

# 13<sup>th</sup> ICCRTS: C2 for Complex Endeavors

**Cajole and Coordinate? C2 in Whole-of: -Government, -Nation, and -Coalition Action**

Topics: 1, 2, 4

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# Cajole and Coordinate: C2 in a Complex Security Environment

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## Abstract

*This paper picks up where the succession of papers presented at the 10th, 11th, and 12th ICCRTS left off in examining multi-level, multi-arena, cross stovepipe learning and adaptation in "whole-of:" action. It focuses on the requirements for and impediments to, vertical and horizontal social networking, and the application of insights from the theory of Effects Based Approaches and the science of Complex Adaptive Systems, to identify strategies for developing more effectiveness and coherence in these complex operations. We will explore the three way tension between the individual, authority, and the community, and the nature of a dynamically adaptive approach to what used to be called Command and Control, but now needs a much broader reconceptualization.*

**Keywords:** Complexity, adaptation, learning, systems, social networking, comprehensive approach, coherence, multi-actor, effects-based approaches to operations.

## 1. Introduction: The Challenge

There is a spreading consensus among the major Western governments<sup>1</sup> that our current security environment is both asymmetric and complex: asymmetric because it pits nation-states against non-state actors in many guises; and complex because it involves very large numbers of continually changing interdependent variables. This consensus has been driven by real, immediate and continuing problems in the field and at home.<sup>2</sup> The familiar metrics of military success based on attrition of an opponent's physical means of waging war no longer seem to apply. International and domestic security and the tasks of peace maintenance, crisis prevention, crisis containment, combat, and post conflict stabilization have become inextricably intertwined to the point that the political, diplomatic, economic, social, cultural and military elements of each challenge have become impossible to separate. Additionally, relief operations for Hurricane Katrina and the 2005 Tsunami have demonstrated a similar complex, human centered challenge that required "whole-of-" responses spanning multiple levels of government, non-governmental actors, and international organizations. The result has been a turn toward broad effects-based thinking<sup>3</sup> centered on the relationship between a physical action of some form and the psychological and cognitive reactions to it. Such thinking revolves about four key foci:

- the *human dimension* of both problem and solution;
- the *complexity* of actors and the 'human terrain', result in the inability to understand entirely, to predict precisely or to reach a perfect decision; and
- the consequent *interconnectedness* of all actions across the peace-crisis-conflict-post conflict spectrum and across all aspects of cooperation, collaboration, competition and conflict; and hence lead us to
- A "*comprehensive approach*"<sup>4</sup> based on a multi-faceted whole-of-government, whole-of-nation, whole-of-coalition, whole-of-organization concept of power.

Given the complex, interdependent and continually changing nature of the problem, the key factors contributing to effectiveness in such a comprehensive effects-based approach are not the quantity of destruction inflicted or even changing public opinions as sampled by polls, but rather the relative rates at which actors are able to learn and adapt. What makes learning and adaptation in a comprehensive approach especially difficult is not only that it must occur on a continuing basis across the spectrum of operations but that it must also take place across the multiple arenas, levels and cultures of any "whole of" government/ nation/ coalition action.

All of the above argues for re-examining what we mean by terms such as "network" and "command and control." The major issue in a comprehensive effects-based approach is not communications connectivity or equipment

interoperability however important both may remain. It is the ability to enable rapid learning and adaptation by individuals and organizations at all levels of all arenas of interaction, and to do so in a way that fosters coherence in their actions and interactions in the complex security environment of which they are all parts. Thus the real challenges are more about improving social networking and hence growing the basis for coherence across stovepipes, and about continually adapting communications and “command” structures to support and enable such networking better and on a timely basis.

Previous papers presented by the authors at the ICCRTS have pointed to the role of effects-based thinking in providing a conceptual framework for the needed interaction and to the primacy of social networking in creating what is no longer a conventional military “command and control” C2 but rather a far looser process of that might be termed “cajole and coordinate.” These papers have also pointed to the requirement for dynamic learning and adaptation as the *sine qua non* of success. While the papers did address how learning and adaptation works within the confines of a military chain of command and how some parallel form of linked learning and adaptation needs to take place in the parallel organizations of related actors -- in fact, such does not routinely take place. Moreover, key questions remained unanswered: how do we learn and adapt across the horizontal and vertical boundaries that define the human organizations involved? And how do foster coherence between them?

In brief, we present in this paper a comprehensive, adaptive, effects-based approach that attempts to address these questions, and in doing so, to deal with

- the challenges of complexity i.e. understanding the situation, the reasons for intervention, setting targets that can realistically be achieved, and creating successful strategies for intervention;
- the fundamental tensions between the interests of individuals, of the relevant communities, and of the authority structures of organizations; and
- the difficulties of harmonising and coordinating a wide range of interactions by many different actors to implement those strategies.

In complex security environments and especially those that pit states against non-states in asymmetric conflict, these three problems are inextricably linked, since it is the first of them that necessitates the emergence of more complex, coherent and capable entities to deal with them than have previously existed, which in turn creates the second (achieving the coherence) and third (making effective use of the new collectives) problems.

To the extent that we are forced to act in complex asymmetric security environments then, these problems are not only inevitable, but also multiplied by the number of largely independent actors drawn from many different national, ethnic and bureaucratic cultures that are involved in “whole of” efforts.

As we struggle to meet both emerging global security challenges and ecological, economic and environmental problems requiring an unprecedented scale of global cooperation, it is increasingly urgent to make progress on this crucial question: how should we proceed in our tentative steps towards coherent and effective action on a greater scale than has ever before been achieved?

### **Structure of paper**

In the following Section, drawing on experience and history, we explore the problems outlined above in more detail, to bring the critical issues in cooperation and coherence into sharper focus.

Then in Section 3, we illuminate those issues by developing a conceptual approach to understanding cooperation and coherence, firstly for two actors, then for multiple actors, and discuss the links with effects-based approaches, networking, and complexity science – including adaptation theory and emergence.

Finally Section 4 summarizes the recommendations and insights that can be drawn from these discussions.

## **2. The Problems of Multi-Actor Cooperation**

In a distributed system of individual complex adaptive systems each characterized by large numbers of interdependent variables, the “control” of any more than a small proportion of the inputs to a given interaction is unlikely at best and the “control” of the outcome of that interaction is nigh on illusory. What we can do is to select a subset of those variables which we can direct or influence and which may -- we hope -- have a significant impact on that interaction and thus increase the probability of an outcome favorable to our interests. This is to say we must have capabilities that give us options, ways of identifying which option or set of options might yield the best result, and ways of implementing the options chosen.

There is a tendency to think that smaller more cohesive actors have an advantage in execution because their options are easily identified, sorted and decided upon. Indeed, they often seem to be far more comfortable with accepting the risks and consequences of setting a potentially catastrophic chain of events in motion. But Ashby’s Law of Requisite Variety suggests a contrary reality: that the advantage lies with the nation-state and with coalitions of nation states. The reason is simple. The greater the number, scope and diversity of the options

available and the variables an actor can potentially influence, the higher is its probability of coming up with a better response than its competitor to a given challenge. But, there is a catch. All this is true only if the nation-state or other actor can identify, select, and implement such a response quickly and reliably enough to deal with the challenge.<sup>5</sup>

The logic of comprehensive approaches is that, the larger the variety of the governmental, national or coalition capabilities at our disposition, the better our chances of success will be. However, the underlying problem here is not the potential availability of the right capability but the ability first to identify and tap it when and where needed, adaptively refine its employment as a situation develops, learn from the ensuing successes or failures, and extract relevant lessons for future choices - whether in a repeated use of the same capabilities or in applying different capabilities.

The real problem in a comprehensive approach is making intelligent adaptive use of the capabilities of a diverse set of networked actors in a coherent coordinated plan of action. If we consider as well those additional actors whose actions we cannot directly influence but who will nonetheless impact on our success, such as indigenous organizations and NGOs, then the challenges of fostering coherence and cooperation within this larger and still more diverse assemblage of actors are still more challenging.

### ***Learning and Adapting Within a Stovepipe***

We can begin by trying to understand the problems of coordination among with actors with a strong shared culture. Earlier papers traced the processes of learning and adaptation through the actions and reactions of a military, and specifically U.S. Navy, system of complex adaptive systems in crisis operations off the coast of Libya in 1986 and 1987, and to a lesser extent, through the parallel actions and reactions of a diplomatic system of systems.<sup>6</sup> These processes worked in three ways. Firstly, there was a sharply delineated command structure that provided direction from the level of the state to that of departments or ministries, to that of operational commanders, to unit commanders, to individuals. However, this formal military command structure was sustained by the second element - a social network of common expertise that rendered the complexities of the tasking and direction required mutually understandable. The third element functioned within this social network - a diverse and changing collection of individuals assuming a host of assessment and decision making functions at every level, adapting their thinking to an immediate shared "sense" of the local situation.<sup>7</sup> We could say the learning and adaptation functioned in the context of a "stovepipe" social network. But, this stovepipe had both vertical and lateral axes (see Figure 1), and both an official wiring-diagram organization and an informal "real" organization of social networks, which linked individuals and networks at different levels and, especially at higher levels, helped bridge the gap to tangential stovepipes.

In actuality, this vertical element was a nested set of stovepipes that converged at the top. The Navy command stovepipe central in our analysis contained parallel stovepipes for logistics, technology support, and intelligence, etc. with all of these stovepipes contained within larger military and departmental stovepipes. They, in turn, existed within a still larger executive branch stovepipe that included all departments and agencies and then within a larger still governmental stovepipe that encompassed all branches of government. Lateral social networks were to be found in each of these stovepipes and included multiple organizations at the same level, but they also stretched beyond to include *ad hoc* tasking of actors who were known to individuals in the Navy or Government networks but who belonged to different network entities, e.g. academic or industry, or who were purely social connections, much as soldiers in Iraq asked their families for support not available in the supply system. The critical new element in this networking introduced by the Information Age was the ability to link those points of contact as needed.<sup>8</sup>

Notice that, in all of the above, the "stovepipe" is not simply a synonym for bureaucratic intransigence but is rather an informal functioning organization with a distinct culture, social network and thought framework that permit the organization to function effectively and to adapt to rapidly changing complex situations.<sup>9</sup> The military stovepipe described, for example, has a strong organizational culture and social network inhabited by well trained and socialized individuals starting with decision-makers who have sufficient confidence in their position and the supporting network to empower the individuals in the network, and who accept the initiative interactions that such empowerment entails. Some of this confidence comes from approved and exercised doctrine, but much of it comes from the shared culture and the resulting shared understanding. This organizational networking and culture are important factors in selecting the commanders and decision-makers involved,<sup>10</sup> in creating a common understanding of a situation and its evolution, and in providing a common framework for adapting to the inevitable unforeseen actions and mishaps. As this implies, a stovepipe's success in learning and adapting or in reaching to other stovepipes is heavily culture and personality dependent. This situation is not unique to the military, and we can trace similar levels of functioning informal organization in different governments, departments and other groups. We can also identify similar social networking and bureaucratic cultures with similar impacts on selection, common understanding, and ability to learn and adapt in other governments, nations and business domains.

## Vertical and Lateral Networking

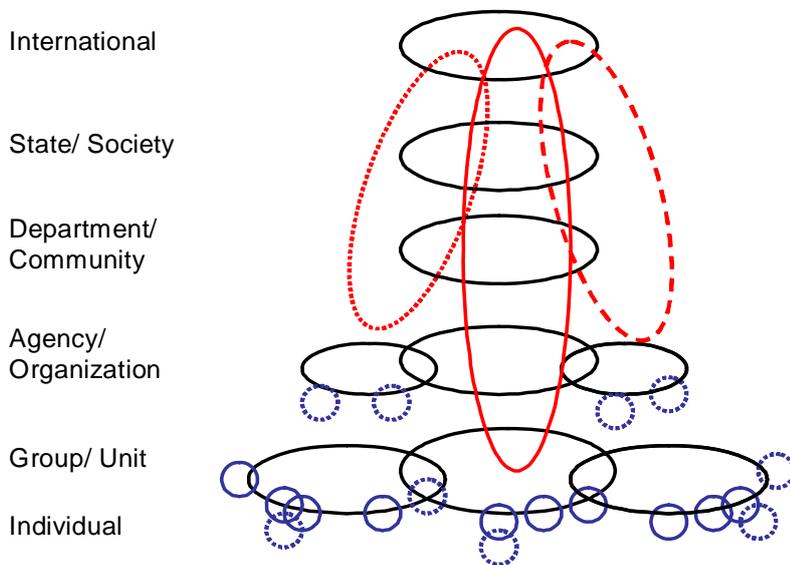


Figure 1

The levels of organization outlined in figure 1 and the vertical and lateral stovepipes themselves are the product of a sociological evolution, that is a selection process between and among complex adaptive social systems that spans the past 8,000 to 10,000 years as individual human beings and extended family groups began gradually over the centuries to create bigger and more complex organizations, governments, nations and an international community. In this process, we can identify and trace the functioning of essential processes that characterize all living systems such as the ability to maintain an identity, to obtain subsistence and to perpetuate themselves.<sup>11</sup> Unlike natural selection in biological systems, the sociological adaptation process is largely an aggregate of purposeful deliberate human decisions including those we can expect to encounter in the stovepipes and the interactions between actors in governments and among governments. In this context, factors like “core values” can be understood as defining the enduring identity of an organization and its culture; “interests” provide the metric for observing, assessing, or making sense of a situation or opportunity; and “networking” the means of evaluating and transmitting information, and so on.<sup>12</sup> Indeed, the entire thrust of this paper is that a better understanding of the challenges and of the potential contained in the idea of a “comprehensive” approach can aid a new round of such purposeful adaptation.

### **Building Bridges**

In a system of complex adaptive living systems such as a ministry, government or coalition, competition is the norm. By one means or another, the individual organizational actors will try to protect core values, interests, resource allocations, etc. As might be expected, this creates a problem with inter-stovepipe cooperation whenever we need to tap the resources of more than one stovepipe, more than government, or more than a single nation, and especially so if we need to do so quickly, flexibly and repeatedly. Yet at the same time, there is a deep seated need for competing organizations to stay within the identity, values and interests paradigm of the larger system to which they belong.

How then do we build social and conceptual bridges to different stovepiped social cultures and networks and reinforce the pull of the larger identity? One approach outlined in a previous paper was to break problems down into action-reaction cycles and the specific tasks that must be undertaken to survive and succeed, and to then identify where different stovepipes might contribute to each other's success.<sup>13</sup> However this approach has its limitations. The speed at which the action-reaction cycles proceed will be different for each stovepipe and for each level in any given stovepipe, to the point that no strictly *quid pro quo* arrangement or agreement is likely to be timely enough and the value contributed by one stovepipe community is unlikely to match the value received or *vice versa*. To be sure, the pressure of a mutually perceived threat to a higher identity can induce willing cooperation, but such cooperation will have distinct limits in terms of the resource trade-offs required. Moreover, if the shared threat or goal persists to the point that it becomes routine, as in the case of insurgencies or nation-building efforts, it will be difficult to sustain the cooperation long term in the face of continuing competitive pressures, e.g. how might a particular adaptation favor my organization's interests?.

Within a stovepipe or a government, cooperation and support can of course also be directed by higher authority. Historically, however, this direction sooner or later runs into much of the same time and resource constraints and reactions, whether internal to a system or as a result of external or political pressure. Furthermore, resort to authority obviously depends on there being an effective, functioning authority to which both the sides that need to be bridged subscribe – which can be problematic when such authority is absent or ineffectual, as sometimes happens when working with coalitions or non-governmental international organizations .

### **Autonomy vs. Community vs. Authority**

This is where the tensions between autonomy – an actor pursuing its own interests alone, community – voluntary adhesion to a social network, and authority – direction come into play and where some of the major challenges for learning and adaptation can be seen. These tensions are hardly new and stretch back to the beginning of civilization.<sup>14</sup>

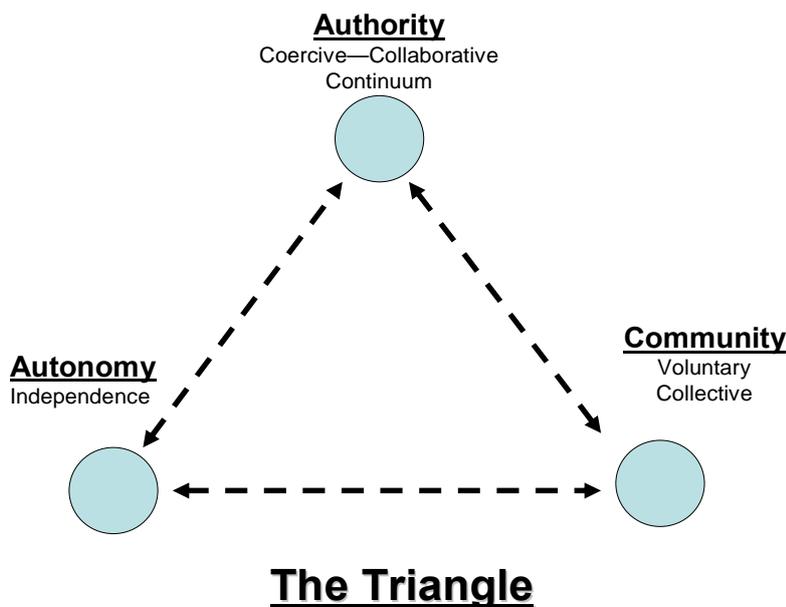


Figure 2

**Autonomy:** In the sociological evolution cited above, the individuals and family groups were the first autonomous actors. They had the best sense of identity and of their immediate interests e.g. their own survival, a detailed understanding of their immediate situation, and the quickest response time in dealing with problems but they were very limited in the scale and scope of what they could attempted and in their ability to sustain any particular action for any considerable duration. The same may be said of autonomous organizational actors.

**Community:** The historic concept of community stems from a wider social network based on common values, culture and interests, and is largely voluntary. The community retains a relatively quick reaction time and, by bringing together local “experts”, probably has a more detailed understanding of a subject or “local” situation than an individual or smaller independent or autonomous group. It also has a substantially greater ability to sustain a course of action (networks can take shifts) as well as greater latitude in the scale and scope of action that can be undertaken. However, such community social networking also demands: a shared understanding of local challenges, e.g. expanding croplands to increase the probability of survival, and how that balances with individual property rights; a shared idea of solutions, e.g. draining the marshes or irrigating the fields; and a shared equitable commitment to a solution, e.g. providing the balanced contribution of labor and resources to carry it out. From a wider perspective, however, such local efforts result in a series of independent organizations each distinguished by its own network, goals and objectives, in other words - stovepipes.

**Authority:** This brings the ability to prioritize, adjudicate and direct action by many different stovepiped communities. It can take a larger, “big picture” view and can undertake and sustain a far greater scale and scope of action, e.g. widespread irrigation projects or storage of grain from a large area to increase the probability of survival of a wider population, but is limited in its speed of reaction as well as its detailed understanding of the local situation. Moreover, the fact that the scope and scale of any large action necessarily span many different stovepipe communities implies that the benefits brought and resource burden demanded for solving a given problem are not necessarily equally balanced for all communities even though it might be in their longer term interests. Hence, an element of forced compliance is a necessary part of authority or governance.<sup>15</sup> However, similar to the loosely networked community, authority still rests on acceptance and a shared understanding of common challenges, proposed solutions and burden sharing. Indeed, history is rife with rulers who ignored this basic ‘social contract’ and sooner or later were overthrown. We will explore these dynamics more fully in Section

3, drawing on complexity theory as needed. But to set the scene, we first make some observations here based on a historical perspective and on experience.

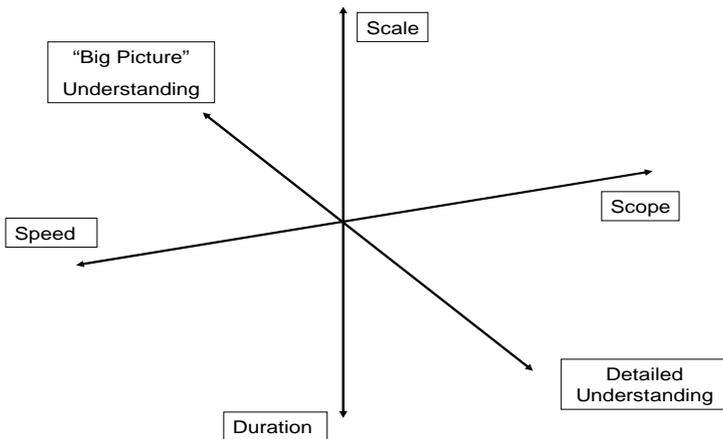


Figure 3

We can think of the capabilities described above in terms of six axes: scale, scope, speed of response, duration of action, and a continuum between the “big picture” understanding and the detailed local understanding (see Figure 3)<sup>16</sup>. We can also plot the relative limits of the advantages enjoyed by each actor, that is, what the individual, the stovepipe community, and authority each bring to problem solving and, by extension, what each contributes or requires in a continuing process of learning and adaptation. We can also connect the points with lines figuratively denoting the combinations of scale, scope, duration, etc. that represent the limits to what the actor can do; in essence, we can bound his option space (see Figure 4).

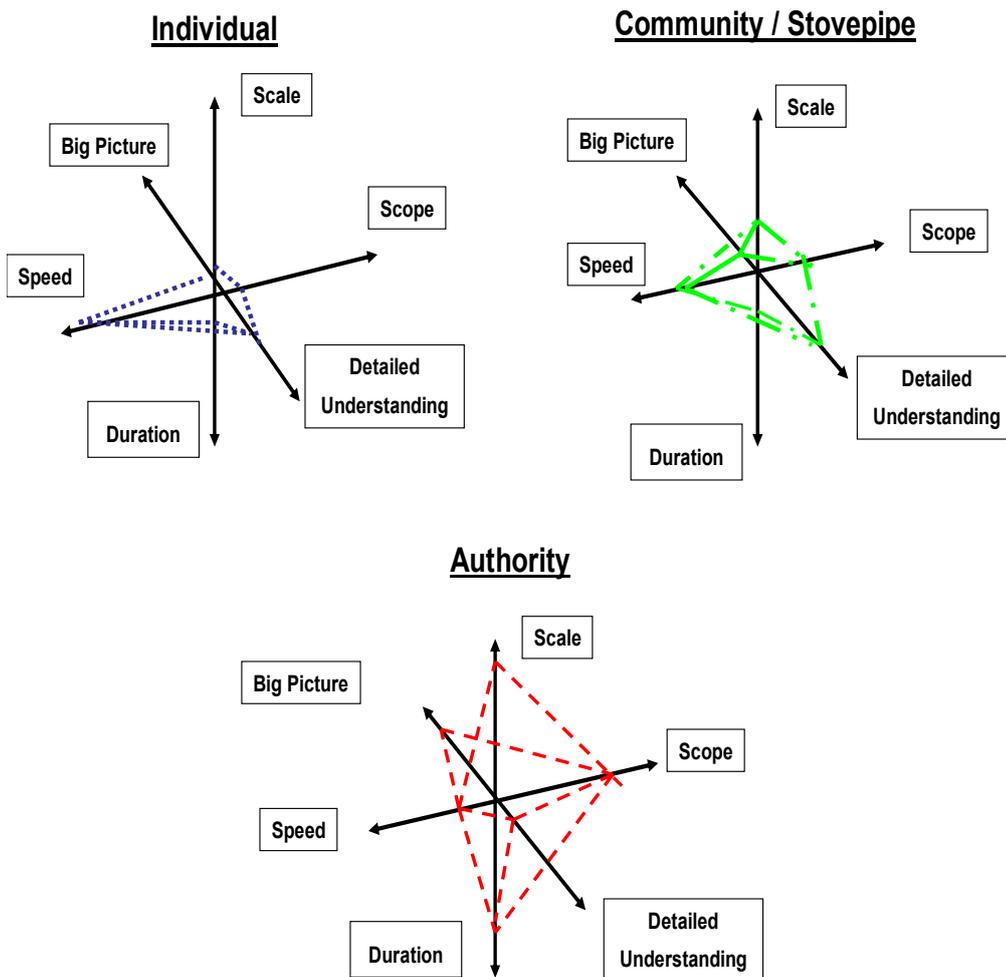


Figure 4

If the scope, scale, responsiveness, duration and understanding needed for solving a problem fall within an actor's option space, then it can theoretically be handled by that actor. If not, then he must either give up on solving that problem, grow his option space, or seek help from other actors.

At the risk of making sweeping generalizations, we speculate that out of the three forms, an individual will have the fastest response time and most detailed local understanding, but lacks appreciation of the "big picture" and has limited capacity for scale, scope and duration. A stovepipe community might also have a fast response time, perhaps a greater advantage in detailed local understanding, scope and scale, but probably still suffers a limited appreciation of the "big picture." With authority, as one might expect, comes a considerable advantage in the scale, scope and duration of action possible and in big picture understanding, but at the cost of less responsiveness and detailed understanding.

Ideally, we would want a mix of the response time of the individual, the detailed understanding and symbiotic working relations of a local community stovepipe, and the scale, scope, sustainability and "big picture" understanding and sense of direction possible with authority.

The object in all of this is of course not to look at the individual, the community and authority as three disparate parts each trying to solve problems on their own. It is rather to define the problem in terms that are basic to all civilizations and all cultures, national, ethnic, religious, bureaucratic and professional, so as to understand how they all function, their limits to consensus and hence, to cajoling, coordination and cooperation. Then we can better understand what the viable options are, and what it takes for each contributing element to play its part, learn and adapt.

In the Navy example, the tensions were smoothed over by a shared culture, shared ways of thinking and a common understanding of the problem and the solution space. In many respects, this sharing and commonality revolved about a shared consensus as to the identity and function of each of the nested stovepipes involved, that is, upon a consensus that existed within the social networking and common culture. Although the consensus varied from one stovepipe to the next, it remained within the framework of the next biggest stovepipe in the nest and within the norms of an overall military culture, permitting shared understanding of the roles of individual decision-makers, of communities (e.g. aviators, surface warfare personnel, etc), and of authority, at different levels of the hierarchy, and forcing transgressors to toe the line.

However when we attempt to link very different stovepipes into a common action, then we are less likely to share their culture and ways of thinking or to have a common understanding of the problems and solution space. Then we must consider and understand the identity of the actor we need to cajole or with whom we wish to coordinate and, specifically, to understand the limits of the consensus within which he must operate.

**Limits of Consensus**

The idea of the limits of consensus is important because it describes how far a decision-maker may cooperate, coordinate, or be cajoled without having to redefine the identity of his system and its underlying culture – most often a long process, never easy, and sometimes risky.

If we return to the description of the individual-community-authority tensions, we can begin to draw out some fundamental elements that might define the consensus (see Figure 5). In this case the interdependent variables are the scale of the action proposed, its scope, the duration of the action and the resource cost to the one cooperating or being cajoled. These limits have an obvious impact on any decision to join in an action, but to the extent that the limits are fixed or not able to be adapted, they represent a limit to cooperation beyond which the stovepipe cannot be pressed.

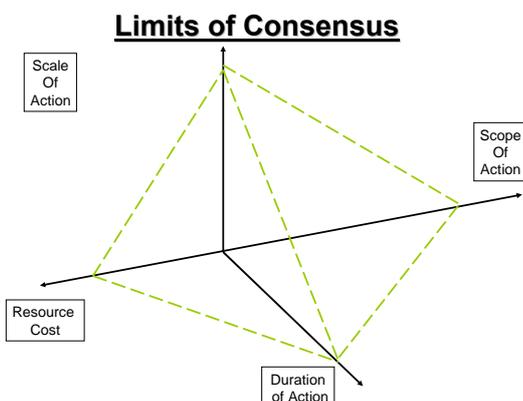


Figure 5

How then do we alter the consensus? Our understanding of adaptation obviously comes into play here, and we will explore it further in the following sections. Here, we simply observe that different cultures and different social networks will tend to perceive the same action or stimulus in very different ways, ways that in part define the cultures and networks in question, and so one key to growing shared understanding is to identify a common framework for thinking as a starting point, a basic concept that is general enough to be understood by all stovepipes as relating to their problems and their solution space. This same shared concept might also foster social networking between actors who had had little previous contact and apparently little in common, so as the concept is shared, the actors might discover commonalities, establish personal links and in the absence of interference, coherence might begin to evolve.

However this sanguine view is readily undermined by the realities of the hurdles of culture, organizational identity and bureaucracy. This is where effects-based thinking and approaches must come in to provide a conceptual base that is applicable across the whole breadth of a government or any other human organization. If we can really put effects-based thinking into practice, we might finally be able to integrate both the varied complex real world problems into a comprehensible whole, and the diverse capabilities of entire nations, organizations, or coalitions into a coherent set of actions.

To make progress in this direction we now turn to a more conceptual approach, based on understanding of complex adaptive systems.

### 3. A Complexity-Based Conceptual Approach to Cooperation and Coherence

#### *Fostering cooperation and coherence between diverse actors*

Let us first consider a single actor (whether an individual, an organization, a state or an alliance) engaging in a complex situation. What we mean by ‘complex’ here is that the underlying dynamics of the situation are interlinked and nonlinear, so that the consequences of an action may play out through multiple interacting pathways and similarly, any event or property of the situation arises as a result of many interacting causal and influence paths. We assume that the actor engages in the situation with some intention – i.e. the actor will wish to influence the development of the situation in some way.

In order to make progress in what is already a very complex scenario, we make some simplifying assumptions. Fully acknowledging that the fields of psychology, cognition, anthropology and social science will paint a vastly more intricate and difficult picture, we posit a simple ‘cartoon’ of the actor’s internal conceptual structures, loosely based on a hierarchy of ends, ways and means, as shown in the following Table:

How frequently changed	What actor wants or intends to achieve (ends --- means)	Actor’s concept of how to achieve Intention (ways)	dependence on actor’s understanding of context	needed contextual appreciation: scope   resolution	
				scope	resolution
Enduring ↓ as environment evolves and understanding develops ↓ as situation and understanding of it develops ↓ moment by moment	Defend core values		none	not applicable	
	Protect/advance interests (Metric: success/ failure) Achieve desired overall end-state	strategy	high	very wide	low
			very high	very wide	low
	Desired operational end-state (Metric: indicators/proxies)	stratagem	very high	wide	medium
		course of action	high	restricted	high
	Desired outcomes/ effects/objectives	plan	high	restricted	high
			medium	narrow	higher
	tasks	procedures	low	specific aspects	very high
			low	local	very high

Table 1

In this rudimentary model, actors' choices and behaviors are based on a bedrock of relatively enduring core values, but successive decomposition into more detailed preferences and choices in particular situations are strongly influenced by their conceptual understanding of the dynamics of those situations. What actors consider to be successful or failed outcomes in the situation are derived from their understanding of what outcomes are possible in the situation or overall environment and how those outcomes stack up against their core values.

To get beyond simply observing and judging the situation implies a strategy, that is a concept of how to deal with the environment as a whole at a given time and a concept of how to influence a specific evolving situation within that environment – the actor's *stratagem*<sup>17</sup>. These in turn give rise to a course of action – a set of proposed objectives and a concerted approach, and a detailed if flexible plan with specific tasks to achieve the desired effects and immediate and long term end-states. All are based on the actor's understanding of the dynamics of the environment, how a particular situation may play out, and what actions might best shape outcomes in a particular direction.. Ideally this process will include appreciation of both shorter and longer term consequences of any action and will include contingency planning to manage proliferating consequences and steer the evolving situation towards the desired end-states. Such an understanding implies an appreciation of the wide variety of complex factors that might drive the situation towards success or failure. Observable subsets of these driving factors then become candidate indicators or *proxies*<sup>18</sup> for tracking effects. Such proxies are useful because they generally have intrinsically smaller scope and faster timescales than success and failure measures, and can therefore provide feedback that is timely enough to assess the trajectory of the evolving situation and guide adaptive action. Indeed, they can become major drivers for decision-making and further course of action choices. It is not difficult to recognize the conceptual and philosophical structure of an effects-based approach in this paragraph,

As indicated in Table 1, the scope of understanding required for the development of strategy is very wide with that for a stratagem only slightly less so but the degree of resolution needed for both is very low. As we move down the table, the scope narrows as attention is focused on particular aspects of the situation and on more specific actions and their consequences, but the level of detail required increases correspondingly. At the lowest level, the scope may narrow to a small focal area, with actions adapted from standard procedures but the degree of resolution required will be of very high detail commensurate with the task at hand.

A key feature of this construct is the attempt to make explicit the impact of the actors' understanding of the situation and its dynamics on the choices they make. For example, two actors with the same core values but somewhat differing interests may arrive at quite different appreciations of the situation and therefore end up with very different measures of success and failure. Similarly, agreement on a desired end-state does not guarantee that the actors will agree on the stratagems, courses of action or detailed plans for achieving that end-state because the actions to shape that end-state will have different spin-off effects that will affect their individual interests differently. Thus, there will be different opinions about how the system dynamics operate that will be exacerbated if there is no agreement on an underlying conceptual framework, e.g. on a common comprehensive effects-based approach. When we are dealing with a complex situation, these differences can have major impacts, since we know that the complexity guarantees that every perspective will be limited, flawed and incomplete – in other words there is no single complete correct view which everyone can be brought to agreement on.

While this crude model can easily be critiqued from many angles, we feel that it has some merit in enabling us to explore the interactions between and among the actors who may be seeking to influence the same situation. We are interested in the conditions under which they will be willing to cooperate, at what level they will be willing to cooperate, how robust that cooperation may be when conditions change, and most importantly, what can be done to foster the growth of such cooperation and to increase its robustness. These questions are explored with this model in the next section, as a precursor to addressing multiple actors.

Then in the following sections, we will examine from a biological and sociological perspective, the ways in which multi-actor cooperation and a collective intent can arise, the possible forms that emerge, and the forces that act on them. Finally, we will bring all these threads together to pose and address the more general and central question of this paper: how to achieve and grow coherence in a multi-actor situation.

### ***Emergence of cooperation between two actors***

Let us take the simplest case of two actors, each with their own interests and hierarchy of situation understanding, intentions and plans as in Table 1. A hypothetical third party with a god's eye view could compare them and note the extent of agreement or disagreement between their corresponding levels of situational understanding, and the extent of actual or potential synergy or conflict between what they currently intend to do.

What each actor actually perceives of the other's interests and hierarchy of situation understanding, intentions and plans is of course open to error of various kinds, but an actor who believes that there is potential synergy between his own actions for example, and those of another, will be motivated to cooperate if he believes that doing so would lead to a better overall probability of success as he defines it. (Willingness to cooperate implies that each is prepared to modify his own thinking, planning and actions in order to realize the potential synergy – we'll return to this point below.)

But “success” is in the eye of the beholder. In a relationship between two complex actors, it is unlikely that there will not be at least nuance differences in the objectives or effects sought, on the details and execution of even an agreed upon course of action, in judgments as to the correct indicators of success, and as a result, differing conclusions as to potential synergies. Where can our actors go from here?

Let us suppose both believe there is potential synergy between proposed courses of action -- even if for different reasons. That means that there is a positive gradient in both their ‘fitness landscapes’ that they can both climb, so provided they both judge the benefits worthy of the costs, cooperation should follow<sup>19</sup>. However, this could be a very fragile cooperation. As the situation evolves – and it will – and as their respective situational understandings develop, they are likely to need to modify their plans, objectives, desired effects, indicators/ proxies for success and failure, and perhaps their overall course of action. What is the likelihood that the originally perceived synergy – the basis for cooperation, will survive? Our conjecture is that synergies of accident (i.e. for different or opposing reasons) are most likely to dissolve when changes occur while synergies based in enduring core values, interests and a common outlook and grand strategy and therefore a more consistent context and conceptual base will be more likely to adapt in concert, and thus be robust as the situation develops. This what we mean by coherence in this context.

If this is correct, and we wish to foster cooperation and coherence, then we must do more than compare proposed courses of action looking for apparent synergies; we must also examine and understand the other actor’s values, interests, desired end-states and proxies for success as outlined in Table 1. Doing so allows us to identify potential sources of divergence, whether primarily in differences of understanding with regard to one or another aspect of this specific situation or in more fundamental and intransigent differences of values and interests. If it is the former, and there is a shared core foundation, then collaborating in the development of situational understanding may lead to convergence and thus offer a possible route to adaptively increase coherence. If values and interests diverge significantly and there is little common ground on a desired end-state then there is no strong basis for developing coherence, although limited cooperation may still be possible wherever objectives are not mutually exclusive and the two actors can agree on some specific tasks that need to be performed.

As the above underlines, the position is unlikely to be black and white. There will be domains of agreement, domains in which each focuses on different but not inconsistent aspects, and some areas of possibly overt disagreement. Clarifying this space will permit the actors to delineate where it is possible to develop robust coherence through synergistic planning based on collaboratively developed understanding, where deconflicted complementary plans might be separately developed, or where it is best to simply stay out of each other’s path.

We now pick up again the question of how and what an actor might be willing to change in order to realize a potential benefit. Suppose once again we have two actors, A and B, who discuss their interests, objectives, desired effects and end states, measures and indicators/proxies of success, their ways (strategy, stratagems and proposed courses of action) and means (capabilities, plans, tasks, and ways of working) in order to determine whether and how they might collaborate. They might also discuss how they arrived at these, in other words they might share and compare their understandings of the situation at the various relevant scopes and levels of detail. In doing so, each is weighing up what he may need to, or be willing to, change, what the other is willing to change and what the benefit impact of such changes would be on the achievement of his ends. A’s benefit in this context could mean that A’s ends are achieved with less of A’s effort, or faster, or more comprehensively. Of course if neither of them makes any change, then any benefit one gets from the other’s actions is not the result of cooperation but of coincidence.

The construct of Table 1 also helps clarify what kinds of changes are possible, and how a given change might result in benefit distributions ranging from totally one-sided to equal.

As a result of interacting with B, A might decide to change his intents in the situation (e.g. because he has come to understand better what is possible, or what consequences might flow from his previous intent), or he may retain his intents but change his chosen course of action (e.g. because he learns that it is no longer likely to achieve his desired outcome, or because better possibilities arise from cooperating with B – so B is going to be making changes too).

In general, a change in A’s ends (i.e. objectives, effects and end-states) should precipitate a corresponding change in specific aspects of A’s ways and means so as to realign them with his new ends, while a change that only enters A’s hierarchy at a lower level (for example a change of A’s course of action) will affect his downstream plans and tasks but not his *intentions* with respect to his upstream stratagem and Success and Failure measures, although the outcomes of implementing the change will of course affect what is achieved against those intentions.

Further downstream again, A may be holding to all his previous ends and ways, but the cooperation with B may make better means available for implementing them, thus improving his likely achievements against his ends. In this case both A and B are making changes at the plan and task levels.

Of course, most of these changes are likely to have an impact on B’s ends as well as A’s. Now, if we accept that any net enhancement (i.e. allowing for offsetting of benefits and detriments) of the outcomes across all of A’s ends counts as a benefit to A, and noting that in general, A and B may agree on some but not all ends, then a given change may enhance a shared end (in which case both benefit), an end valued by one but not the other (in

which case the benefit is asymmetric) or more than one end – for example one favored by A and another favored by B, in which case various benefit distributions may be reached.

One might be tempted to claim that unless there was benefit to both sides it would not be cooperation, however there are finer distinctions to be made here – the benefit from helping a less mature partner to improve their effectiveness in pursuing ends that one does not care about, might rather accrue over longer timescales and wider scopes than presently considered. Benefit might also derive not from the direct impact of changes to either's ends, ways or means, but rather from indirect effects of those changes – for example through their influence on the perceptions and behaviors of third parties. However, in general, it is reasonable to expect that cooperation usually leads to shared benefits, at the very least on the strength of enhanced outcomes against those ends to which both are willing to subscribe. If there were no such agreed ends, one might expect that any cooperation would be very fragile and accidental.

Clearly, the possible interactions between two actors with dynamic hierarchies of situational understandings, intents and capabilities as in Table 1, are already complex enough. For example, our simple constructs permit us to identify ways in which:

- accidental benefits to each other's intents may arise,
- one's ability to achieve his own ends can be improved through cooperation in developing situational understandings, leading to his ability to develop more effective ways,
- both may derive benefit to their different but not inconsistent ends, through cooperation on a specific course of action or task,
- one may be willing to change aspects of his ways and means to create a benefit for the other, under certain conditions,
- both may derive benefit from a change to one's plan or actions, or
- from complementary changes in each's plans, and
- the robustness of their cooperation in actions can be enhanced by also cooperating in their development of situational understanding – provided that there is sufficient congruity in their aspirational measures of success in the situation, and
- congruity in aspirational measures of success may be increased by cooperation in developing wide-scope situational understanding, provided there is sufficient congruity in core values,
- potential for increased coherence between two actors may be identified and realized, through looking for sub-sequences in Table 1 which diverge after a point of partial agreement, and investing cooperative effort in addressing the cause of divergence.

This list is not exhaustive, but it suffices to illustrate the richness of the two-actor interaction space. One way to organize and study this space is to examine the average distributions of changes and benefits that result from their repeated interactions over some time.

This creates a trade space within which collaboration may be explored, as illustrated in Figure 6 below. The horizontal axis of the space shows who does the changing (A does all the changing and B doesn't change in the bottom left-hand corner, vice versa in the bottom right-hand corner, and equal amounts in the middle) and the other axis shows who benefits from the change (similarly: from A gets all the benefit and B gets none, to vice versa, and equal benefits in the middle). Thus the intersection of the midpoints of each axis represents perfectly symmetric cooperation – A and B change by equal amounts and benefit by equal amounts from those changes.

The broad green region running left to right in the diagram represents the domain where irrespective of who is doing the changing, the benefits from those changes are of approximately equal value to both parties. Repeated interactions in this zone imply a very high degree of congruence in ends, since a change that enhances achievement against the ends of one party, equally enhances achievements against the ends of the other party. When equal benefits flow from each change, there is likely less concern about who is doing the changing, especially if inequities in this also average out over time. One might say the green zone represents the high-cooperation zone, but a closer examination below will suggest a more complex view.

By contrast the blue and yellow zones represent interaction domains where the benefits flow mainly to one party or the other. We will explore below the dynamics that can lead to such inequitable outcomes, but we can make the observation that these zones correspond to interactions between actors with low congruence in their objectives – i.e. what benefits one makes no difference to the other. One might say that these zones represent low-cooperation potential, but again, a closer examination below will lead to a revised position.

Opposite corners are symmetrical with respect to interchanging A and B, so represent the same situation with roles reversed. For example the top left corner represents the situation where A does all the changing and A gets all the benefit from those changes. One interpretation might be that B is irrelevant, in other words, A and B are independent. Or, maybe B is not irrelevant at all - maybe B is much more competent and A is relatively

inexperienced. Then as a result of the cooperative interaction with B, A has learned a great deal from B and realizes it can achieve much more by changing its approach, while B has not learned anything valuable from A. Similarly at bottom right, B could be learning from A, or again they could simply be independent.

The other two opposite corners correspond to an interesting mixture of possibilities: exploitation, confusion or indeed deception or subjugation – A does all the changing but B gets all the benefit from the changes in one corner, and vice versa in the other.

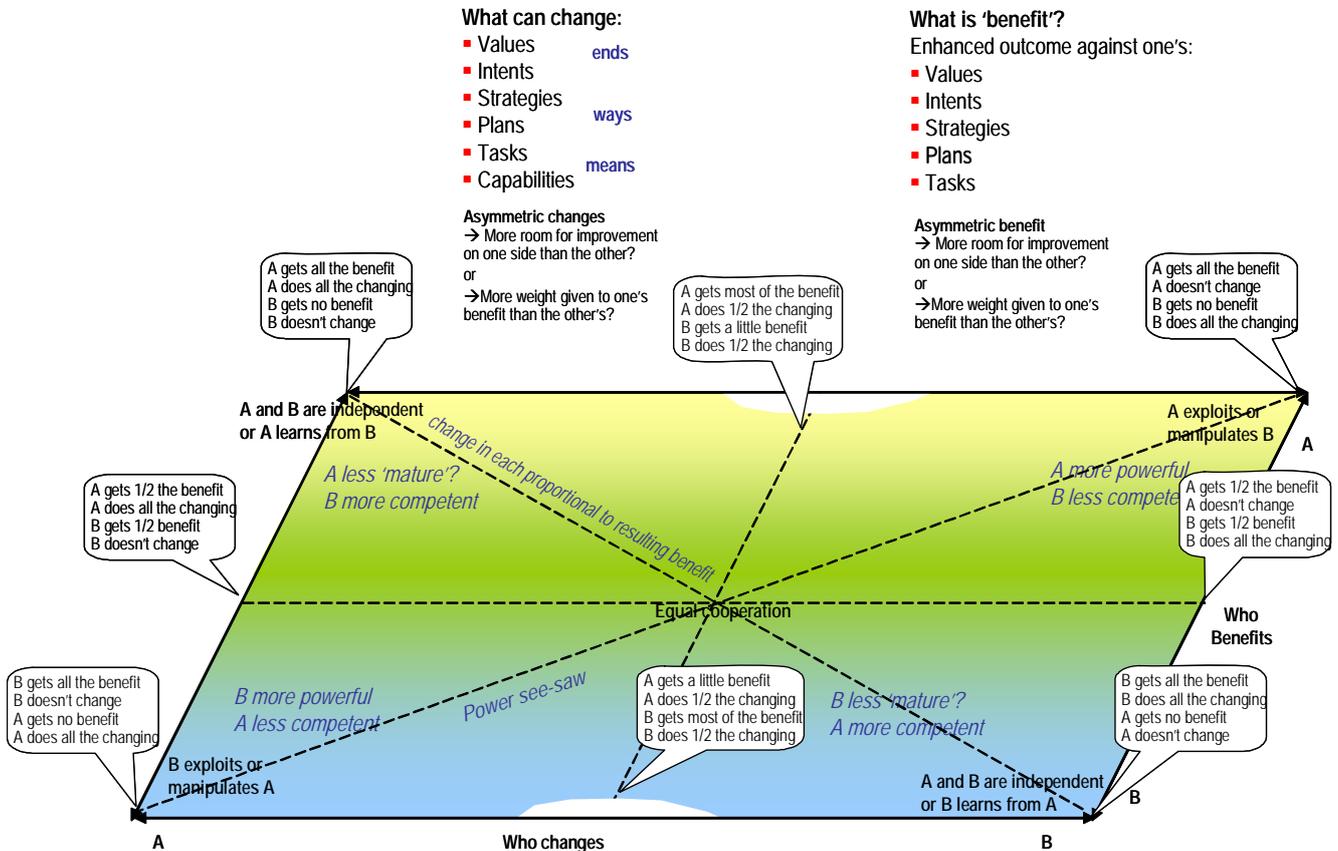


Figure 6 : A Two-Actor Cooperation Trade Space

As usual though, it is not the extremes that are most relevant but the intermediate ranges. In the upper half of the trade space, A's objectives benefit more than B's from changes brought about by their interactions, but the reason varies significantly across the space. To the left of center, it benefits mainly from its own changes – in other words it is adjusting its ways and means to better achieve its own ends, while to the right of center, it benefits mainly from persuading B to make changes to its ways and means to align better with A's ends. Thus the left hand side of this region might correspond to A being somewhat less mature in its understanding, planning and capabilities than B is, and lifting its game with B's help. Moving away from the left hand edge and towards the center equates to B making more adjustments to its own ways and means in order to benefit A. One would expect that B would only do that if there were some benefit for its own ends as well, thus the region along the top (no benefit to B) and towards the middle of the space would be mostly empty, but as B's benefit increased away from the top of the space, so would its incentive to change. To the right of the center line, A is still getting most of the benefit but it is B that is doing most of the changing, and at little benefit to itself. This suggests a power asymmetry between them which A is using to its own benefit.

The diagonals are also very interesting. The top left to bottom right diagonal maintains a constant break-even cost (share of change) to (share of benefit) ratio for each, with small shares of change and of benefit towards one corner and large shares of change and of benefit towards the other. Thus all else being equal, the calculus of cooperation is constant along this diagonal, but not compelling. In fact it suggests that A and B are relatively independent since each's benefit return correlates with their own effort into making a change. This could result from A and B holding disjoint but not inconsistent objectives. In this case they may be willing to cooperate in a quid pro quo (on average) fashion, for example exchanging services or sharing information.

The other diagonal could represent a range of power relationships, from A dominant in the top right corner to B dominant in the bottom left corner. What is noteworthy about these regions is the total asymmetry – one consistently gets much less benefit from the relationship than the other, in spite of being the one doing all the

accommodating. It might also represent situations where one actor is prepared to make changes that provide greater benefit to the other's objectives (which it doesn't share) for the sake of the value it places on its own smaller share of the total benefits.

This suggests another dimension in this space that should also be discussed – the magnitudes of the changes and the benefits. Obviously a large share of a small benefit might not be as attractive as a smaller share of a much larger benefit. So this means we should also consider what the potential impact of the cooperation might be – where are the greatest payoffs to be found? Interestingly, and perhaps counter-intuitively, we propose that they are not necessarily in the green zone of Figure 5.

First we note that the potential benefits of cooperation between two actors who have similar objectives fall into two broad categories: complementary cooperation where the benefits stem from the relevant different capabilities that each brings, and supplementary cooperation where the benefits stem from the additional similar capabilities that each brings.

Now, recall that interactions in the green zone imply high congruity between the intents of the two actors. Of course high congruity of intents can arise in very different actors, but as pointed out in Section 2, to the extent that the congruity stems from more extensive similarities, for instance in their previous histories, in their knowledge base, in their relationships with other significant actors, and in their abilities and ways of working, then the potential impact of their cooperation is likely to be more limited than it would be with actors that add more to each other's diversity. For example, cooperation from an actor that had closer relationships with certain target groups in the situation might be much more valuable for advancing one's objectives, than one that could add capacity to an existing strength.

On the other hand, the more different two actors are, the less likely they are to find easy agreement on each element of Table 1, so achieving cooperation is going to be more difficult, require more investment of time and effort by both, and also require more effort to maintain it as the situation develops. However the return on that effort may be very significant for each actor through complementary actions by the other that shape the environment in ways that render his own actions more feasible and effective.

Our very general conclusion is that the more similar two actors are, the easier it may be to achieve cooperation, but the less value may be gained by each from doing so, while the more different they are, the more potentially valuable, and the more potentially difficult it will be. This suggests that we need a range of strategies for engendering cooperation rather than a unitary approach.

We postulate that if potential partners A and B are similar in that they have strong overlap in their interests and concepts of success and failure for the situation, they will easily operate in the middle (green) region since any changes that improve outcomes against a success measure or a proxy for one, will be valued by both. What varies left to right across the zone is the relative maturity and competence of A and B. In this case, the focus is on using one's strengths to help the other's weakness. If the weakness of actor B is in his situational understanding then A's cooperating with him in its development will not only strengthen B's ability to act effectively in pursuit of his own ends, but more importantly, will help to bring about closer alignment of his actions with A's. So this cooperation strategy will readily grow coherence.

Power balance is an issue to the extents that each also aspires to ends that are not supported by the other, but of course this will always be the case to some degree with real actors. The temptation for the actor who is more powerful is to put pressure on the weaker to divert some of their effort to supporting the stronger partner's objectives at the expense of their own. The current return on that strategy may well justify the foregoing of possible future benefits from cooperation.

For potential partners that have strong rivalry and clashes of values, the situation is a little more complex. They might be maneuvering along the power see-saw diagonal especially if the focus of the interaction is on their differences with respect to their values and success and failure goals, or fundamental differences in their perspectives on the drivers of the situation's dynamics. Nevertheless, they might also have a lot to gain from carefully negotiated cooperation in defined domains. As Google quickly proves, there are many ways to make strange bedfellows. The challenge for the actors in this kind of relationship is to defuse the power struggle and to step outside of rigid traditional roles and views in order to make space for finding and nurturing the mutual benefit domain, which could be very significant indeed, simply because they are so different. Such a cooperative relationship is not likely to ever become coherent since the underlying agendas on each side are so different, but steps could be taken to make it as robust as possible.

A fuller and more thoughtful discussion of the many issues alluded to here is certainly needed, but beyond the scope of the present paper. Rather, we now turn to the situation of not just two, but many actors, in order to inquire into the origins of coherence in collectives of various kinds.

### ***Emergence of the Collective versus the Individual***

An individual human actor can be defined as having an identity with some set of core values and interests and an ability to act to advance his or her own interest. These same properties (continuing existence, identity, ability to act, and self-interest) can also describe an actor that is a collective entity in distinction from a set of individuals

acting independently. We can think of many examples that meet these criteria – sporting teams, businesses, combat teams, government departments, religions, and so on. But to understand the dynamics of the emergence of a collective, we must turn to the disciplines that have witnessed, and studied, the greatest proliferation of such events that we know of – biological science, and more recently, the sociological evolution that has produced the organizational actors that make up our security environment – groups, organizations, communities, governments, states.

The history of life on this planet is the history of survival against the odds, the history of successful innovation to solve life’s problems. A recurring theme throughout that history has been the emergence of cooperation and coherence between previously independent and indeed competing entities to form new, more complex entities with greater powers to apprehend, shape and exploit their environments than was possessed by their precursors. While there have been many successful examples, we cannot conclude that this process of complexification is either inevitable or easy. Each transition – the emergence of complex (eukaryotic) cells with nucleus and organelles through a series of symbiotic mergers, the development of genomes with complex architectures, the appearance of multicellular life, the evolution of the eusocial insects, and the flowering of human cultures and institutions – to name but a few – have been accompanied by momentous struggles between the different and conflicted interests of the individual elements and the interest of the many, of the short-term and the long, of the smart and powerful few and the less-endowed multitudes, of the compliant masses and the renegade cheats. On each occasion, these essential tensions have had to be resolved in one way or another (and life has indeed displayed a staggering variety of ways) in order for the new coherence and cooperation to take root.

This struggle between the interests of the individuals and the interest of the collective is the epitome of *multilevel selection*<sup>20</sup> – the interaction between adaptive processes happening simultaneously at two or more levels. In brief, when stabilizing adaptations at the collective level are strong enough to counter individual level adaptations from causing the collective to disintegrate, then a collective identity begins to be forged and emerges as an actor in its own right. But there are different ways that this can happen, and they can result in different kinds of collectives that have different strengths and weaknesses.

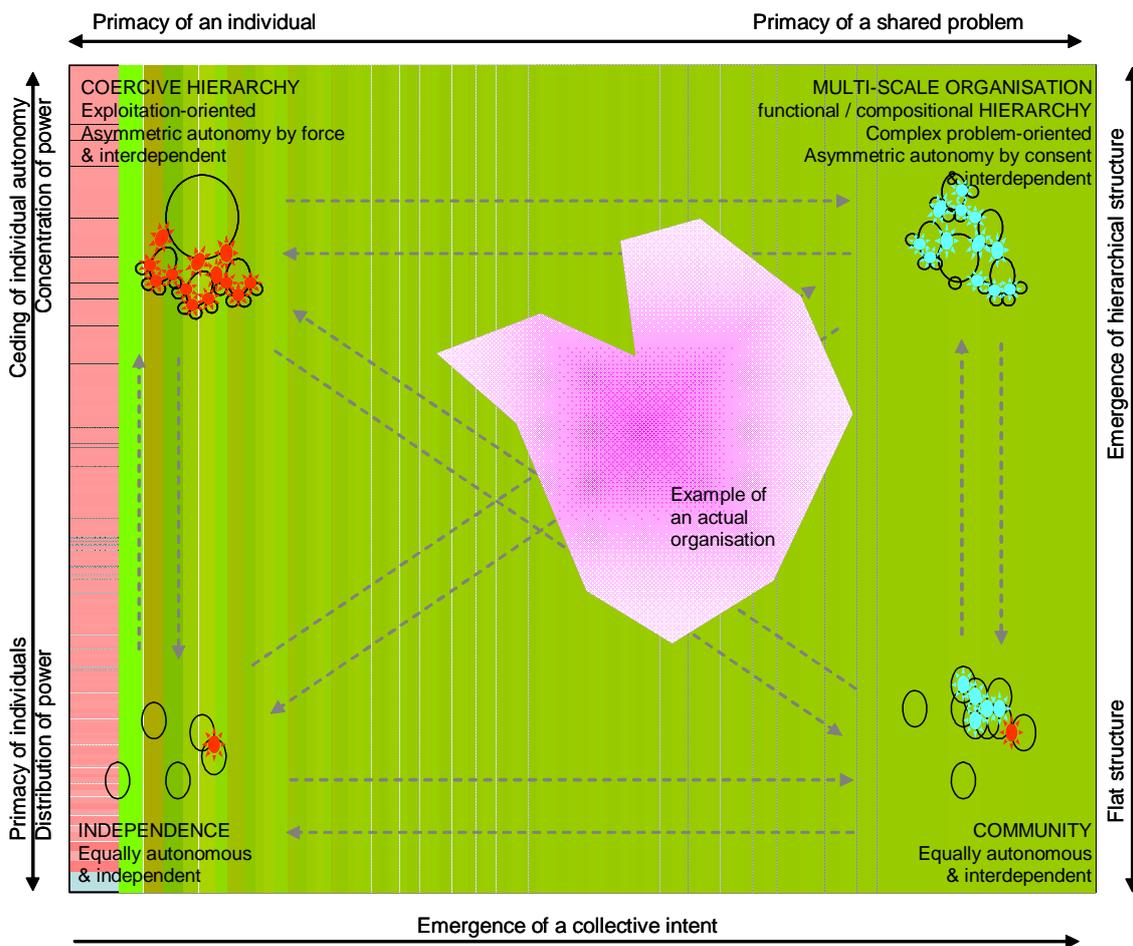


Figure 6

We are interested in understanding the different ways in which collectives can arise, what forces shape them, what stabilizes them, what drives them apart or drives them to change to a different form, and what each form is more or less suited to. This of course is what the study of history and the social sciences is all about. What is intended here is to meld those studies with the lessons of biology in the context of complexity theory to improve our ability to foster coherence and collaboration where we need it most, whether through cajoling, coordinating or indeed some other c-word.

In order to do this we postulate four constructs, with the intention of delineating the space of possibilities spanned by these abstractions at the extrema. We conjecture that this space encompasses the range of actual collectives that may arise (described at an appropriate level of detail), and that the forces that we identify as operating on our abstractions will similarly map onto real drivers of the dynamics of actual collectives. Because we necessarily omit many complicating features of real collectives, the conclusions we will draw must be taken with caution and treated as no more than suggestive for real situations.

Our postulates are based on conceptual analysis, a review of biological examples, and of a history of social institutions. All tell the same story, an elaboration of the Autonomy-Community-Authority triangle presented in Section 2. We have identified some principal pathways between autonomy or independence and three forms of interdependence: community: two extremes of authority – hegemony or coercive hierarchy, and a multi-scale organizational hierarchy, as illustrated in Figure 6 above, and defined and discussed below.

The key properties to examine in each case will be the interests of the nascent collective and the interests of the component individuals and how conflicts between them are handled, the drivers for specialization, the topology of interaction<sup>1</sup> networks, the types of problems the collectives are able to solve, and the forces that operate to drive a particular collective either towards other forms or to stabilize its current form.

### ***Pathways to interdependence***

#### Autonomy

The simplest case to consider is Autonomy – where each actor, whether human or organizational, is free to pursue his own interests, and is essentially independent of other actors. Interactions between actors are *ad hoc*, but may be marked by conflicting interests such as competition for resources. There is no communication or cooperation, although inadvertent benefit to one from the self-interested actions of another cannot be excluded. The outcomes of conflicts are determined by direct or indirect competition, and so apart from these interactions, the topology of the resulting network is largely disconnected.

The core limitation of autonomy is that the kinds of problems that autonomous individuals can solve are limited by the individuals' own sensing, decision-making and action capabilities. To survive and thrive, each actor must be able to provide for his own needs, and so must possess all the required functions to do so. However, limited specialization can occur through niche exploitation in heterogeneous environments, and through amplification of small variations in the properties of actors through positive feedback (eg an actor who happens to have a small initial advantage in exploiting one kind of resource in the environment can increase that advantage by improving his ability to exploit that resource through his own adaptive processes).

#### Community

One obvious pathway to increase the benefits to actors is through voluntary association and cooperation. Such a community can form in an interaction space, where the actors can freely enter into (and leave) mutually beneficial interactions with others, or aggregate their efforts to solve shared problems in a way that they could not achieve through their individual efforts. Barter transactions, cooperation to harvest resources on a larger scale than the actors' own scale, or to achieve some enduring mutual goal, such as cooperation to build defenses, are obvious examples that can be traced through human history. Once such cooperation begins, a community emerges as a collective actor, its continuing existence reinforced by the bonds of mutual benefit, its ability to act emerging from the cumulative coherent actions of its members, and its self-interest defined by the aligned overlapping self-interests of individual members. Such a community can take many forms including that of the stovepipes discussed earlier, but it will typically display a clustered topology in its network of interactions, where each cluster develops through the interactions stemming from a particular threat or opportunity. In addition to the specialization that can arise naturally in populations of autonomous actors, communities can foster specialization through the comparative advantage<sup>21</sup> of trade and exchange. This is a particularly fertile route to the development of many specialized capabilities, and the enlargement of the community's access to environmental resources.

However communities are limited or vulnerable in a number of ways, stemming from the inherent limitations of the individual members and their retained self-interests that may conflict, for example:

- Freeloaders are community members who partake of the benefits of cooperation without bearing their share of the cost. If not dealt with, freeloaders can weaken the community's bonds. Successful communities develop sophisticated ways of detecting and ejecting or punishing freeloaders, but to the extent that the

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<sup>1</sup> For simplicity, we only consider direct interactions, and do not distinguish between different kinds (communication, competition, predation, cooperation etc)

exercise of force is involved this represents a move away from pure community and towards a power-based organization.

- Common resources of the community are vulnerable to over-exploitation and neglect because individual members' self-interests are better served in the short term by continuing to exploit them, than by restraint and investment in their maintenance. This is the well-known Tragedy of the Commons<sup>22</sup> problem, and successful management of it requires enforced compliance with mutually agreed rules that serve the community's long-term interests at the expense of their short-term interests. It therefore introduces a measure of enforcement and a ceding of individual autonomy to the collective.
- Communities do not scale up very well. Their ability to be effective in serving the interests of their members and in the absence of enforcement mechanisms, relies on members' ability to recognize each other and to recall outcomes of previous cooperative interactions<sup>23</sup>. As communities get larger they will naturally fraction into smaller communities that are internally cooperative, but more weakly linked with each other. This leads to a multiscale, cluster of clusters topology. Communities that need to function over larger scales (such as markets) must develop regulatory and governance mechanisms to facilitate them, thereby again introducing the ceding of individual autonomy to the collective, and enforcement mechanisms.
- Multiplayer game theory tells us that some cooperative strategies that yield better outcomes for all, are not accessible when each player pursues their own narrow and immediate best interest. Avoiding the trap of these Nash equilibria<sup>24</sup> requires some players to forgo their short-term interests. The collective therefore needs ways of modifying the pay-off matrix of individuals to enable greater benefits to be realized, but again this implies a departure from the pure community model.
- The kinds of problems that communities are best able to solve are those that yield to the cumulative efforts of many individuals contributing their efforts (eg agriculture, building infrastructure) or are separable and able to be dealt with locally (eg organizing the division of labor within local groups). What they are not good at are multi-scale problems with deep underlying complexity that call for coherent interventions in many dimensions and scales. Such complex problems (eg mitigating climate change), require a commensurately complex level of organization to deal with them<sup>25</sup>, which again implies a departure from pure community as we have defined it.

#### Coercive Authority.

A heterogeneous population of autonomous actors or of small disunited competing communities is vulnerable to exploitation by actors with an ability to subjugate by force or to appropriate the fruits of other actors' labors. When this happens in an ongoing and systematic way, the actors become bound in a coercive authoritative structure or hegemony, where the interests of the many are suppressed<sup>2</sup> to serve those of only one community - the powerful few. The resulting system emerges as a collective entity, whose interests are defined by those of the dominant members who in turn will act to preserve its continuing existence and enforce the subjugation of its members.

Subjugated actors may be entrapped in this system in a variety of ways, including reliance on the hegemon for protection from external threats, e.g. feudalism, with a gradual loss of their multi-functionality and potential for autonomy. A coercive authority will typically enforce its power distribution through an interaction network with a hierarchical or tree topology. It may use its power to modify the roles of its members to better serve the interests of the rulers, and this may lead to specialization of individual or community capabilities and loss of multi-functionality, but this specialization is driven by seeking to increase the efficiency with which the dominant members can exploit the collective's efforts and maintain their power base.

A coercive authority may be able to solve some problems better than autonomous individuals or community organizations, but the kinds of problems that can be solved are limited to those that are within the decision-making capacities of the power clique. What it achieves in essence is an amplification of the power to act by harnessing the labors of many<sup>26</sup>, but without a commensurate amplification of the power to understand or the feedback needed to support better decision-making with a resulting limited capacity to deal successfully with very complex problems. When this limitation is combined with the skewed distribution of the benefits that result from solving a given problem, the hegemony risks rebellion by the subjugated, conflict within the elite community, or a re-evaluation of the need for its services leading to its eventual undoing – something that is manifest in numerous historical real world examples..

#### Authority: Multi-Scale Organization

At the extreme, each of the three foregoing types of actor contains the seeds of its own destruction a lack of scale, specialization and depth in autonomy, an inability to deal with conflicting interests in community, and inequities and an inability to deal with complex problems in the case of coercive authority. This brings us to our fourth type of collective, the multi-scale organization. A multi-scale organization has a recursive structure, usually both compositional: groups of groups of groups... of individuals, and functional: functions of functions... – but this structure comes about from the development of complex solutions to complex problems.

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<sup>2</sup> The extent to which individual self-interests are harmed can vary from minor (eg a brief local infection) to total (eg killing of farmed animals)

Coercive authority also displays a functional structure, specialization and power relationships, but whereas the organizing principle underpinning the hegemony is the rulers' self-interest, in a multi-scale organization the organizing principle derives from the perspective of the collective's interest in what it takes to deal with the complex problem.

Individual members may perceive different benefits and costs to their own self-interests in participating in the multi-scale organization, and their potential contributions may be more or less important to the organization's interest. Unlike the coercive authority which resorts to force to overcome conflicting interests, the multi-scale organization will seek to work through compensation and consensus – i.e. its structural and functional relationships are attained by mutually agreed modification of individual payoffs, and specialization is driven by effectiveness from the complex task perspective. In other words, the multi-scale organization is focused on creating the range of capabilities (various functions at each relevant scale) that the situation calls for, and on being able to orchestrate their application in a coherent way. The topology of the network of interactions in a multi-scale organization therefore depends intimately on the details of the particular complex problem it is dealing with and in particular, should mirror its relevant scales. Since we know that complex problems are inherently multi-scale, we can safely expect that it will not be flat, fully connected or fully disconnected.

Because a multi-scale organization is brought into existence as a response to a complex problem, its continuing existence is bound up in the trajectory of the problem. For example a natural disaster such as an earthquake calls for a complex set of rapid coordinated and coherent actions from a very large number of actors at multiple scales, requiring a similarly multi-scale organization to orchestrate them. But once the emergency has passed and the local systems are again able to function normally, the multi-scale organization dissolves and the actors return to their previous autonomy.

### ***Application to Real World Complex Endeavors***

There are several remarks that need to be made before we can explore the application of these ideas to real complex endeavors:

1. For the sake of clarifying the extrema of the space of possibilities we have described four idealized collective constructs that define the conceptual space of what is possible. However real collectives will inevitably display a mixture of their characteristics. Such *hybrid* collectives will populate the space between the extrema and will exhibit different trade-offs between the characteristics in tension: power concentration vs power equality, problem focus vs dominant leader focus, collective interest vs individual interest, short-term interest vs long-term interest, punitive vs rewarding etc.
2. While we have discussed the emergence of a multi-scale organization from a community of individuals faced with a complex problem, those 'individuals' themselves can in fact be any of the types of pure or hybrid collectives. This raises the interesting observation that the way in which self-interest versus collective interest is handled can be markedly different within the organization compared to within one of its components. In a similar vein, while we might expect a multi-scale organization to spontaneously dissolve when its job is done, we recognize that its component members will often have a much stronger drive for self-preservation and continued existence. To the extent that participation in the multi-scale organization has provided them with a justification and *raison d'être*, they will actually have an incentive to keep the problem alive, or find replacement problems.
3. In real situations, most actors will arrive with previous histories over which their particular collective has been shaped, which will make them more or less suited to entering into particular kinds of higher-level collectives in the situation.

In essence, individuals, communities, and organizations of all shapes and sizes are complex adaptive systems in their own right. They will seek resources and tend to perpetuate themselves; they will have an identity buttressed by a culture, some form of core values and interests; and they will learn and adapt, changing and making trade-offs, thriving, surviving or failing on the outcome. Accordingly, autonomous actors, communities and authorities may be expected to be in a state of continual change as they meet new challenges and co-evolve in the interactions with each other and the environment in which they find themselves.

For example, in a natural disaster relief scenario, one can expect to see aspects of all four collective constructs operating. We postulate that to the extent that a genuinely problem-focused complex functional multi-scale organization emerges, it can in principle orchestrate a more coherent response to the entire situation than any other construct – but this must be tempered by an analysis of the costs of doing so and their justification in terms of the increased benefits. Similarly, we postulate that, in general and all else being equal, to the extent to which a multi-scale organization acquires characteristics of a personal-power-focused coercive hierarchy, it will dilute its coherence and effectiveness. However again, 'all else' are rarely equal and this must be tempered by a consideration of the particulars of the situation.

The calculus of the most effective strategies in a given real situation is therefore itself a complex problem.

To illustrate, when there are thousands of actors, the overheads of the intense interactions needed with all of them to achieve sufficient consensus to orchestrate their roles might rapidly swamp the benefits of doing so. More

scalable approaches will use a mix of strategies and will probably exploit the inherent efficiencies of hierarchical organizations – for example grouping actors into a number of functional and/or geographical bases and devolving authority to particular actors to orchestrate intents and actions within each group, and higher level functions to other particular actors to similarly orchestrate between the groups.

Interestingly, this brings us back full circle to the reality that was described in Section 2, illustrating that the construct discussed there – nested sets of stovepipes, converging at the top – is in fact a natural construct for dealing with complexity, in that case, complexity in one's own organizations. We note also that in that instance, the approach was facilitated by the shared culture and a higher command level (government) which could direct and arbitrate – in other words by both a degree of innate coherence, and by organizational authority that had coercive power. As Section 2 demonstrated, this combination was very effective in permitting not only individuals' effective and adaptive action within their stovepipes, but also their networking through the development of social network communities spanning the stovepipes, which in turn facilitated organizational coherence, learning and adaptation.

One of the theses of this paper is that extending this approach to collections of actors with less innately shared culture and no shared higher command authority (as we find in many of the situations we are now in), is a viable and potentially effective strategy, though more difficult to implement than it was in the US Navy case. Thus, one of the motives in our study is to explore those difficulties and ways around them, in particular through network-enabled adaptation – as well as to develop deeper understanding of the dynamics of cooperation and collectives.

Returning to the example of earthquake relief operations, in the immediate aftermath of the disaster one can expect that many autonomous actors (themselves collectives whose self-interests are partially aligned with the needs of the situation eg in humanitarian relief, but also possessing their own continuing existence and identity needs), will arrive and independently start local rescue work, which can be very effective locally, but not as effective overall from a perspective of the entire situation – for example, more accessible areas may be over-served while more needy but remote areas are neglected.

The question is, how well can the actual complex needs of the whole situation be serviced by a set of actors operating in one part of the space portrayed in Figure 6, compared to another part?

Firstly, it is obviously possible in principle – although not a trivial exercise – to develop a comprehensive problem-oriented multi-scale view of success and failure for earthquake relief operations, which would include saving lives, reducing suffering and injury, preventing disease, repairing and restoring infrastructure and essential services, and assisting local organizations to cope with their own losses and become effective again, all in appropriate consultation with those affected so that relative priorities are based on the real needs.

If the objectives of the individual autonomous actors are mapped onto such a comprehensive problem-oriented description one could expect partial coverage at the scales commensurate with the actors' scales of operation, but because of their limited capacity to apprehend the entire picture (as illustrated in Figure 3), one can also expect that their actions will produce unintended consequences at other scales, that they will each have different partial perspectives on the situation, and will have difficulty appreciating the overall priorities.

Over time, local subsets of actors may develop mutually beneficial cooperation to increase their effectiveness in their extended shared operating areas, improving their big picture capability and efficiency of coverage in those areas, but from the perspective of the overall situation there are still likely to be higher-priority needs unmet, a lack of coherence in actions at different scales and in different sub-regions of the situation, as well as unintended consequences. Further, as interactions between the actors increase, those aspects of each actor's objectives which are not aligned with the situation's needs can lead to competition and personal power asymmetries which may reduce effectiveness.

To move beyond these limitations the organization of the actors has to move towards the top right corner of Figure 6, with a degree of ceding of the individual autonomy of the actors in order to create decision-making structures that correspond to the structure of the problem situation. These structures must generate the needed scales of big picture views and scales of action, orchestrate the available capabilities of the actors to match the needs of the situation and must be able to adapt the organization and learn as the situation develops. These requirements are beyond the capacity of any individual actor, but must somehow emerge from the set of actors. While it is possible to argue for the appropriateness of a multi-scale organization as the "ideal" structure for dealing with complex endeavors, what is of greater relevance to the focus of the present paper is how such a structure comes about, and how its coherence and effectiveness can be fostered. To answer this we have to examine the forces acting to push the collective towards, and away from, the multi-scale organization construct.

### ***Role of Adaptive Processes in the Emergence of a Collective***

Earlier publications<sup>27</sup> have discussed adaptation as an iterative process of a *change – evaluate – select – implement* cycle. It includes all the ways in which living or engineered systems might improve their success or fitness for purpose, thus becoming better able to manage the complex problems posed by their environment.

The processes that we have discussed whereby collective actors emerge, are clearly adaptive processes, so theoretical understanding of adaptation can both clarify their dynamics, and offer avenues for shaping them. In

fact, as mentioned above, it is the interaction between adaptive processes at the individual and collective levels that drives the emergence. The outcome therefore depends on how this interaction between adaptive processes at different levels actually plays out. Since adaptation is an open-ended creative process the outcomes are not foregone conclusions – new mechanisms can be generated (by adaptation at either level) to reinforce or weaken the drivers towards or away from any outcome. This is where opportunities arise to foster outcomes we prefer.

At the individual level, factors that reinforce existing independence include lack of trust in others, isolation, lack of communication, adequate rewards from independent action and insufficient perceived rewards for changing.

At the collective level, the adaptive processes that reinforce the collective derive from the mechanisms discussed above for forming various types of collective. What we are saying here is that the way in which these various drivers have an impact is through the individual actors' perceptions of potential benefit or harm to their interests from entering into or leaving such relationships. Thus, what binds the individual to an existing collective is his desire for the net perceived benefit, or the fear of the threatened harm.

Similarly, also at the individual level, the factors that might cause an existing collective to which he belongs to disintegrate back to independent actors, include individuals' perceptions of greater net benefit from independence, of reduced power imbalance, loss of trust in leadership or of confidence in the community, and reduction in the perceived needs for protection or other services, or for dealing with a complex problem. All of these cases weaken the ability of the collective's adaptive processes to continue binding individuals.

There are also factors that drive the adaptation of a collective from one form to another in the space spanned by the poles of community, coercion and multi-scale complexity. These are the factors that modify the relative strengths of the different drivers we have discussed. But we stress again that the open-ended creative processes of adaptation leave us all the room we might wish for to shape and influence the collective's development.

#### **4. Recommendations and Insights**

##### ***Fostering the emergence and coherence of a complex multi-scale organization***

The bottom line should come as no surprise – there is no single one-size-fits-all silver bullet that can solve all the problems of engendering multi-actor cooperation and coherence in all situations, but there are many observations and insights that can be drawn on to help make the best of any particular complex situation.

A key determinant of the degree of success that can be achieved in a complex endeavor is the quality with which comprehensive multi-scale measures of success and failure can be articulated, and good indicators or proxies for them identified. This goes to the heart of the effects-based approach, which we conclude to be essential for many reasons<sup>28</sup> - not least of which is that it lends itself to being the shared conceptual context within which we can seek to grow coherence between potentially cooperating actors, as discussed in Section 3.

A second key determinant is the ability to communicate and empower the development of social networks that span the naturally-occurring stovepipes and collective constructs that arise. This point goes to the heart of how complex multi-scale systems (organizations) can arise or emerge. We know of no evidence that they can be successfully deliberately designed. Rather, examples we know of such as markets, religions, and governmental systems, have arisen through natural processes of interaction between their components and with the complex situation, with feedback from those interactions influencing their ongoing development.

If we wish to foster the emergence of effective multi-actor cooperation then we must start with addressing these two determinant factors by adopting an effects-based approach and by investing effort in articulating a comprehensive and multi-scale set of aspirational measures, and by growing the communication networks and links between them in a way that enables, supports and is responsive to the actors' own developing social networks even as these learn and adapt to a given situation. But while these two factors are, we believe, both necessary for the emergence of a complex multi-scale multi-actor organization that is attuned to the complex environment it finds itself in, they are not sufficient.

What is still needed is the motive force to grow the organization and to grow its coherence. We argue that, in a system of complex adaptive systems like our security environment, this motive force will stem from many adaptive processes, occurring at different scales, different tempos, linking different actors, and stimulated by many diverse events, that will arise in a given situation. The scope, diversity and interconnectedness of these adaptive processes likewise offer us many options for interventions at various scales to foster the coherence of the nascent complex collective, in addition to the two major enablers mentioned above.

We have discussed many insights and examples of how to do this in the preceding sections, so to summarize here we point to a few key aspects:

- A complex situation or problem will necessarily involve many diverse actors, views and approaches to the point that it is unrealistic to expect total coherence in their actions.

- Alignment of specific intents may permit ‘accidental’ cooperation under some conditions, but does not guarantee sufficient robustness to support continued cooperation when those conditions change. As outlined in table 1, robustness springs from having common antecedents and multiple points of alignment between the cooperating parties.
- We can increase the likelihood of success by looking for areas of potential partial coherence, that is, the common ground in their hierarchies of interests, end-states and intentions, by identifying divergences stemming from differences in situational understanding, and by growing coherence in a continuing process of adaptation.
- Given some common ends, a partial congruence of understandings, intents and actions (and hence partial coherence) can be grown using adaptation, by
  - [1] cooperating on the development of situational *understanding* – specifically collaborating on:
    - understanding the causal and influence network operating in the situation to ascertain what pathways do or do not influence the common ends;
    - agreeing on measures and indicators of success and failure for those ends, and also
    - expanding the agreement space by developing the big picture understanding needed to assess what outcomes are possible, desirable, undesirable, likely, etc; and,
  - [2] similarly, by cooperating on the development of *actions* – specifically collaborating on:
    - the development of *more detailed* understanding of the causal and influence network operating in the situation to figure out what pathways do or do not influence the agreed success and failure measures, and hence what proxies should be targeted;
    - and hence developing cooperative plans to do so.
- The value of cooperation between and among actors is a balance between the effort and opportunity costs and the potential for meaningful coherence. It is easier to establish cooperation and to grow coherence with similar actors, but it may be more valuable to establish limited cooperation with very dissimilar actors precisely because their dissimilarity could potentially yield more valuable results.
- As actors of various kinds and at various levels begin to emerge as organizational entities, we can identify where they arise in the space of Figure 6, and support organizational adaptation and networking to encourage the development of desirable traits to better cope with the complex situation to be addressed.
- Both the adaptive processes that stabilize the emergent collective and those that shape its collective intents with respect to the complex situation need to be addressed

**Conclusion: We Need a Second Wave Transformation**

In a sense, the high technology “transformation” of the “Revolution in Military Affairs” must undergo a “second wave” transformation centered on the three concepts we have discussed: effects-based thinking, complexity and adaptation, and a “comprehensive approach” to problem solving.

This implies a need to reverse the engineering approach to communications networking that all too often operated on an “if you build it, they will figure out how to use it” approach and instead to let the communications networking be driven by the social networking of emergent collectives – networking that will change and evolve even as the situation and the actors in it evolve. It also implies a need to look at organization in an equally flexible way balancing authority with the social networking and expertise of stovepipe communities and the capabilities of the individual in multi-scale organizations. The result is likely to be a new direction starting with the thinking, going to the social networking, and then to an ever-changing and adapting interaction network (see Figure 7).

**Which Direction?**



***It's about the People!!***

Figure 7

## 5. Acknowledgments

AMG would like to thank a number of colleagues for stimulating and constructive discussions and feedback in the development of these ideas – particularly Alex Ryan, Matt Berryman and Vanja Radenovic.

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<sup>1</sup> See Clemente et al. NATO Effects-Based Approach Lecture Series, 13<sup>th</sup> ICCRTS paper.

<sup>2</sup> The impetus for the new transformation is in some ways obvious. The events of 11 September 2001 demonstrated the menace that terrorists could present when armed with even the peaceful implements of modern society. Yet, terrorism by ethnic and religious fanatics or anarchists is not new. We have been coping with terrorists and low intensity conflicts for centuries. What is new is the looming confluence of such fanaticism with the availability of weapons of mass destruction effort especially nuclear or still more frighteningly biological weapons with the potential to eliminate most of the human race. There is no effective deterrent to a terrorist so armed, willing to give his or her life, and so convinced of a mission as a divine agent as to accept even the most dire of consequences for humanity. There is no waiting for the first blow to fall. That would be too late. Instead, we are left trying to figure out how to use the military power we have created to prevent not just the attack but also the conditions that gave rise to the terrorists. While conventional war has not gone away, the pressing problems have become those of maintaining peace, preventing and containing crisis, and stabilizing a complex and often dysfunctional world.

<sup>3</sup> We need to be clear as to what is meant by the term “effects-based.” In 1999, the US Navy experimented with what was then labeled effects-based operations or EBO at its annual Global Wargame. It did not work. One of the authors, Dr. Smith, found himself in a conversation with the late Vice Admiral Art Cebrowski. They agreed there were three problems with what had been attempted.

- First, what had been tried was really effects-based *targeting* not *operations*. That is, it was focused on attrition in the context of major combat operations whereas the wargame was as much about peace maintenance, crisis containment, conflict avoidance and peace restoration as it was about fighting.
- Second, because the approach focused on physical targets, it made unrealistic assumptions both as to what we could know about a situation and what we could predict.
- Third, the approach was process driven and required a large staff to implement, whereas the Navy wargame centered on a Battle Group staff of about 20 people.

Yet both saw something very important at the heart of the approach: the connection between a physical action of some sort – and not necessarily a violent action – and a psychological or cognitive reaction. This connection was basic to the 400 + crisis response operations that had been conducted by US military forces over the preceding 60 years and seemed to lie at the heart of what militaries would be asked to do in the unstable world of the future. They also agreed that to discard the effects-based approach would be to throw the baby out with the bathwater, and Dr. Smith was promptly tasked with expanding the thinking, concept and theory of effects-based operations to reflect its applicability to the full-spectrum of crisis and conflict. That work was tested in two additional wargames and published by the CCRP in two books. It is this broad approach as it has evolved over the ensuing years in the United States, especially at the Joint Forces Command, in the UK at the Defence Concepts and Doctrine Centre, in France at the Centre Interarmées des Concepts, des Doctrine et d'Experimentation, and in Germany at the Bundeswehr Zentrum von Transformation, and in NATO that will be discussed.

<sup>4</sup> This term was introduced in NATO's Riga Summit in 2006 and embodied the need for a broader national and alliance approach to national security.

<sup>5</sup> The world's reaction to the fumbled U.S. reaction to the Hurricane Katrina disaster is a case in point. The expectation was that because the country had an unparalleled scale and scope of options available to it, it could manage to respond. In the end, however, it was the inability to organize and coordinate the relief effort across the many agencies and levels of government that stymied the US effort.

<sup>6</sup> Smith, EA and Grisogono, AM *Towards a Synthesis of Complex Adaptive Systems Theory and Effects Based Approaches to Operations: Warfighters to Coalition - A Case Study of Multi-level Adaptation in Effects-Based Operations*, 11th ICCRTS, Cambridge UK, Sep 2006

<sup>7</sup> One group that does this exceedingly well is the U.S. Marine Corps. By having a shared and challenging crucible experience, every Marine learns that not only is “every Marine a Rifleman” (unity of effort), but that they are part of a chain of riflemen that go back to the beginning of the republic. They teach their proud and noble tradition to the point where once a Marine becomes a Marine – he's inextricably tied to both the past AND the future. One of the biggest benefits of this type approach is in the gained trust of someone who shares your ethos, mission and experience – whether or not it was shared at the same time or place. Even Marine Officers, be they infantry, aviation, supply etc.... all start together at “The Basic School” which provides that same shared experience.

<sup>8</sup> See discussion of the Naval Intelligence social network during the 1986-7 Libyan operations in Smith, *Effects-Based Operations: Applying Network Centric Warfare in Peace, Crisis and War*. CCRP: 2002. pp. 517-520.

<sup>9</sup> This is not to say that bureaucratic cultures are all good or that change is needed, but rather that we cannot remove the stovepipe without undermining much of the understanding of complex subjects that the stovepipes enable.

<sup>10</sup> A good commander, for example, will expend considerable effort choosing and/or vetting his staff officers and subordinate unit commanders and then testing their reactions under exercise conditions to the point that there is both a mutual understanding and a trust and confidence in both directions. Bound up in this effort is a recognition that a failure to do so can have a major impact on their ability to learn and adapt quickly and independently when needed.

<sup>11</sup> James Grier Miller, *Living Systems*, Denver: University of Colorado, 1995. pp xvi ff.

<sup>12</sup> Miller. p. xix.

<sup>13</sup> Smith and Clemente, *“So it's connected...now what?: C2, Effects-Based Operations and Whole of Government Action*, Paper for the 12<sup>th</sup> ICCRTS

<sup>14</sup> Arnold Toynbee in his *Study of History* points to the development of authority and civilization as a function of the need to expand agriculture respectively in the Nile, Tigris-Euphrates, and Indus valleys. Small projects might be handled by the individual, larger irrigation efforts required social networking and community action while much larger efforts to irrigate as well as to store grain against the possibility of famine in one or another area required the development of the state and the authority of a god-king. Arnold J. Toynbee, *A Study of History*, Vol. 1 *The Geneses of Civilizations*. Oxford Press, Oxford, 1962. pp. 271 ff.

<sup>15</sup> It is interesting to note that most early civilizations solved the problem of accepting this direction by making the authority figure a god-king.

<sup>16</sup> Big vs. Small Picture. When my aircraft carrier visited, Toulon France nearly 20 years ago, my friends and I headed to a beautiful little tourist village west of Toulon called Bandol. When strolling through town I noticed advertisements for a Salvador Dali art exhibit that was going to take place in the casino the upcoming weekend. These weren't professional posters, but 8X11 sheets that were run off on a cheap black and white printer. What they lacked in beauty, they made up for in volume – there was one in nearly every window. The print that accompanied the words was a somewhat impressionistic portrait of Abraham Lincoln. After 5 days of running into this poster, I decided to stop by the casino to catch the exhibit – and see what this Lincoln portrait looked like for real. The paintings were huge and exhibited in a large open

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space with pictures on all four walls. Spending a minute or so with each piece, I had gone completely around the room when I realized I had yet to find Abraham Lincoln – the one I'd come to see! Spinning around I found it – across the room on a wall I had already visited. How could I have missed it?! I started walking across the floor in a direct beeline to the 16th President, and when I was about halfway across – Lincoln disappeared and in his place was a nude woman gazing out a window. This was my introduction to Dali's "Gala Contemplating the Mediterranean Sea Which at 20 Meters Becomes The Portrait of Abraham Lincoln." I stood at the transition point, moving back and forth to play with the illusion, and marveled at how someone with a normal length arm could paint something that looked so different depending on how far the viewing eyeball sat from the canvas. I grabbed my friend at this moment of epiphany and said – LOOK!! Isn't THIS what we're fighting for? Do we deploy in support of liberty and freedom around the world ... or to protect our loved ones. Dali's painting made it clear – it's both – and at the same time! Which picture is closer to the truth? There's only one picture – and the answer is both. (MC)

<sup>17</sup> BRIG GEN Huba Wass de Czege – private communication (AMG)

<sup>18</sup> Proxies are discussed in references 38 below

<sup>19</sup> This obviously assumes rational actors and glosses over the difficulty of making rational judgments in complex situations. Simon's bounded rationality would be a better model, but this is an initial cursory exploration of the issues ...

<sup>20</sup> Mark Ridley *Mendel's demon* Phoenix, 2000 pp 134-145

<sup>21</sup> Ricardo's Law of Comparative Advantage <http://socserv2.socsci.mcmaster.ca/~econ/ugcm/3ll3/ricardo/prin/index.html>

<sup>22</sup> Garrett Hardin *Tragedy of the Commons* Science 13 December 1968: Vol. 162. no. 3859, pp. 1243 - 1248

<sup>23</sup> Robert Axelrod *Effective Choice in the Prisoner's Dilemma* The Journal of Conflict Resolution, Vol. 24, No. 1 (Mar., 1980), pp. 3-25

<sup>24</sup> see for example Martin Shubik: *Game theory, complexity and simplicity* Complexity, Vol. 3, No. 2. (1997), pp. 39-46.

<sup>25</sup> JK DeRosa, AM Grisogono, AJ Ryan and DO Norman *A Research Agenda for Complex Systems Engineering* IEEE Systems Conference,

<sup>26</sup> Bar Yam – Multiscale complexity

<sup>27</sup> Grisogono, AM *Co-Adaptation*, invited paper 6039-1 Complex Systems Conference, SPIE International Symposium on Microelectronics MEMS and Nanotechnology, Conference 6039: Complex Systems. Brisbane, Dec 2005.

Grisogono, AM *The Implications of Complex Adaptive Systems Theory for Command and Control*, CCRTS, San Diego, June 2006.

<sup>28</sup> Smith E.A *Effects-Based Operations and Complexity, Networking, and Effects-Based Approaches to Operations*. [www.dodccrp.org](http://www.dodccrp.org)