groups with high levels of trust and a rich shared understanding of their capabilities and the context such as in this medical community.

Overall Conclusions

The primary purpose of our undertaking here was to report on the evidence, collected by SAS-065 that supports the hypothesized link between C2 Maturity and C2 Agility. We were also interested in seeing whether or not the N2C2M2 and subsequent work on C2 Agility were sufficiently "mature" to provide the necessary theoretical, methodological, and measurement framework to test C2 Maturity and C2 Agility related hypotheses and, more generally, explore issues related to these subjects.

Case Studies pose unique challenges. One is, of course, constrained by only knowing what happened and not what could have happened. Thus, while we found we could use the maturity model and the literature on C2 Agility to describe what we understood from the source materials on these natural disasters and the response to them, we could not go

[21] The annual Mass Casualty Incident drills of the Thai medical system involved up to 50 casualties.

[22] The authors were members of a research delegation of the Israeli Defense Forces that visited Thailand in late January/ early February 2005 to learn about the Thai medical response and to develop guidelines to help hospitals to prepare for future disasters.

back and test what would have happened if the entities in question took a different C2 Approach. Despite this obvious limitation, we felt that there was ample evidence to reach the following conclusions with regard to the relationship between C2 Maturity and Agility:

- The more complex and dynamic the mission and situation, the more network-enable the C2 Approach must be to succeed. Put another way, entities that adopt less network-enabled approaches to C2 are not able to successful cope with complex and dynamic missions and environments.

- Entities that had higher levels of C2 Maturity were able to adopt a more appropriate C2 Approach than entities that had lower levels of C2 Maturity.

- The more mature an entity's C2 capability, the more able it was to manifest agile behaviors.

- Being able to adopt Edge C2 in response to a rapidly changing context, an organization must be able to rapidly form task clusters of small teams "hardened" by professional competence and thus capable to self-synchronize. A good illustration of this can be found in the Thai medical organization's response to the Indian Ocean Tsunami

- The connectivity and performance of supporting systems can constrain the adoption of more network-enabled C2 Approaches and hence lower the effective maturity of entities. As a result, their agility will be compromised.

Given that the theme of this year's ICCRTS is "Operationalizing C2 Agility", we were also interested in ascertaining whether or not this community is equipped to take on the task of moving Agile C2 from a theory to military practice. In short, our answer is "Yes". Taken together, the results of the 17 validation case studies and experiments[23] underscore

[23]Using the experimentation platform ELICIT (Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust), 37 experimentation trials were conducted over a period of three years in

that the NATO NEC C2 Maturity Model provides a sufficiently well-developed and articulated conceptual framework to guide efforts aimed at empirically ascertaining the C2 Maturity and C2 Agility manifested by an entity or Collective in a particular set of circumstances. This makes it possible to look at projected behaviors and associate a degree of C2 Maturity or C2 Agility to simulated or predicted results and thus, to undertake a variety of C2-related analyses and assessments. These assessments are necessary to ascertain the effectiveness and efficiency of proposed ways to improve C2 Maturity and C2 Agility. This, in turn, prepares us to make progress in improving C2 Maturity and hence C2 Agility, in a systematic way which is on the critical path in a journey to "Operationalize C2 Agility".

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