The Future of Command and Control

The Agility Advantage

A Survival Guide for Complex Enterprises and Endeavors

David S. Alberts

CCRP
Focus & Convergence for Complex Endeavors

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- sponsoring a series of workshops and symposia;
- serving as a clearing house for command and control related research funding; and
- disseminating outreach initiatives that include the CCRP Publication Series.

This is a continuation in the series of publications produced by the Center for Advanced Concepts and Technology (ACT), which was created as a "skunk works" with funding provided by the CCRP under the auspices of the Assistant Secretary of Defense (NII). This program has demonstrated the importance of having a research program focused on the national security implications of the Information Age. It develops the theoretical foundations to provide DoD with information superiority and highlights the importance of active outreach and dissemination initiatives designed to acquaint senior military personnel and civilians with these emerging issues. The CCRP Publication Series is a key element of this effort.

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Acknowledgments

This book embodies my current understanding of a subject that I hope will capture the imagination of many in the coming years. My interest in agility would not have been possible but for the support I have had from the various Assistant Secretaries of Defense (C3I) and later (NII) who each encouraged this endeavor. I am indebted to the support I received from Art Money, John P. Stenbit, Linton Wells II, and John G. Grimes.

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Members of the NATO Research Group SAS-085, which I am fortunate to chair, share my vision about the potential of agility to dramatically improve our various institutions. Our group is currently working on a set of case studies and experiments that are designed to validate our ever-evolving view of a conceptual model of C2 agility.

We expect to complete our report sometime in 2013. It remains to be seen how much of what I present here will survive. Based on past experience, I expect the product of SAS-085 will improve on my articulation of agility concepts. Further, it will provide a wealth of empirical evidence and lessons learned from their diverse set of experiments and case studies. The members of this group that have taken time away from their own assignments to help me hone my thoughts and have not already been recognized are: Philip Farrell, Michael Henshaw, Paul Pearce, Arne Norlander, Björn J. E. Johansson, Micheline Bélanger, Hernán Joglar, and William Piersol. Key contributions to SAS-085 are being made by Claudia Baisini, Agatino Mursia, Agostino Bruzzone, Nancy Houston, and Robert J. Gregg.

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The experiments reported here were conducted in the CCRP sponsored ELICIT environment (Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust) using abELICIT agent software.

ELICIT enjoys favor from many researchers. I am grateful for the pioneering uses of ELICIT by the Naval Postgraduate School, Boston University, the Network Science Center at the U.S. Military Academy at West Point, Portuguese Military Academy, Defence Research and Development Canada, Military Polytechnic Academy (Army of Chile), and the Defence Academy of the United Kingdom. ELICIT experiments designed and conducted by the Singapore Military Academy and the U.S. Army Research Laboratory have made important contributions to the body of evidence. These efforts sustained interest in evolving this capability. The development of ELICIT is a result of the extraordinary efforts of Mary Ruddy and her team of developers. The version of the agent code used in the experiments for this book, and the analysis tools that made it possible to analyze the resulting transaction logs, was developed by Szymon Letowski. Jimmie McEver and Danielle Martin Wynn made significant contributions to earlier versions of this software and the experiments with human participants, thus providing the foundation for this effort.

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Finally, I would like to thank you, the readers, for making this effort worthwhile. Ultimately, your creativity and hard work will be responsible for progress.

Washington, DC

August 2011

Prologue

A Call to Action

Prologue

A Call to Action

We find ourselves in a new, as yet unnamed age, in which we are increasingly interconnected, interdependent, and pressed for time. Our ability to predict, and hence to plan, has been greatly diminished as a consequence of the complexity and dynamics of our environments and the nature of the responses necessary to survive and prosper.

Survival in this new age requires, above all else, agility. This book provides a detailed definition of agility and explains why this is so. It explores the reasons why agility is an essential ingredient of the solution to many of the most challenging problems of our time. It probes the nature of agility and seeks to identify its enablers and the factors and conditions that present impediments to its realization.

Agility is, of course, not a new or recently discovered property of humans, collections of humans, or of the products they produce. Indeed, agility has been long recognized as a virtue. What has changed is the relative importance of agility in the scheme of things. For reasons that will be explained in this book, agility has moved from a nice-to-have capability to an essential, even existential, capability.

When viewed as only nice to have, agility has often been sacrificed to meet a schedule or to contain costs. Contributing to this failure to ensure that agility is an integral part and parcel of us, our enterprises, endeavors, and products, has been a lack of,

- appreciation of the costs of a lack of agility
- accepted metrics to gauge potential agility
- a definitive, empirically supported, quantitative link between levels of agility and performance or effectiveness
- "how-to" experience
- training and educational materials

This book is a call to action.

The message is that the world has changed and that agility is the appropriate—perhaps the only—response. This message will fall on deaf ears or will remain just a bumper sticker or PowerPoint slide until the following four things happen.

> First, the capability I call agility needs to be better understood.

> Second, the importance of agility in this new age needs to be more generally recognized, quantified, and supported with empirical data.
>
> Third, individuals and organizations will need to be provided with a set of concrete actions they can take to improve their agility and the agility of the products and services they provide.
>
> Fourth, a way of measuring agility and translating degrees of agility into a measure of value needs to be provided and employed.

This book is intended to enable readers, their organizations, and the endeavors in which they participate to answer this call to action. It will help readers think about and understand the consequences of our interconnected, interdependent, and fast-paced world and the resultant need for agility. It will help readers understand the grave consequences of a lack of agility, and of inaction.

This book, having hopefully motivated readers to take agility seriously, will provide a conceptual framework, a set of metrics, and the results of a series of experiments to bolster their ability to understand agility and take the actions necessary to improve their agility, the agility of their organizations, and the agility of the products and services they provide. Translating the concept and theory of agility into an implementation strategy and a set of practical steps that can make entities more agile will be difficult, but I believe well worth the time, effort, and costs involved since they are sure to be repaid time and time again. If there is anything we have observed from past failures, it is that doing it right the first time, even if it costs more and takes more time in the short run, turns out to provide us with greater capability at a lower cost in the long run. In this case, this means greatly increased attention to agility, as we continue to invest in infostructure and to make changes in the ways we do business to take advantage of the opportunities that are created by new and improved capabilities.

Chapter 1

Agility Myths

Although this book provides a detailed definition of *agility*, it is a common word and each of us has come to understand its meaning somewhat differently. Prior to reading this book, many readers will have formed an opinion about the wisdom of embarking on a journey to improve the agility of our organizations, enterprises, and endeavors, particularly in light of increasing pressure on budgets.

Based upon my discussions regarding agility with many of you, I have witnessed something similar to the discussions I had more than a decade ago, when the subject du jour was network centric warfare (NCW). Now, as was then, "there is no shortage of exaggerated claims, unfounded criticisms, and just plain misinformation about this subject."[1] Given the overwhelming and positive reaction to an identification and discussion of some

1. Alberts, Garstka, and Stein. *Network Centric Warfare*, 1999. p. 5.

myths attendant to NCW, I thought it would be useful to look at some of the myths and misunderstandings that I have encountered thus far concerning agility.

The following discussion of these myths will help set the stage for the more detailed discussion of agility and the accompanying evidence presented in this book. Hopefully, it will help prepare readers who may believe there is more than a grain of truth in some of these myths, or who share some of these misunderstandings, by alerting them to maintain an open mind and to carefully look at the explanations and examine the evidence before coming to any definitive conclusions regarding the meaning of agility or its applicability.

> *Myth 1: Agility would be nice to have, but we simply cannot afford it.*

This myth involves two faulty assumptions. The first is that we can be successful, given the challenges we face, without being more agile than we currently are. This book discusses the nature of these challenges and comes to the opposite conclusion—that we cannot afford not be agile. I conclude that our rigidity is an existential threat. However, even when the consequences of a lack of agility do not pose a threat to our existence, they are very costly.

The second faulty assumption is that becoming more agile will be very expensive. There are, of course, different approaches to improving agility, some which involve more investment than others. Indeed some changes that can make us more agile involve little or no cost. Readers will see, for example, how a simple policy change, such as enabling individuals to find alternate means to share information if the prescribed means is not working, can have a significant impact on agility. Furthermore, there is a relationship between efficiency and agility. Improved agility can actually reduce costs. Readers will see that being able to adapt to circumstances can reduce workload, improve performance, and enhance agility, while offering an opportunity to reduce costs under certain conditions.

> *Myth 2: We are already as agile as we can be.*

Even if I conceded that there are entities that are as agile as they can be (which I do not), this is simply not the case for all individuals, organizations, processes, and systems. It seems more appropriate to first ask the following two questions: "How agile do I need to be?" and "How agile am I?" The answers to these two questions will determine how much improvement in agility is required. Only then are we concerned with the question of feasibility. The first phase of the agility improvement process outlined in this book is designed to ascertain an entity's agility shortfalls and the remedies that have the potential to improve their agility. It seems to me that coming to the conclusion that you cannot improve your agility, before you even know what you need to do, makes no sense.

> *Myth 3: Agility means you spend all your time preparing for something that will never occur.*

Clearly one hopes that many things we currently prepare for will never occur. However, it still makes sense to prepare and prepare well. Agility is not only about reacting to an event or situation. It is also about being pro-active. If one can develop a capability to anticipate problems and, by taking some action, avoid them, so much the better. It makes no sense to prepare for everything one can think of. By the same token, one cannot think of everything that could occur. Agility is a new way of thinking about and preparing for the unanticipated.

Myth 4: Agility is just another word for indecision.

We admire a decisive person. However, we should not confuse decisiveness with prudence. Knowing when to make a decision is almost as important as the decision that is made. We all know people who will not act unless they have perfect information (or think they do). They wait and wait until the window of opportunity closes. We all know people who act too quickly and impulsively. Agility is not about postponing decisions, but it is about preparing oneself to be in a position to act. Agility is about dealing with the unpredictable or unanticipated. One should not confuse acceptance of the fact that one cannot adequately predict events nor fully understand the consequences of one's actions with indecisiveness.

Myth 5: Agility will undermine traditional command and management authority.

The truth of this assertion depends upon how one views command authority, how one applies the concept of agility to command and control, and upon the specific changes to command and control (C2) concepts, doctrine, and approaches made in an effort to improve C2 agility. There were critics that made this same assertion when NCW was introduced. After we engaged these critics, we found that their concerns had two separate origins. First, they simply misread or misinterpreted what was written. Some critics believed that the proponents of NCW were advocating replacing traditional C2 with self-synchronization. Some forgot that self-synchronization was based upon a premise of the existence of command intent, adequate shared understanding, competency, and training. Second, they had a very narrow view of command authority that did not, in fact, correspond to established military practices. For example, some of these critics believed that there was only one acceptable way of exercising command (e.g., command by order) and did not recognize the validity of mission command. The problem was not with the concept of NCW itself, but how it was interpreted. (N.B. This is not to say that some of the early writings could not have been articulated more clearly). Nowhere in this book, is it proposed that one should adopt an inappropriate approach to accomplishing the functions we associate with C2. In fact, the experimental results show that a traditional approach is the only approach that works in some circumstances. However, experimental results also show that a traditional approach does not work best (or work at all) in all circumstances.

> *Myth 6: An agile force is a force that cannot do anything well.*

This myth takes aim at two components of agility—flexibility and adaptability. The implication is that only by focusing on one way of accomplishing something can one develop adequate capability; that is, any effort to be flexible (learn more than one way) or adaptable (to be able to adopt more than one organizational approach to a mission) will result in unacceptable performance. Let's put aside, for the moment, the reason we seek flexibility and adaptability. Rigidity results from the inability to change (e.g., when the school book solution does not work and the entity is incapable of doing anything else). There is evidence that learning more than one way to do something is not only possible, but that it results in a better understanding of the what is needed for success in different circumstances. Agility does not require that an entity develop a large number of approaches. As readers will see from the results of experiments, a well-selected few can greatly enhance agility.

Myth 7: It is not human nature to be agile; we are creatures of habit.

While we are creatures of habit, there is ample evidence that humans are the most agile ingredient in organizations. Human behaviors make up for many shortcomings in organization structure, policy, processes and systems. Without the exercise of common sense, organizations would fail far more than they currently do. The agility of individuals regularly finds its expression in the informal organizations and the work-arounds that occur in almost every organization and undertaking. To the extent that individuals do not exhibit initiative, it is probably more a result of the constraints imposed by organizational rules, incentives, and cultures than it is a result of an inherent quality of humans.

Myth 8: Survival of the fittest determines what is important. If the institutions that have survived are not agile, then agility is not important.

One of the points made early on in this book is that we are witnessing the dawning of a new age. Institutions that are well-adapted to a previous age are not necessarily well-suited for a new age. In fact, one could make a better case that the institutions that are optimized for the characteristics and nature of the last age (and accustomed to success) will have more than their share of problems adjusting to a new age. The experiments reported on in this book, where the nature of the mission challenge was varied, graphically illustrate this point.

Myth 9: Agility is not a new idea. If we could be agile we would be.

It is true that each of the aspects that comprise what I mean by agility here are not new. However, they have not been treated holistically before. The synergies that are possible have not been adequately explored. Of equal importance is just because we know something, does not mean we behave accordingly. If we did, there would certainly be less obesity around. Furthermore, we have spent almost all of our lives in an age where we were able to succeed using an industrial age approach. Even if agility is not new, the need for it has increased. With this increased need, increased interest, attention, and progress will be sure to follow.

Myth 10: Decision-makers demand quantifiable results. Agility is not quantifiable.

This book demonstrates that agility can be quantified, and that the agility of two options can be compared. Furthermore, more agility does not necessarily result in more cost. However, the question of "How much agility do you really need?" is a far more difficult question to answer, but it is not any more challenging than the same question applied to many of the areas in which we currently make large investments (e.g., how much cyber security do we need?). In fact, many of the difficult questions that are front and center in the minds of those making investment and policy choices today involve risk assessment and management. Investments in agility are ultimately about what risks we are willing to take and what risks we are not willing to take. Being able to make these investment decisions involves risk management. Enhanced agility actually helps manage and reduce these risks.

Myth 11: Agility is all about speed of reaction, but sometimes speed is not as important as ensuring an appropriate response.

Actually, agility is about responsiveness rather than speed. Speed is an absolute measure (e.g., how many seconds did it take to react?). Agility requires that, if action is necessary, it be taken in a timely fashion. Timeliness is not an absolute measure, but a measure relative to the situation. Agility does not require that one act as soon as they are able to act; rather it involves a consideration of when would be the appropriate time to act. Readers will see, in the discussion of responsiveness, that agility can involve an option to buy time, so that adverse consequences are mitigated while preparations for a more effect response are made.

A Caution

It is important to realize that each of these myths reflects a valid concern. It would be unfortunate if, because of these concerns, that agility was not pursued vigorously. It would be equally unfortunate if, because of the way in which these concerns are addressed, they are dismissed out of hand. The concerns that give rise to these and other similar statements must be given due attention on our journey to agility.

Chapter 2

Organization of this Book

This book will take willing readers on a journey of discovery and prepare them for success in complex enterprises and endeavors that characterize this new age. As is the case with adventurers embarking on a journey, there is some basic preparation required before embarkation. Mountain climbers, for example, prepare by understanding the challenges and dangers they will face, learning what capabilities they need to succeed, and by mastering the methods and tools they will need.

This book will be organized into the following seven parts.

Part I: Fundamental Concepts

This first part is devoted to a discussion of the fundamental concepts needed to understand the need for and the nature of agility. This section identifies the characteristics of situations, tasks, and problems, explains which of these characteristics make problems particularly challenging for individuals and organizations, and explains why increasing agility may be more effective in dealing with these problems than other approaches.

Part II: A New Age

This part will review the developments that have led to the dawning of this new age and explain why the challenges that we find so daunting are a direct consequence of the capabilities that are associated with the information age. It will explain why the methods and tools of previous ages are no longer as useful as they once were. Fortunately, the information age has provided us with some of the capabilities we need to successfully meet these new age challenges. Thus we now have an opportunity, should we choose to take it, to build on a set of information age capabilities to develop the capability to be agile; a capability that will enable us to survive and prosper.

Part III: A Plan to Improve Agility

We find ourselves mal-adapted and ill-equipped to tackle the challenges and dangers of this new age. We find ourselves without the one essential capability we need to survive. This section provides the four steps required to develop the capabilities needed to survive in this new age as we form and participate in complex enterprises and undertake complex endeavors.

Part IV: Understanding Agility

Having shed the myths and commitments to the ideas and practices that are holding us back from becoming more agile, it will be necessary to develop an in-depth understanding of agility. This section provides an overview of the components of agility that, taken together, will permit individuals, organizations, and collectives to better cope with the dynamics and complexities in their environments.

Part V: Agility Experiments and Analysis

In order to illustrate and explore the concept of agility as it applies to individuals, organizations (enterprises or collections of organizations), and the infostructures (systems and information-related processes) that support these entities, a series of agent-based experiments were designed and conducted. These experiments explore the relative ability of entities with different approaches to organization and different information sharing policies to cope with a variety of conditions and circumstances. Several ways to visualize and measure the agility that is manifested are introduced. The results of these and related human experiments form the basis for developing both a better understanding of agility and ways to improve it.

Part VI: Potential Agility

The experiments discussed in Part V involve creating situations and observing behaviors. The results obtained reflect the agility, or lack thereof, that is actually manifested. This part of the book discusses potential agility—the ability of an entity to cope with changes in circumstances in the future. A model of potential agility represents our best understanding of the factors that determine agility. A basic structure for a model of potential agility is introduced and a number of factors believed to determine agility are identified. Evidence to support the inclusion of these factors in the model is presented. This model, when used in conjunction with observations and analyses of manifest agility, provides the tools we need to better understand and improve agility.

Part VII: Improving Agility

Change is difficult, and change of the magnitude required by the imperative to make agility a central focus for individuals, organizations, and collectives is daunting, perhaps paralyzing. This section addresses the question "What do we do next?" This concluding part of the book begins by restating the agility imperative and identifying a number of reasons why individuals and organizations are not agile. A process to improve agility is described and the importance of a balanced approach, one that focuses on both improving theory and practice, is explained. The book concludes with a discussion of the road ahead including the identification of high priority initiatives.

Part I

Fundamental Concepts

Part I

Fundamental Concepts

What makes situations or tasks so daunting, problems so difficult to solve? Conversely, what makes other situations manageable, tasks easier, or problems simpler? Why are some situations routinely handled, some tasks accomplished with ease, or some problems easily solved by some individuals and organizations and not by others? Why are the approaches and tools that have served us so well in the past, no longer able to effectively deal with many of the situations we face? Is there a new way of thinking about how we deal with these challenges that provides a more promising approach and, if so, what is it? Understanding the answers to these and similar questions will help us understand the basic forces at play in this new age, how these forces are increasing the difficulty of the challenges we face, and set the stage for developing the capabilities we need to meet this set of challenges.

In this, part I of our journey, we begin by answering these questions. The section entitled Problem Difficulty identifies the characteristics that make situations challenging and problems difficult. It provides a means to distinguish between those problems that are still amendable to traditional approaches and practices and those that are not. The characteristics of the most challenging problems suggest an approach that, if it proves to be feasible, could provide the answer. This approach is to be better prepared by developing or enhancing agility. Part I concludes with a review of the basics of agility.

Chapter 3
Problem Difficulty

Situations, tasks, and problems all involve choice. The success we experience depends upon our ability to make the right choices in a timely manner. However, making a correct choice,[2] while necessary, is not sufficient to deal effectively with situations or to accomplish tasks. When actions are required (and they are not always required), one must also have the capability to carry these actions out. This capability to act is not discussed in this section, but will be treated later on in this book. This section will focus on the characteristics of the decision problems that make some situations, tasks, and problems difficult to deal with, accomplish, or solve.

Fortunately, many decisions can be made correctly and in a timely manner with little difficulty or effort. We, as individuals and as organizations, have learned over time

2. I do not mean to imply there is only one "correct" choice that can be made. Readers should interpret this to mean making a choice that is good enough, not necessarily an optimal choice. Often simply avoiding an incorrect choice, a choice that materially reduces future flexibility or results in adverse consequences is sufficient.

effective and efficient ways[3] to approach these decisions. The best, or at least good, ways of dealing with these problems have become habits for individuals and have been incorporated into the doctrine and standard processes of organizations. On the other hand, there are times when a correct and timely decision may elude us despite the availability of considerable resources and time. In between these two extremes lies a vast array of decision problems that differ in difficulty and in the approaches that can be employed to solve them. Understanding the characteristics of these decision-making challenges and the resources we have available will allow us to intelligently allocate our limited resources and develop a strategy that has a good chance of success in dealing with the array of problems that we face or can expect to face.

For the purpose of this book, a decision involves a choice between two or more real options, options that differ significantly with respect to the expected outcomes and the value of these outcomes. Sometimes one of the options may be preferred in all situations. In other cases, different options will be preferred under different circumstances. In Part V of this book, the results of a campaign of agility-related experimentation provides both exam-

3. In situations and circumstances that persist over a relatively long period of time, humans tend to learn and improve and, as a result, become fairly adept. This is not to imply that the decisions they make will be optimal; rather they will be close enough given the consequences of error and the other costs involved. Russ Ackoff, who with C. West Churchman and Leonard Arnoff, wrote the seminal book on operations research, defining the field for a generation, referred to the decision process that resulted in these 'for all intents and purposes optimal' decisions as *satisficing*.

ples of circumstances where one organization-approach option dominates and cases where different options are required to successfully cope.

Decision-making is a two step process. First, the decision problem must be formulated; that is, stated in a way that completely specifies the objective (what constitutes success) and the context (the conditions that apply). Second, a choice must be made. The quality of a decision-making process is measured by the correctness (appropriateness) of the choice that is made, the time it takes to make this choice [both in absolute time and in timeliness (that is, relative to the dynamics of the situation)], and efficiency, which is a function of correctness and the resources that are consumed in the process.[4] It is important to consider both correctness and resource consumption when measuring efficiency because it does not make sense to be efficient without regard to accomplishing a task. In other words, spending no resources and not accomplishing anything is not efficient.

We often take the first step, the formulation of the problem, for granted. However, if the problem is incorrectly or incompletely formulated, either a solution cannot be found, or any solution that is developed will, in fact, not be appropriate for the situation. Traditional decision theory considers a problem formulation to be complete if it specifies: 1) the different circumstances that may occur and their probabilities, 2) the consequences of selecting each of the options in each circumstance, and 3) the value to us of the consequences (outcomes).

4. In experiments conducted by my colleague Marco Manso, he includes timeliness as an aspect of efficiency.

At this point, it will be useful to make distinctions between different kinds of decision problems. Decision problems or situations can be grouped into three broad categories—simple, complicated, and complex. These problems or situations differ in a number of ways. Making a simple decision only requires a selection from a set of known options with the simplest ones involving whether or not to take a specific action (e.g., buy or not buy, shoot or not shoot).[5] Both complicated and complex decisions involve the development of a set of options, the criteria for choosing among them, and the rules that govern how these criteria are to be combined to permit comparing potential options.

The distinction between complicated and complex is not one of degree, but a qualitative difference.[6] Being able to arrive at an appropriate choice, in the case of complicated decisions, is simply a matter of understanding how to approach the problem, having and properly utilizing available information, and expending the necessary amount of effort. However, being able to arrive at an appropriate choice, in the case of complex decisions,[7] cannot be guaranteed despite the expenditure of unlimited time or effort. The reasons for this are explored later in this section.

5. See *Understanding Information Age Warfare*, p. 23–p. 123.
6. While in everyday usage these terms are often used interchangeably, this distinction is important for a serious study of decision characteristics.
7. Complex decisions are decisions that involve complex situations or endeavors.

Problem Difficulty

Decision problems that can be completely formulated, and these include both simple and complicated decisions, may nevertheless be computationally arduous to solve because of the number of options, circumstances, and possible combinations of consequences, but they do not present us with new age challenges. In fact, information age capabilities make it easier for us to cope with these situations, accomplish these tasks, and make these decisions. We are increasingly able to make appropriate choices more rapidly and with a greater degree of assurance than ever before. This is because when we are able to acquire perfect or near-perfect information, we are, in theory, able to guarantee that we can find the optimal solution for completely formulated simple and complicated decision problems. This assumes that the knowledge and the information necessary to formulate and solve simple and complicated problems can be obtained by the individual or organization.

However, when the time and cost required to obtain the knowledge and information needed, and/or the time and cost required to determine the optimal solution exceeds a certain threshold, it is not worth it to seek an optimal decision in practice. In these cases, our problem-solving objective shifts from "finding the optimal solution" to "finding the most appropriate solution," where most appropriate takes into consideration the costs of information acquisition and problem solving as well as the benefits of finding a better solution. In real-world situations, the cost of providing decision support is often not the deciding factor. Rather, the time available for the decision is often the driving consideration, since a failure to select an option in a timely manner (indecision) is, in fact, an action with adverse consequences. As readers will have no doubt experienced for themselves, an 80 percent solution may often be the most appropriate solution, even in cases where all of the information needed is readily available and the optimal solution is obtainable. There is an often repeated saying, "The best is the enemy of the good."[8]

Introducing a dose of reality into this discussion requires the recognition that even with the most sophisticated of information age capabilities to find and process all of the information that is available and bring to bear all of the knowledge that exists, there will be, at least, some residual uncertainty.

The nature and extent of the uncertainty associated with a situation or decision problem affects our ability to both formulate the problem and find an acceptable solution. Although uncertainty is usually associated with the conditions that exist or will exist, there are other elements of problem formulation that we may not know with sufficient certainty. For example, even if we know what conditions exist or will exist at some time in the future, we may not be sure of the outcomes associated with a given action or the consequences of selecting a given option. Given the key role that uncertainty plays in determining problem difficulty, a more detailed discussion of uncertainty is merited.

8. While it is difficult to discover the origin of this proverb, two 18th century examples include in Italien *Il meglio è l'inimico del bene* in the *Questions sur l'Encyclopédie* article, "Dramatic Art" (1764) and in French *Le mieux est l'ennemi du bien* from Voltaire's Dictionnaire Philosophique (1764)—also translated as leave well alone.

Uncertainty

Uncertainty is defined as *the quality or state of being uncertain, a lack of certainty*. To be uncertain is to be indefinite or indeterminate, ambiguous, inconsistent, unreliable.[9] Synonyms include: doubt, dubiety, mistrust, suspicion, while related words include: concern, disquiet, worry, distress, hesitation, reserve.[10] Uncertainty has degrees associated with it, from just short of total certainty to completely unknown.[11]

Uncertainty is something that clearly troubles us humans. We can be uncertain about many different kinds of things—whether something will or will not occur (or even if it has or has not occurred), whether some action we take will affect something, or whether or not it will change what someone may or may not do. Uncertainty may be simply a reflection of reality or a reflection of our lack of knowledge and understanding. Thus, the same situation may present different degrees of uncertainty to different individuals or organizations, depending on the state of their knowledge or information.

To different degrees, humans and organizations find it challenging to live with high levels of uncertainty; perhaps because it interferes with our quest for control. Science and religion are both, in their own ways, attempts to reduce and deal with uncertainty. This is a testament to

9. Webster's Third New International Dictionary.
10. Merriam Webster's Collegiate Thesaurus.
11. The expression, *unknown unknowns*, is used to refer to the fact that while we know that there are some things we do not know, there is also a class of things that we do not even know we do not know—those are completely unknown.

the discomfort that is caused by uncertainty, whether it is real (inherent in the situation) or perceived. The nature of the uncertainty that is present in the problems we face in the 21st century, and the ways we have to reduce and/or deal with this uncertainty, is one of the threads we shall follow in this book as we examine the nature of the new age in which we now live and our ability to function and succeed in this new age.

Uncertainty and probability are related. The probability of an event or outcome reflects its likelihood of occurrence. If it is certain that something will occur, we say it has a probability equal to 1. If it is certain that it will not occur we say it has a probability of 0. The set of numbers that fall between 0 and 1 reflect or measure how likely it is that an event will occur. Maximum uncertainty exists when the probability of an event is equal to .5, when the probability that the event will occur equals the probability that it will not occur. This has given rise to the saying *it is a coin toss*, meaning we have no idea or information about which outcome will occur. This maximum uncertainty represents the complete absence of information or knowledge about the probabilities of what could occur. It may be, as in the case of a coin toss, a reflection of the physics of the situation, or it may be a result of our lack of knowledge and understanding of the situation. When we do not have any knowledge of the probability of an event, our best guess is .5.

However, the relationship between uncertainty and discomfort is probably not linear. For example, we do not necessarily perceive ourselves to be twice as uncomfortable when the probability of an event is .5 as when it is

.25 or .75. The relationship between event probability, perceived uncertainty, and discomfort varies from individual to individual and organization to organization, and remains a rich subject of exploration for cognitive and social science.

Since there is this basic relationship between uncertainty and probability, the degree to which we know (are certain about) the probability of an event becomes as important as the actual or perceived probability of the event itself. To put it another way, we are, at times, uncertain about how uncertain we are.

It has been shown that humans are not particularly adept as estimating probabilities in general, and are even less adept at trying to estimate low probability events. Michael Shermer, in his 2008 article in *Scientific American*, illustrates this point by posing how often miracles occur, defining a miracle as a one in a million event.[12] Take a moment to estimate the probability of a miracle happening to you in any given year. Perhaps you guessed one miracle a year, perhaps one in 10 years. Shermer calculates a bit more than 15 per year. Perhaps events that have a one in a million probability of happening are not quite as rare as we are apt to believe, given the large number of opportunities we have to witness such an event.

12. Shermer, Michael, "Why our Brains Do Not Intuitively Grasp Probabilities," *Scientific American*, September 3, 2008, p. 42.

A more sobering look at the inability of individuals to accurately estimate probability is reported in a paper by Carmen and Koorman.[13] The authors found that the individuals studied appear to be aware of some of the qualitative relationships between health-related risk factors and probabilities. However, they have very poor perceptions of the absolute probability levels as reported in the epidemiological literature, and this affected their health-related decisions. Figure I-1 is taken from their paper.

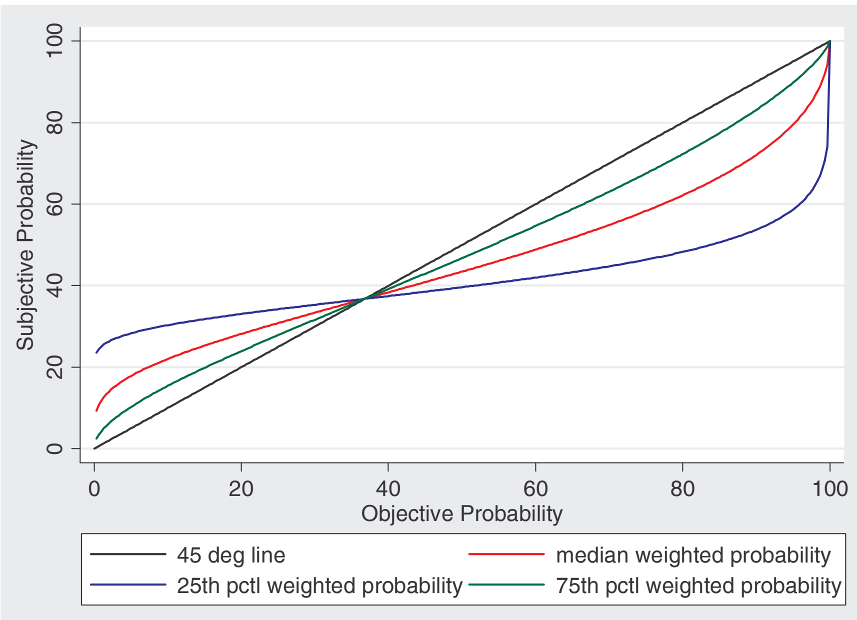

Figure I-1: The Relationship Between Subjective Risk and Epidemiological Risk

13. Carman. K. G. and Kooreman, P, "Flu Shots, Mammogram, and the Perception of Probabilities," 2010, http://www.iza.org/conference_files/riskonomics2010/carman_k5978.pdf.

Readers will note that these individuals overestimated low probability events and underestimated high probability events, and in general were less accurate as the probability of events approached 0 or 1. Interestingly, these individuals were fairly accurate in understanding that coin-toss events (near a 50-50 chance) were indeed coin tosses.

Nassim Nicholas Taleb has written a *New York Times* bestseller book about the impact of the highly improbable called *The Black Swan*.[14] Among the many stories and musings that provide interesting vantage points on probability and its estimation and perception, is one called "The Dependence on Theory for Rare Events." Taleb relates a discussion he had with a Lehman Brothers employee who offered the view, as reported by the Wall Street Journal, that the frequency with which the events of August 2007 were a once in 10,000 years occurrence. Taleb observed that we had not one but three events of this kind and in just three days. Of course, it is theoretically possible for multiple rare events to take place in a short period of time, but the odds are that this perception of probability was simply incorrect. The Lehman employee's perceptions however, we not unique; the extremely small likelihood of such an occurrence was shared by a large number of people, particularly people who one could presume were the most knowledgeable. Could the perceptions of these experts be based on experience or empirical evidence? Taleb thinks not. He points out that the more remote the event, the less we can get empirical data, and thus the more we need to turn to

14. Taleb, Nassin Nicholas, *The Black Swan: The Impact of the Highly Improbable,* 2nd Ed., Random House, 2010 p. 350.

theory. But, of course, theory without empirical evidence to test it, is simply a story. Bottom line—both individuals and science are not very good at estimating the probability of rare events.[15] To the extent that we must deal with very low probability events, this short-coming becomes problematic.

The significance of any amount of uncertainty depends upon how important it is to reduce it. Importance, of course, depends on the nature of the problem. Specifically, it depends on the risks involved. Risk is about the consequences of making an incorrect choice. Thus, the importance of reducing uncertainty or finding ways to deal with residual uncertainty depends on the cost of error. This brings us to the next determinant of difficulty, risk.

Risk

Risk is commonly defined as *an exposure to an undesirable circumstance or outcome*. Although risk is usually associated with damage and loss, a failure to capitalize on an opportunity is also an undesirable circumstance. Thus, risk is about both incurred losses and opportunity losses.

An exposure is, of course, another way of saying a probability greater than zero. Thus, risk is present when there is a combination of a non-zero probability of a particular outcome and a not insignificant adverse consequence that an entity associates with the outcome. I purposely did not say that risk was equal to the probability of an

15. An event does not necessarily have to be rare for individuals, even experts, to have difficulty predicting it with a high degree of accuracy. Take the weather, for example.

outcome times the magnitude of the disutility associated with the consequence, the mathematical equation for expected loss, because I do not believe that risk is a linear function of the combination of the severity of the consequence and its probability of occurrence.

Figure I-2 depicts a two-dimensional risk space. Points in the space, defined by a combination of the probability of occurrence and the severity of the consequences, represent different types of risk.

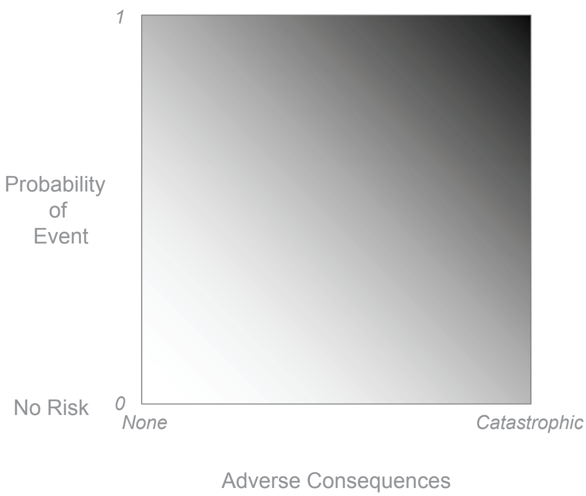

Figure I-2: Risk Space

The risk space is depicted in shades of gray to reflect the relative importance of dealing with the risks which correspond to particular combinations of probability and consequence. Thus, as the probability of a particular outcome increases and/or the adverse consequences increase, the importance of addressing the risk increases. Therefore, it makes sense, from a risk management perspective, to pay more attention to these situations.

The discussion that follows assumes that we are dealing with a set of situations that are known and understood, specifically that we know enough about the event or outcome to be able to estimate its probability of occurrence and the nature of the consequences. Later in this book, we will discuss how to approach risk management when we are, for a variety of reasons, unable to adequately estimate the probability of events or predict their consequences.

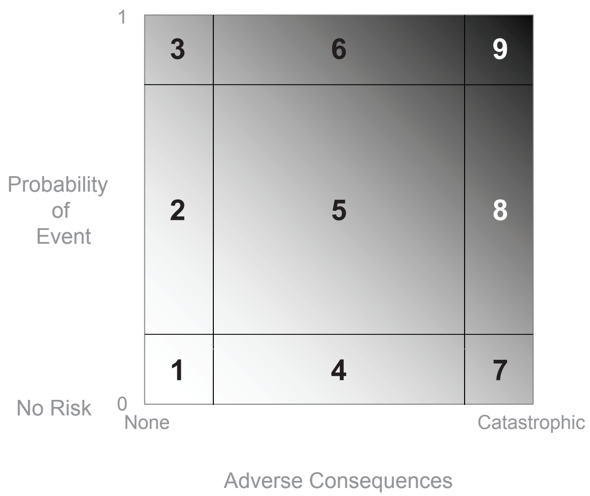

Figure I-3: Types of Risk

The risk space in figure I-3 has been divided into nine areas or risk types, numbered 1 through 9, each of which calls for a different risk management approach. I did not make the area associated with each risk type the same size because the risk management strategy proposed here is based on an explicit recognition of the tails of the two distributions involved. That is, events with a very low or a very high probability of occurrence as well as those events that are either inconsequential or involve catastrophic consequences. These risk types form the edges of the risk space. The middle of the risk space presents us with a different problem situation, one that is more amenable to traditional risk management and decision theoretic approaches.

Risk types 1, 2, and 3 (left-hand side of the space) involve events which have little or no adverse impacts. The events that fall into the area associated with risk type 1 and perhaps those that fall into the area associated with risk type 2, are safe to ignore. Risk type 3 situations will only present a problem if there are a large number of these occurrences. This could, if not addressed, cause death by a thousand cuts. However, given that risk type 3 events have a relatively high probability of occurrence, it can be assumed that we are familiar with these situations and have found ways to avoid or treat the cuts so that their overall impact is acceptable.

Risk types 4, 5, and 6 involve events that have significant adverse consequences. There are a number of ways that individuals, organizations, and systems can deal with these risks. Specifically, individuals can be educated and trained, organizations can be structured and managed, and systems can be designed and tested. The appropriate choices come down to a set of cost-benefit trades. For example, when faced with risk type 4 situations, buying insurance may make the most sense. Insurance was invented to spread low to moderate probability risks across a large population. As a result, individual entities are able to protect themselves from potential losses of consequence by incurring a manageable cost. Examples of insurance include healthcare, home, and car insurance for individuals and business interruption, liability, and key man insurance for companies.

As the probability of an event increases, the risk moves from being a risk type 4 to a risk type 5. Insurance premiums increase accordingly and at some point other actions begin to make more sense in managing these risks. The objective of these other actions is to move in the risk space from being in area 5 back to area 4 by reducing the probability of the event, or to area 2 by reducing the costs that may be incurred (see Figure I-4).

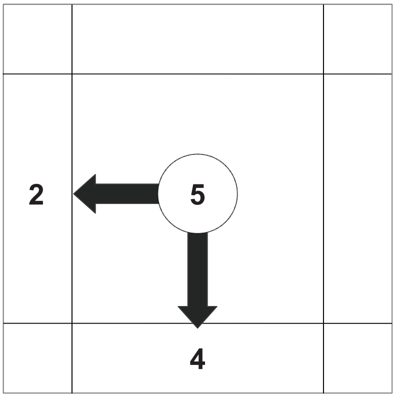

Figure I-4: Reducing Risk

For example, home security measures such as outdoor and timed lighting, signs that indicate the presence of a security system, perimeter fences and barriers, are believed to have a deterrent effect. In the world of cyber, there are analogous measures that can be taken from passwords and other more effective forms of user authentication to the creation of multiple domains that place obstacles in the path of intruders. Likewise, watch lists, baggage searches, X-ray machines, and pat downs are designed to make air travel safer. These measures hope to prevent or reduce the likelihood of a burglary, unauthorized access to systems, airline hijacking, or bombing.

Other types of action are meant to reduce the damage that would be caused if these events did, in fact, occur. For example, fire sprinklers or fire suppressing systems can reduce fire damage. Similarly, seat belts, crush zones, and roll bars can reduce crash injuries. Encrypted data, layered defenses, and honey pots can reduce the probability of the success and/or the damage caused by a cyber attack.

Many of these measures, however, are not taken until after a first attack has occurred and their effectiveness depends in large part on the degree to which the attack has been understood. How one responds to successful attacks or to events of nature is very important in determining whether or not future risk is increased or reduced. A lack of imagination can be the equivalent of closing the barn door after the cows have gone. This may satisfy someone's need to do something, but will, in many cases, not be effective; particularly when the adversary thinks and responds asymmetrically.

As the probability of an event increases, its location in the risk space moves from area 5 into area 6. At this point, the types of risk avoidance and mitigation actions cited above are no longer optional, but become mandatory. Type 6 risks need to be dealt with routinely. The nature of the choices that individuals and organizations make with respect to the measures and actions they adopt for risk types 4, 5, and 6 are a reflection of their tolerance for risk. The financial crisis of 2008–2009 came about, in part, because individuals, organizations, and indeed governments did not either understand the risks they were taking or chose to ignore them. Later in this part of the book, I will discuss how investments in agility constitute an appropriate response to risks of various types.

Risk types 7, 8, and 9 are associated with consequences that cannot be ignored. Entities or systems cannot survive, even in the short-run, if they have not evolved, learned, or been designed and built to deal with the events and outcomes associated with risk type 9. Lest one think that if insurance makes sense for risk type 4, it also makes sense for risk type 7, should consider the following illustration of why this is not the case. A typical risk type 4 might be an automobile accident that involves only property damage. Depending on the vehicle(s) involved, the monetary damage can, relative to the individual's net worth, be quite high. However, the loss after insurance would, in virtually all cases, be manageable. A fatal accident would be an area 7 risk. Insurance is clearly not going to help the deceased be made whole again.

Problem Difficulty

Longer term survival depends on being able to adequately deal with events and outcomes associated with risks in area 8, as well as those in area 9. For the most part, individuals and organizations recognize this need and have, in a variety of ways, managed these risks well enough. However, many individuals and organizations have ignored or discounted risk type 7. Some will continue to dodge the bullet, while a few will suffer significant losses, or even perish as a result. Entities that ignore risk type 7, consciously or unconsciously, choose to live under the Sword of Damocles,[16] a sword hanging by a thread that could break at any moment. Until these entities choose to think about and then learn to effectively deal with these risks, they, unlike Damocles, who immediately regretted his choice and returned to a poorer, but safer life, continue to court disaster. As we shall see later in this book, many of today's organizations have evolved structures and processes that make them ill-suited to successfully deal with risk type 7 situations. These organizations need to understand their systemic vulnerability to risk before it is too late.

Surviving, and hence successful entities and systems, have either been designed or have adapted to their environment and the stresses that are a normal part of their environment or competitive space. However, these entities, regardless of the degree of success they have had to date, may be vulnerable to risks associated with events or circumstances that have yet to occur. From a probabilistic view, these entities have not necessarily been tested by risks that fall into areas 1, 4, and 7. Since risk type 1 can

16. The *Sword of Damocles* is described by Cicero in his Tusculan Disputations.

be ignored and risk type 4 can be managed, this leaves us with only risk type 7 that poses an existential threat. Thus, risk type 7 poses the greatest continuing challenge for even the most capable and successful organizations.

This book will help readers better understand and manage these different types of risk by determining and developing appropriate levels of agility. As will be explained, agility is quite possibly the only strategy that individuals and organizations, and the systems they create can employ to effectively deal with risk type 7.

Time Pressure

As has been mentioned previously, one's ability to make an appropriate decision depends on its degree of problem difficulty relative to one's decision-making capacity. Problem difficulty is a reflection of the amount of information and information processing required. The amount of information, the available tools, and the competency of the individuals and organizations involved determine how much time is required. Time pressure is simply the time required relative to the time available. Stable situations, even ones that involve quite difficult problems, may be manageable given the availability of sufficient time to reach a decision. On the other hand, even simple decisions can be quite challenging if time is very limited.

Problem Difficulty

The amount of time available depends on the dynamics of the situation. Within the time available, the situation must be understood, and if a response is needed, it must be taken. Thus, the time available for decision-making is only a fraction of the total time available.

Time is an important resource, and just as other resources, it needs to be properly allocated. Thus, a time budget needs to be carefully considered. For example, can the time required to understand the situation be reduced? Can the time needed to act be reduced? Is having more time to make a decision likely to improve its correctness? As the time available changes, does the relative amount of time budgeted for these activities need to change? These are some of the questions that will be addressed later in this book as we explore ways of dealing with time pressures in the case of difficult situations.

Time becomes an issue when something is changing or will, if no action is taken, change. For example, a decision-maker could be faced with a situation that is currently unfavorable, but the losses being incurred are currently acceptable and will remain acceptable for a considerable time. Contrast this with a situation in which the losses currently being incurred are unacceptable, and if they continue, will become catastrophic. Another example involves the correctness of the decision. In a changing situation, the course of action or a plan (an embodiment of a set of decisions that anticipate future conditions) that is best at a given point in time may, due to changing circumstances, no longer be a good decision or an effective plan. As the expected life of a plan decreases, the pressure to plan more quickly increases. Thus, the dynamics of the situation are a major determinant of time pressure.

To this point we have seen how uncertainty, risk, and time pressure can make even simple decisions difficult, and complicated decisions more difficult. Complex decisions, as stated earlier, are not simply vastly more complicated, but are qualitatively different. Complexity has a profound impact on uncertainty, risk, and time pressure. To understand why this is so, we turn our attention to the nature of complexity.

Chapter 4
Complexity

It has become fashionable to invoke the term *complexity* as if, by merely asserting that something is complex, this either explains why nothing can be done or it constitutes an understanding of the nature of the situation and indicates a way forward. Complexity, like the terms *uncertainty* and *risk* discussed previously, has been used, and continues to be used, in a variety of ways. In many cases, those using this term are actually referring to things that are complicated rather than complex. This is not surprising since an English thesaurus lists them as synonyms. However, as mentioned earlier, it is important that we recognize that there is indeed a real difference, since the appropriate response depends on whether something is complicated or complex.

Some dictionary definitions of the word *complex* refer to the difficulty which one may have in comprehending a situation, a system, or a phenomenon giving synonyms like baffling, mystifying, puzzling, confusing, and obscure, and antonyms such as clear, simple, plain, recognizable, explicable. Some definitions refer to the number of parts involved and the ways that these parts fit together—elaborate, composite, compound. The dictionary definitions that correspond most closely to the meaning of complex as I use it in this book refer to the interactions between and among a system's[17] parts or components—intricate, interrelated, intertwined, compound, mingled, blended, discontinuous and Gordian.

Complexity is a concept that is of interest to both theorists and practitioners in many fields—systems theory, cybernetics, artificial intelligence, chaos theory, and more recently, complexity science, complex adaptive systems, and a host of applied sciences related to biology, sociology, economics and the like.[18] A number of methods and tools have been developed to help understand and explore the complexity to be found in a variety of situations and problems. These include fuzzy logic, agent-based models, artificial realities, neural networks, data mining and farming, and genetic algorithms.

However, to understand why we are no longer in the relatively well-ordered information age, but in a new, and less well-behaved age, it is not necessary to become an expert in complexity theory. It is important, however, to understand what conditions give rise to complexity, how the presence of complexity affects the nature of the challenges we face, and what this requires of us to

17. System here includes living or biological organisms, organizations or social systems, as well as communications and information systems. System here also includes what has been called systems of systems, and in the CCRP literature federations of systems.
18. A map of the development of sciences, theories, and methods that are related to complexity may be found at http://en.wikipedia.org/wiki/File:Complexity-map-overview.png#file.

successfully meet these challenges. Understanding the basics of complexity will help us understand why agility is a must-have capability in this new age.

The sense of the word complexity, as I use it here, speaks to our inability to predict what is likely to happen. However, the statement, "If it is complex, then one cannot predict," is not an adequate definition of complexity. A failure to predict can come about for a variety of reasons, some of which have nothing to do with complexity. Therefore, while complexity always leads to a diminished capacity to predict, the converse is not true. That is, an inability to predict means that one is dealing with complexity. Thus, while complexity is closely related to uncertainty and risk, it is not as simple as saying that when the level of uncertainty rises to a given level the situation is complex, or that when prediction is no longer possible we are dealing with a complex situation.

However, the inverse of the converse (we can predict therefore the situation is not complex) is true. Decisions are not complex when we can predict the outcomes that are associated with various options. This distinction is important because our ability to predict can, in some cases, be improved while in other cases it is either not possible or practical to significantly improve our ability to predict. Furthermore, how well we can predict will, in large part, determine the most appropriate solution strategy. For example, simple and complicated decisions are manageable using well-known decision theoretic approaches, while complex decisions cannot be successfully approached in this manner.

A useful definition of complexity for our purposes needs to identify what conditions, other than simply a lack of available knowledge, information, computational resources, and time, need to exist to give rise to our inability to understand and predict. Dictionary definitions give us a good point of departure. Dictionary definitions of complexity focus on our inability to understand and deal with situations (or systems) that are complex, and suggest that there is something in the way that individuals in an organization, entities in a collective, the components or parts in a system, a system in a system of systems, or a set of effects in multiple domains relate to one another that creates this degree of incomprehensiveness or complexity.

What is it about the ways individual entities relate to or interact with one another that gives rise to complexity?

Our inability to understand a situation, as it unfolds, is embodied in the jargon of complexity and the concept of emergence. When something emerges, it just appears as if out of a cloud. We do not see it forming or gathering momentum; rather we first notice it when it has already been formed. As a result we cannot trace back to discover what actually happened. The cloud in question is formed by a set of interactions. The emergent behaviors are a result of this set of interactions. The interactions, in turn, are a result of the existence of a type of relationship that exists between and among entities, parts of a system, or effects. This type of relationship is called feedback.

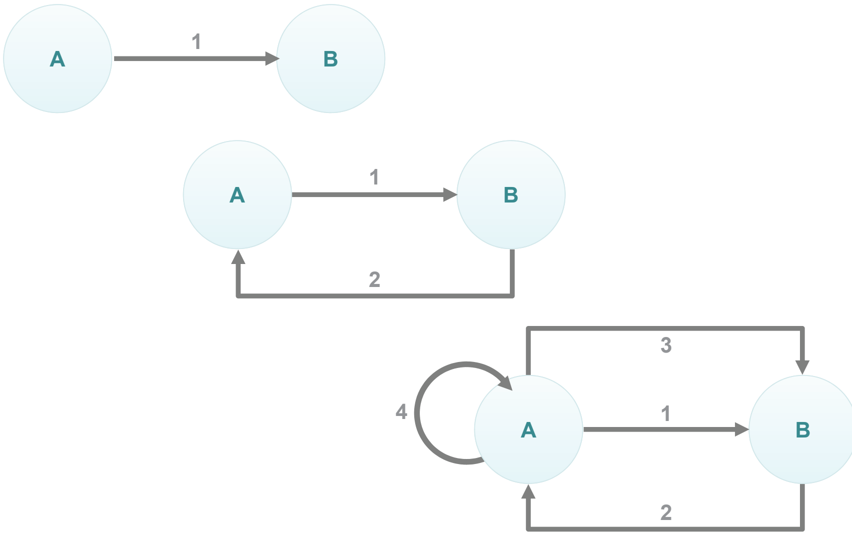

Figure I-5: Feedback Loop

Feedback involves a set of interactions between two or more entities. Feedback is often depicted as a loop. For example, as in figure I-5, an action initiated by or a change, **1**, in the state of **A**, affects the state (or perceived state) of **B**. **B** recognizes this change in **A**, and takes an action or changes its state (**2**). This creates a loop, but the consequences often do not end there because **A** could then react to **2** and take an action or change its state represented by **3**. An action taken by **A**, could also impact some aspect of **A**. While figure I-5 depicts feedback involving only two entities, these individual feedback loops can affect more than two entities and, of course, there can be many different feedback loops and entities involved in multiple feedback loops.

The existence of feedback, or the sheer number of entities or parts involved, do not, in of themselves, create complex behaviors. But in cases where there are a sufficiently large number of entities or parts, the nature of the feedback mechanisms that exist determines whether a collective or system is truly complex or whether it is simply complicated.

Feedback provides entities with information about changes in circumstances that when properly recognized and understood can be used by entities to modify their behaviors in appropriate ways in response to these changes. Some changes can be safety ignored while others require immediate responses. Entities[19] that are able to sense important aspects of both themselves (be self-aware) and their environments, can then, based upon an assessment of the situation (their state and/or the state of the environment), modify their behavior if appropriate (act, don't act, do this, do that), and be more agile than those that cannot.

There are a wide variety of capabilities that entities could have with respect to their ability to sense, process, make decisions, and react to changes in their environments. In the experiments reported on in part V of this book, the relationship between some of these capabilities, measures of mission effectiveness and efficiency, and agility are explored.

19. The term entities is used here to include humans, collections of humans, other biological forms, computer programs, machines and robots, systems, and collections of systems.

The modifications in perceptions and behaviors that human entities exhibit depend on the specifics of their cognitive abilities, education, training, and personality. If they are part of an organization, these reactions and behaviors also depend on assigned or perceived roles, responsibilities, and organizational culture. If the entities are agents, the behavior palette is determined by the entities' design and programming. The degree of sophistication associated with changes in behavior, of both humans and software agents,[20] may range from a selection from among a small set of current behavior options to the development of new behaviors. The term environment is used here to refer to everything outside the entity. However, since the state of other entities can be a significant part of an entity's environment, entities can, in fact, react to changes in the states of other entities or can be constrained by the perceptions or reactions of other entities. Among the factors that can affect an entity's reactions are the quality and timeliness of the information that is available. Therefore, the aspects of the environment that are of interest include not only kinetic or physical effects, but include informational, economic, and social effects as well as psychological effects.

There has been much attention paid by various scientific disciplines as to how entities of various kinds react to stimuli and environmental conditions. Therefore, a great deal is known about the behaviors of which entities are capable, and the specific behaviors that are associated with specific conditions. In some cases, we can routinely

20. This also applies to systems of humans and systems that consist of both humans and software agents that have been called socio-technical systems.

predict an entity's behavior in response to familiar circumstances. But predicting entity behavior in unfamiliar circumstances or predicting the behavior of entities we do not understand and/or cannot relate to (e.g., cultural ignorance) remains challenging.

Furthermore, the inter-relationships between the state of self, the states of others, and the state of the environment means that, for all intents and purposes, self cannot be viewed or analyzed as separate and apart from the situation as a whole. This intimacy makes entity-based decomposition difficult if not impossible, increases complexity, and hence problem difficulty.

Collective behavior, on the other hand, has been less well-studied and, for reasons that we shall see, is far more difficult. Perhaps, at this point in time, it may even be impossible to fully understand and adequately predict.

The existence of feedback loops is not confined to interactions between and among individual entities, but may also involve interactions among a combination of environmental variables, as well as interactions between entities and environmental variables. This gives rise to a number of inter-connected feedback loops involving multiple assessment processes. The collective behavior that results depends upon the form of these relationships between and among both entity and environmental variables. The specific assessments made by individual entities that result in modifications of their behaviors are based on the information that is available to the entities, their ability to process and understand this information, and their perceived values of specific environmental variables.

For example, if the temperature (an environmental variable) rises above a certain threshold, a person is increasingly likely to take some action (e.g., remove some article of clothing, turn on an air conditioner). However, each entity potentially has a different set of thresholds and different preferences for specific responses to changes in temperature.

Temperature, the price of an air conditioner, the cost of operating one, and the sales of air conditioners are thus all related to one another as a function of time. Changes in weather, the unemployment rate, and/or the cost of energy can also have an impact on the nature of the relationships between and among these variables. If dealers use a heat wave as an opportunity to raise prices, demand may be suppressed—and since dealers' behavior may be influenced by customer behaviors—a lack of customers at these higher prices may, in turn, prompt price rollbacks. On the other hand, customers may not be price sensitive in times of heat waves and increased customer interest could influence dealers to not lower prices, but to even raise prices more. Time plays a role here since there are delays associated with information dissemination, the translation of intent into action, air conditioners supply, etc. Thus, there are potentially a great many relationships (inter-related feedback loops) that need to be considered if one is to understand and predict entity behavior above and beyond a simple supply-demand curve or a single entity's values and decision-making process.

The dynamic behavior of entities and the dynamics of the circumstances, both determined by the existence of feedback loops, are the basic ingredients in the creation of complexity. As the number of feedback loops increase or as the strength of their inter-relationships increases, the potential for complexity increases. As a result, it becomes increasingly difficult to understand the dynamics that are driving the set of behaviors and thus, increasingly difficult to see the big picture. This is where the concept of emergence comes in.

Emergence, in its everyday sense, means to appear, take shape, rise into view.[21] Interestingly enough the word *emergency* which seems like it would share a common origin with emergence, is defined, in part, as an unforeseen combination of circumstances.[22] For the purposes of our discussion, emergent behavior can be thought of as a combination of these meanings, that is, rising into view from an unforeseen combination of circumstances. This captures the two key ideas. First, it is difficult or even impossible to envision the collective outcome by focusing on the behaviors of individuals, and second, both individual outcomes and the collective outcome are often unforeseen.

The following statements are all true for complex situations and systems.

- The whole is more than the sum of the parts.

21. Merriam-Webster Learner's Dictionary: http://www.learnersdictionary.com/search/emergence.
22. Ibid.

- Small changes in initial conditions may produce large changes in outcomes.

- The response surface contains discontinuities.

- Even perfect information about the initial conditions is not sufficient to predict behaviors and outcomes.

- It is beyond our current abilities to establish cause and effect relationships between individual behaviors and outcomes.

- Global behavior emerges from the set of local[23] interactions that take place.

Complexity and Problem Difficulty

Part I began by posing a number of questions. Specifically, what makes situations or tasks so daunting, problems so difficult to solve? Conversely, what makes situations manageable, tasks easy, or problems simple? Why are some situations routinely handled, some tasks accomplished with ease, or some problems easily solved by some individuals and organizations and not by other individuals and organizations? The motivation for seeking answers

23. The idea of local behavior found in the complexity literature comes from a preoccupation with physical interactions. In the information age, interactions can and do take place between entities that are not in close proximity geographically, but who possess the ability to interact virtually or through an intermediary.

to these questions was that these answers would help us understand the basic forces at play in this new age and set the stage for developing the capabilities we need.

The answer to the first two of these questions is to be found in the relative amount of uncertainty, risk, and time pressure associated with the situation, task, or problem at hand. Each of these factors is determined by both the nature and complexity of the environment and the capabilities of the entity. Complexity, both of the environment (the challenge) and of the entity in the form of an individual, system, organization, or collective (self), directly or indirectly affect these three dimensions of problem difficulty—uncertainty, risk, complexity. Figure I-6 depicts how these characteristics of the challenge and self are related to one another and to problem difficulty. Readers should note that these boxes are color coded—white means it is an attribute of the entity or self, blue is a characteristic of the situation or problem, and a cross-hatch of white and blue means that both contribute.

Complexity

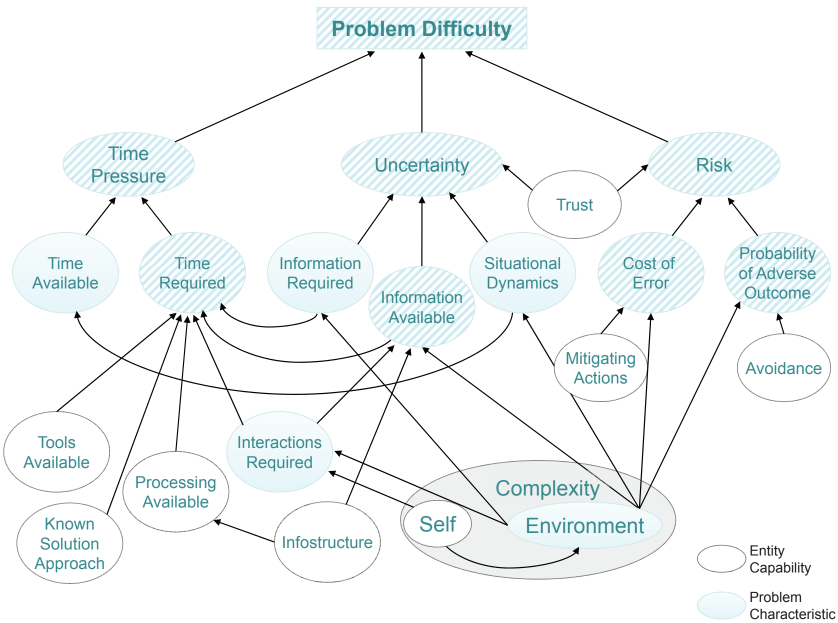

Figure I-6: Sources of Problem Difficulty

The answer to the third question (why some individuals or organizations are able to successfully tackle difficult problems) lies in the degree to which the characteristics of individuals and organizations match the demands of the situation or challenge. Individual competency clearly plays an important role. But the way organizations are structured and the ways in which they approach problems and tasks is also a major factor. As we shall see in Part V, the ability of organizations (or collectives) to deal with various challenges depends on the nature of the interactions between and among participants and on the flow of information.

If there were no complexity present, problem difficulty could be reduced to manageable levels, at least in the long run, by making appropriate investments in research, education, training, information collection, processing, and distribution systems. However, given current knowledge, tools, and experience, the presence of significant amounts of complexity makes it impossible to reduce problem difficulty to levels that are manageable when using the problem-solving approaches that are currently being employed by many individuals and organizations.

Clearly, a new approach is needed. And, this new approach is agility.

As will be explained later in this book, it is the agility of individuals, organizations, collectives, and systems that ultimately makes the difference.

An introduction to agility is provided in the next section.

Chapter 5

Introduction to Agility

Agility is not a way of reducing problem difficulty, but rather a way of dealing with the combined effects of the presence of complexity and uncertainty.[24]

Someone reviewing the characteristics of complex situations and systems identified previously could be forgiven if they experienced a sense of frustration and hopelessness. The need to control has been identified as a basic human need. A lack of control has been identified as a major source of stress. However, the characteristics of complexity directly challenge our ability to fully understand situations or control outcomes. Complexity also greatly increases the risks we face.

Let us review the list of truths about complexity and see how its presence reduces our ability to understand, reduces our control, and increases risk.

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24. Even if complexity were not present, certain situations or problems have significant levels of uncertainty that require agility in addition to statistical decision theory.

The whole is more than the sum of the parts.

This property of complexity takes off the table the main approach we have been taught to tackling difficult problems. This approach, known as reductionism, involves breaking up the problem into manageable pieces. That is, to decompose the problems into a series of smaller, easier problems that can be solved.

Small changes in initial conditions may produce large changes in outcomes.

This property of complexity gives us little room for error and makes reliable prediction all but impossible.

The response surface contains discontinuities.

This property of complexity takes away approaches to improving performance based upon incremental improvements.

Even perfect information about the initial conditions is not sufficient to predict behaviors and outcomes.

This property of complexity serves to put a limit on the value of information and calls into question the underlying assumptions and the investment strategy of information age organizations that focus single-mindedly on providing the right information to the right place at the right time.

It is beyond our current abilities to definitively establish cause and effect relationships between individual behaviors and outcomes.

This property of complexity makes it likely that we will face situations that we do not completely understand and cannot hope to understand.

Global behavior emerges from the set of local interactions that take place.

If it is local interactions that give rise to the outcomes that occur, we can no longer think about organizing activities solely from a top-down perspective. The simple fact is that complex systems or situations cannot be predicted or controlled. The best that one can hope for is to exert some influence to keep behaviors within acceptable bounds.

As a result, there is virtually nothing left in our traditional tool kit to deal with the degree of difficulty that attends complex endeavors. Agility is not only the logical response to complexity and the uncertainty, risk, and time pressures that are associated with complex situations, tasks, and problems, but perhaps the only response.

Many words have a more specialized definition that is accepted in an academic or scientific community in addition to their meaning when used in everyday conversation. This is a source of confusion, particularly when there needs to be an interdisciplinary conversation, a conversation that includes members from a number of different disciplines, educational levels, and backgrounds. If there is to become a widespread understanding of the concept of agility and its application to individuals and the organizations, processes, systems, and products that we design, develop, and use, we will need to avoid jargon. This introductory discussion of agility and the discussion of the basic concepts needed to understand why agility is an existential capability in this new age is intended to level the linguistic playing field and promote meaningful dialogue.

The concept of agility will be explored in depth from multiple perspectives throughout the remainder of this book. Since you, the reader, have almost certainly used the term agility and have come to associate specific ideas and properties with this term, this introduction is provided to help you relate your current view of agility to the concept that is described in this book. Whether you choose to adopt the meaning of the word as it is employed in this book is not important; what is important is that you understand the sense in which the term is being used here and can translate these ideas into your own language.

Some years ago, when I became seriously interested in exploring agility as a way of dealing with what I thought of as profound uncertainty and, as a practical way of coping with complexity, I began to engage a variety of colleagues. It soon became apparent that there was a wide variety of ways in which individuals articulated their thoughts about agility and the meanings that they attached to terms closely related to agility. Every meeting, it seemed, began with a lengthy airing of individual perspectives and as a consequence, little progress was made. Finally, it was determined that we needed to set aside a number of days to devote to a more systematic discussion of agility and to try to develop a common language. As a result of these meetings, a number of agility-related concepts, alternatively labeled as dimensions, attributes, properties, components, or capabilities, were identified. These included responsiveness, robustness, flexibility, resilience, adaptability, and innovativeness.[25] I think that the term component is the best among the terms that have been used to date. A component implies that it is a part of something, not just an enabler or influence. In mathematics, a component of a vector is an integral part of the vector's direction. In chemistry, a component is one of the minimum set of substances required. As readers will see later in our discussion, at least two of these components are needed for an entity to exhibit or manifest agility in a particular circumstance. Different combinations of these will come into play as circumstances change.

There was a strong sense among those participating in these discussions that agility was, in fact, an overarching concept that encompassed all of these six properties, or what I call components of agility. Further, that these properties could be associated with a wide variety of entities (e.g., individuals, organizations, processes, systems, machines). A major reason for this was that, in any given entity, these properties of agility are interrelated. Looking at one or any subset of these components was, therefore, going to result in ignoring some, perhaps significant, synergies or adverse interactions between and

25. The specification of agility as a composite or umbrella variable with these six properties was first developed in a US/UK bilateral meeting and first appeared in *Power to the Edge,* pp. 127–128 (see acknowledgments).

among them. Thus, to be able to understand agility, or any subset of the components of agility, one needed to look at the concept and the impacts of agility holistically.

In other words,

> Agility is more than the sum of its component parts.

Having come to the conclusion that agility was a meta-concept and having settled on its six properties was a major step on the road to developing a useful definition of agility. However, merely listing the components of agility does not provide a useful definition. A useful definition should provide some guidance as to how to answer the following questions. Why would you want to be more agile? How do you know if you are more or less agile? After considerable discussion, the following simple definition was developed.

> *Agility is the capability to successfully cope with changes in circumstances.*[26]

It is important to note here that agility is not simply about being successful; rather it is about maintaining success in light of changed or changing circumstances. Changes in circumstances may be quite predictable or they may be totally unanticipated. Not all possibilities are equally likely. Not all potential changes in circumstances deserve equal attention.

26. This simple definition has been modified since to emphasize some aspects of agility that were felt to be not readily apparent. A more detailed discussion of agility later in this book incorporates some of the additions to this definition that have been suggested by others.

Figure I-3 identified nine categories of risks associated with present or future circumstances. Changes associated with risk areas 1, 2 and 3 may be safely ignored, since lavishing attention on these possibilities distracts entities from preparing for and dealing with legitimate concerns. Learning to ignore these potential distractions frees up time and resources that can be devoted to developing a capability to successfully deal with traditional requirements and with Black Swans. Of the remaining six risk areas, 6 and 9 are associated with events that occur with high frequency. These high probability events are likely to have been experienced in the past, if not by a particular entity then by another entity. Thus, it would be reasonable to conclude that entities would specify these circumstances in any statement of requirements for a system, process, or organization.[27] Dealing with these requirements should be, at least in theory, quite straightforward, and entities should be able to anticipate and prepare for them as a matter of course. Traditional preparation activities such as planning, education, training, exercise, and rehearsal are designed to help entities cope with known requirements. In practice, for a variety of reasons, these often get short-changed and as a result, entities are simply not prepared for the circumstances they encounter. This failure is not a failure to be attributed to a lack of agility but rather to a lack of ability or competence.

27. If the reader feels that these simplifying assumptions are not appropriate, then the solution would be to add additional dimensions to this chart—a third dimension that divides the space into known and unknown, and a fourth dimension that divides the space into familiar and unfamiliar.

Risk area 7 involves rare events that have important consequences. These are one of the most significant challenges of the age of interactions. Events that are (or thought to be) rare present a challenge for planners and decision-makers. This is because the traditional approach to rational decision-making is based on expected values. Very low probability events that have high, even catastrophic consequences have, nevertheless, low expected values, at least for a particular instance of one of these low probability events. As pointed out in the discussion of uncertainty, not only are humans not particularly good at estimating probabilities in general, they are even worse at understanding low probability events. This, plus the fact that there is a huge difference between the probability of a single event and the probability that no low probability-high consequence event will occur, makes coping with Black Swans challenging. For example, if the probability of occurrence is one in a million, people tend to ignore this possibility. If there are 100 equally low probability-high consequence events, the situation is quite different. Many people would conclude that there is only a 1 in 10,000 chance that one of these 100 events will occur, and not feel particularly threatened. In fact, the probability that none of these events will occur is equal to 1 in a 100, a far cry from the 1 in 10,000 that many people intuit. Furthermore, there is a time dimension to consider. If this estimate covered a period of a year, then the risk of something occurring in a 10-year period would be approximately 1 in 10. This probability calculus provides at least one explanation as to why what we think of as rare events occur more often than we expect and why we tend to be caught unprepared.

Some readers will conclude that improving education and training in probability theory would enhance our ability to prepare for low probability events, and to some extent it would. However, due to the complexity of our environments and the increasing complexity of our new self—a heterogeneous collective—being able to estimate these probabilities and being able to understand and develop optimal responses for all or even a small fraction of the relatively high probability events, is unrealistic. We need a different approach, one that improves our agility so we are not so dependent upon making predictions in the head winds of complexity.

In Part IV, Understanding Agility, I will build upon this simple definition. Starting with a more detailed discussion of each of the terms, I will enhance this initial definition to provide a point of departure from which we can develop an overall understanding of what benefits agility has to offer entities, and to enable entities to make better informed investment decisions regarding how much agility is desirable. These investment decisions, properly framed, will turn out to be a function of the nature of the circumstances faced (relevant aspects of the environment plus the status of self) and the state of our understanding of these circumstances.

Part I Review—Part II Preview

This first part of the book was devoted to a discussion of the fundamental concepts needed to understand the need for and the nature of agility. The three determinants of problem difficulty—uncertainty, risk, and time pressure—were identified. The concept of complexity was introduced. The relationship between complexity and problem difficulty was explained. The reasons why traditional approaches to problem solving were not up to the task of dealing with complex problems and complex endeavors were identified. The inevitable conclusion that a new approach was needed was reached. Part I concluded by introducing the concept of agility and by asserting that agility was the appropriate response to levels of problem difficulty that could not be reduced by other means.

Since some level of complexity has always been a part of our environment and is present in many of the situations we face, readers could well be wondering what's different about this new age that makes dealing with the consequences of complexity more important. Part II will explain why. It will review the developments that have led to the dawning of this new age and explain why the challenges that we find so daunting are a direct consequence of the capabilities that are associated with the information age. It will explain, in greater detail, why the methods and tools of previous ages are no longer as useful as they once were.

In this part of the book, the U.S. military is used as an example of an organization that has invested heavily in information age technology and has sought to transform itself into an information age enterprise. In this discussion the focus is on how information age concepts and technologies have affected the way the military is organized and on how it is attempting to bring to bear available information and assets in the planning and execution of its missions. It will also look at the ways in which military missions have changed, relate these changes to the realities of the new age, and identify the challenges to information age capabilities that have and are being developed by the military. The conclusion that will be drawn is that an information age military is not up to the challenges of the new age.

Fortunately, the information age has provided us with some of the capabilities we need to successfully meet these challenges. Thus, all of us have an opportunity, should we choose to take it, to build on a set of information age capabilities and to develop new age capabilities that will enable us to survive and prosper.

Part II

A New Age

Part II

A New Age

The dawning of new age is not just of academic interest; on the contrary, it is vitally important to individuals and organizations to recognize that something fundamental has changed, when a tipping point has been reached. Whether one is the dominant force in a competitive space, a peer competitor, or simply an entity trying to survive in one's environment, being aware of potentially disruptive trends, technologies, and other changes in one's environment and responding appropriately, can make the difference between maintaining one's competitive edge or even whether one survives or perishes.

Responding appropriately requires a rich understanding and both a capacity and a willingness to change. Two out of three is not enough. At times, organizations at the top of their game have been shown to have a propensity to fail to recognize when conditions are changing, even when there have been some internal and/or external gadflies who have articulated a clarion call.[28] Even if a change has been acknowledged, these best-in-their-class entities seem to have a problem with disruptive change.

This book, as was stated early on, is a call to action. It is a plea to pay attention, analyze, and respond, without undue hesitation, to the birth of a new age. It is because we are in a new age that agility has become an existential capability. To understand why this is so, we need to understand the nature of this new age and how it differs from the previous ages. A misreading of the nature of the age in which we live, work, and compete results in an improper formulation of the problems we face. As a consequence, we will be far less successful, succeed less often, and perhaps even fail. For this reason, I will spend a considerable amount of time discussing the nature of the age that individuals and organizations believe they are in, as indicated by what they say, their investment priorities, and how they behave.

If one were to ask the question "What age are we in?," I suspect that most people would answer the information age. However, when asked to describe what this means, the explanations proffered would vary considerably. Furthermore, these descriptions would likely be comparative, explaining how the information age differs from other ages, most often the industrial age. Optimists might focus on the new technologies and related capabilities that are associated with the information age. Pessimists

28. A clarion call is a strong request for something to happen, http://www.learnersdictionary.com/search/clarion+call; powerful request for action or an irresistible mandate; it derives from the sound of a clarion, a medieval trumpet, http://en.wikipedia.org/wiki/Clarion_call.

might focus on the new challenges this age presents to individuals and organizations. A balanced view would recognize that the inventions of the information age have solved some persistent industrial age problems, but that these very same technologies have also created a set of new problems and challenges. Thus, each age presents opportunities and creates challenges. Some individuals and organizations prosper while others struggle.

In the set of definitions of a particular age, a large proportion of these definitions focus exclusively on the debut of the technology du jour. But equating the beginning of an age with the first instance of one of its enablers, or even with its widespread availability, represents a fundamental misunderstanding of what an age is. To properly date the onset of a new age, it is necessary to understand what constitutes an age. What makes one age different from another? This question can be addressed from a number of perspectives that involve different, inter-related effect spaces. These effect spaces include economic, political, and social effects. When the combined effects (in the spaces of interest) result in a qualitative change (a sea change[29]) affecting how we live, work, and relate to our environment, then we have entered a new age.[30]

29. Commonly taken to mean a transformation, the phrase *sea change* was traced by Michael Quinion (http://www.worldwidewords.org/qa/qa-sea1.htm) to William Shakespeare's *The Tempest*, Full fathom five thy father lies | Of his bones are coral made | Those are pearls that were his eyes | Nothing of him that doth fade | But doth suffer a sea-change | Into something rich and strange. (http://www.william-shakespeare.info/act1-script-text-the-tempest.htm).
30. *Network Centric Warfare*, p. 15.

A new age changes relative importance and influence. Thus, a new age changes the status quo with respect to the wealth, power, and influence of institutions (such as church, state, industry) vis-à-vis each other, and relative to the individual and it changes the relationships of the entities within each of these groups to one another. This re-alignment of influence and power is a major aspect of a new age.

The use of the word *we* implies that it is not necessary for all of this earth's inhabitants to be in the same age at the same time. Arguably there exists some subset of individuals that currently find themselves in the industrial age, others that find themselves in the agrarian age and perhaps some that are still in the stone age.

As we have progressed from age to age, the complexity of our environments has increased at a more rapid pace. While each age has given us new approaches and tools that could enable us to cope with increased complexity, we seem to be in a constant state of playing catch-up. Alvin and Heidi Toffler called this phenomenon *Future Shock*.[31] Although by some accounts, we have been in the information age for many decades, we still speak about information age transformation as something that is in the future; yet we are living in a world that is being defined by information age technologies, products, and services, and the complexities they engender. In each previous age entities have managed to find ways to successfully cope with the complexity in their environments. Each successive age not only presents individuals

31. *Future Shock*, Alvin Toffler, 1984, http://www.alvintoffler.net/.

and organizations with new challenges but also provides new conceptual frameworks and tools that can be used to tackle these problems. However, there have always been winners and losers. The winners are those entities who learned to leverage the new technologies and co-evolve their approaches and business models to cope with the new challenges and increased complexity present in their environments (or perhaps were just better designed or adapted). The losers have been entities that would or could not adapt.

Chapter 6

Understanding a New Age

Understanding the ways in which one's world is changing is the first step in a journey from being a native of one age to an immigrant in a new age.[32] Both the differences and the similarities between the world one lives in and the new world are significant. The differences tell us what may no longer work while the similarities provide a solid foundation upon which to build. Therefore, before providing an in-depth discussion of the information age and what I believe is rapidly becoming its successor, an approach to comparing ages one to another is provided.

Three useful ways to understand the differences between and among ages is to look at:

1. The means of influence, power, and wealth;

32. The terms *digital native* and *digital immigrant* date at least to 2001 when they appeared in Marc Prensky's *On the Horizon*, MCB University Press, Vol. 9 No. 5, October 2001.

2. What limits the ability of these entities to be even more effective; and

3. The nature of the entities that exercise influence and power and create wealth.

That is, one can look at the entities that are well-adapted to an age and those that are not as well suited to compare and contrast one age to another.

Means

Over the years, the contributions of various means of production (the inputs and processes that result in something of value) have shifted. Land, manual labor, and more recently capital, have become less important as a raw material in creating value or wealth. In the information age, human capital, information (knowledge), and particularly information and communications technologies, have become increasingly significant. The proportion of wealth coming from material products is diminishing relative to that coming from intangible products and services.

The agrarian age was about products related to the land and livestock. The industrial age was more about products mass-produced by machines. As a result these products became cheaper and more widely available. In turn, the new economics of material goods has a cascading series of effects that we associated with the industrial age. The information age created new information and communications technologies which productized information and its dissemination. As a result, the information age is changing the economics of information. We are still experiencing the effects of these new information-related products and services and their ever increasing affordability. This new economic reality has created the conditions for disruptive change that is carrying us into yet another new age.

The availability of means (wealth) is related to our ability to store and exchange it. Until quite recently, wealth was represented by and stored in the form of physical objects. Thus, wealth-related transactions were fairly straightforward. Increasing one's wealth has an intangible component. An example would be the goodwill embodied in a business. Valuing goodwill has always been somewhat of a challenge for sellers and buyers, but payment has traditionally been in a tangible form (the intangible value is translated into a tangible commodity). As the importance of intangible wealth increases, it becomes more likely that wealth transactions will involve exchanges of intangible forms of wealth. The information age is about information. Information is an intangible that does not have the same characteristics as tangible manifestations of wealth. The value of information will be a key variable in examining the characteristics of both the information age and the age that is rapidly succeeding it.

Limits

In addition to limits that result from the affordability and availability of means, the success of an enterprise, in any age, is limited by the capabilities of its creation processes and the receptivity of the marketplace to its products and services.

The nature of an entity's creation process determines both the quality (attractiveness) of the product as well as the enterprise's productivity or efficiency (ratio of outputs to inputs). The quality of what is created or produced together with the price at which it is offered determines its receptivity in the marketplace. Apple announced its long anticipated iPad in 2010 (a tablet computer with wireless connectively). As the unveiling was taking place, Apple's stock dropped. As soon as the price structure was announced, Apple's stock went back up. The price drop was a reaction to the iPad's features and quality (some disappointment relative to rather high expectations) while the subsequent rise in stock price was a reaction to its unexpected affordability (a lower price than had been predicted). It should also be noted that these price changes were displayed in real time with video of the iPad's unveiling event. Finally, there is the presence of feedback. Greater market receptivity means more sales and an opportunity to gain market share and either lower unit costs and/or improve quality and hence increase attractiveness, which in turn increases market receptivity and so forth.

Nature of the Entities

Power and influence, until very recently, has been almost exclusively vested in nation states and organized religions. Wealth has been created by enterprises—entities that have been state or privately-owned—farms, factories, or companies. As we progressed from the agrarian to the industrial age, the size of these engines grew. Some became vertically integrated, some merged with former competitors; some became conglomerates.[33] Despite their size and scope, these entities remained traditional organizations with well-defined boundaries until quite recently.

Traditional organizations have owners, someone in charge. Those in charge establish intent and allocate authorities and responsibilities, either directly, or they delegate these decision rights to a duly selected body (e.g., a board of directors). In military terms, there is a single chain of command. The relationships between and among members of these traditional organizations are relatively clear. Processes are well established in standard operating procedures (SOPs). There is clear individual accountability. However, in practice, these formal relationships and processes co-exist with informal ones that emerge in response to dysfunctional behaviors in an effort to improve information flows, access to expertise, or to facilitate the accomplishment of tasks. The informal organization notwithstanding, there is little doubt about what company or institution people are working for.

To accomplish their intent,[34] whether it is to govern, serve, influence, or create wealth, enterprises must accomplish a great variety of tasks. Clearly, some of these tasks are core. Their ability to accomplish these core tasks is central to their identities and competitive advantage. Many tasks are not core tasks. In fact, these non-core tasks can

33. A corporation consisting of a number of subsidiary companies or divisions in a variety of unrelated industries, usually as a result of merger or acquisition.
34. In almost all cases, the survival of the entity is incorporated into intent as a priority.

often be accomplished more effectively and efficiently by organizations that consider these tasks to be their core tasks. Even in the case when there is no cost or quality advantage, freeing management or its valued employees to deal with issues related to their core is desirable. This is a form of the economic theory of comparative advantage. The origins and an overview of the theory of comparative advantage from Wikipedia states:

> *Comparative advantage was first described by Robert Torrens in 1815 in an essay on the* Corn Laws*. He concluded it was England's advantage to trade with Poland in return for grain, even though it might be possible to produce that grain more cheaply in England than Poland. However it is usually attributed to David Ricardo who explained it clearly in his 1817 book* On the Principles of Political Economy and Taxation *in an example involving England and Portugal. In Portugal it is possible to produce both wine and cloth with less work than it takes in England. However the relative costs of producing those two goods are different in the two countries. In England it is very hard to produce wine, and only moderately difficult to produce cloth. In Portugal both are easy to produce. Therefore while it is cheaper to produce cloth in Portugal than England, it is cheaper still for Portugal to produce excess wine, and trade that for English cloth. And conversely England benefits from this trade because its cost for producing cloth has not changed but it can now get wine at a cheaper cost, closer to the cost of cloth. The conclusion drawn from this analysis is that a country should specialize in products and services in which*

> *it has a comparative advantage. It should trade with another country for products in which the other country has a comparative advantage. In this way both countries become better off and gain from trade.*[35]

Although this theory originated in the context of trade between and among countries, the basic argument applies to any organization and outsourcing. Trade and outsourcing both create interdependencies and, depending on the extent to which they take place, change the nature of the enterprise.

Outsourcing[36] became commonplace in the latter part of the 20th century when the common practice of own, manage and directly control[37] increasingly gave way to contracting out for products and services. Clearly, organizations have always relied on others to provide certain products and services but these were choices of necessity. The movement to outsourcing involves a choice to take something that one has traditionally accomplished for oneself and instead depend on some other entity to supply the product or service. At first, suppliers were found for supplies and parts that it no longer made sense to produce, taking into account delivery, mailing, and security, that were either more trouble than they were worth to do internally, or could be done less expensively by others. Outsourcing has grown to include services that were once thought to be part of an organization's self including

35. http://en.wikipedia.org/wiki/Comparative_advantage.
36. This discussion of outsourcing is based on *A Brief History of Outsourcing* by Rob Handfield. See http://scm.ncsu.edu/public/facts/facs060531.html.
37. Ibid.

accounting, human resources, and data processing. How an age affects outsourcing choices determines the nature of the core and defines self.

Comparing Ages

In the remainder of Part II, the key characteristics and beliefs of the information age are reviewed and illustrated by taking a look at the ongoing transformation of the U.S. military. But even as this information age transformation is taking place, the environment in which the military must function is also changing. The changes that are taking place in the environment (or mission space) are not unique to the military but parallel the changes that we are all experiencing. These ongoing changes are discussed in terms of the impacts they are having on means, limits, and entities. The metric most closely related to the information age, the value of information, is introduced. The approach taken to leveraging information age technologies and the articulated value proposition that has been adopted by the U.S. military and its allies is explained. An assessment of progress in military transformation identifies a gap between theory (potential) and practice (actual) that is a direct reflection of how the information age is perceived.

The discussion then turns its attention on the changes taking place that profoundly affect military missions as well as organizations in other domains. The defining characteristics of this new age are identified, and the age is given a name that reflects what makes it qualitatively different from perceptions of the information age. Part II then concludes with a discussion of the challenges and opportunities that accompany this new age.

Chapter 7
The Information Age

Origins of the Information Age

It seems to be taken for granted that we, at least in the developed world, are currently in the information age. It also seems to be common wisdom that despite the dramatic changes that have taken place as a result of the widespread availability of sensors, communications networks, and computers (desktops, laptops, tablets, PDAs, smart phones, point of sale equipment, etc.), we are far from fully realizing the potential of commercially available, information-related technologies. The organizations to which we belong are still in a process of adapting themselves. As a result, we are far from fully realizing the potential power of the information that is readily available.

While it is certainly the case that we have yet to fully exploit the opportunities presented by existing information technologies, it is becoming more and more apparent that what most people think of as the information age is rapidly being transformed into a new age. To understand why this is the case, it is necessary first to review the origins of the information age and its defining characteristics in terms of means, limits, and self, and compare these to the emerging realities of the 21st century. This section focuses on the nature of the information age while the following section introduces and provides a name for this new age.

Some claim that the information age dates back to the 19th century and the invention by Samuel Morse of the telegraph.[38] By this logic it could also be claimed that the information age dates back to the invention of the printing press in 1440 by Johannes Gutenberg. Indeed back to 888, the earliest known example of block printing, the *Diamond Sutra*, a Buddhist scripture. These inventions involve improvements in our ability to capture (record for later use) and disseminate information. Humans have always needed information. Some information could be directly obtained from organic sources, one's senses, and when they were invented, directly from various sensors (e.g., spyglasses), while other information could only be obtained second hand from others, or later on from books, and more recently from online sources. Thus, humans have always needed to capture informa-

38. This claim was made in an exhibition at the National Museum of American History entitled *Information Age: People, Information, and Technology* (http://photos.si.edu/infoage/infoage.html). I found a reference to this exhibit when I googled information age to see what some of the different perspectives were. Wikipedia was the first item that appeared, and incidentally shared the view that the information age dates to the telegraph along with the above. Our book *Information Age Anthology* (Papp and Alberts) was the fourth item that came up and the first reference to a book on the subject. The third item that appeared is a magazine called the *Information Age*.

tion, communicate it to others, store it, and provide a means of accessing stored information for a wide variety of purposes.

Over the years there have been many inventions that have continued to improve information reach (ability to provide, at least a subset of available information to others that are not synchronous in time and space) and richness (the capability to represent information).[39] Until the information age however, an individual's access to information that could not be directly sensed or communicated (which had been previously captured and stored) and to other individuals (as sources and stores of information, knowledge, expertise, and perspective) was, in practice, highly constrained by the costs, time, and distance. In addition, one had to pay a large penalty in reach to gain richness, and vice versa. Figure II-1, Pre Information Age Richness vs. Reach Trade-Off, depicts this penalty in the form of a concave transfer function.

39. See *Understanding Information Age Warfare*, p. 46, for a discussion of richness and reach. These concepts were introduced in Evans and Wurster's book *Blown to Bits* to explain how the internet has changed the economics of information. In *Understanding Information Age Warfare* we added a third dimension, the quality of interactions which is the key enabler of the age of interactions to be discussed in the next chapter.

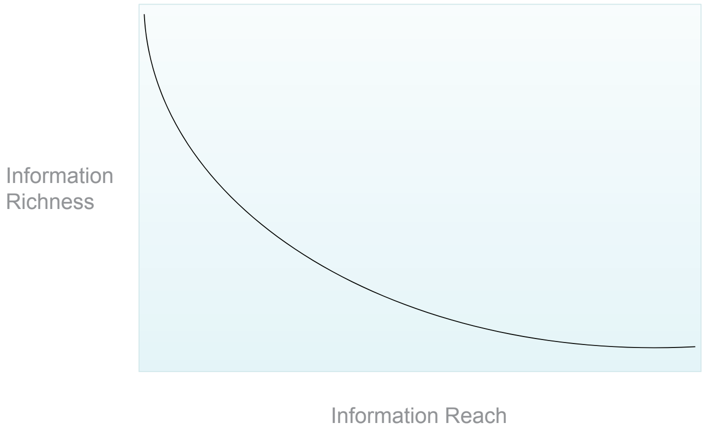


Figure II-1: Pre-Information Age Richness vs. Reach Trade-Off

As information and communication technologies continued to improve, it became not only possible to improve both reach and richness simultaneously, but to do so affordably. These developments changed the economics of information and the shape of this transfer function from a concave to a convex curve (see figure II-2, Information Age Richness vs. Reach Trade-Off). The shape of this curve indicates that one does not have to give up Reach for Richness, or Richness for Reach, but can increase both with a given investment.

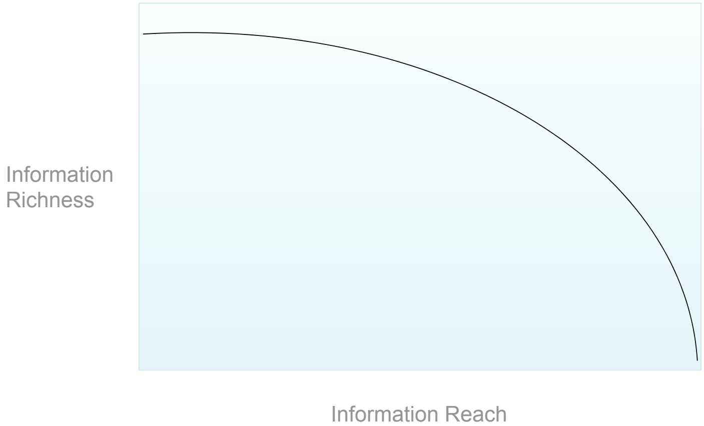


Figure II-2: Information Age Richness vs. Reach Trade-Off

The beginning of the information age (or indeed any age) does not occur with an invention or set of inventions. Nor does it occur when these inventions become widely available. Rather ages begin only when the changes that were enabled by a set of technologies are manifested. Ages begin when business as usual changes. There is a lag between the development of new technologies and capabilities and the onset of a new age. In this case there was a lag between the inventions that affected the capture and communication of information and the dawning of the information age. This lag amounts to the time it takes to commoditize and disseminate a technology or set of technologies, have them adopted, and then for the changes enabled by these capabilities to be manifested in a variety of adaptations including changes in micro and macro economics, politics on a variety of scales, and individual and societal behaviors.

Arguably the delays involved in exploiting new technologies have diminished with each successive age. The information age thus began not when information and communication technologies were invented, but rather when success in various arenas no longer depended on an industrial model. When, for example, success in business no longer depended on significant amounts of land, labor, or capital.

Information Age Defined

There have been many definitions of the information age. The following are a few that are representative of the commonalities and diversity of the definitions that have been offered.

> A period beginning in the last quarter of the 20th century when information became easily accessible.
> —wordnetweb.princeton.edu/perl/webwn

> Characterized by the ability of individuals to transfer information freely, and to have instant access to knowledge that would have been difficult or impossible to find.
> —en.wikipedia.org/wiki/Information Age

> A form of culture where electronics joins members of diverse cultural backgrounds together. Greater quantities of information than ever before are available to individuals, yet certainty

> about the way systems operate is less and more subject to question.
> —oregonstate.edu/instruct/anth370/gloss.html
>
> The current stage in societal development which began to emerge at the end of the twentieth century. This period is marked by the increased production, transmission, consumption of and reliance on information.
> —cyber.law.harvard.edu/readinessguide/glossary.html
>
> Global social organization. Automation increases efficiency in manufacturing… Information based industries arise.
> —infinicorp.com/VEX/appendix/technology-classification.htm
>
> The future time period when social, cultural, and economic patterns will reflect the decentralized, nonhierarchical flow of information.
> —www.globalsecurity.org/military/library/policy/army/fm/3-61-1/gloss.htm

Definitions of the information age, like the definitions of previous ages, tend to focus on either technology, society, or both. Some definitions reflect a belief that technology drives society, some the reverse, and some that technology and society changes are inter-related. In the mid-1990s, at the request of the then president of the National Defense University, this author embarked on a project to develop (with co-editor Daniel S. Papp) a multi-volume

Information Age Anthology[40] to explore the nature of the information age and create source material for educational institutions who it was felt were not adequately focused on these issues. In our preface to the first volume, we identified complexity and change as the defining characteristics of the information age. This was an acknowledgement of our discomfort with the increased complexity and the accelerating pace of change we were experiencing. We believed that a sea change was upon us. However, the complexity and change we were reacting to is still bedeviling us more than a decade later. As we shall see, the information age has sown the seeds for even greater complexity and an even more rapid pace of change even as it has given us new tools to cope with these changes. Uncomfortable levels of complexity and change are not unique to the information age. Rather they are a signal that a new age may be dawning.

In the introduction to this anthology, the following definitional description of the information age is provided.

> *The Information Age. That is what many pundits, writers, and analysts have already labeled these concluding years of the twentieth century and the beginning of the twenty-first century. This characterization of our time is based on the widespread*

40. This anthology is available at the DoD CCRP website www.dodccrp.org. The links to the three volumes are: Volume I, in four parts, Part 1: *Information and Communication Revolution*; Part 2: *Business, Commerce, and Services*; Part 3: *Government and Military*; Part 4: *International Affairs* (http://www.dodccrp.org/files/Alberts_Anthology_I.pdf), Volume II: *National Security Implications of the Information Age* (http://www.dodccrp.org/files/Alberts_Anthology_II.pdf), Volume III: *The Information Age Military* (http://www.dodccrp.org/files/Alberts_Anthology_III.pdf).

proliferation of emerging information and communications technologies and the capabilities that those technologies provide and will provide humankind to overcome the barriers imposed on communications by time, distance, and location and the limits and constraints inherent in human capacities to process information and make decisions. Advocates of the concept of the information age maintain that we have embarked on a journey in which information and communications will become the dominant forces in defining and shaping human actions, interactions, activities, and institutions.

This description of the information age incorporates most of the ideas contained in the examples of the definitions listed above and more. Some of the key ideas contained in these various views of the information age are:

1. Technologies that make it easier to capture, store, access, and exchange information are becoming ubiquitous.

2. These capabilities are making distances (physical, economic, cultural, social) less relevant.

3. As a result, we are able to have access to more information from a greater variety of sources.

4. These capabilities will to some extent overcome human information processing limitations.

5. These capabilities have and will continue to change our institutions and societies.

Clearly the nature of the information age is difficult to adequately capture in just a few words. To understand the import of an age, one needs to take a systematic look at the changes to means, limits, and self.

Information Age Means

In economic terms, the information age involves a re-alignment of the sources of value—the raw materials needed for value creation. Of the traditional means of production (value-creation) land, labor, and capital, the creation of wealth in the information age no longer depends on land nor, for that matter, on physical labor. Capital is still required to start up, but the amount required is far less relative to individual means than ever before. The human component in means has shifted from a physical contribution to a cognitive contribution that is measurable not in terms of physical effort or work (calories), but rather means in ideas. In the information age, firms succeed by leveraging information and communication technologies (as raw materials) to amplify an idea to create value on a significant scale. This is true even if the company is producing a concrete product such as concrete.

If one looked at the composite of say the Fortune 100 companies and classified them by the nature of their products and business models, one would find a point in time when a historic change occurred, when the number of firms that had products that depended directly on information and communication technologies (providing means) and/or firms whose business models depended on ideas enabled by these technologies to create competitive advantage became significant. This would include not only those firms that produced and sold the direct products of these technologies (e.g., Xerox, IBM, AT&T) but those firms who created value by leveraging these technologies.

We'll look at examples from Cemex and FedEx. Cemex revolutionized the cement industry by breaking with the tradition that required job sites to schedule cement truck deliveries well in advance (sometimes several days). This allowed the cement companies to optimize their production and delivery schedules, but forced job sites to play it safe (since they had to pay for a delivery whether or not they were ready to accept it—cement has a brief shelf life once in a mixer). Good for the cement company, not so good for construction companies. Cemex used information and communication technologies to enable a change in this business model that allowed job sites to order in near real time. In the company's own words:[41]

> *Our new web-based inventory management system allows our customers to focus on their construction projects, without worrying whether there's sufficient cement in their silos. This new system automatically communicates and coordinates cement deliveries among our customers, our carriers, and us; enables us to monitor, replenish, and optimize cement-inventory levels at our customers' ready-mix plants; and keeps our customers apprised of the status of their cement deliveries.*

41. See Cemex website (http://www.cemex.com/ps/ps_cs.asp).

FedEx differentiated itself by providing not only improved shipping services, but by also providing something new: information about the status of shipments. With the success of FedEx, tracking information is now the norm; that is, it is now business as usual in the shipping business.

A business model describes an entity's approach to creating value to gain or maintain a competitive edge in a particular space. In order to recognize when the business model of an organization, an industry, or a governmental agency is an information age model, one needs to look at how a better product or service, reduced time to market, or a better price (or some combination of these value-enablers) is being achieved.[42] Information age business models[43] create competitive advantage in their ecosystems by developing information and communications technologies and by leveraging these technologies. In order words, they sell information, use information to enhance their products and services, or provide the means to create and distribute information. These entities are creating competitive advantage by using an information age model instead of an industrial age model and, as a result, are dominating their competitive spaces making other entities adapt to remain competitive.

The information age is thus about information becoming a strategic asset. This new reality extends far beyond the world of business where value can be reduced to

42. *Network Centric Warfare*, figure 3, p. 31.
43. See *Network Centric Warfare* chapter on Information Age Organizations, pp. 25–51, for a discussion of how information age organizations were found to be creating competitive advantage.

traditional economic measures like return on investment or market share. For example, in the world of geo-politics, the information age makes it possible for non-state actors to possess sufficient means, using the power of information to influence large numbers of people, to rival state actors. Recent events in Iran, Tunisia, and Egypt show the power of social networking to mobilize large numbers of individual actors to challenge the power of the state. These efforts do not always succeed in effecting changes, at least immediately, but they are having a profound effect on the relationship between governments and the governed. These events demonstrate that the economics of information have changed dramatically from the inception of the information age. Cost is no longer a barrier to entry. Almost anyone can now afford information age technologies, increasing the degree to which events are interrelated. The popular uprising in Egypt was clearly influenced, perhaps even enabled, by the events in Tunisia.

Information Age Limits

The shift from the physical to the virtual has profoundly altered constraints related to time, distance, weather, geography, and mass. Information, once only available in a physical form, can now be stored and moved virtually. The technologies associated with information have also had a dramatic effect on both the economics of information and in turn, on the costs involved in every link of the value creation chain. More affordable computers and less expensive communication costs result in the wider dissemination of these capabilities creating opportunities to reach people, improve processes, and create new markets. This makes it possible for almost everyone, not just governments or large corporations, to have instant access to information and to effectively communicate and interact with an arbitrarily large number of other individuals, regardless of distance or governmental interference. Previous limits or constraints that involved a lack of relevant, accurate, timely, and assured information have been relaxed or eliminated.

Thus, the new economics of the information age have freed us from previous limits on means; that is, lower costs have increased the availability of information and communication capabilities. This has offered opportunities to improve, and indeed, develop new value creation processes. The book *Network Centric Warfare* contains a discussion of how commercial organizations were (in the 1990s) leveraging information age technologies to create value in new ways. These included one or more of the following: creating and leveraging improved awareness and shared awareness, substituting information for mass or human resources, creating virtual organizations, virtual collaborations, virtual integration, self-synchronizing distributed efforts, precision manufacturing and retail, and focused logistics. Each of these was made possible by the relaxing of one or more constraints or limitations that existed prior to the information age.

Information Age Entities

The information age is not only about the opportunities provided by information-related technologies, but about the conditions and problems that their adoption and utilization create. Two of the challenges that have frequently been discussed are 1) changes in the amount of time decision-makers have to make decisions prompted by the widespread awareness of events as they are unfolding as a result of the availability of information, and 2) the ability of others to obtain and leverage the latest information age technologies. In fact, cutting-edge technologies are often obtained and used by small groups well before larger, more bureaucratic organizations can acquire them. As a result of 1) decision-makers certainly feel pressured to act, and as a result of 2) may actually need[44] to respond more quickly to situations that are increasingly more complex.

The democratization of information has created pressures to act ever more quickly. The sights and sounds of disasters and expectations (perhaps somewhat unrealistic) of rapid response is putting increasing pressures on governments and other institutions to move ever more quickly, whether it be in disaster relief endeavors such as the 2004 Asian tsunami, the Katrina hurricane along the Gulf Coast of the United States in 2005, or most recently an earthquake in Haiti in 2010.

While information technologies and their widespread availability have indeed created pressures to respond more rapidly to events, they have also provided enhanced means to do so. This is because of a combination of the following: the time it takes to become aware of an event is reduced as information can travel across the globe almost instantaneously; analysis and consultations require less

44. Whether they actually need to or not depends on the particular circumstances, but there is certainly a perceived need to respond more rapidly.

time, aided by information processing and display capabilities, even if the participants are geographically dispersed; the lag time between a decision and a response can also be reduced. However, there is a limit to one's ability to decrease response time while maintaining the ability to make good decisions. This limit is a function of the nature and capabilities of self. Entities need to change not only what they do and how they do it, but they may also need to change who they are to take advantage of the opportunities created by information age concepts and technologies.

In fact, organizations have not only used information age technologies to improve their products and services, but, to varying degrees, have also changed themselves and their relationships to one another. In political or geopolitical terms, these changes are reflected both in their instruments of power and in the relative significance of various actors on the world scene. In organizational terms, it is not only about their products and services, but also about the form and structure of their organizations. For each of us, on a personal level, the information age is about a change in the ways that men and women conduct their affairs.[45]

Information age capabilities have hastened and broadened a movement to outsourcing. It is now not uncommon to find many individuals who may seem to outsiders or even to some insiders to be employees of an organization who are actually not employees but who are either self-employed contractors or who work for a company to

45. Taken from the preface to Volume I of the *Information Age Anthology* (Papp and Alberts, 1997).

whom the work has been outsourced. These individuals may wear a corporate uniform, they may sit in offices along with actual company employees, and they may be, in fact, a majority of the work force. Outsourcing clearly increases the complexity of self but also has the potential for increasing agility. What impact does this have upon the organization and upon organizational structures? Does it alter the culture? Does it affect trust relationships? Does it give rise to a different sort of informal organization? Is outsourcing no longer a choice but a necessity to compete? While the answers to each of these questions is undeniably yes, it remains for us to fully understand the nature of the changes that outsourcing causes to organizations, and how these changes affect an entity's agility.

The information age has also affected the most senior positions in organizations, those designated as Chief (fill in the blank) Officer. These top-level positions reflect what an organization thinks is existentially important. Hence, the arrival of chief information officers is a signal of the arrival of the information age and the duties that they are assigned as a reflection of their view of the nature of the information age. While the first chief information officers, or CIOs, may have been appointed in the 1970s,[46] the information age would not be well-established until it became the norm for firms to have a CIO. Early CIOs were focused almost exclusively on information technology (IT)—a reflection of both the cost of these investments and a general lack of understanding

46. See article written by Jeff Wacker, entitled *CIO 2.0: The Next Dimension* (http://www.informationweek.com/news/188701749).

how best to get a proper return on these investments. At that time, computers were very expensive (mainframes) and needed to be managed centrally.

The introduction of the personal computer (PC) in the early 1980s changed the IT landscape. As communication networks became digital (routers instead of switches), communication and information processing technologies and the systems they created began to merge. As a result of these advances, the role of CIOs has evolved over time. By the last decade of the 20th century, many CIOs were responsible for far more than IT acquisition and maintenance. How an organization views the role and responsibilities of the CIO is an indicant of what age the organization is in. Organizations that have CIOs that are focused on IT and not information, have in reality C*IT*Os, and are still in the industrial age. Those whose CIOs actually have power over the way organizations create and leverage information, have moved into the information age.

In 1996, Congress passed a law that required all federal agencies to have a CIO that reported directly to the head of the department or agency.[47] This legislation was focused primarily on both improving the acquisition, use, and disposal of information technology.[48] However, this legislation also requires heads of executive agencies to establish goals for improving the efficiency and

47. Later collectively known as Clinger-Cohen Act, Congress passed the Information Technology Management Reform Act of 1996 and the Federal Acquisition Reform Act of 1996.
48. Information Technology Management Reform Act of 1996 – Section 5112 Paragraph B Use of Information Technology in Federal Programs. This Section enumerates the responsibilities of the Director OMB.

effectiveness of agency operations and, as appropriate, the delivery of services to the public through the effective use of information technology.[49] Some have interpreted this legislation to mandate an information age transformation of the federal government because it also mandated the heads of executive agencies to analyze the missions of the executive agency and, based upon the analysis, revise the executive agency's mission-related processes and administrative processes before making significant investments in information technologies that are to be used in support in the performance of those missions.[50] This language takes pains to caution executives not to simply automate business as usual, but to rethink the way they deliver their agency's services in light of the opportunities provided by IT.

This legislation reflects an information age expectation that decision-making and business processing can be greatly improved by information technology. Organizations in both industry and government have invested large amounts of their scarce funds in building infostructures that make it possible for individuals throughout an organization to be better informed and better connected. The ability to improve situational awareness at all levels of an organization naturally leads to two questions. First, how could improved awareness benefit the organization? Second, is it worth the investments that have been and continue to be made? To answer these questions, one needs a conceptual framework and a metric of value for information.

49. Ibid., Section 5123 Performance and Results-Based Management, Paragraph (1).
50. Ibid., Section 5123 Paragraph (5).

Value of Information

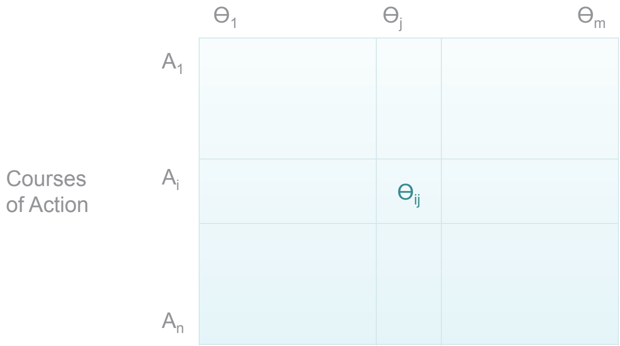
If the information age is all about the relative importance of information as a means, and the impact that this increasingly important source of wealth and power is having on entities, then it stands to reason that it would be useful to be able to measure the value of information. A measure of the value of information could be used to determine the value-added by a new or improved information-related technology or by an adaptation of process or organization.

Part I discussed the characteristics of problem difficulty. What made one problem more difficult than another, one situation more daunting than another? In this discussion, the point was made that situation, tasks, and problems all involve choices or decisions. Success in these endeavors requires that correct decisions are made in a timely manner. An approach to measuring the value of information is to ascertain the impact of information on the quality of decision-making.

Decision theory[51] provides an approach to measure the value of information by examining its impacts on the expected value of a given decision (or set of decisions). The theory approaches decision-making rationally by estimating the expected value of each of a number

51. Two sources for those who want to become familiar with traditional decision theory are Miller, D. W. and Starr, M. K., *Executive Decisions and Operations Research*, Prentice Hall, and Raiffa, H. and Schlaifer, R., *Applied Statistical Decision Theory*, Wiley.

of courses of action. A decision-theoretic approach to decision-making is based on the problem formulation provided in figure II-3.



$$\max EU(A_i) = \Sigma\, p(\Theta_j)\, U(O_{ij})$$

A_i = i^{th} course of action
Θ_j = j^{th} state of nature
O_{ij} = outcome that occurs if the i^{th} course of action is taken and the j^{th} state of nature occurs
$p(\Theta_j)$ = probability that the j^{th} state of nature will occur
$U(O_{ij})$ = utility of the ij^{th} outcome
Σ = sum over all j
$\max EU(A_i)$ = find course of action with the maximum expected utility

Figure II-3: Decision Theoretic Problem Formulation

An information-centric view of the world argues that information is a strategic asset and that better information from a larger variety of sources contributes to improved decisions by improving the ability to:

1. Identify a more complete set of courses of action or options to choose among.

2. Identify a more complete set of possible states of nature.

3. Estimate the probabilities associated with various states of nature.

4. Predict the outcomes that could be expected to occur.

5. Understand the utility of various outcomes.

6. Calculate expected utilities.

Improved decision-making (better, faster, and more efficient decisions) is a critical link in conceptual models and value chains dating from the mid-1970s. Figure II-4 depicts the over-simplified OODA loop that dominated military command and control analysis circa 1975.

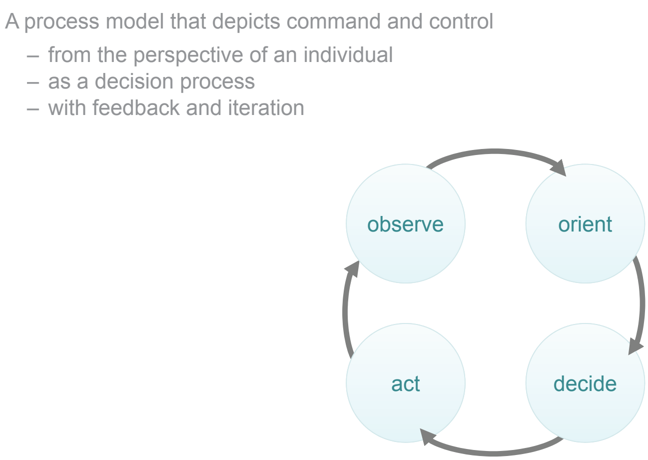


Figure II-4: C2 Process Model

This simple feedback process model clearly implies a value chain where better observations (improved quality of information) leads to better awareness of the situation (orientation), which in turn leads to better decisions and more effective actions. In this conceptualization of command and control, it is the existence of feedback that corresponds to control. Implicitly, it is also an instantiation of the commander-centric view that prevailed at the time and, to some extent, still persists despite the harm it has caused organizations.

Although widely attributed to John Boyd, students of his work claim that the only extant diagram of his presents a more complicated view of the process in question. Figure II-5, taken from the book *Science, Strategy and War*, by Frans P.B. Osinga,[52] purports to have been Boyd's actual view.

52. ISBN 0-415-45952-4, (chicagoboyz.net/blogfiles/OsingaBoydThesis.pdf).

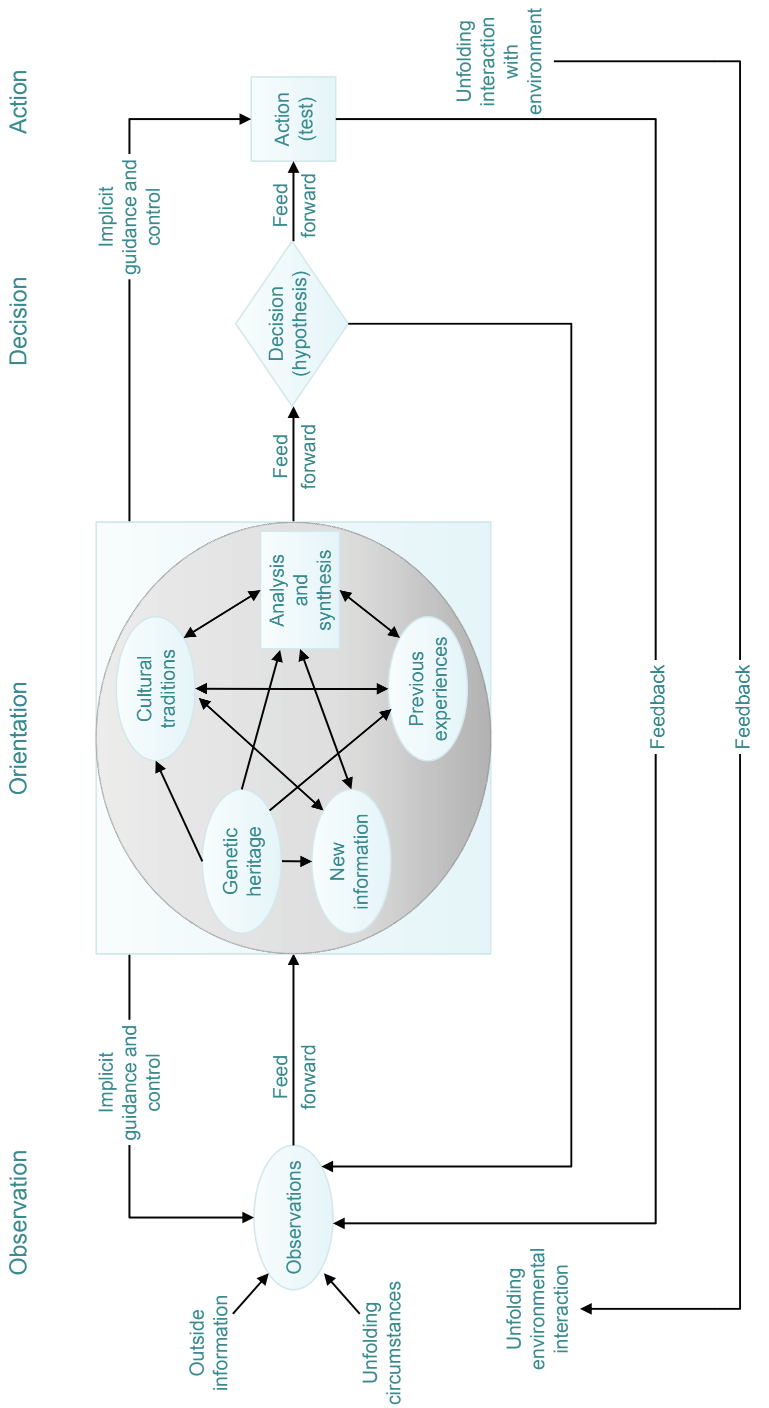


Figure II-5: Boyd's Real OODA Loop

The fact that virtually all of the discussion has focused on an overly simplistic conceptualization of military decision processes illustrates a tendency to ignore the true nature of reality in favor of a formulation of the problem that is easier to solve.

Figure II-6, dating to the same time period, presents a value model focused on the enablers of decision quality. The model was intended to provide a basis for assessing the value of the processes and systems that support decision-making. Since measuring decision quality in real-world situations is somewhat problematic,[53] this model also introduced intermediate measures or indicants of decision quality. Readers will note that these indicants are derived from the idea of the decision theory based concept of the value of information.

53. The most direct method for determining decision quality (correctness, timeliness, etc.) is to know ground truth. Another popular approach is to see what actually happened—if the outcome was a good one, then the decision was considered a good one. Clearly, this does not account for all of the factors that affect outcomes. In fact decisions can be perfect, and things do not actually turn out as well as expected. A better way to measure decision quality is to see if the decision made was the best that could be expected, given the information and knowledge available. This approach also has its problems. All of these require a great deal of information and understanding. The intermediate measures are meant to be used when it is not possible to link with any degree of certainty specific decisions to specific outcomes. Given the complexity inherent in the 21st century, this will be most of the time.

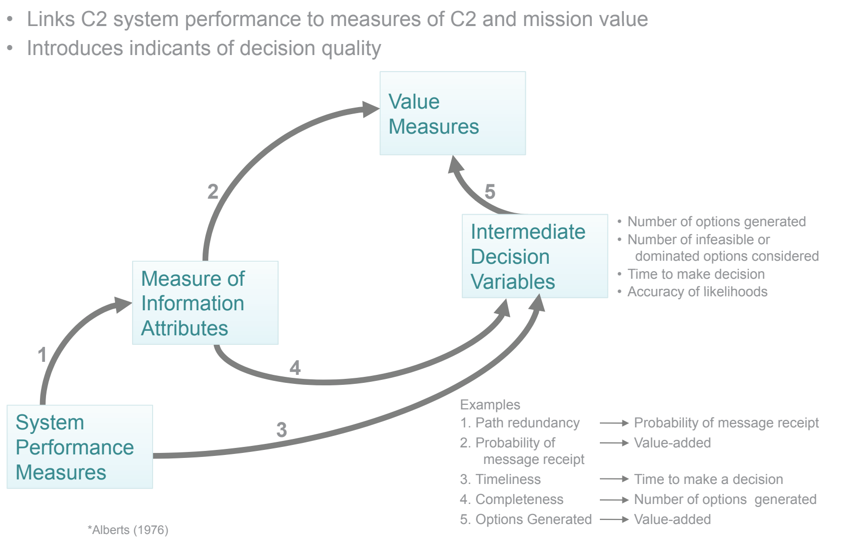


Figure II-6: Decision-Oriented Value Model

The quality of the decisions that are made on the one hand is directly linked to the quality of awareness and shared awareness and on the other hand is directly linked to more effective and efficient actions. Actions, in turn, are linked to the quality of outcomes—the bottom line. Both these views emphasize information and the critical role information plays in decision-making. This focus on the link between information and decision-making is second nature to those who have adopted what they think of as an information age perspective. Unfortunately, such an exclusive focus on the information component of the value chain ignores an equally important enabler of value creation, an enabler that can make an indispensable contribution to not only information quality, but also to an organization's ability to leverage information. This enabler, which is central to the new age, will be discussed later in this book.

Based on a belief in the power of information and its critical link in creating value, organizations have invested considerable sums in IT and in building systems to capture, transmit, process, and display information. Whether or not in practice these investments pay off, depends on the ability of organizations to co-evolve their concepts of organization, and their approach to command and control (in military organizations) or management (in civilian organizations). Co-evolution also requires changes to education and training to create the appropriate mindsets, knowledge, and skills.

The following section discusses the efforts of military organizations to affect an information age transformation. That is, to transform the way they are organized and do business so they can better leverage information technologies and information to improve decision-making and the processes that support decision-making.

Chapter 8

An Information Age Military

This section reviews how the U.S. military has responded to the opportunities and challenges associated with the information age. It will look at a new theory of military operations, circa 2000, the implications of this new theory, and the extent to which this theory has become practice.

For military organizations, the information age began when mass (assembling a large number of physical forces) and classical maneuver (movement of physical forces) was, when possible, abandoned in favor of the massing of effects from geographically disbursed entities. This change in means is associated with the development and subsequent adoption of the concept of network centric warfare (NCW). The theory of NCW took a fresh look at how, in the domain of the military, competitive advantage can be created. NCW took aim at not only means (mass vs. massed effects) and limits related to physical constraints, but also the traditional military self. The potential impact of NCW on military organizations was the most transformational aspect of NCW, but also the most controversial. Other terms replaced NCW in the early 21st century. The term network centric operations (NCO) was coined to re-enforce the idea that NCW tenets applied not only to traditional combat but also to all sorts of military and civilian operations. Other countries for a variety of reasons adopted network-enabled capability (NEC). Over time the meanings of these terms became synonymous.

NCW Theory

The concept of NCW, an attempt to seize an opportunity to create competitive advantage by leveraging information age concepts and capabilities, was first introduced in detail to a wide audience in 1999,[54] over a decade ago. The book sought to provide a theoretical foundation for an information age transformation of the defense establishment. The authors and other proponents of NCW sought disruptive change. The book and the ideas expressed garnered mixed reviews at the time. A quite complementary review[55] stated that:

> *Three men and a book with a new idea propounding the emerging concept of network centric warfare—this is what I call an integrated approach to harnessing the best brains to realize an emerging concept of war. At first glance on the title, readers would be intimidated by the term "network centric warfare" as it could easily be mistaken as another highly*

54. http://www.dodccrp.org/files/Alberts_NCW.pdf.
55. A review in the *Journal of Singapore Armed Forces*, by LTC Tan Kim Seng (http://www.mindef.gov.sg/safti/pointer/back/journals/2001/Vol27_4/8.htm).

> *technical book just like any thick computer book in the bookstore. On the contrary, this book is just about how to fight a war intelligently using information superiority and how to wire-up an entire military organization's platforms, hardware, weapons systems and doctrine to target the enemy without him even knowing what hit him. The authors, I would say, wrote the book with the noble intention to prepare the new generation of military officers to "understand and articulate the power of information superiority in warfare from a Joint perspective." It is a timely book for the military to take a close look at how we should use information technology closely in the form of "information superiority."*

This review adopted what became the prevailing view of the information age when it identified the new source of power as information superiority. This review also recognized the potential of NCW to be truly transformational. However, potential is not the same as realized. NCW theory introduced a new value proposition, but NCW practice would determine the extent to which value was created. NCW practice was ultimately shaped by popular perceptions of the nature of the information age. The value created would be constrained by the ability of military institutions to change despite the vision of NCW theorists and the hopes of NCW proponents. To reiterate, the transformational power of NCW lies in the extent to which changes in means, limits, and self are made. As it turned out, the practice of NCW has fallen far short of its theoretical limits.

Critics of NCW

When new technologies and capabilities are adopted but are employed in a way that results in incremental rather than transformational change, it may signal a period of transition—a temporary pause in the evitable march of process. In this case, a pause or period of consolidation in adaptation (innovation) enabled by information age technologies and the capabilities they provide. I would argue that to resume this march, there needs to be an acceptance of the fact that there is indeed a gap, or shortfall, between what is possible and what has been achieved. Progress has been slowed, or stopped, as a result of impediments that are cultural or institutional, and not as a result of a lack of potential or opportunity. This recognition is necessary to encourage and enable individuals and organizations to move on to the next level of capability rather than be satisfied that they have achieved all that is possible.

Information age militaries have defined themselves, not by the vision of the authors of NCW, but by what has happened with respect to the adoption of NCW concepts as reflected in policy, organization, and doctrine. An assessment should be based on the practice of NCW, not the rhetoric.

Theorists and proponents are optimists. They see possibilities. Pessimists and critics focus on problems. History has proven that more time is required for transformation than is at first thought by its theorists and proponents, and more progress is made than thought possible by pessimists. In fact, although many military organizations have made enormous progress in acquiring and fielding information age capabilities, and have increasingly used these capabilities well, they are still basically operating under the (circa 2000) existing set of rules. Among the many reasons for this is it takes time to fully appreciate potentially transformational ideas.

Some critics, indeed some proponents, of NCW incorrectly equated the word network in NCW to mean the information and communications infrastructure that supports an individual[56] or organization. They did not correctly understand that NCW was more about the networking then networks…about the power that can be generated by a network centric force…derived from the effective linking or networking of knowledgeable entities that are geographically or hierarchically distributed.[57]

These critics, bolstered by similar misunderstandings among some vocal, but ill-informed, advocates of NCW, mischaracterized NCW, and then questioned its suitability, vulnerability, dependence on unproven technol-

56. The individual here is usually seen in military organizations to be the commander. *Power to the Edge* argued that this was a mistaken construction and that the term *individual* should literally be taken to mean all individuals, not just senior commanders. As this book is written, there remains significant numbers of people, some in positions of authority, who maintain a focus on senior commanders—a commander centric view. Unless and until these attitudes change, these organizations will have one foot stuck in the industrial age. As a result, their value created will be limited.
57. *Network Centric Warfare*, p. 6.

ogy, and desire to automate warfare.[58] Perhaps the most systematic critical treatment of NCW was written by Thomas P.M. Barnett. Creatively entitled, *Seven Deadly Sins of Network Centric Warfare*[59], this piece, written as a devil's advocate take on NCW, argued among other things that NCW longs for an enemy worthy of its technological prowess. In a nutshell, this view of NCW represents an industrial perspective of an information age idea. The fear of information overload is raised, as well as the burden NCW would place on commanders to integrate intent across the force. Both these concerns assume that attitudes, training, and processes remain essentially unchanged, and military officers will not be able to adapt to new ways of doing business. This view, if it ultimately proves to be correct, will relegate the implementation of NCW to the lowest common denominator, limiting the improvements to incremental gains from processes that are improved (faster, less error), but not transformed. This amounts to using the power of the information age to improve industrial processes.

58. An article by Col. Alan D. Campen, USAF (Ret.) "Look Closely at Network Centric Warfare," *Signal Magazine*, January 2004, quoted a number of NCW critics. These included Naval War College Professor Dr. Milan Vigo who argued that successes of NCW were in situations where none of the losers "have the capability to disrupt or even interfere with U.S. space-based and airborne sensors and computer networks, vulnerabilities that could easily be exploited by a more capable and resourceful adversary." Another critic cited falsely asserted that NCW claims to eliminate the fog of war and then asserts "that the fog of war will not go away—it will appear in new and different forms." Another critic cited echoes this theme, "it isn't difficult to see the fog of war being replaced by the fog of systems."
59. http://thomaspmbarnett.com/globlogization/2010/7/24/blast-from-my-past-the-seven-deadly-sins-of-network-centric.html.

Barnett also presents the view that NCW is inappropriate for operations other than war. While nothing could be further from the truth, the issue here is not what NCW means, but how it is implemented. This boils down to a question of the boundaries of a networked force. An exclusive focus on internal connectivity, whether the entity in question is the U.S. military or the U.S. government, may be an information age perspective, but it is not appropriate for the new age in which we live.

Another comprehensive critique by Giffin and Reid was presented, in a series of three papers, at the 8th International Command and Control Research and Technology Symposium (sponsored by the CCRP) in 2003.[60] Unfortunately, this well-written critique built its case on a mischaracterization of the basic premise of NCW and what was actually said in the book. The authors argued that NCW was predicated upon "a discredited body of ideas in economics and business theory called *new economy theory*."[61] However, NCW was not based upon this theory. Indeed, this is a case of critics arguing that, even if you did not say something, you really meant to say it. The business analogies discussed in NCW were meant to illustrate the potential of bringing information technologies and related innovations to bear. The fact is that the value creation ideas illustrated by these analogies remain valid. Indeed, empirical evidence supporting the basic premise that information technologies have the power to transform organizations and business practices continue to accumulate. These authors seize

60. http://dodccrp.org/events/8th_ICCRTS/Tracks/track_5.htm.
61. Giffin and Reid, *A Woven Web of Guesses, Canto One: Network Centric Warfare and the Myth of the New Economy*, p. 2.

upon a reference in NCW to Metcalfe's Law, which they see as the basis for new economy theory, to build a case against NCW. Specifically, they apply this law to profit projections. Then they cite the dot-com bubble and its collapse with the fall of the NASDAQ Stock Market from its bubble-generated historic high as proof that NCW is doomed to failure. What they failed to do is either read or understand the extended discussion of Metcalfe's Law as it relates to NCW contained in the book.[62] To summarize, the authors of NCW never said that one would receive exponential value from investments in networking capability, but made the argument that networking the then disconnected force would likely generate more value than spending a similar amount of resources on more platforms. This thesis has also proven to be correct.

Their second paper[63] addresses methodological and epistemological considerations. While accepting the ultimate conclusion of the tenets of NCW (a robustly networked force improves information sharing; information sharing and collaboration enhance the quality of information and shared situational awareness; shared situational awareness enables self-synchronization; these, in turn, dramatically increase in mission effectiveness), Giffin and Reid argue that the NCW tenets are not sufficient to justify this conclusion.

> *We are in complete agreement with proponents of the NCW thesis that recent progress in the domains of information and communication technology has*

62. *Network Centric Warfare*, pp. 251–265.
63. Giffin and Reid, *A Woven Web of Guesses, Canto Two: Network Centric Warfare and the Myth of Inductivism*.

> *dramatically improved and will continue to improve military capability. We also agree that this progress creates a compelling case for organizational, materiel, doctrinal and behavioral change. But for the reasons presented, we cannot accept that the three preceding tenets justify this final assertion.*[64]

They acknowledge that the NCW tenets were actually offered as a series of hypotheses and not claimed to be proven facts. In this paper they are issuing a warning to militaries not to jump to conclusions. I share their concern. It appears they are arguing for a systematic exploration of these claims—something I wholeheartedly support.

In their third and final paper,[65] they suggest a number of research questions that focus on knowledge development and what today would be called social networks. Based upon the common misconception that NCW is all about technology and information, they suggest that the focus should be on cognitive processes and interacting decision-makers. I and the other authors of NCW and many of its proponents agree. In fact, we said as much within the first 10 pages of the book. Specifically:

> *Myth 2: NCW is all about the network.*
>
> *Actually, NCW is more about networking than networks. It is about the increased combat power that can be generated by a network-centric force. As*

64. Ibid., p. 18.
65. Giffin and Reid, *A Woven Web of Guesses, Canto Three: Network Centric Warfare and the Virtuous Revolution*.

> *we will show, the power of NCW is derived from the effective linking or networking of knowledgeable entities that are geographically or hierarchically dispersed. The networking of knowledgeable entities enables them to share information and collaborate to develop shared awareness, and also to collaborate with one another to achieve a degree of self-synchronization. The net result is increased combat power.*[66]

As has often been the case, in the final analysis, the concerns of critics of NCW are, by and large, shared by many of its sober proponents. It is just a question of seeing a glass half-full or half-empty.

Practice of NCW

What NCW turns out to be in practice depends as much on how the information age with which it is so closely associated is perceived. Unfortunately, many continue to perceive both the information age and NCW as primarily technological (an industrial age perspective). Many organizations are narrowly focused on information and the power of information to improve existing organizations and processes. Relatively few are focused on the transformational aspects of the concepts embodied in the network-centric value chain that can turn the DoD and other military organizations into new age organizations.

One can look at different views of information sharing to illustrate the differences in these three perspectives. Those adopting an NCW technology perspective do not

66. *Network Centric Warfare*, pp. 6–7.

deal with issues of information sharing at all; rather they focus their energies on building a more capable infrastructure (communication pipes and information systems). Those that see NCW as all about information focus on first identifying the information requirements of processes, entities, engineering systems, and communication solutions that satisfy these needs.[67] This amounts to paving the cow paths. Those with a more advanced information age perspective recognize that business as usual needs to be re-invented, preferably concurrently with investing in more capable information infrastructures.

Unfortunately, there are some who are reluctant to invest in information sharing capabilities until users can testify to the benefits. This creates a chicken and egg situation, because the consumers of information find it hard to imagine the capabilities they could have in the future, and even harder to re-invent their processes, organizations, and even themselves to take advantages of these capabilities. In DoD, as in many other organizations, the result has been incremental improvements in process and organization that fall far short of the potential that is enabled by improved infostructures. The major impediment to progress is not a lack of technology. It is not a lack of belief in the importance of information. It is not

67. This perspective places a great deal of faith in information exchange requirements (IERs) that can be identified as the basis for system design.

a result of a lack of money or other resources. Rather, it is the inability of some organizations to re-invent their approaches to command and control.[68]

When it was recognized that NCW was being interpreted and implemented in ways that were destined to severely limit its potential, it became necessary to write another book that would emphasize and further explain the transformational potential of NCW. The nature of the limited perceptions of the information age, in general, and NCW, specifically, that persists can be understood by looking at the ways the tenets of NCW (Figure II-7) have been interpreted.

The NCW value chain is depicted in the following.[69]

68. There is a command and control approach space (see *Understanding Command and Control*, p. 75, Alberts and Hayes, 2006). The problem is that many organizations only consider approaches in a very small part of this space and thus limit the possibilities for improvement. This topic is discussed in detail later on.
69. This slide has been used in countless briefings on NCW. Note the word *collaboration* is used twice in these tenets. Its first use (enhancing quality of information and shared awareness) speaks to collaboration in the information domain. The interaction between two or more entities is focused on the information itself (is it correct? timely? or this other piece of information seems to be at odds with…., etc.). The second use of the word (situational awareness enhances collaboration and self-synchronization) speaks to interactions in the social domain. How do we (one or more entities) work together to respond?

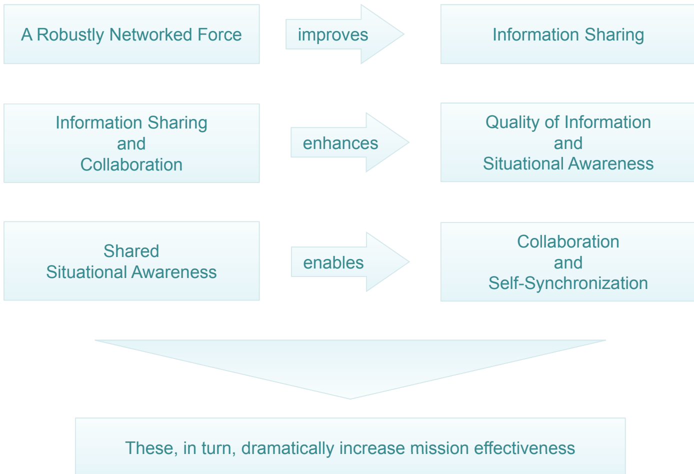


Figure II-7: Tenets of NCW: The NCW Value Chain

The first tenet has been understood and approached, as discussed above, in different ways. Many seem to think that this is the only actionable tenet and have entirely focused their implementation efforts on building a robustly networked force. "Let's get the enablers in place" view dominates the plans of many organizations. The second tenet is taken, by many, to be an automatic consequence of the first. It is taken for granted and little work is going on to understand and foster this important link between information sharing and collaborative behavior and improved quality of information and shared awareness in the value chain.

The third tenet was characterized early on in the discussion of NCW as where the magic happens. Perhaps this was because while the tenets of NCW contain the explicit assertion that the achievement of shared awareness will enable self-synchronization, NCW does not provide a description of how self-synchronization can be made to reliably occur. NCW does not prescribe what specific changes in doctrine, organization, processes, education, training, and systems are needed to ensure that self-synchronization occurs when appropriate.

The capability to self-synchronize is essential to properly leverage available information and create value. Self-synchronization can enable organizations to get the most out of their most valuable resource—their people. In order to do this, entities need to change their approach to focusing their efforts and facilitating convergence. *Power to the Edge* presents a set of principles that, if adopted, can enable organizations (and coalitions or collectives) to develop concepts of operation, doctrine, and approaches to organization and command and control that enable them to realize this largely unrealized potential.

Network Centric Warfare provided examples, but stopped short of providing a prescriptive answer. In academic circles, this is called leaving it as an exercise for the student. It is not surprising that proponents of NCW have focused their attention on the enablers rather than on the third tenet, the tipping point of NCW. This is the link between shared awareness and self-synchronization.

NCW Version 2: Power to the Edge

To remedy this, NCW concepts needed to be re-articulated and expanded. A new book was written to explain what needed to be done to create and leverage shared awareness. This new book, *Power to the Edge*, focused not on the information age enablers, but on what was being enabled. It focused on how the improved ability to capture and disseminate information could be used to empower individuals at all levels of the organization, and, in doing so, enable the creation of edge organizations with new approaches to command and control.

Power to the edge principles need to be applied to the way organizations approach what the military refers to as command and control, and what others call leadership, management, and governance. An organization or a collection of organizations delegates decision rights, disseminates information, and permits and facilitates interactions both between and among members and those in other entities. The term *command and control* itself is problematic because it, over the years, became associated with how it should be done as opposed to the what or the purpose of command and control. To some extent this is true for the terms *leadership*, *management*, and *governance* as well. These terms have become synonymous with traditional approaches and rely upon a set of associated assumptions. The term *focus and convergence* was recently suggested as a replacement and this idea has been favorably received by many.[70]

> Power to the Edge *is about changing the way individuals, organizations, and systems relate to one another and work…involves expanding access to information and the elimination of unnecessary constraints.*[71] Power to the Edge*, when fully achieved*

70. See article on *Agility, Focus and Convergence* (http://www.dodccrp.org/files/IC2J_v1n1_01_Alberts.pdf).
71. *Power to the Edge*, p. 5.

> *in each of the domains of warfare, provides the conditions that allow NCW to reach its fully mature form—a self-synchronizing capability.*[72]

Power to the edge requires that individuals in organizations, and organizations in coalitions or collectives, change their mindsets regarding the value of information. They need to move away from the view that the value of information derives from its exclusivity (that leads to hoarding) to the view that the value of information derives from its widespread availability (that leads to sharing). Without individual and organizational acceptance of this new value proposition, the changes in information sharing behaviors that are needed to achieve mature levels of NCW will not occur. It is unlikely that the practice of NCW will advance much beyond the lower maturity levels defined by the *NATO NEC C2 Maturity Model*,[73] and will fail to realize its full potential. As a result, the investments in infostructure will have limited returns on investments, and the organizations will be less effective than they should be.

Implementation of power to the edge principles involves the following changes to the way information is handled:

- Ownership of information is transferred from those that collect and/or process information to the organization as a whole.

72. Ibid., p. 6.
73. http://dodccrp.org/files/N2C2M2_web_optimized.pdf.

- Responsibility of determining what information is needed by whom (and when) moves from supervisors and information collectors[74] to information consumers.

- Collectors and processors of information are required to make their information available in a useful form (tag and post).[75]

- Consumers shape their own information positions by pulling the information as opposed to having it shaped for them.

But power to the edge principles were meant to apply to more than how we deal with information or with the decision rights associated with information seeking, dissemination, and utilization. These principles are also applicable, as we will see, to interactions.

An Assessment of Information Age Militaries

To reiterate, ages are defined by practice, not by theory or promise. Military organizations have, since the mid-20th century, developed, deployed, and employed technologies associated with the information age. For most of this time they used these new capabilities to improve industrial age processes. It was not until the 20th century came

74. The responsibility for restricting the distribution of information (sensitive, classified) remains with collectors, processors, and supervisors who tag the information accordingly.
75. *Tag* refers to a selection from an existing set of key words, or creating a new key word, to reflect content. *Post* refers to submitting the information to a website, application, or shared space.

to a close that a new theory of warfare was articulated. This new theory was introduced to a very skeptical audience as NCW.[76]

With the acceptance of NCW as a transformational idea, the U.S. and other military institutions undertook efforts to upgrade their information infrastructures. They sought to replace point-to-point links and information stovepipes (silos) with a more networked information environment. In the decade since the theory of NCW was introduced, policies promoting widespread information sharing have been adopted, although these policies have not been aggressively enforced. As a result, some holes are being punched in silos and some collaborative processes have been introduced. This has also unleashed a re-examination of information related assurance and security (now sometimes referred to as cybersecurity).

Information age militaries retain much of the organizational characteristics of their industrial age predecessors. They are, in fact, still largely industrial age organizations with information age capabilities. Given that one's approach to command and control involves a delegation of decision rights that, in large part, determines who may make what decisions, who may interact with whom, and how information is disseminated, unless there are significant changes in how an organization approaches command and control, the promise of NCW will remain unrealized.

76. Alberts, D. S., et al., *Network Centric Warfare*. 1999.

In part V of this book the results of a series of experimentally informed analyses that explore the consequences of remaining with an industrial age approach to command and control on key links in the NCW value chain (relating information sharing, quality of awareness, extent of shared awareness, and mission success) are presented. This series of analyses illustrates the enormous opportunity cost (loss) incurred despite the investment in information age technologies if organizations do not co-evolve their doctrine, processes, and organizations.

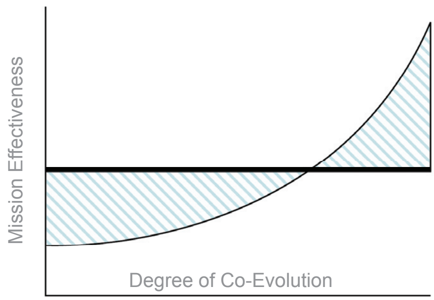


Figure II-8: Mission Effectiveness and Co-Evolution

This failure to complete, or even make significant progress in co-evolution in the U.S. and other militaries seems puzzling, particularly given the prominence that the idea of co-evolution in the seminal writings on NCW and defense transformation. The idea of co-evolution was so central to the thinking of the time, that the graphic in figure II-8 that I developed to illustrate the consequences of a failure to co-evolve (a slide in a briefing requested by the then Chairmen of the Joint Chiefs of Staff of the potential adverse consequences of separating the flow of information from the chain of command) was chosen to be the logo of DoD's Command and Control Research Program.

In terms of this graphic, I would estimate that the progress made by militaries in co-evolution would place them a bit to the right of where the curve crosses the break-even point in mission effectiveness. The investments in infostructure have resulted in positive returns, but these results have been very modest compared to the potential.

Upon reflection, I believe that the problem is that these organizations think they are doing well. They look at the information-related capabilities that they have fielded and feel successful. This is because they think of themselves as information age organizations. A focus on information makes sense. The pronouncement that information is a strategic asset sums up the prevailing perception of what it means to be in the information age. Organizations that take this statement to heart may find it difficult to look beyond information. Organizations that have a laser-like focus on information can easily be blind to an important aspect of their environment and the challenges it poses, as well as ignoring important opportunities to become more effective in coping with these challenges. Because of their blindness, their march of progress is on pause. Hitting the play button will require that they recognize what has become the reality of their information age is being superseded by a new age.

An assessment of the progress of the U.S. DoD and other militaries can be summed up in just a few words. Having prepared the battlefield, the U.S. military and other militaries are now paused, waiting to embark on a journey of transformation. Had these organizations taken the idea of power to the edge as it was intended, progress may have been far greater than in fact it has been. To remind readers, the basic idea of power to the edge is to be found in the first half of the following quotation:

> Power to the Edge *is about changing the way individuals, organizations, and systems relate to one another and work…involves expanding access to information and the elimination of unnecessary constraints.*[77]

Militaries, on the other hand, have been almost exclusively focused on the second half of this quotation.

77. *Power to the Edge*, p. 5.

Chapter 9

A Dawning of a New Age

Information age technologies have not only improved our ability to collect, store, process, and disseminate information, but they have also had a profound effect on a variety of interactions. The products of technologies and the services that have been created to exploit the capabilities that these technologies provide have enabled interactions where they did not exist before. This has facilitated interactions that were difficult or previously expensive, improved the richness of interactions,[78] and greatly increased the speed of interactions.

> *As a result, we are seeing an explosion of interactions that has, in and of itself, changed the world in which we live.*

The explosion in the number of interactions has created new feedback loops, increased the number of entities and variables involved in existing feedback loops, and increased the links between and among previous

78. *Understanding Information Age Warfare*, p.48.

independent domains. As a result, the world is growing more and more interconnected. This increase in interconnectedness has created both possibilities and interdependencies between entities that did not previously exist.

Feedback, normally a local phenomenon, is increasingly taking on a more global nature. At the same time the dynamics of the situation have increased as well. Much more is happening and it is happening more quickly. As a result, this new world is fraught with risks and abounds with challenges as a result of this explosion of interactions, but it is also a world of increased opportunities made possible by the interactions that are taking place and those that could take place.

New Age Challenges and Risks

This new age was described and predicted in both *Network Centric Warfare* and *Power to the Edge*, but this vision remains largely unnoticed and unappreciated. As a result, this vision became overshadowed and forgotten as the information age was defined in practice by an almost exclusive focus on information and organizational adaptations that minimized the co-evolution of self, and viewed the collective as an extension of self.

The increase in interdependencies, both between and among entities, and between and among environmental variables, has dramatically increased complexity. The increased speed of these interactions has given us less and less time to react. With increased complexity and dynamics, as was explained in part I of this book, comes increased uncertainty, risk, and time pressure. This translates into increased problem difficulty.

Our most challenging problems in this new age have two characteristics in common.

- First, the problem to be solved involves a multidimensional effects space.

- Second, no single entity, however large or powerful, can make progress by itself; any solution requires collective[79] action.

These aspects of the endeavors we must undertake are, in part, a result of the changes to our world brought about by information age technologies and the capabilities they have enabled. If we look at a wide range of 21st century endeavors, from terrorism and cyber-terrorism to natural and man-made disasters, we find that they have not only a military or security dimension, but also political, social, and economic dimensions, and an adverse impact in any one of these amounts to failure. Tackling these, as we have repeatedly found out, cannot by accomplished by a single entity. In some cases they require a whole of government solution, in other cases an international coalition, and in other cases a public-private effort. As a consequence of these two aspects of the complex endeavors we need to participate in, the information needed will come from a large number of sources and will need

79. The use of the word *collective* here refers to a collection of sovereign entities that although may differ in purpose, objective, organization, culture, and capabilities, have some interest(s) in common.

to be widely shared. Furthermore, to develop the critical mass of effort, individual entities will need to coordinate, collaborate, and self-synchronize their efforts in a manner consistent with the situation. Narrowly focused actions and/or unilateral action, however well-intended, can often have an adverse impact on situations. As a consequence of these two aspects of the problem, these problems involve levels of complexity that defy information age approaches and solutions.

In the earlier discussion of complexity, the critical role that feedback plays was identified. Feedback requires both a connection or interaction[80] and information. Interactions affect behaviors and states,[81] and the information provides the basis for recognizing changes in state and influences decisions that change behaviors. Sometimes the changes in behaviors that take place are appropriate and other times inappropriate, and often counter-productive. When the number and frequency of interactions are increased, the result is more state changes and more frequent state changes. As our ability to sense these changes in states increases, and if information about these changes in states is made more widely available, then more and more entities and their behaviors are impacted. This means that a single change in one entity's state can result in an increased number of other changes in the states of other entities, and in turn can result in a set of further changes. This is referred to as a

80. A connection can be physical, informational, cognitive, or social. An interaction involves both an action and a reaction.
81. A state being defined as a set of variables, each of which have a particular value. A change in state occurs when one or more of the values of the state variables change.

cascading of effects. Such cascades can be unpredictable and, once started, difficult to contain, with quite severe adverse consequences.

In terms of the risk space introduced in part I of this book, the increased interactions we are experiencing in this new age is increasing the likelihood that significant adverse consequences will occur. Figure II-9 shows the change in the relative size of the nine risk areas that are a result of increased interactions and increases in the speed of interactions. The net result is that the risk types that cause us the most difficulty are increasing. This makes it even more urgent that we find and adopt an approach to managing these risks.

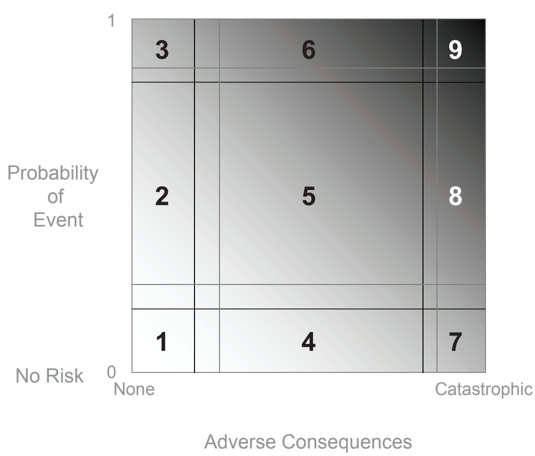


Figure II-9: Effect of the Increased Number and Speed of Interactions in a Multi-Dimensional Effects Space on Risk

Some readers will no doubt remember an informative documentary TV series created and hosted by James Burke called *Connections*, that aired in the late 1970s.[82] Mr. Burke entertained and informed us by answering such questions as: "How did the popularity of underwear in the 12th century lead to the invention of the printing press?" In case after case, Mr. Burke traced the dependencies between inventions and coincidences that resulted in significant developments. Many of these took decades, if not centuries, to unfold. The pace of developments was and remains largely dependent on the state of information-related technology and the spread of information. The book, *Connections*, first published in 1978, preceded the PC and the internet. The basic idea, that we live in a world determined in large part by connections, remains central to our ability to understand and cope. What has changed is that more and more connections are becoming interactions, and dependencies are becoming interdependencies. The first chapter of the book,[83] based on this series, is called the "Trigger Effect." It describes an event in November 1965 that serves to illustrate the potentially adverse effects of systemic fragility; a fragility that has dramatically increased as the information age has matured and with the advent of the age of interactions.[84]

> *…just before sixteen minutes and eleven seconds past five o'clock, a small metal cup inside a black rectangular box began slowly to revolve. As it turned, a spindle set in its centre and carrying a tiny arm also*

82. http://topdocumentaryfilms.com/james-burke-connections/.
83. Burke, James, *Connections*, Simon and Shuster, 1978.
84. Ibid, p.3.

rotated, gradually moving the arm closer and closer to a metal contact. Only a handful of people knew of the exact location of the cup, and none of them knew that it had been triggered. At precisely eleven seconds past the minute the two tiny metal projections made contact, and in doing so sat in motion a sequence of events that would lead, within twelve minutes, to chaos.

The event referred to here was a blackout of historic proportions that affected millions of people, not only those living in the electrically deprived area that encompassed the major cities of the Northeast United States, but all with some connection to individuals and businesses affected. Burke attributed this to the interdependent nature of technology. In fact, technology only created the conditions that made this sequence of events possible. Our ability to understand the complexity of the electrical grid we ourselves created, our mindsets, and the behaviors of people and organizations in both the public and private sectors turned this possibility into a reality. In other words, this was not inevitable.

What is inevitable is the creation of more feedback, and faster feedback loops increase complexity, and with increased complexity the risks we face have increased, in a non-linear manner. This is not because of the presence of feedback alone (although it does increase the amount of information available), but is a result of the sets of behaviors that this feedback causes in the affected individuals, organizations, systems, and things.

The existence of interactions, a change in one state that causes or influences a change in another state that in turn changes the first state or at least has the potential to do so, creates dependencies and interdependencies. These interdependencies span boarders and oceans and they leap across domains. As a result, changes in state almost anywhere on the globe can result in countless changes all over the world at speeds that defy deliberate analysis and responses. The result has been increased globalization.[85] The development extends far beyond markets and economics to any domain that is dependent on or affected by information and a virtual interaction.

One way to think about this new world is to picture it as a collection of interconnected networks (see figure II-10).

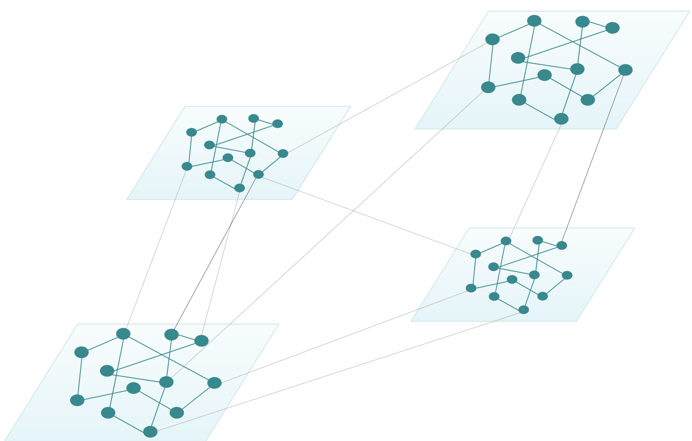


Figure II-10: Inter-Dependent Networks

85. The word *globalization* is most often associated with economics. Increased globalization means the market has become worldwide.

Think of each of the four networks depicted in figure II-10 as layers. Each layer, in reality, consists of many individual networks, or a set of services and/or relationships. There are, of course, many more than four networks, but these will serve to illustrate the nature of the new age. Let us think about the bottom-most layer as the set of networks that provides communication services, another as the networks that provide access to information and analysis services, the third as the providers of financial services, and the fourth set of networks as buyers and sellers of consumer products. If the communication services did not exist, then the interactions that take place would be limited to physical interactions and access to information would be very limited. In the age of interactions, there exists a set of communication networks that connect almost everyone. As a result these individuals (or increasingly software agents), no matter where they are located, have the ability to access information and initiate transactions of various kinds with an almost limitless set of individuals and organizations at anytime without significant costs or delays. A garage-based producer of t-shirts can ply his wares globally just like a major manufacturer with a well-established distribution system. A sheep herder in Mongolia can monitor the price of cashmere. Buyers can compare products and prices not only locally but globally. For physical products, the costs and delays of shipping, although these have been greatly reduced, inject some friction into the marketplace. But for virtual products and services such as music, movies, and financial transactions, distance and delay is not a factor. The same is true for ideas and information. Individuals can interact with others who share interests and/or ideologies.

Unfortunately, the same is true for those that wish us and others harm. Hackers, criminals, terrorists, and rogue state actors also have access to these capabilities and are increasingly using cyberspace for their ends. Their actions increase complexity and make interactions more uncertain and risky, adding to the challenges we face.

In this interconnected world, the set of state changes involving a multi-dimensional effects space cannot be understood by any one of our established disciplines. In fact, even a set of effects confined to a single dimension (e.g., economics, undersea oil wells) may not be well-understood, despite a well-established discipline with an extensive body of knowledge. Interdisciplinary efforts are greatly hindered by the structures and reward systems that universities currently employ. Recent efforts to promote interdisciplinary research and analysis have fallen far short of what is needed to understand problems that have multi-dimensional effects spaces.

Today we face an even more scary set of scenarios than the failure of the electrical grid in 1965. Instead of simply an electrical grid upon which we all depend, we now are increasingly dependent on a vast and heterogeneous collection of information and communication networks, both public and private, that many call the internet (a contraction of the term *World Wide Web*, or the www that precedes internet addresses). Others refer to this collection as the *Cloud*, perhaps from the way these capabilities have been portrayed on countless PowerPoint slides. This set of interconnected networks carries far more than simply electricity to power our computers and other electronic devices and appliances; it carries the information we need to inform our decisions, instructions to those who need to act, funds to pay for products and services, and provides access to applications that perform a large variety of tasks for us. The Cloud connects regardless of location, distance, or time zone. Due to the proliferation of wireless devices, one need not be tethered to an electrical outlet. This makes it increasingly possible for entities to continuously interact with one another. The number of entities to which a single entity can be connected is virtually limitless, while the number of entities with which a single entity actually interacts has grown exponentially. This is due in large measure to the economics of Cloud connectivity.

I think the mental model that comes to mind when one thinks of the Cloud is very useful. A cloud brings to mind a number of qualities and attributes that capture some of the important aspects of the age of interactions. Clouds are dynamic and ephemeral. We cannot see the droplets that collectively create a cloud—only the effect. We cannot predict the way a cloud changes before our eyes. And clouds hide things from sight and prevent us from seeing the world clearly. Clouds block the sun or source of light—a metaphor for knowledge. They are also real and symbolic warnings. Complexity creates the clouds that are characteristic of the age of interactions.

The world of connections James Burke described in the late 1970s seems, in retrospect, a much simpler time. It is orders of magnitude more difficult to understand the collection of interdependencies that exist today than it is to understand the electrical grid. The sets of behaviors that result are orders of magnitude more complex than the behaviors of the electrical grid. As a result, we simply cannot predict the consequences of changes to the state of the Cloud. We cannot decompose the Cloud. We cannot surgically cut the connections that are a direct or indirect consequence of the Cloud. The challenge of the age of interactions is to successfully cope with the potential adverse consequences of a clouded reality and take advantage of the opportunities enabled by the interactions that are possible.

The need to cope with increased risk and complexity is not new. We and our institutions have long since adapted to the levels of complexity that seemed formidable at the time. We have by and large adapted to the complexities associated with the industrial age, and we are learning, as individuals and organizations, to cope with the increased complexity brought about by the increased access to information and the need to deal with increasing amounts of information in compressed periods of time. But even as we are adapting to the information age by improving our infostructures, and by helping individuals and organizations create value from their increased access to information, it is becoming increasingly clear that the complexity of the challenges we face in the 21st century are outstripping our ability to meet them, armed only by industrial and information age solutions.

The problems that demand our attention are no longer local but are global problems with local consequences. These range from problems associated with the stewardship of the earth like global warming or sustainable production to the seemingly intractable problems of armed conflict, poverty, population growth, pandemics, terrorism, nuclear proliferation, natural disasters, health-care, and economic crises. Their complexity is a consequence of the interdependencies that make these problems difficult to understand and tackle.

The complexity of the age of interactions is a two-edged sword. The first edge is the complexity of the problems that challenge us. The second edge is the inevitable complexity of the solutions to these problems. I have focused on the nature of the problems—specifically on their multi-dimensional effects space. By virtue of the nature of our expertise and experience, these problems require diverse interdisciplinary teams to find appropriate solutions, and a host of entities to implement these solutions. Getting a set of disparate entities to work together is the other edge of the blade.

In terms of organization, we are, for the most part, stuck in the industrial age. What passes for information age organizations are likely, in fact, to be industrial age organizations that possess information age technologies. The realities of the new age demand collectives that can focus their efforts and converge on solutions with a speed that would make even the most well-tuned, optimized industrial age organization jealous. The central organizational challenge of the new age is how to organize a set of sovereign entities, or more accurately, how to organize, equip, and incentivize an arbitrary set of entities so that appropriate collective behaviors emerge.

As this is being written, the Euro is under attack and the response from various members of the European Union and its institutions appears less that coherent. There are many reasons for the apparent lack of command and control, not the least of which is that not having a pre-planned response available to meet this crisis, the collective was unable, in real time, to work out an agreed strategy and set of actions. The case studies performed by the NATO Research Group SAS-065 illustrate the current state of the art of collective organization. These case studies document the difficulties encountered in focusing the individual contributions of entities in a wide variety of collective efforts.[86]

This new age presents us with a set of problems that defy existing plans and approaches, make prediction all but impossible, expose us to significant risks, and put us under time pressures for which we are unprepared. To make matters worse, our institutions—military and civilian, public and private—now live in a proverbial glass house for all to see. Every action taken or not taken is second guessed and immediate results are expected, whether it is reasonable or not. In effect, correct decisions are demanded even before the facts are known and appreciated.

It is becoming increasingly clear that the two strategies being pursued by almost all of our institutions caught unprepared for this new age are both doomed to failure. The first is to ignore the increased scrutiny and expectations and to wish they would go away. The second is to stand firm in the belief that we know how to solve these problems and that all we need is to get better at what we do.

86. SAS-065 Final Report can be found at http://www.dodccrp.org/files/N2C2M2_web_optimized.pdf.

Fortunately this new age, the age of interactions, provides opportunities as well as challenges. It is here we need to look for solutions. To use a frequently employed metaphor, we need to shine a light into the darkness to find keys, not continue to look under the lamppost, because it is easy to see what is there.

New Age Opportunities

While the existence of increased feedback and increased access to information creates a set of problems; these developments also have the potential, if used effectively, to contribute to improvements in outcomes by creating an opportunity for higher quality decisions—both more correct and more timely.

Two legacies, one a belief, the other institutional, both outdated, have effectively tied our hands. The first is a belief in our ability to predict; the second is our notion of self. We, because of the potential power of interactions, have an opportunity to leave these legacies behind us as we enter the age of interactions.

First, let us consider how to approach our inability to adequately predict. There are many who believe we need more of what has worked well in the past. They would have us invest more in information collection, processing, analysis, and research. The only problem is that no matter how much is invested and how much information we collect and process, there will always be some important piece of information that we do not have. The same holds true with analysis and research. No doubt we can create an improved understanding of aspects of the problems we face. But again, we will not be able to know everything we will need to know.

Fortunately there is another approach. This new approach accepts that we will not be able to adequately predict or plan. Instead, the focus of this new approach is to possess the attributes that enable an entity to cope effectively with change. In other words, entities need to focus on agility.

Second, let us consider how to approach the requirement for collective action. The answer lies not, as many would have us believe, in making a collective look more like ourselves. Rather the answer lies in changing our view about self to make us more effective in collective endeavors. With the convergence of the organizing principles that we apply to both ourselves and collectives, we need to come full circle and make collectives more agile.

Part II Review—Part III Preview

The information age, as it has found expression in our institutions, has been almost exclusively about improving our ability to communicate and process information. The changes that have taken place to the economics of information have led to virtually universal connectivity and greatly increased access to information. Increased connectivity and increased information flows create the conditions for interactions and feedback. This, in turn, has created increased complexity and dynamics. Increased complexity and dynamics create more uncertainty, risk, and time pressures. As a result of increased uncertainty, risk, and time pressures, the problems we face have become more difficult, while, at the same time, there is a need to solve these problems more quickly.

In the information age, the U.S. military used these new capabilities to improve existing approaches and core competencies. The focus was on sustaining rather than disruptive innovations. This has resulted in improving what they were already quite good at.

In a world where one can adequately predict the missions that one will be assigned, and choose to work with a set of partners with whom command arrangements have been worked out and practiced over time, success can reasonably be expected. If things turn out differently, in cases where missions are unexpected and partners unfamiliar, what can one reasonably expect?

Part III presents a survival guide for the age of interactions. Step 1 of the survival guide involves acceptance of the limitations imposed by the increased complexity and dynamics of this new age. Step 2 is the recognition that the most appropriate response to the complexity-related challenges in this new age is agility. Step 3 is the undertaking of a priority effort to better understand agility and how to improve one's agility. Step 4 is to translate this understanding into actions and a capability to be more agile. Part III prepares us to embark on a journey to understand and improve our agility, the subject of part IV of this book.

Part III

A Plan to Improve Agility

Part III

A Plan to Improve Agility

The crucial capability needed to improve one's chances to successfully meet the challenges inherent in the complex enterprises and endeavors that characterize this new age is no secret; it is agility. Improving one's agility is not as simple as recognizing that it needs to be improved. In this, part III of the book, a results-oriented plan for improving agility is presented. This plan consists of four inter-related tasks. Benefits will start to accrue almost immediately and demonstrable success will come in increments as progress on these tasks is made.

Despite the fact that small steps will produce results in the near term to convince even skeptics that the journey is worth the effort, many may find agility a road too far. This may be because beyond the foothills of the journey, the path requires some fundamental changes in attitude, priorities, and processes. To those who have concerns, doubts, even fears, I would point out that the motivation for undertaking this journey is compelling. Whether or not one accepts reality, there is a choice to be made—a clear choice. On the one hand depend on more of the same policies, practices, and approaches that have been increasingly ineffectual or, on the other hand, try a new approach that has a demonstrated potential to succeed.

Ironically, some very successful organizations will have the most difficulty in coming to terms with what they need to do and then doing it. But at the heart of this survival guide is a very simple, easy-to-understand prescription. For the tennis players out there, it is the advice they likely will have received any number of times. The prescription is as simple as it is effective.

"Keep your eye on the ball."

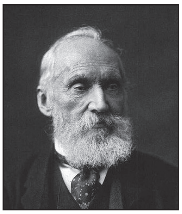
For some reason, many of us find this so difficult to do. Yet, when we watch the pros and look at their eyes, we see that they do indeed keep their eyes on the ball until the ball actually hits the racket, and then they follow through. When we succeed in our efforts to keep our eyes on the ball, we find it works, but as soon as our attention wanders, we are back to our old bad habits.

The ball we need to keep our eyes on to survive in this new age is agility. But it is hard to keep one's eyes on agility when there are distractions that vie for our attention. These distractions are a result of our continued belief that many long-held assumptions are still valid. Tried and true approaches can still work. Therefore, the plan's first task is to accept new age realities.

Chapter 10
Accept Reality and the Agility Imperative

Task 1: Accept New Age Realities

Simply stated, in this new age, we, on the one hand, are facing significantly more challenging situations, while on the other hand, we are equipped with a set of outdated approaches and tools. Unfortunately, we are in denial. This denial manifests itself in the need to cling to a set of myths that, in effect, oversimplify the problems we face. As a direct consequence of our incorrectly formulating these problems, we continue to employ familiar approaches and tools. Our denial is a prescription for disaster. Previous generations have also been in denial.



Lord Kelvin

Lord Kelvin, a leading scientist of his day,[87] is reputed to have said, "You can understand perfectly, if you give your mind to it."[88] He identified the pressing challenge of his day, as the need to improve measurement. Specifically, he said:

> *There is nothing new to be discovered in physics now, all that remains is more and more precise measurement.*[89]

This implies that he believed that the models available at the time had 1) completely and correctly identified the variables and their relationships, and 2) with a knowledge of their values at time t, the values of the dependent variables of interest at time $t + \Delta t$ could be predicted. Lord Kelvin concluded that any inability to predict was due to a lack of available information (information that was available if one looked in the right place with the right instruments), rather than a basic attribute of the phenomenon in question. Earlier in this book, I listed a number of statements about phenomena that are complex. Among the characteristics of complexity that I listed was, "even perfect information about the initial conditions is not sufficient to predict behaviors and outcomes." Lord Kelvin's conclusion reflects a belief in determinism and a denial of the existence of complexity.

87. William Thomson, 1st Baron Kelvin, (1824-1907) served as President of the Royal Society.
88. http://zapatopi.net/kelvin/quotes/.
89. Lord Kelvin was reported to make this statement in 1900 in an address to an audience of physicists gathered at the Royal Society.

Fast forward 100 years. In 1995, the Chairman of the Joint Chiefs of Staff expressed a belief in our ability to predict, based on developments in information-related technologies, specifically intelligence, surveillance, and reconnaissance (ISR).

> *We will know the effects of our actions—and understand what those effects mean—with far more fidelity, far earlier than anything we have experienced to date. This dominant knowledge, in turn, will make any subsequent actions we undertake even more effective…*[90]

The information age transformation of the U.S. DoD and other militaries has been and continues to be focused almost exclusively on improving our information positions. This unbridled faith in technology and in our ability to understand if we, as Lord Kelvin put it, only "give your mind to it," has effectively blinded us with a need to invest in and develop a critical capability, perhaps the most critical capability we need in this new age. We need to take off this conceptual blindfold if we are to have a better chance of success. Only by doing so can we recognize and acknowledge that solutions and approaches that depend upon highly accurate information, near-complete knowledge, reductive analysis, and accurate prediction will, in the face of the increasing complexity of both the environment and the endeavors we undertake, simply not work.

90. Admiral William A. Owens in an introduction to *Dominant Battlespace Awareness* (Johnson and Libicki) National Defense University Press, Washington, DC, 1996.

To move to a more age-appropriate approach, one that involves a substantial investment in the capability to deal with uncertainty, we first need to accept the fact that we will need to deal with significant amounts of residual uncertainty, and this residual uncertainty will profoundly affect our ability to determine the appropriate actions to take and our ability to predict the complete set of effects of our actions.

The first myth that needs to be abandoned, if we are to survive in this new age is:

> Myth 1: Uncertainty can be reduced to manageable levels provided that enough is invested in information-related technologies and improving information-related processes.

Having accepted the fact that, despite our investments in information and communication technologies and the improvements we make to our information-related processes, there will still be a significant amount of uncertainty. We need to turn our attention to how we choose to prepare to deal with this uncertainty, and the associated risks.

If we accept the idea of residual uncertainty, but believe we can survive and prosper by having a deliberate planning process that, over time, develops a set of contingency plans that can be called upon when needed, we have not fully appreciated the nature of the uncertainties we face.

As this was being written, millions of gallons of oil were spewing into the waters of the Gulf of Mexico, at least in part, because the contingency plans that were developed were inadequate. As the circumstances of this catastrophe become understood, we are sure to find a number of things that were not done or not done well. Many will attribute the fault to avoidable human error or to decisions made that ignored existing processes and procedures.[91] While these events certainly may have increased the probability of an accident, focusing solely on fixing the problems observed will not be sufficient to reduce the risk of future catastrophes to acceptable levels. There is a systemic problem. This problem is an implicit belief that we know or could know the most likely exposures (risks) we face, and can identify the set of scenarios that are likely to occur. In other words we believe that proper planning (plans that deal with the identified set of scenarios) will adequately protect us.

Interestingly in the Joint Staff Officers Guide, AFSC Pub 1, the following observation regarding this kind of deliberate planning is made in the chapter on Crisis Action Planning:

91. An example is the news article from the *Financial Times*, "Sharp increase in BP spill estimate," by Stephanie Kirchgaessner and Anna Fifield, published June 15, 2010. "One top executive, Rex Tillerson of ExxonMobil, countered the claim by pointing a finger of blame at BP, telling the congressional sub-committee that the Deepwater Horizon accident would have been preventable if "established procedures" had been followed" (http://www.ft.com/cms/s/0/307a8cf8-7885-11df-942a-00144feabdc0.html#axzz1UeSJZCdg).

> *In peacetime, deliberate planning procedures are used to evaluate anticipated future situations to which the United States must be prepared to respond militarily. These situations are hypothetical predictions of regional conditions and scenarios that are considered so critical—because of their relative probability, importance to U.S. national security, and difficulty in scale of military response required to resolve them—that plans to respond to them must be prepared before they occur. Twelve months or more may be required to identify adequate responses, conduct the evaluation to select the best course of action, and prepare a feasible OPLAN. It is noteworthy that these potential situations are based on the best available intelligence, but are still hypothetical to the extent that not all conditions can be predicted, and, even if all variations of a future situation could be anticipated, they could not all be planned for.*[92]

They correctly conclude that deliberate planning alone is not a complete answer. The DoD response to this shortcoming of deliberate planning is called crisis action planning. Crisis action planning procedures are used by the JPEC to plan for and execute deployment and employment of U.S. military forces in time-sensitive situations. These procedures ensure:

- Following logical procedures that begin with recognizing the problem and developing the solution, and progress to preparing and executing the operation order;

92. http://www.fas.org/man/dod-101/dod/docs/pub1_97/Chap7.html.

- Rapid and effective exchange of information about the situation, its analysis, and alternative military responses;

- Timely preparation of military courses of action for consideration by the National Command Authorities (NCA); and

- Timely relay of the decisions of the NCA to the combatant commander to permit effective execution.

Sadly, the approach to the crisis action planning described seems like deliberate planning on steroids. One is expected to recognize the problem and develop an appropriate response, but not in a matter of weeks or months, in near real time!

The unstated assumption here is that those situations that were missed (not thought to be significant or have a high enough probability to have been identified), if they should occur, can be quickly understood, and that solutions can be developed and implemented quickly. As far as I can see, there is no valid reason for making this assumption. In fact, there is ample evidence to the contrary. Unexpected situations are more likely to be unfamiliar to us and therefore we are less likely to know a solution. If by some chance we know or are able to find a solution quickly, it is not likely that we are prepared to move quickly to implement the solution. It is likely that we will be doing whatever it is for the first time. We can be expected not to implement it competently. Think of the challenges from the most recent oil spill to Katrina and the Tsunami. NATO Research Group SAS-065 has used these and other challenges to determine the maturity of the command and control of our individual and collective responses.[93] It would be difficult to conclude that we are prepared to deal with complex endeavors from these case studies.

The second myth that needs to be abandoned, if we are to survive in this new age, is:

> Myth 2: Risks can be avoided with proper planning.

Post mortems of less than ideal performance, whether it is a failure to prevent a terrorist attack or a failure to provide an appropriate response to a disaster, point to a lack of coordination and information sharing more often than not. Almost universally there is a recommendation to put someone in charge or to enhance their authorities. Perhaps it is because we want someone to blame the next time around. More likely, it is our belief in the need for hierarchies to organize and control the efforts of large numbers of individuals.

For many of us, hierarchical organizations are all we know. We have never worked in any other kind of organization. While we see the shortcomings of hierarchies, particularly mature hierarchies that have become increasingly bureaucratic, it is the devil we know. We accept these shortcomings because we believe that they still nevertheless work, or work well enough. We find

93. See SAS-065 Final Report at http://www.dodccrp.org/html4/research_nato.html.

it difficult to imagine any other form of organization. When we look at what we perceive to be the chaos of coalition environments or collectives, we yearn for order and a sense of control. It is not surprising that we think that if only we could impose some discipline, in the form of a chain of command on entities participating in a complex endeavor, things would improve. This is just wishful thinking. Unfortunately, reality intrudes on this delusion.

We are operating under two misperceptions. The first is that simply putting someone in charge (translation: put us in charge) will actually improve the situation. The second is that the individuals and entities involved will or should accept our kind offer. While I can imagine spirited debate on the question of what it would take, in addition to simply putting someone in charge, to actually improve performance, the question seems moot given the fact that in coalitions of the willing, this is, as we have seen numerous times, simply not practical.

Hierarchies are ingrained. In the multiple versions of the principles of war that exist, various military organizations have found it important to include a principle that addresses, in one form or other, their idea of command and control.

- "Unity of Command—For every objective, seek unity of command and unity of effort. At all levels of war, employment of military forces, in a manner that masses combat power toward a common objective requires unity of command and unity of effort. Unity of command means that all the forces are under one responsible commander. It requires a single commander with the requisite authority to direct all forces in pursuit of a unified purpose." (U.S. Army)

- "Firm and continuous command and control." (Soviet / Russia)

- "A single, unambiguous aim is the keystone of successful military operations." (UK)

A desire to have someone in charge is understandable. What is not understandable, indeed quite unacceptable, is to confuse this desire with reality and cling to the belief that there is no other way to get the job done. In other words, to refuse to accept the necessity of exploring other approaches or even the possibility that other approaches might be, under certain circumstances superior.

The third myth that needs to be abandoned, if we are to survive in this new age is:

> Myth 3: We need to put someone in charge and establish a clear chain of command because traditional organizational forms or approaches to command and control work best.

There has been an ongoing debate about whether we are now in a new economy—an economy where some of the basic assumptions or principles of economics no longer hold. Similarly, there is a debate about the changing nature of war.

While there are a number of versions of the principles of war, they share a number of themes and assumptions. For example:

- "Offensive action is the practical way in which a commander seeks to gain advantage, sustain momentum and seize the initiative." (UK)

- "Offensive—Seize, retain, and exploit the initiative. Offensive action is the most effective and decisive way to attain a clearly defined common objective. Offensive operations are the means by which a military force seizes and holds the initiative while maintaining freedom of action and achieving decisive results. This is fundamentally true across all levels of war." (U.S.)

- "Concentration of force involves the decisive, synchronized application of superior fighting power (conceptual, physical, and moral) to realize intended effects, when and where required." (UK).

- "Mass—Mass the effects of overwhelming combat power at the decisive place and time. Synchronizing all the elements of combat power where they will have decisive effect on an enemy force in a short period of time is to achieve mass. Massing effects, rather than concentrating forces, can enable numerically inferior forces to achieve decisive results, while limiting exposure to enemy fire." (U.S.)

These assumptions, while they may have been true at some point in time, and under some conditions (and may be so today, although in perhaps fewer circumstances), should no longer be taken as givens.

The geo-political environment has changed and the court of public opinion, both domestically and internationally, is increasingly more important to the achievement of strategic objectives than ever before. The Powell Doctrine of *overwhelming force* has both its ardent proponents and detractors. The arguments advanced and countered by those advocating this doctrine and those opposing it, to a large extent, represent different perspectives on self and the mission. Some proponents identify first with the military and see the rest of government and, at times, even the public, which the government is meant to serve, as else (else refers to anything but self). As a result they favor what is best for the military mission. They note that public support is often fickle and unlikely to last for an extended period of time. They conclude that a short, decisive victory is in the best interest of both the military and the country at large. Others see this doctrine as a disproportionate use of force, and more likely to, from a comprehensive perspective, make a bad situation worse by alienating rather than winning hearts and minds. It is important to note that the fundamental problem here is a resistance to change one's perception of self, and with a change in that perspective, a change in the nature of and the constraints associated with the mission. If self, mission, and environment are traditionally defined, then it follows that traditional views are still valid.

As a consequence, traditionalists hold that the principles of economics and of war remain true, while others argue that key principles have been overtaken by events—events that require a new and different perspective. Certainly, there has been enough change that has taken place to warrant a re-examination of these basic principles.

The fourth myth that needs to be abandoned, if we are to survive in this new age is:

> Myth 4: There is nothing new about this current age, except its name. Our tried and true solutions are just as applicable today as they have been in the past.

Recognizing these four myths will enable individuals and organizations to at least take the first steps necessary to meet new age challenges unencumbered by legacy ideas and approaches.

In particular, a greater understanding of the applicability and limitations of our information collection and processing, planning approaches and processes, and organizational structures and practices is needed to lay the foundation for progress.

A wider recognition of the fact that information collection and/or information sharing, while necessary to develop an appreciation of situations and respond appropriately, is not sufficient. This recognition needs to translate into a greater investment of time and resources in learning better ways to deal with residual uncertainties, to prepare individuals to operate with inadequate information.

Accepting the limits of traditional organizational forms and their inappropriateness for complex endeavors should open the door to experimentation that explores a new form of organization: the collective. Strictly speaking, the collective is not an organization, but a collection of entities, each of which may be organized in a different way. This notion of a collective, and the need to understand how to manage a collective (or to use more appropriate language, how to focus and converge the efforts of the participants in a collective), lies at the heart of the age of interactions.

Task 2: Recognize the Agility Imperative


Moltke, the Elder

Having accepted that one cannot adequately predict the future or develop a plan that (to paraphrase Helmuth von Moltke, the Elder[94]) survives first contact with reality, one can either be paralyzed by the futileness of current approaches or be invigorated by the challenge. The observation that it is not the plan, but the process of planning, is important and takes us one step in the right direction, but not far enough to constitute an appropriate response in the new age. It is in how we conceive the process of planning, what we do in our planning pro-

94. http://www.h-net.org/~german/gtext/kaiserreich/moltke.html.

cesses, and what we expect to achieve that determines the appropriateness of our response to uncertainty and risk.

If our planning process is in the mold of the U.S. deliberate or crisis action planning processes, then we have missed the point. The deliberate planning process adopts the view that planning is anticipatory decision-making. The crisis planning process assumes that we can approach unanticipated situations like we approach those we anticipate. There is the expectation that these two planning processes constitute a complete solution.

While planning is indeed useful and we should not abandon planning, we must adjust our expectations. We must recognize that we need to do more than plan. We must prepare. In this case, preparing for the future in the new age means we must develop agility. This is the agility imperative.

It is not that many individuals and organizations do not recognize that agility is important; it is the fact that they put agility in a list of many other desirable attributes and capabilities. The agility imperative asserts that agility is not merely a nice to have, but an existential requirement. Agility should not be in a wish list, but should be central to one's being. Without agility, there is no future.

Chapter 11

Understand and Improve Agility

Task 3: Understand Agility

At this point, the argument is tautological. Agility is the answer because of the way that agility is defined. By definition, if we can improve agility, we will increase the chances of success in unanticipated circumstances. The challenge is, of course, to understand the nature of agility. We must be able to understand: What are the key determinants of agility? How can agility be improved? How we can measure agility? How do we determine how much agility is needed? Only as we begin to understand agility, can we then take the appropriate actions to improve our agility and achieve the levels of agility required in this new age.

Part IV of this book, Understanding Agility, is an initial attempt to paint a picture of agility in broad brush strokes. It will provide a conceptual model of agility—one that identifies the key variables and the relationships between and among these variables. It will provide an initial set of measures of agility that can be used as a yardstick to determine current levels of agility and to measure progress. In doing so it will provide us with the concepts and metrics we can use to undertake an experimental campaign designed to identify the enablers and inhibitors of agility. This will enable us to explore the effects of a variety of stresses and challenges in the context of focusing the efforts of a collective and converging on a desirable state. Part V of this book will report on the results of a campaign of experiments conducted for this book as well as the results of related experiments. These results not only help us to understand agility in the context of teams, organizations, coalitions, and collectives, but they demonstrate how to explore agility and prepare us to undertake focused efforts designed to improve agility.

Task 4: Improve Agility

As we improve our understanding of agility, its enablers, and its impediments, we can begin to improve our agility. Although it is highly unlikely that we will develop too much agility in the near term, it is nevertheless important to have an appreciation of how much agility we need, given our circumstances. Part VI of this book, Potential Agility, identifies a number of actions that can be immediately taken to understand how agile we currently are, how much agility we may need, and how to improve agility. The context for this discussion is complex endeavors, and the subject of our agility investigation is the command and control, management, or governance needed to organize the efforts of participants in the endeavor.

The four inter-related tasks in this plan to improve agility should not be approached sequentially, but should be undertaken simultaneously. One should not wait until each task is completed before starting to take on the next task. Progress in accomplishing one facilitates progress in the others. Implementing this plan should be an iterative process—a process that will yield increasing results with each iteration.

Part IV

Understanding Agility

Part IV

Understanding Agility

In 1995, the Chairman of the Joint Chiefs of Staff expressed a concern regarding the unintended consequences of information technologies. The results of the study I was requested to undertake[95] to address these concerns were published as a book in 1996.[96] The opening sentence "Military organizations are, by their very nature, resistant to change"[97] constitutes a thinly veiled cry for increased agility. By 2002, this book was out of print and in response to continuing demand for this book, a revised and updated treatment of the subject was published as *Information Age Transformation*. This time the need for agility was made explicit. Agility was identified as a key characteristic of an information age organization. Furthermore, it was argued that agility was "a characteristic to be sought even at the sacrifice of seeking

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95. The question was posed to the Director, J-6 who was Admiral Cebrowski. He requested that I take on this effort. The results were presented by me to the Chairman later that year.
96. Alberts, D.S., *The Unintended Consequences of Information Age Technologies* (NDU Press, 1996). (Also available at http://www.dodccrp.org/html4/books_downloads.html).
97. Ibid., Chapter 10, section on measuring agility, p. 85.

to perfect capabilities associated with specific missions or tasks."[98] Thus, agility was clearly identified as a must-have capability—an imperative.

98. Alberts, D.S., *Information Age Transformation* 2002, p. 82. See http://www.dodccrp.org/files/Alberts_IAT.pdf.

Chapter 12

Defining Agility

Over the years there has been some discussion of agility—its definition, its constituent properties and attributes, and its measurement. Many of the words used to describe agility are understood a bit differently in different communities. Several groups, some of which were international in their composition, have grappled with the semantics of agility. There have been a number of attempts to create a Rosetta Stone so that individuals and organizations with different understandings of the key words could orient themselves. In fact, SAS-085, the NATO Research Group formed to address C2 agility is developing their version of a Rosetta Stone.

The CCRP sponsored an effort aimed at looking at existing definitions and identifying differences. This effort produced a paper presented at the 13th International Command and Control Research and Technology

Symposium.[99] The linguistic point of departure that I chose for this book is a result of these efforts at semantic harmonization. While over time I expect that there will be a linguistic coalescence around many of the terms related to agility, there will need to be a ongoing dialogue regarding the language of agility given the diverse communities of interest. The important thing for readers to keep in mind is that the ideas associated with agility are what is important. The labels that I, or others, attach to these ideas are less important than it is to have others be able to translate the concept into to their own languages and by doing so, understand the concept. That is, to make the concept available to a broad audience.

This investment in semantic interoperability is worthwhile because an in-depth understanding of agility is required to transform the way we think, the investments we make, and the way we measure value. Reaching this degree of understanding will take some time. The aim of this book is to provide readers with a useful orientation, a point of departure for incorporating agility into their design, investment, or operational decision-making and/or conducting their own in-depth examinations of the subject.

I shall begin by taking a closer look at the underlined phrases in the simple definition of agility previously provided.

99. McEver, Jimmie, et al. "Operationalizing C2 Agility: Approaches to Measuring Agility in Command and Control Contexts, " *13th ICCRTS Proceedings*. See http://dodccrp.org/events/13th_iccrts_2008/CD/Launch_CD.html.

> ***Agility** is the ability to successfully cope with changes in circumstances.*

An *ability* is a "quality or state of being able," a "power to perform," a "competence in doing," a "natural or acquired proficiency." Agility may be a property of interest in a diverse set of entities, including systems, people, organizations, and collections of individuals and/or organizations. Thus, agility refers to a set of characteristics and behaviors that enable, for example, a person or organization to *successfully cope* in a dynamic environment.

The word *cope* has a connotation of dealing with something that might cause problems and at least coming to terms with the situation.[100] An older usage of the word provides a more active meaning, that of engaging in a contest and coming out even or with success.[101] Thus while the adverb successfully, may not be strictly required in this definition of agility it has been included to make it clear to modern audiences.

100. From http://www.dictionary.com, cope 1. to struggle or deal, esp. on fairly even terms or with some degree of success (usually fol. by *with*): *I will try to cope with his rudeness*. 2. to face and deal with responsibilities, problems, or difficulties, esp. successfully or in a calm or adequate manner: *After his breakdown he couldn't cope any longer*. 3. *Archaic*. to come into contact; meet.

101. From http://www.merriam-webster.com/dictionary/cope Middle English *copen*, *coupen*, from Anglo-French *couper* to strike, cut, from *cop*, *colp* blow, from late Latin *colpus*, alteration of Latin *colaphus*, from Greek *kolaphos* buffet Date: 14th century *intransitive verb* 1 *obsolete* : strike, fight 2 a : to maintain a contest or combat usually on even terms or with success—used with *with* b : to deal with and attempt to overcome problems and difficulties 3 *archaic*: meet, encounter.

To some, the word cope implies being reactive. However, the understanding of those who crafted this definition (including that of this author) was that the sense of the word cope should not to limited to reacting to problems or situations. Successfully dealing with responsibilities, problems, and difficulties can involve anticipation and being proactive. For example, one way to deal with a situation is to avoid it by taking some preemptive action. Readers should therefore keep in mind that agility can be a first-strike capability. Furthermore, a change in circumstances does not always involve a stress or create adversity. Change may also present opportunities that, if one is agile, can be exploited to improve an entity's position. Finally, one can strive to influence or effect a change in circumstances to avoid a situation with adverse consequences or to create a set of conditions that, in turn, can be exploited for advantage.

However, after giving a variety of presentations on agility and as new members have been introduced to ongoing research activities, this point needs to be made repeatedly. To clarify the matter, the previous definition has been modified[102] to explicitly incorporate these ideas.

> ***Agility*** *is the ability to*
> *successfully effect, cope with, and/or exploit*
> *changes in circumstances.*

102. Professor Reiner Huber deserves the credit for advocating the incorporation of *exploit* and Michael Henshaw deserves the credit for advocating the introduction of *effect* into the definition.

Since agility is about success, it only makes sense in the context of a desired state, a purpose, or a task at hand. The nature of what constitutes a desired state or the missions or tasks that an entity may undertake can be as diverse as the entities themselves. Success, for the purposes of this book, involves maintaining one's position in state space or maintaining an acceptable or satisfactory level of performance, effectiveness, and/or efficiency. Thus, an entity is agile only if it achieves a satisfactory state or acceptable level of performance. Success in this context is subjective.

However, the fact of success in an endeavor or in a competitive space does not imply agility. Agility explicitly requires change—the ability to deal with a dynamic situation. There can and will be many changes in the environment. These changes fall into several categories. Some of these changes will not affect an entity; that is, they will not result in a change in the entity's measures of interest. Other changes, those that are significant, will or will have the potential to 1) result in a less than satisfactory level of effectiveness and/or efficiency, and/or 2) create an opportunity that, if exploited, would result in a significant change to effectiveness and/or efficiency.

In situations that are stable or change in ways that do not have a significant impact on an entity's state, entities still need to succeed, but they do not need agility to be successful. The phrase *changes in circumstances* refers to changes that can either have a significant adverse impact or present significant opportunities for improvement. These changes in circumstances are not limited to exogenous changes, but also include endogenous change.[103]

While the word agile is derived from the Latin *agilis*, meaning to drive, act,[104] an entity may possess a set of characteristics that make it possible for that entity to successfully cope with a set of changes in circumstances without taking action. That is, under certain circumstances, a change in entity behavior may not be necessary to exhibit agility. Thus, agility has components that are both passive and active. Passive agility involves characteristics that allow an entity to continue to operate effectively as is, despite changes in circumstances or conditions. An example of this passive quality is versatility (formerly referred to as robustness). Looking at figure IV-1 we see three screws. The one on the left can only be used with a normal or slotted screwdriver, the one in the middle requires a Phillips head screwdriver, and the one at the right can be used with either one.

Figure IV-1: Versatility of Screws

103. This point was recognized and articulated by Professor Reiner Huber, Universitaet der Bundeswehr Muenchen.
104. See http://www.merriam-webster.com/dictionary/agile.

Consider now figure IV-2. Both screwdrivers pictured can work with two of the screws in figure IV-1, albeit a different two.

Figure IV-2: Single Purpose Tools

Figure IV-3: Versatile Tool Kit

However, pictured in figure IV-3 is a more versatile screwdriver. It can be used with all three screws (and in fact with many more not pictured). However, it requires changing the tip in an appropriate way in order to accomplish this feat. This is what I would call active versatility. It requires one to recognize the situation and decide on an appropriate response (the correct choice of tip and presumably a timely response).

However, an entity's agility would be severely constrained if the entity lacked the ability to be active or proactive, that is, to seek to influence circumstances and when circumstances threaten to have an adverse impact to anticipate and avoid or minimize the adverse consequences by effectively responding and/or adapting when required. Active agility requires the ability to recognize that there is or will be a significant change in circumstances. Active agility also requires that an entity be capable of responding appropriately. This may involve taking an action, stopping an action, changing a process, or changing one's approach to management, governance, or command and control. It may also involve changing one's perceptions or even the way success is defined. An appropriate response changes self or the environment in a way that avoids or minimizes adverse impacts to an entity's measures of interest.

Improving agility involves getting better at recognizing significant changes in the environment and developing the ability to respond appropriately. The greater the variety of circumstances that an entity can recognize and respond to the more agile the entity will be. A measure of agility needs to account for both the amount of variety and the levels of effectiveness that can be maintained.

Figure IV-4 depicts the agility of an entity with both a passive and active component where there are two conditions of interest.

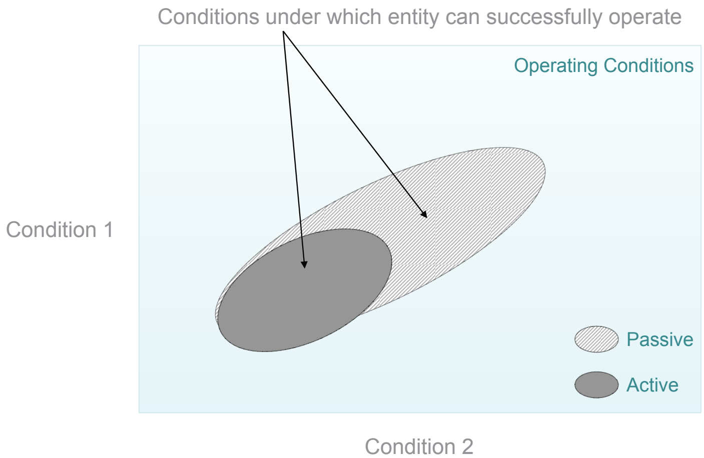

Figure IV-4: Passive and Active Agility

The innate qualities or design of the entity (its passive component) permit it to operate under the conditions that form the solid ellipse in figure IV-4 without the need to sense and respond to conditions. Having an active component allows the entity to extend the set of conditions under which it can successfully operate as depicted by the striped ellipse.

Chapter 13

Basics of Agility

Agility is a difficult concept to fully appreciate because of its many facets. We are not used to thinking or conditioned to think about things from the perspective that agility requires. Therefore, a quick look at the basic ideas associated with agility and its measurement may help some readers focus on the essence of agility. This quick look consists of sound-bite answers to key questions. These answers will be more fully explored in the remainder of this book. I believe we know enough to know that agility is an existential capability, and we know some of the things that enable or inhibit agility, but there is far more to know if we are to improve our agility to meet the challenges we face.

What is agility?

Agility is a capability that enables an entity to succeed in changed circumstances.

Why do we need agility?

Circumstances are guaranteed to change in ways that are not anticipated or expected.

Do we need to consider all possible changes in circumstances?

No. Only some changes in circumstances are relevant. These are changes that have the potential to significantly reduce effectiveness or that provide an opportunity to significantly improve performance or efficiency.

Why are our traditional approaches to complexity and uncertainty inadequate or inappropriate?

Traditional approaches rely on either predicting the future or reducing uncertainty to manageable levels. Neither is possible given the complexity that is present.

How much agility do we need?

The amount of agility needed is a function of the complexity of the situation and the costs of error.

How can we measure agility?

When we speak of agility, we are either referring to manifest agility or potential agility. Manifest agility measures how well an entity has responded to a change in circumstances. Manifest agility is a relative measure—it is the difference between an as-is scenario and a might-have-been scenario. Potential agility is an estimate of how well an entity will respond to some future unspecified change in circumstances. Potential agility is a relative measure that can be used to compare the agility readiness of two entities or the relative impact on an entity's potential agility of alternate approaches, policies, processes, or investment options.

How do we improve our agility?

Agility can be improved by putting in place or enhancing its enablers and by removing or reducing the effects of its inhibitors.

Does agility require that we must be equally good at everything and under all possible conditions?

No. Agility does not require an entity to be equally good in a changed circumstance, rather that an entity's performance, effectiveness, and efficiency need to be satisfactory.

Are there situations where we do not need agility?

Yes. If there were no possibility of a change in circumstances then there would be no reason for an entity to seek or develop a capability to be agile. Therefore, investing any resources in agility would be a complete waste of effort. Instead, in this case, an entity should seek to improve its ability to deal with the circumstances, in effect, optimizing for these conditions.

Dynamics of Change

Change is an essential prerequisite for agility. Without change entities do not need to be agile to be successful. I'm using *entity* to represent a wide range of subjects, including individuals, teams, organizations, processes, systems, as well as a system of systems or an organization of organizations (e.g., coalitions and collectives). *Self* represents the entity to which we belong, in which we participate, and of which we are a part. The relationships between and among self, other entities, and the other variables in the environment create feedback loops that, in part, determine how a change somewhere ripples through the network of entities and other environmental variables. Changes in distant nodes can have consequential effects on self, while changes to self may affect other entities in unanticipated ways with unanticipated consequences.

There is a constant interplay between changes to a particular entity, self (which may consist of multiple entities), and changes in the environment including nonself entities. These dynamics are depicted in figure IV-5.

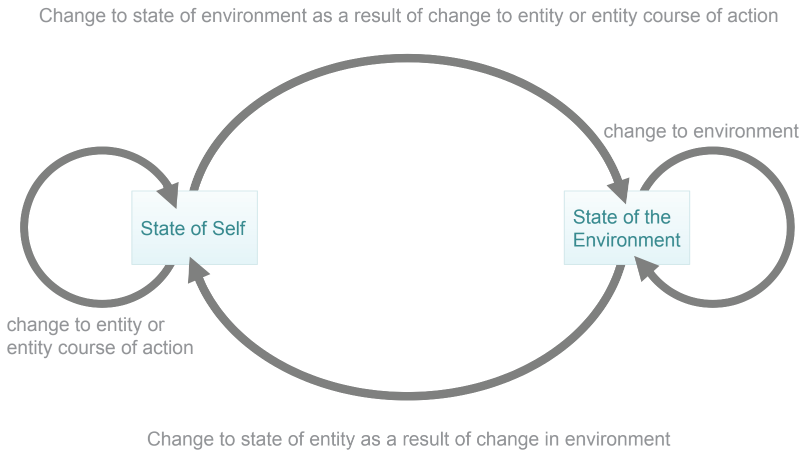

Figure IV-5: Dynamics of Changes in Circumstances

For the sake of this discussion, let us assume that an entity, self, has adapted to the current situation and that the value of its objective function exceeds some minimum threshold. That is, from self's perspective, all is satisfactory. This means that the only impetus for changing self's course of action or changing self (purpose, structure, approach) is an inherent desire for perfection—that is, improving beyond what is acceptable performance. Experience shows that many successful entities lose their edge and become complacent in this situation. They seem to be lulled to sleep by what they perceive is a satisfactory situation in a stable environment. At this point in time, self's situation can be thought of as being in stasis, balance, or equilibrium.

However, changes in the environment occur all the time. These changes have the potential to significantly affect self (see the arrow from/to the state of the environment).

However, for the most part, these changes are simply noise. Only a relevant change in the environment will, if correctly perceived as such, motivate a change to self's course of action or self (the arrow from the state of the environment to the state of self). Thus, a relevant change in the environment moves the world from a stable to an unstable state. For self to regain a state of equilibrium, a response is required. This is represented in the above chart by two arrows—the first from the state of self to the state of self (a change to self), and the second from the state of self to the state of the environment. From self's perspective, this unstable situation continues to exist until the value of self's objective function is restored to a satisfactory level. In order for a new equilibrium to be reached, relevant entities[105] in the environment (e.g., competitors, adversaries) must attain states that are also satisfactory to both these entities and to self. Otherwise the changes to self or self's course of action will immediately trigger another round of changes. During a period of instability, there may be many changes to both the state of the environment and the state of self. These changes may cascade and result in additional changes that may or may not require self and other entities to respond.

To summarize, agility is the ability to cope successfully, that is, to maintain an acceptable level of effectiveness and efficiency in the face of changes in circumstances that result in a loss of equilibrium.

105. A relevant entity in the environment is one whose state is of interest to self. That is, the state of an entity (including the value of the entity's objective function) determines, in part, the value of the entity's (self) objective function.

Chapter 14

Components of Agility

One way to improve an entity's agility is to establish or enhance one or more of the following six components of agility[106] identified[107] in part I of this book.

106. I finally settled on the term *components of agility* as an appropriate label for these six capabilities. Previously these six were described in a number of ways. Early on they were referred to as dimensions of agility and later as enablers. More recently they were described as coping mechanisms. Each attempt to find an appropriate term has not, for a variety of reasons, met with lasting success.

107. This discussion of agility builds on previous discussions in CCRP Publications (makes modifications I now believe appropriate), as well as incorporates the results of meetings of the Focus Convergence and Agility Team, a group of interested members of the C2 Community that met regularly under the sponsorship of the CCRP. A new NATO Research Group was created in early 2010 to consider C2 agility. This group, SAS-085, is, as this is being written, discussing the definition of agility and building a conceptual model of agility. These discussions have also influenced my treatment of the subject. It is impossible to know what the conclusions of SAS-085 will be since their final report is not due until 2013 (see Acknowledgments).

- Responsiveness
- Versatility[108]
- Flexibility
- Resilience
- Innovativeness
- Adaptability

Understanding each of these components of agility and the ways in which they are related to one another and the overall agility of an entity is necessary to design, develop, and effectively employ the strategies, approaches, methods, and tools needed to achieve an appropriate level of agility. The meaning of appropriate is determined by the characteristics of the circumstances we face.

The first five of these are related to different kinds of stresses or opportunities, while the last of these, responsiveness, is an essential ingredient when passive measures are insufficient and active agility (anticipatory or reactive) is required.

Responsiveness

While passive agility, as previously explained, does not require an entity to do anything to remain operating within acceptable bounds, this capability is associated

108. This component of agility has been previously referred to as robustness.

only with a limited set of circumstances; that is, when conditions remain within the operating envelope defined by an entity's characteristics. For example, a system may be designed to accommodate a 50 percent increase in communications traffic without experiencing significant impacts to mission or task effectiveness, timeliness, or efficiency. But passive agility has its limits, and when conditions fall outside of the design envelope, the entity can no longer maintain an acceptable level of performance without making some change. In other words, to remain within or to regain an acceptable level of performance an entity must be active or proactive. Active agility enables an entity to respond in a timely manner and/or to anticipate, or even to preempt a change. Active agility requires that an entity recognize that some action is necessary, decide on what action is necessary, and take that action.

Responsiveness is related to the time it takes to recognize and respond to a change or anticipated change in circumstances. A change in circumstances may either represent a stress that can adversely affect the ability of an entity to perform or an opportunity that an entity can seize upon to improve performance or effectiveness or maintain performance or effectiveness at a lower cost and/or with less risk.

Figure IV-6, Anatomy of Responsiveness, depicts a number of key concepts related to the relationships between responsiveness and agility. First, it identifies the baseline performance (the dotted line), that is, the performance that would have occurred had the change in circumstances never occurred. Second, it identifies the steps that are necessary to respond and juxtaposes these steps to the changes that might occur in a measure of value that reflects either the performance or effectiveness of the entity. Third, it identifies what actually occurred (the solid line). Fourth, it indicates that a measure of manifest agility is a function of the difference between baseline and actual performance over time (the area between the two lines).

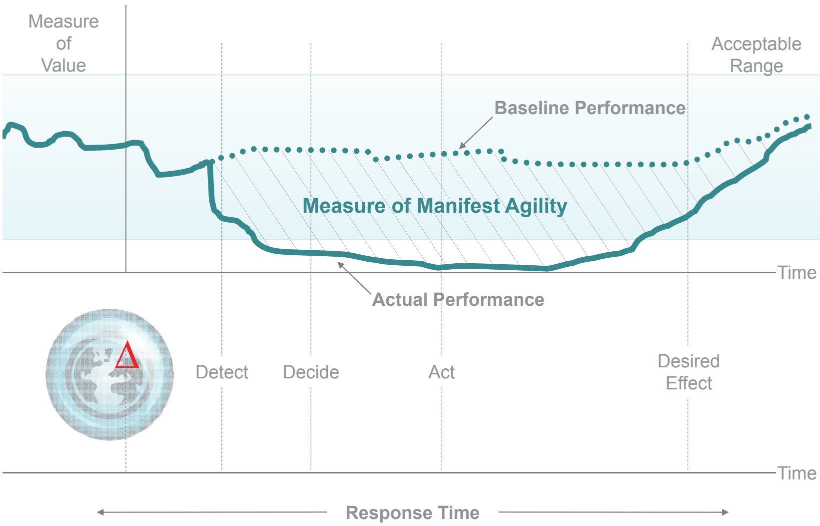

Figure IV-6: Anatomy of Responsiveness

The blue-shaded area on the graph on the top of the figure depicts the range of values for performance or effectiveness that have been determined to be acceptable. The time line begins with the situation under control, that is, within acceptable limits. The Greek symbol delta (Δ) indicates a change in circumstances that will either have an adverse impact on the measure of value (related to the level of performance) or present an opportunity to improve value or effectiveness. This change starts the clock for calculating response time.

The first time period of interest is the time it takes to detect this change. During this time-to-detect period, the measure of actual value may or may not change and in fact may even improve. In figure IV-6, the measure of actual value (the solid line) first wanders a bit and then drops precipitously at which time the change is, in fact, detected. How long in practice it takes to detect a change depends on a great many factors. This will be discussed later in the context of agility and complex endeavors.

Once a change in circumstances has been detected, the nature of the change that has occurred needs to be understood and assessed. The entity needs to determine if a response is required, and if so, the most appropriate response from the options available. Going from detection to a decision regarding a response is the sensemaking phase of the response process. This time period is a reflection of sensemaking responsiveness. In reality, decisions are not all taken at the same instant, but occur over some period of time. Sensemaking can be reflexive, almost automatic, or it may involve a considerable amount of information processing, analysis, and problem solving. Depending on the situation, consultation, and collaboration may be an essential part of this process. As a result, the sensemaking phase in the response process can take a considerable amount of time and require significant resources.

Once a decision or set of decisions about how to respond has been made, these decisions need to be implemented. Again, this may be quite simple, or it may be logistically challenging. The time required to act is a function of the nature of the actions required and the conditions under which these actions are to be taken. However, having taken action is not the same as having created the desired effects. The action may have immediate effects and alter circumstances. On the other hand, the effects that will eventually be created may take some time to begin to manifest themselves and not have the desired result until some additional time has passed. In figure IV-6, the value graph depicts a situation where the effects of the actions taken do not manifest themselves immediately. This affects lag results in a situation that remains unacceptable for a period of time before performance or effectiveness is restored to acceptable levels.

The time required to restore the measure of value to an acceptable level (response time) and the adverse impacts that occur during this time period (consequences) depend on the nature of the endeavor, the nature of the stress, and the entity's available response options.

An entity can change the shape of the responsiveness curve. As depicted in figure IV-7, an entity can employ a strategy to buy time. Sometimes referred to as temporizing, this approach seeks to accomplish one or more of the following: limit immediate damage; restore, at least in part, some effectiveness; forestall further deterioration; and enhance the effectiveness of later actions. The dashed line in figure VI-7 depicts the results if such a strategy (buying time) were employed.

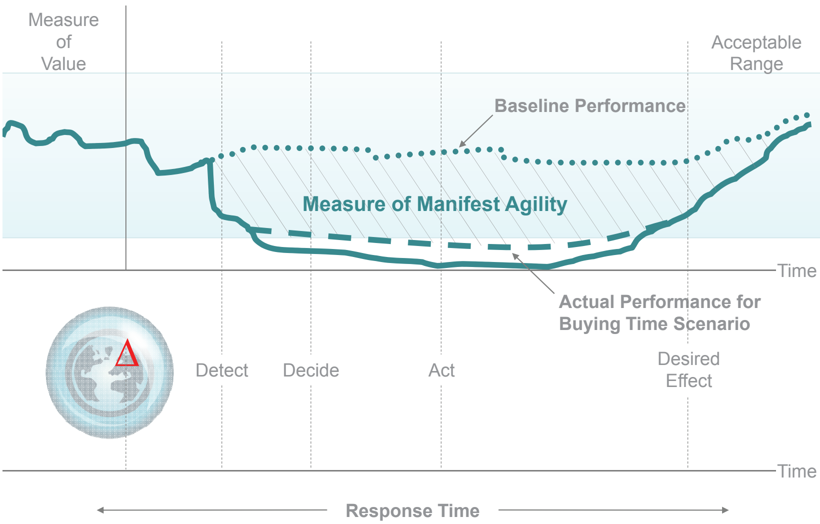

Figure IV-7: Anatomy of Responsiveness, Buying Time

Readers should not assume that entities must wait until a change actually occurs to begin to respond. There will be circumstances in which it may be possible to anticipate a change and entities may choose to take one or more actions in anticipation of events. These actions may include going on alert, increasing readiness, and/or taking some preemptive action.

Figure IV-8 depicts the impact that an anticipatory strategy can have, if it is successful (the dashed and dotted line, ●— ●—). The adverse impact associated with this scenario is far less than with a buying-time scenario. As depicted in figure IV-8, the ability to anticipate and take effective action prevents effectiveness from being degraded below an acceptable level and hence reduces the response time. Readers should note that, as a result of anticipation, the time required for decisions to be made, action to be taken, and effects to be realized can be reduced. Thus, the impact of anticipation can be more than simply starting the ball rolling earlier. The ball can also roll faster, not being burdened by obstacles that have yet to present themselves.

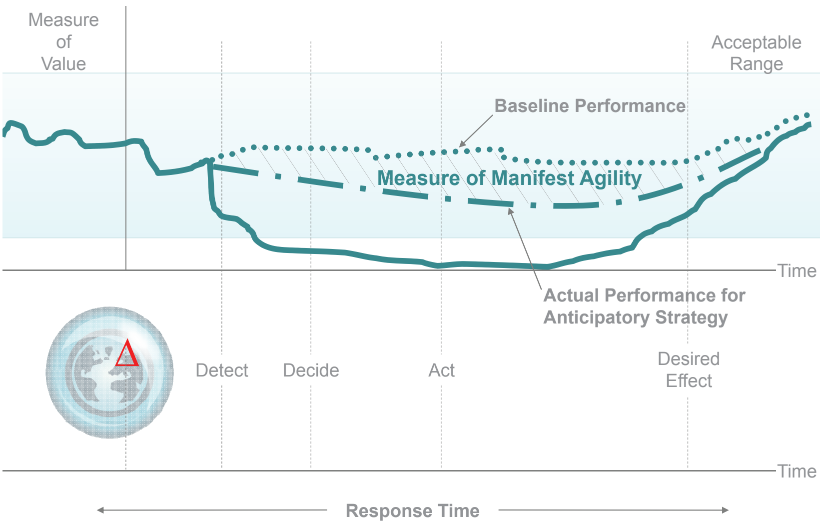

Figure IV-8: Anatomy of Responsiveness, Anticipatory Strategy

There will be times when an event or situation can be avoided or preempted entirely as depicted in figure IV-9.

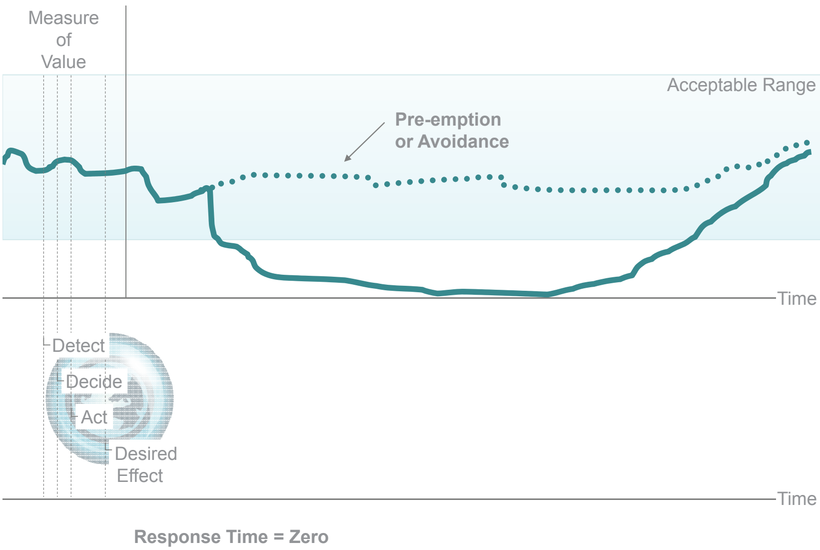

Figure IV-9: Anatomy of Responsiveness, Preemption

In this case, the decision to act, the taking of action, and the effect all take place prior to when the event would have occurred. The curve depicted in this figure represents both the actual time under a successful preemption strategy and the baseline. This baseline, if it were known or could be estimated, could be used to measure how agile the entity was (manifest agility). If the event were prevented, then the effectiveness observed over time could be compared to what would have occurred if the event had taken place and the entity was forced to react given its capabilities. Conversely, if the event actually took place, the actual experience could be compared to the baseline to see how much effectiveness was degraded for how long and compared to an estimate of what it would have been had the entity been unable to cope or respond effectively.

Developing a series of response curves, as depicted above, can provide important information and insights that can be used to better understand the impact of various response strategies and inform agility-related investment decisions. They can also provide information that can be used to measure the manifest and/or potential agility of the entity in question. If the curves are based on actual experience, then they depict manifest agility. If they are based on results from experiments, analyses, or simulations, they would contribute to an assessment of potential agility.

Responsiveness, while necessary, is not sufficient in of itself to make an entity agile; it must be paired with one or more of the other properties associated with agility (versatility, flexibility, resilience, innovativeness, and adaptation). Thus, to be agile an entity must both be responsive (respond in a timely manner) and effective. The trade-off between response time and the nature of the response that can be mustered is one of the critical considerations in developing or improving an entity's agility.

There are a number of words that have been used to refer to or to explain a lack of responsiveness. The words inertia and resistance have such a meaning. Inertia comes from the Latin *iners*, meaning idle or lazy. One speaks of a resistance to change or a reluctance to act. If an entity possesses either property, it would presumably show up in a manifested lack of responsiveness and depending on the associations that attend to the word, the properties of resistance and reluctance would also be manifested in a lack of flexibility, a lack of adaptibility, and so forth. SAS-085 is currently undertaking a series of case studies and conducting a series of experiments and analyses designed to improve our understanding of agility and to inform the development of a conceptual model that builds on previous work. During these discussions various members have proposed their own models or views of agility and the variables that they think are important. One such model, based conceptually on control theory, suggests that resistance is an important variable that should be operationally defined and measured.[109] Given the similarities and overlaps in the meanings of many English words that are associated with some aspect of agility or lack thereof, the approach I have taken is to find a minimum set that captures the ideas and work with others to map other words to one or more of this minimum set. At this point, I believe that the components of agility identified here constitute a complete set as they have been defined. The SAS-085 case studies and experiments are designed to test whether or not the behaviors they observed can be adequately described by these components of agility. They are also working on their own version of a Rosetta Stone. Given that no plan survives first contact with reality, I expect there will be modifications to the conceptual model presented in this book. Furthermore, only after a considerable amount of work has been done improving our understanding of agility in different contexts will there be a semblance of convergence with regard to the language of agility.

109. The SAS-085 member that first advocated the inclusion of the variable resistance (and also stiffness) is Dr. Philip S. E. Farrell from DRDC Canada. This work has not yet matured.

The following five components of agility, when combined with the ability to respond in a timely manner, account for the various ways that an entity can cope with and/or exploit changes in circumstances.[110]

Versatility (previously robustness[111])

Change in Circumstances: The nature of the mission or task changes in significant ways.

This component of agility permits the entity to achieve an acceptable level of performance or effectiveness in accomplishing the new or significantly altered task or mission.

The nature of complex endeavors places almost all entities into situations that are, at least in part, new and unfamiliar. More often than not the mission or task that an entity is prepared to undertake is not the mission or task that is actually required. Although known by some

110. This is currently a hypothesis.

111. The term that was originally selected to convey the idea of being able to successfully take on a new or altered task or mission was robustness. This choice of words came from the idea of having a robust capability across the mission space. Given that the word robust conveys a number of meanings and, as a result, has caused some confusion, I have decided to use the word versatile instead. http://www.merriam-webster.com/dictionary/versatile Etymology: French or Latin; French, from Latin *versatilis* turning easily, from *versare* to turn, frequentative of *vertere* Date: 1605 1: changing or fluctuating readily : variable <a versatile disposition> 2: embracing a variety of subjects, fields, or skills; *also*: turning with ease from one thing to another 3 a (1): capable of turning forward or backward: reversible <a versatile toe of a bird> (2): capable of moving laterally and up and down <versatile antennae> b *of an anther*: having the filaments attached at or near the middle so as to swing freely 4: having many uses or applications <versatile building material>.

in advance, this realization often comes after the entity is engaged in a complex endeavor and requires that the entity take on what they consider to be a new or changed mission or task. In the past, there has been considerable resistance on the part of some military organizations to accept this responsibility, which they have dubbed *mission creep*.[112] This is an aspect of a lack of agility that is not confined to military institutions. The same term has been used to describe an analogous situation in economics.[113]

Having chosen here to use the term versatility instead of robustness, the question arises as to whether there is a meaning that was attributed to robustness that is not included in versatility. In the initial discussions of agility found in information age transformation, the term robustness was initially defined to include more than changes in missions and tasks. Specifically, robustness was defined as the ability to maintain effectiveness across a broad range of missions or tasks, circumstances, and conditions. It includes the ability to maintain effectiveness under attack and when damaged and/or degraded, as well as across the spectrum of conflict. By 2003, as reflected in *Power to the Edge*, which devoted a full chapter to agility, resilience was split out from robustness. Therefore, robustness refers only to changes in missions or tasks, as well as a catch-all—circumstances. Given that

112. For a discussion of this topic see Siegel, Adam, "Mission Creep or Mission Misunderstood," published in *Joint Forces Quarterly*, Summer 2000 (http://www.dtic.mil/doctrine/jel/jfq_pubs/1825.pdf).
113. For a discussion of mission creep in the economic domain, see Hockett, Robert, "From Macro to Micro to "Mission-Creep": Defending the IMF's Emerging Concern with the Infrastructural Prerequisites to Global Financial Stability" 2006 (http://scholarship.law.cornell.edu/cgi/viewcontent.cgi?article=1061&context=lsrp_papers).

the word *circumstances* is part of the simple definition, and that resilience, flexibility, innovativeness, and adaptability all are about particular sets of circumstances, it really does not make sense to include circumstances as a catch-all in the definition of robustness. Hence, I have limited my definition of versatility to changes in missions and tasks. I have omitted a reference to the spectrum of conflict because it was merely an example in a military context and is covered more generally in missions and tasks. After this discussion of the components of agility, I will examine whether or not any additional components are needed, and if so, what they are.

Flexibility

Change in Circumstances: The response to the situation selected by the entity cannot be implemented, does not work, or does not work well enough in a particular situation.

This may be a result of a related stress (damage incurred), a lack of available information or expertise, a perception on the part of a partner or a third party, or it may be the result of an adversary's decision or action.

Flexibility provides an entity with more than one way of accomplishing a given task. This permits the entity to try another response instead of having to stick with an ineffectual, infeasible, or preempted response. Having to move to a less-preferred option or an alternate response may not yield the same results (had the original response been successful), may have some undesirable side effects that the preferred option did not have, and/or may not be as cost effective as the preferred approach; but having one or more alternatives is, nevertheless, better than not being able to do anything but continue with a doomed-to-failure course of action.

There are many examples of flexibility in the context of equipment, systems, processes, and organization. Flexibility requires both a recognition that a preferred option is not working or will not work and the availability of alternatives. In many cases, these alternatives have not been specified or planned for in advance but are identified as workarounds by individuals.

For example, having a face-to-face meeting may be the preferred approach to reach agreement on an assessment of the situation or on a collaborative course of action, but if such a meeting is impractical in the time frame required, having the ability to hold an Internet meeting or a video conference may be more effective than a telephone conference or a meeting of a subset of individuals or organizations or no meeting at all.

Resilience

Change in Circumstances: The destruction, interruption, or degradation of an entity capability.

This may be as a result of an action by an adversary, an act of nature, a self-inflicted wound, an accident, or an inevitable result of complexity.

Resilience provides an entity with the ability to repair, replace, patch, or otherwise reconstitute lost capability or performance (and hence effectiveness), at least in part and over time, from misfortune, damage, or a destabilizing perturbation in the environment.

Examples of other design decisions that can contribute to resilience are: redundant components, excess capacity, reserves, and fault-tolerant designs and systems. These are all passive and reflexive ways to improve resilience. A rapid response maintenance capability is an example of an active capability.

Innovativeness

Change in Circumstances: A situation for which the entity has no known adequate response.

The property of innovativeness permits the entity to generate or develop a new tactic or way of accomplishing something—a discovery or invention.

Adaptability

Change in Circumstances: A mission challenge that an entity, by its very nature or by its established organization or processes, is ill structured to undertake.

Adaptation permits an entity to change itself, that is, to change its organization, processes, and/or structure to become better suited for the challenge.

Interactions and Synergies Between and Among the Components of Agility

As pointed out earlier, the degree of responsiveness an entity possesses directly impacts the efficacy of the other components of agility. This is because an entity's responsiveness determines the time budget available and because behaviors that increase responsiveness also contribute to agility. The following example illustrates how responsiveness directly impacts flexibility, innovativeness, and resilience, either by constraining these components or enhancing them.

Flexibility provides an entity with more than one way of accomplishing a task. This permits the entity to try another response instead of having to stick with an ineffectual, infeasible, or preempted response. The amount of time available is directly related to both how many of the available ways are feasible (the option set) and how many different options can be explored and, if necessary, tried. An entity's ability to anticipate can enhance flexibility by both increasing the time budget available. The intelligence community has made enormous investments in what they refer to as *I&W* or indications and warnings. The purpose of I&W is to focus attention in the right place and to buy time. Success here depends not only on having the technical means (sensors and other collections systems) but also on the ability to analyze the data collected, share it appropriately, and make sense of it. The right set of metrics points one in the right direction to look for either things that have happened or, in many cases, things that have not happened. I&W enhance the ability to anticipate and hence prepare.

On the other hand, a lack of I&W means that the earliest one would be aware of a problematic event would be when the event actually takes place, is subsequently observed, and the information transmitted to an appropriate individual or organization. The failure to anticipate may take some options off the table because the time needed to exercise these options may not be available, making them infeasible.

Innovation permits an entity to generate or develop a new tactic or way of accomplishing something, that is, a discovery or invention. Having a sufficient amount of time can contribute to one's ability to innovate, assuming that the other conditions for innovation are present, because coming up with something new usually takes more time than to implement an existing option or plan. Innovation, in turn, can contribute to flexibility by providing an option not previously available.

The lack of innovativeness severely constrains flexibility by limiting the response set to pre-identified options. Given the profound uncertainty and inability to adequately predict that is characteristic of the situations of interest here, it is not reasonable to expect that all the options one would need would have been previously identified. This is, of course, not a new problem. The often-quoted saying that No plan survives first contact with the enemy is evidence of some recognition of this problem. However, despite this awareness, military organizations remain committed to planning processes that stress the expected rather than preparing for the unexpected.

Resilience provides an entity with the ability to recover from some damage or degradation. Having more time can also contribute to resilience by providing more of an opportunity to take steps to avoid the damage or mitigate the damage that would otherwise result from an event. There are many cases when, without anticipation, there is simply not enough time to react. Waiting to respond to a cyberattack on an information or communications system until some human becomes aware of the attack and responds in human time puts one at a decided disadvantage.

In addition to responsiveness directly affecting the other components of agility, these components can affect each other. For example, resilience impacts flexibility since the adverse impact of an event can make some, previously available options infeasible as a result of a lack of required capability (communications) or resource (personnel or equipment). Resilience can, at least to some degree, prevent this from occurring and keep more options on the table.

Given the interdependencies between and among the components of agility, one can better understand why the language of agility differs widely across individuals and disciplines. Fortunately, the ideas themselves do not differ as much as they appear to. If one is willing to look past the labels attached to the ideas behind the labels, the chance to develop widely shared understandings among disparate groups will be enhanced.

Inhibitors of Agility

There are, of course, a number of reasons for a lack of agility. Sometimes to improve our agility, we do not need to take action; rather, we need to stop doing something we are currently doing. This is because a failure to be agile can be traced not only to a failure to develop or improve the capabilities that enable agility, but can also be traced to a set of characteristics and behaviors that inhibit agility. These inhibitors of agility include,

- an unrealistic, overly simplistic model of reality
- a narrow view of self
- confidence that the best approach is known (knowable)
- restrictions on access to information
- stove-piped organizations
- reliance on approved planning scenarios and models
- optimized processes and investments
- resistance to change
- lack of diversity
- risk intolerance

- fear of failure
- lack of basic research
- lack of adequate education and training
- disincentives
- lack of diversity

Armed with only my observations of a wide variety of organizations over decades and the logical implications of the conceptual model of agility presented in this book, I am prepared to assert that the individuals and organizations that exhibit one or more of these characteristics and behaviors have been designed to fail. While possessing even one of these inhibitors may, under the right set of circumstances, contribute to failure, the more of these inhibitors of agility that an organization or collective possesses, the more likely it is that they will fail and fail catastrophically.

Readers need only look at case studies of the high profile failures that have occurred in recent years that involve organizations that were widely perceived as being successful to find evidence that supports this assertion. A closer look at any one of these examples will, I believe, uncover one or more of the behaviors identified above.

For example, the U.S. difficulties in Iraq and Afghanistan can be traced to both civilian and military organizations possessing, at least to some degree, virtually all the characteristics and behaviors identified above. Their widely discussed set of assumptions regarding what would happen after Saddam was disposed certainly were, in fact, unrealistic and overly simplified. A lack of information sharing within, with coalition partners, and with the Iraqis was systemic; the myopic view of self prevented building an appropriate coalition or collective; and the resistance to making the changes necessary (stay the course, etc.) delayed critical course corrections.

At times, the U.S. military has displayed a lack of command and control agility. This is a result of an inability to embrace appropriate approaches to collective command and control. This lack of agility (flexibility) stems from an inability to imagine nonhierarchical approaches to accomplishing the functions associated with command and control. The flexibility that is required is inhibited by a localized sense of self, a belief that they are good at what they do (if not the best), an excessively stove-piped organization, and disincentives to joint behaviors that are a result of culture and promotion policies.

The high profile set of what have been called intelligence failures that have occurred in recent years has generally been traced to a failure to connect the dots. In hindsight, the information that was needed to identify and prevent terrorist attacks was available but was not known to the right individuals and organizations or, for other reasons, its significance was not understood. In a sense, these failures can be characterized as a lack of I&W agility. This lack of agility has been attributed to the intelligence community's failure to transform itself from a cold war institution to one that is designed to meet today's challenges. In recent years, progress has certainly been made, but the task is more difficult because a number of the characteristics and behaviors that inhibit change to self. The connect-the-dots problem, while often associated with a lamented lack of systems capabilities, is not primarily a technical problem. Rather this problem is due to prevailing culture, incentives, and organizational structure and policy.

These failings are, of course, not limited to the military. The same set of challenges and some of the same inhibitors have been noted in economic development efforts. Serrat notes that development is a complex, adaptive process that has, with few exceptions, been approached and conducted in a traditional, linear fashion based on limited and out-of-date insights, and wishful assumptions. He notes that "if the assumptions are based on invalid theories of change (including cause and effect relationships) and on inappropriate tools, methods, and approaches derived from those, development agencies jeopardize the impacts they seek to realize."[114] Serrat builds on the efforts of Snowden and Boone[115] to identify the danger signals to look for in different decision contexts. In simple contexts, with established good practice, a context that is appropriate for trained but not expert personnel, these danger signals include: 1) complacency and comfort, 2) desire to make complex problems simple, 3) ingrained thinking, and 4) overreliance on good practice if the context shifts to a complicated or complex one. In complicated contexts, where experts are required, the danger

114. Olivier Serrat, "Understanding Complexity," *Knowledge Solutions,* November 2009..

115. David Snowden and Mary Boone, "A Leader's Framework for Decision Making," *Harvard Business Review*, November 2007, pp. 69-76.

signals include: 1) overconfidence in their own solutions and the efficacy of past solutions, 2) analysis paralysis, expert panels, and 3) exclusion of views of nonexperts. Those faced with complex contexts may exhibit the following danger signals: 1) temptation to fall back into habitual command and control mode,[116] 2) temptation to look for facts rather than allow patterns to emerge, and 3) desire for accelerated resolution of problems or exploitation of opportunities. In what the authors characterize as chaotic contexts (and I would include as part of complex endeavors) the following danger signals were identified: 1) applying a command-and-control approach longer than needed, 2) cult of the leader, and 3) missed opportunity for innovation.

Thus, there appears to be ample opportunity to observe and note that in diverse fields of endeavor, the level of complexity present in their environments is beginning to, or has already, overwhelmed practitioners and experts alike. Furthermore, the response of many of the individuals and organizations involved exhibit at least one, if not more of the inhibitors of agility identified above.

Requisite Agility

Agility is a desirable capability but that does not mean that it makes sense to devote unlimited resources to achieve whatever level of agility may be possible. The level of agility that is desirable depends on the set of circumstances we face; we refer to this level of agility as

116. This is an exact quote. I find this observation very interesting since it offers some insights into how others perceive the term command and control.

requisite agility. This is the level of agility that will, if we achieve it, 1) allow us to prevent or minimize the probability of events that are associated with adverse impacts and to maximize the probability of events that offer us opportunities, and 2) minimize the costs and/or maximize the gains should these events occur. Thus, agility is about both the mitigation of any adverse impacts that are created, and the ability to seize opportunities that may arise.

The reader should note that achieving requisite agility is not a guarantee of success, but rather it significantly improves the probability of success. Requisite agility, by definition, gives us our best chance of successfully coping/exploiting since the analysis that determines how much agility is desirable includes a consideration of costs—both the costs associated with residual uncertainties and the adverse impacts that may result, and the costs of achieving this level of protection from risk.[117]

Agility is power. The power of agility manifests itself in the increased effectiveness and efficiency of all aspects of enterprises—materiel, systems, processes, structures, and individuals. But, of all these contributors to agility, this new source of power lies, not in information per se, but in the nature of the relationships that are possible between and among entities.

117. This definition of requisite agility represents a refinement of the way requisite agility has been explained previously. This term, suggested by Professor Reiner Huber and adopted by NATO Research Group (SAS-065) that developed the *NATO NEC C2 Maturity Model*, defines requisite agility as that which is required by the situation and does not explicitly discuss the inclusion of a cost-benefit calculation.

Chapter 15
Conceptual Model of Agility

At this point in our journey of understanding, we have the conceptual building blocks we need to construct a generic[118] model of agility. This section will assemble these concepts into a simple conceptual model that will be used in the next section to generate agility-related hypotheses. These hypotheses, when instantiated in a way that makes them testable, will contribute to efforts to: 1) validate the conceptual model and determine the degree to which it is useful in improving both our understanding of agility, and 2) improving the agility of individuals, teams, organizations, systems, and collectives.

Each building block consists of a set of variables and interrelationships (submodel). Assembling these building blocks or submodels requires that we specify the relationships between and among them. The next step is

118. This generic model will need to be instantiated (a specific entity, a specific mission, and a specific set of circumstances) before it can be applied. Once various instantiations have been developed, the generic model can serve as an integrating function that helps us extract some general truths about agility that are entity, context, and mission independent.

to identify a minimum set of submodels. To begin with, there needs to be a model of self (to include one or more entities) and a model of the environment, and there needs to be a set of relationships between these two models that account for the influence of one on the other. Specifically, how the state of the environment impacts the state of self and how actions taken by self impact the environment.

Since our purpose here is to capture the concept of agility, we need to specify a set of variables that determine agility, in this case, the agility of self. Agility both presumes the existence of change and requires an acceptable level of effectiveness and efficiency. Thus, our conceptual model of agility needs to identify the variables within self and the environment that determine effectiveness and efficiency (as perceived by self) and those that represent changes in circumstances both external to self (environmental) and internal to self.

One of the most challenging aspects of defining agility is how to measure it. That is, how to represent the state of agility, which is the output of this conceptual model. As I analyzed the data generated by the experiments reported on in part V of this book, I found it relatively easy to compare the agility of an entity by comparing the results of a baseline case to a treatment case where the baseline represented the status quo and the treatment represented a change in circumstances. But these comparisons did not satisfy the need to show how well an entity was able to cope with and/or exploit changes in circumstances. To accomplish this, I needed to find a way to represent a set of changes of interest and depict the ability of an entity to deal with this set of changes. The results of my efforts resulted in what I call an agility map, an example of which is provided in figure IV-10.

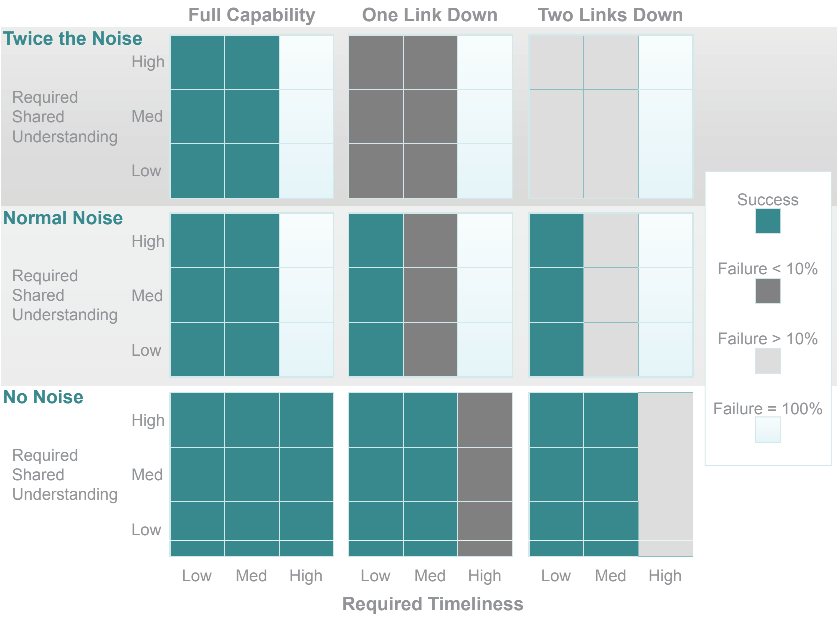

Figure IV-10: Agility Map: Edge with Adaptive Policy Under Varying Noise and Sustained Network Damage, Industrial Age Challenge

The dimensions and boundaries of this map are defined by the set of circumstances that is relevant in the case at hand. For each region of this territory, it is, at least theoretically, possible to determine whether or not an entity (in this case, self) is able to maintain an acceptable level of performance. For areas where self can maintain acceptable levels of performance, the map is colored to reflect this fact. Areas where self cannot operate successfully are left blank. In nondeterministic situations, the colors used can reflect probabilities. The construction of agility maps is discussed in detail in part V of this book and examples such as the one depicted in figure IV-10 are provided. Thus, one of the outputs of the conceptual model presented in figure IV-11 is an agility map.

A simplified overview of the concept of agility, using the building blocks that have been identified, is presented in figure IV-11.

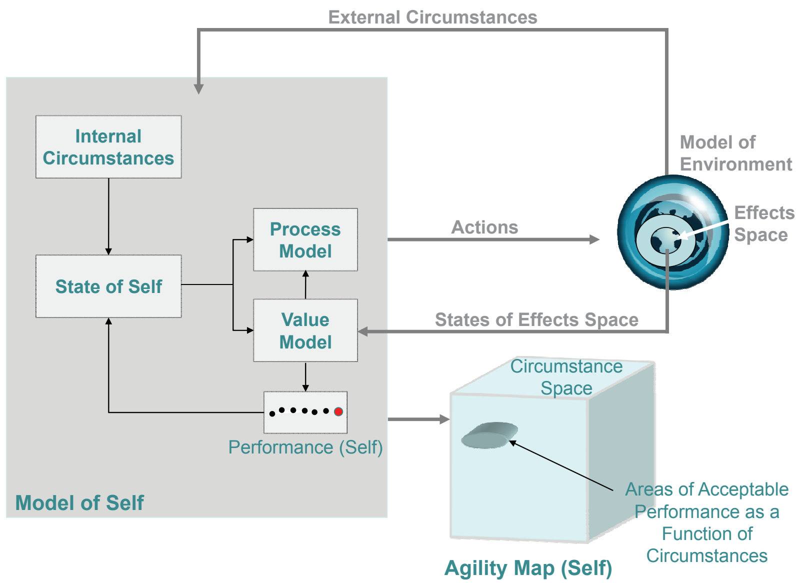

Figure IV-11: Conceptual Model of Agility

As part of a model of self, there is a subset of variables that serve to specify the state of self at any given point in time. The state of self is, in part, a function of variables that represent the characteristics and capabilities of self, self's condition, and self's intent. Changes in the values of these variables are a reflection of a change in circumstances (self) and alter the state of self. The state of self determines what, if any, action will be taken. The translation from the state of self into actions is represented here by a process model. Also included in a model of self is a set of variables and relationships that determine the current level of effectiveness and efficiency (see the red dot in figure IV-11). This value model also specifies the acceptable ranges for these variables. The current levels of effectiveness and efficiency, relative to the bounds of acceptable performance that have been set, impact the state of self. The values of the variables contained in the value model are determined, in part by internal variables, the state of self and, in part by external variables.

The model of the environment also contains a number of submodels. These include a subset of variables of interest to self (and other key entities) called the effects space (self). The environment also includes models that represent the states and value functions for nonself entities whose perceptions and actions are of interest to self or that can significantly affect variables in the effects space. Thus, the effects space (self) is only a subset of effects space variables, those that affect the state of self. Readers should note that when the state of nonself entities is of interest to self, these state variables are also included in the effects space (self).

Figure IV-12 depicts a state of equilibrium from self's perspective. This is because the measures of effectiveness and efficiency are within acceptable bounds.

In the situations of interest to us, this state of equilibrium will not last indefinitely. At some point, circumstances, either external of internal, will change. This may be a result of a number of different causes. These include: 1) an exogenous event that directly causes a change to the condition of self (a cyberattack), 2) a change in the state of a nonself entity of interest (the collapse of a government), 3) a change to the environment at large (a natural disaster), and 4) an endogenous event such as a change in intent or an addition to self.

A change in circumstances has the potential to cause self's level of effectiveness or efficiency to move outside of the acceptable bounds set by self. A change or a change in circumstances, either internal or external, could change these bounds, making some outcomes that were previously acceptable now unacceptable or vice versa. Readers should note that these changes need not be adverse. Instead, self may recognize an opportunity to improve either effectiveness and/or efficiency and hence alter the acceptable bounds.

If, for whatever reason, self perceives that it has moved outside of the acceptable range or is likely to do so as a result of an event that has occurred or is likely to occur, self will endeavor to take appropriate action. Readers should note that if an action is required, then whatever capabilities self has as a result of self's passive agility are no longer able to cope (or exploit). The actions required may, at least for some period of time, restore equilibrium (see figure IV-9). In terms of the agility map, the situation (circumstances) has changed and is in a different part of the map.

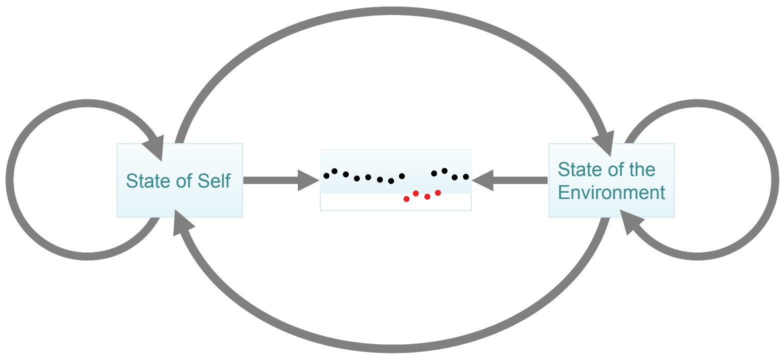

Figure IV-12: Concept of Agility Restored Equilibrium

The actions taken by self may or may not result in the restoration of an acceptable level of performance. Furthermore, self's response may trigger responses on the part of other entities and create a cascade of consequences that are, at best, difficult to predict. Exogenous and endogenous events create movement that is ultimately reflected in the agility map. Understanding the nature of changes in circumstances is essential if one is to understand agility and develop this capability.

Changes in Circumstances

Clearly, there are a great many potential changes in circumstances. As depicted in figure IV-8, the concept of circumstances includes both a set of variables within self (internal) and a set of environmental variables (external). Circumstances include characteristics of self, conditions or constraints under which self is operating, and capabilities of the collective organization and individual systems. For the most part, we tend to think of circumstances as being in the physical domain. However, circumstances that involve variables in the information, cognitive, and social domains are equally important. For example, characteristics of self may include not only size and logistics capacities but also how one is organized or one's culture. Conditions or constraints not only include physical or resource limitations like network connectivity and bandwidth and time constraints, but also policy choices or prescribed levels of trust.

A change in circumstances may also occur if there is a change to perceptions or values. Examples include what is deemed to be acceptable or the way self calculates value. Examples of a change in what constitutes success (what has been referred to as mission creep) include such a change. A change in what is deemed acceptable is reflected in a change to acceptable bounds. This, in turn, directly affects the calculations which are reflected in the agility map.

A change to the value model occurs when either a new value variable is introduced (a consideration that was not part of the calculus previously) or there is a change in the relationships between and among the variables of self, the environment, and the value model. For example, there is a change to the relative importance of a variable. In all cases, a specific change in circumstances can be expressed in terms of a set of variables taken from one or more of these submodels. This is also reflected in a change to the agility map.

> The greater the variety of circumstances that an entity can recognize and successfully respond to, the more agile the entity will be.

Thus, the degree to which an entity possesses agility is reflected in the amount of territory that is colored in the agility map. The agility maps of entities can be compared to determine relative agility.

Understanding the different kinds of changes that can take place is important for a systematic treatment of agility. Changes in the status quo can be classified in a number of ways. One useful way to sort them is to look at what is directly affected by the change. This approach results in an illustrative set of changes sorted into two groups. The first group contains changes to the state of the environment while the second group contains changes to the state of self. Figure IV-13 provides some examples of each.

Sorting by what was affected by the change

Environment
Conditions of Nature
States of Other Entities
Relationships with Other Entities
Measures of Interest

Self
Purpose
Objective Function
Value of Objective Function
Personnel
Leadership
Communications
Information
Knowledge
Cohesion
Trust
Equipment
Resources

Figure IV-13: Types of Changes of Circumstance

Modeling Self and the Environment

In order to be of more than academic interest, both the models of self and the environment need to contain more than simply the variables that directly affect the value calculus. The variables that affect the value variables must also be represented. Consider the set of variables that directly affects value (value model) as forming a chain. Each link in this chain represents a condition that has a significant influence on the condition represented by the next link in the chain. The point here is that while a given link has a significant influence, it does not completely determine the state of the next link. That means that there are other variables whose values need to be known and considered. While it would be impossible to identify all such variables, the goal of a model is to identify the ones that have a significant, or first order, impact. Furthermore, as one follows the links in the chain away from the end that represents mission effectiveness and efficiency (the bottom line), the first link in the chain describes a set of characteristics of, in one case self, and in the other case, the environment. These characteristics create the conditions for subsequent behaviors.[119]

In the situations of interest here, some of the characteristics of self that determine this set of initial conditions are controllable. These are sometimes called *design variables* or, in the case of experiments, *treatment variables*. The experiments reported on in part V, delineate the organizational approach an entity or collective takes to accomplish the functions we associate with command and control, management, or governance and related policies and practices. These are among the key controllable variables that are explored. The actions taken by an entity (the response) can be expressed as the values of a set of controllable variables that are thought to directly or indirectly affect one or more of the links in the value chain.

In the case of the environment, its characteristics are largely uncontrollable (at least by self). In the experiments reported on in part V, these uncontrollable variables constitute key characteristics of the challenge. For example, the complexity of the problem and the level

119. In the *NATO Code of Best Practice for C2 Assessment*, this first link in the change consisted of what are referred to as "dimensional parameters."

of noise in the information that is available represent two characteristics of the mission or the environment in which the mission takes place.

A process model is a task-oriented view of how an entity or collection of entities responds to changes in circumstances and generates products or outputs (indicants of task accomplishment) in the form of the values of a set of variables that is associated with the performance of mission-related tasks and/or mission outcomes. Different missions or tasks may require, depending on the degree of granularity desired, different process models to produce appropriate products or outputs. These products and outputs are aimed at creating effects (changes to the values of the variables of interest in the environment[120]) that, if they actually occur, translate to changes in performance (value of the situation to self) by the value model.

The set of measures of value should include, at a minimum, effectiveness and efficiency (value realized/ resources expended). The value realized (as perceived by self) may be a function, not only of the degree to which a task has been accomplished, but also of the prevailing conditions and circumstances. A given set of products may be sufficient for success in one circumstance but not in another.

120. While some view the environment as external, it is becoming more widely understood that in complex endeavors, the entity or set of entities that comprise self are an integral part of the environment and that the effects space will contain variables related to both internal and external impacts.

The execution of a task results in products/outputs that occur over time. These, in turn, create effects, changes to variables of interest in the environment, which may affect circumstances, which in turn may affect the value calculation. However, for the moment let us assume that the nature and magnitude of the changes that may occur in circumstances are within expected bounds. The effects that are created over time result in changes in value over time. Being able to measure or estimate the measures of value over time make it possible to create graphs like the one highlighted in figure IV-14 and those depicted in the discussion of responsiveness.

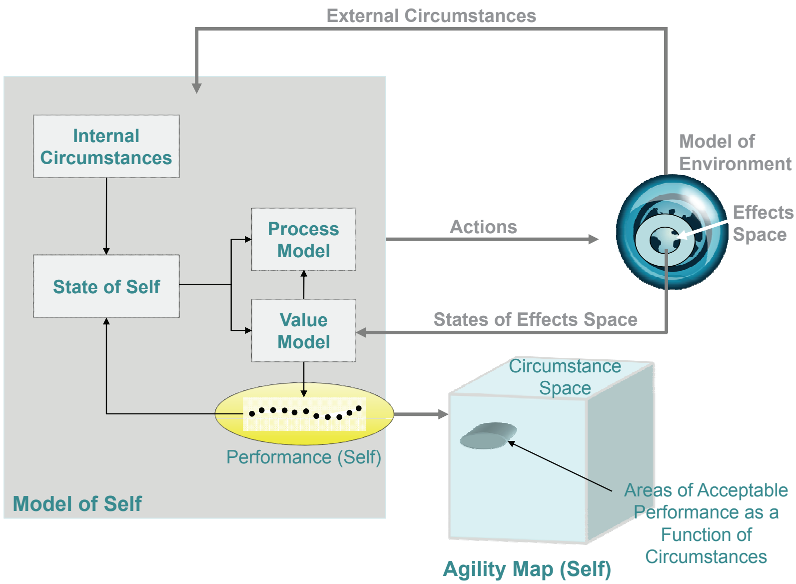

Figure IV-14: Conceptual Model of Manifest Agility

The situation depicted in figure IV-14, although dynamic is by and large, predictable. The entity faces a situation that is normal—a situation that remains bounded within acceptable limits. If the situation could be counted on to remain so indefinitely, there would be no need for agility. However, in today's world this normal is not normal. Complex endeavors are characterized by unanticipated events and consequences. Agility is required to cope with the unanticipated events and consequences that have the potential to create effects that result in unacceptable levels of performance, effectiveness, and/or efficiency. Therefore, the next step in constructing a model of agility is to identify those changes in circumstances and conditions that have the potential to impact the measures of value and cause these to become outside acceptable bounds.

Although it has been quite common for policy makers and analysts to think of changes in circumstances as uncontrollable exogenous events, our definition of circumstances includes internal changes that occur. These may be intentional or accidental. Given the interconnectedness that characterizes our world, internal and external changes are more closely related then ever before. Examples would include changes in weather and the resulting changes in the ability to maneuver (move from one place to another), events like earthquakes or an outbreak of disease, a coup d'état, the failure of a plan, the loss of a capability, or a loss of trust.

The list of potential game changers is literally endless. Each of these changes may have both direct and indirect consequences that cause other changes to occur. For example, a coup d'état may result in some faction coming to power that was friendly, replacing a regime that was neutral or even adversarial. As a result, this entity may wish to join a complex endeavor. This, in turn, has numerous consequences that may impact other entities and the systems they utilize. In this case, an external change caused an internal change (the composition of the collective and the arrangements of the systems that support the collective). The failure of a plan may have multiple interrelated consequences. For example, it may result in a loss of popular support, a change in strategy or even mission, and a change in leadership. On the other hand, it may increase popular support and result in more resources being allocated to the cause.

The nature and significance of the specific changes that occur depend on an entity's perspective. In complex endeavors, the entities of interest include the collective itself, the participating entities, the teams and individuals that are part of these entities, and the collection of systems that are available to individual entities and to the collective. The model of agility that has been presented has informed the design of the analyses and experiments presented later in this book. These experiments involve instantiating this conceptual template for an individual, a team or organization, a system, a collective, and a collection of systems.

Chapter 16
From Manifest Agility to Potential Agility

The conceptual model of manifest agility depicted in figure IV-14 can be used to determine whether or not and the extent to which agility has been manifested. Alternatively, it can be used to develop predictions of manifest agility based on the process models of self and environment, and their interactions. In its current form, this model provides us with a guide to the observation of entity behavior and an approach to expressing the agility an entity manifests in a given situation (one that has occurred or one that has been simulated). When combined with an instantiation of circumstance space, this conceptual model can produce an entity's agility map. This, in and of itself, is a major step forward on our journey to understand agility in general and the agility of a specific entity.

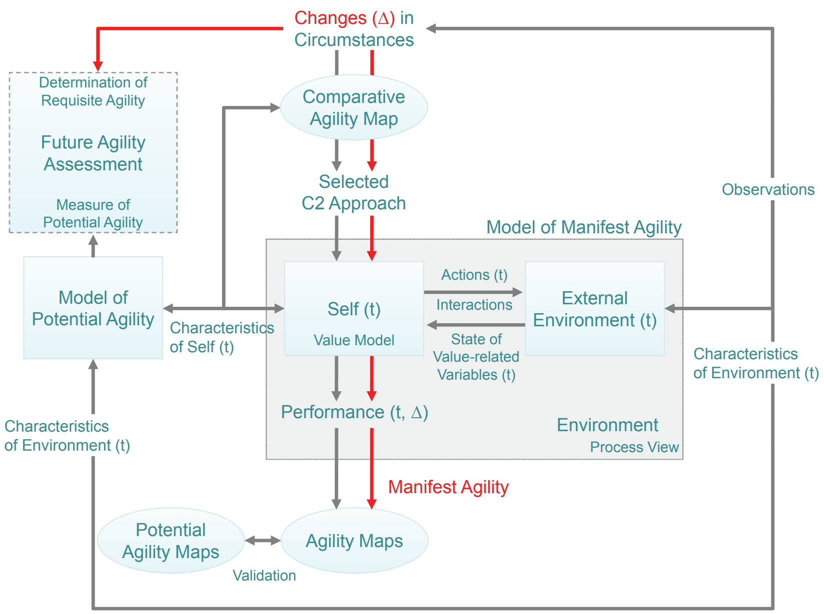

Figure IV-15: Potential and Manifest Agility Models

Figure IV-15 builds on the conceptual model of manifest agility by extending it to introduce a model of potential agility. Figure IV-15 also depicts the relationship between the model of manifest agility (a process model that, when driven by a set of changes in circumstances, produces projections of manifest agility) and a model of potential agility (a causal model) that uses indicants or markers of agility to predict manifest agility. The process model tells us what happened, while the causal model explains why it happened.

The characteristics of self are, to a significant degree, shaped by the selection of a specific approach option.[121] The appropriateness of the approach option that is selected will determine the relative agility of the self.

Figure IV-15 provides the structure and organization for a campaign of experiments and related analyses that drill down into the *black boxes*, expose their inner workings, and provide the evidence for useable models of agility, both process and causal or explanatory models. These models will enable us to make better-informed decisions regarding agility-related investments and inform critical trade-offs. Among these critical decisions are: 1) the selection of a set of approach options that an entity should be capable of implementing, 2) the balance between investments in technology and education and training, and 3) the balance between efforts to protect against cyberattacks and the need to share information broadly.

Figure IV-15, while greatly simplified, nevertheless contains a number of important concepts that are implicit or implied and that merit further discussion. First, self can be viewed from a number of different perspectives, and the boundaries of self constitute what is called a *unit of analysis* (e.g., a small team, a set of teams that comprise a larger organizational unit, or a collection of independent entities). Having defined self, there are a number of other actors with which self interacts that need to be included in environment.

121. The concept of approach, while natural to think of in terms of teams, groups, organizations, and collectives, can be applied to information systems as well, particularly those that incorporate intelligent agents or customized search engines.

The actions taken by self and the changes that take place in the environment as a consequence involve reactions by other entities. This set of actions and reactions can be thought of as interactions between self and environment, where environment includes other actors that are not part of self. Given that self and environment contain humans, perceptions are very important. The mental models of the humans involved ultimately determine actions/reactions. Thus, when developing more detailed models, self and environment perceptions must be accounted for. Trust is a perception. Trust, in its many forms, must be an integral part of these models. Trust shapes perceptions and behaviors. Reducing the differences between an entity's perceptions and reality provides an opportunity to improve performance that should not be overlooked.

Self contains a *value model* that drives behaviors. This value model determines, as a function of the state of the environment and the perceived state of self, what constitutes an entity's goals and objectives,[122] which in turn determine the acceptable performance range and what current (and projected) performance is. The state of the environment, since it contains humans and collections of humans, includes perceptions and value models.

Finally, figure IV-15 is a static representation of what is a very dynamic set of processes that are taking place simultaneously in the physical, information, cognitive, and social domains. Feedback loops abound within self, within the environment, and involving elements of self

122. Depending on the nature of self, goals and objectives can be provided by an external entity or self-generated. Additionally, they may be shaped by an external entity and filled in by self (e.g., mission orders).

and the environment. Time is an important dimension. The complexity of the situation (a function of the number and types of feedback loops and the patterns of interactions that result) and the time pressures involved, in large part determine the difficulty of the problem.

Our goal however, is to do more than simply observe and chronicle entities' struggles with complexity and change. We are interested in understanding what makes an entity agile and in improving entity agility. In order to do this, we need to be able to go from a model of agility that is descriptive to one that is predictive and then prescriptive.

Moving from a descriptive model to a predictive model requires the ability to do forensic analysis. The model depicted in figure IV-15, while it provides an approach to estimating manifest agility using observations and measurements from actual events, simulations, or assumption-based analyses, does not provide the detail necessary to identify the proximate causes of the agility manifested (or lack thereof). The ability to trace back and identify the reasons why a given level of agility was manifested (forensic analysis) requires replacing the black boxes with appropriate process-value models that contain the specific variables that are believed to be related to the value chain that ultimately results in manifest agility.

Identifying the reasons for the agility that is observed in a particular case allows us to develop hypotheses that, when tested, provide evidence regarding the markers of agility. These markers are the enablers and inhibitors of agility. The values of these markers constitute, in some combination, a measure of potential agility.

Figure IV-16 illustrates possible relationships between a variable that is thought to be a marker and a measure of manifest agility. If the variable in question enables agility, then increases in the value of this variable should translate into increases in manifest agility (see graph on the left). On the other hand, if increases in the value of the variable translate into decreases in manifest agility, then this variable is an inhibitor of agility (see middle graph). When variations in the value of a variable do not appreciably affect manifest agility (bottom right graphic), then the variable is unrelated to agility, and thus, is not suitable as an indicant or marker of agility.

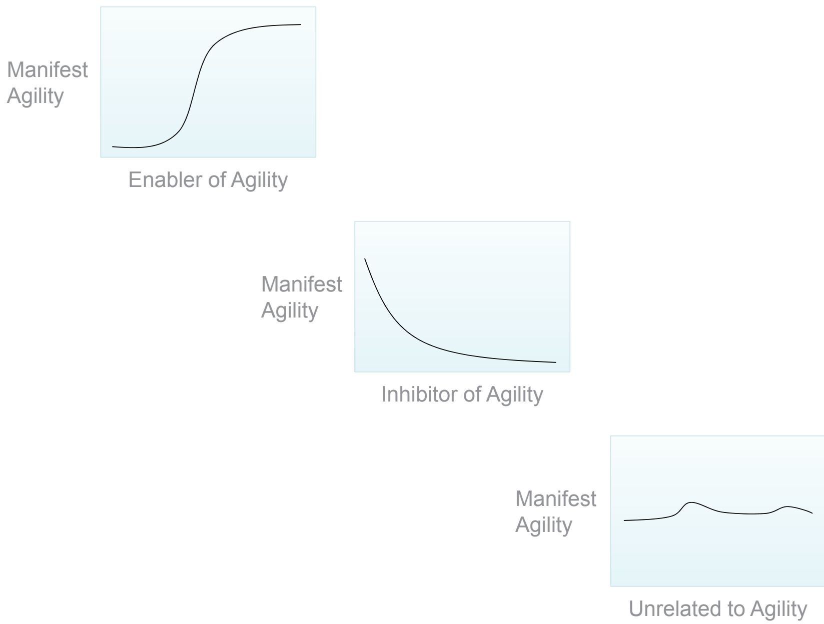

Figure IV-16: Enablers and Inhibitors of Agility

Reality may not be quite this simple. There can, of course, be cases when a variable is, within a certain range, associated with increased agility and outside of this range has a negative impact on agility so that it is sometimes an enabler and sometimes an inhibitor (and perhaps at other times neither). There will also be cases when a variable is an enabler, if and only if some other variable is in a certain value range. Despite these complications, the idea of measuring potential agility by identifying the variables associated with instances of manifest agility, as a result of observation, experimentation, and analysis is conceptually straightforward.

When a sufficient set of markers has been identified, and the relationships between and among these markers and the agility value chain have been determined, the descriptive model of agility becomes a predictive one. Exploratory analyses using a predictive model allows us to develop rules that, if followed, are expected to improve agility.

To reiterate, potential agility, unlike manifest agility cannot be directly observed. Potential agility is about being prepared for unanticipated future events or changes in circumstances. Thus, potential agility must be inferred from a set of markers or agility-related variables that reflect the characteristics of the entity and/or are included in the appropriate process-value model. Three interrelated process-value models will be used to identify a set of markers. The first models the functions associated with command and control, management, and/or governance, and provides output measures associated with these functions that include goal setting, delegation of decision rights (roles and responsibilities), setting rules for interactions and information-related behaviors, and resource allocation. The second is a model of individual decision- or sensemaking. The third is a model of the communications and information systems that support the above functions of management.

This set of process-value models will ultimately enable us to relate the agility of individuals, systems, organizations, and collectives to one another. This will allow us, for example, to see how the agility or lack thereof in individuals impacts the agility of organizations; how a lack of agility in systems impacts the agility of individuals; and how the agility of organizations impact the agility of collectives.

Figure IV-17 is an integrated process-value model that relates the quality of systems, the quality of individual sensemaking and the quality of entity decision-making (command and control, management, or governance) to task accomplishment for individuals and mission accomplishment for the organization or collective.

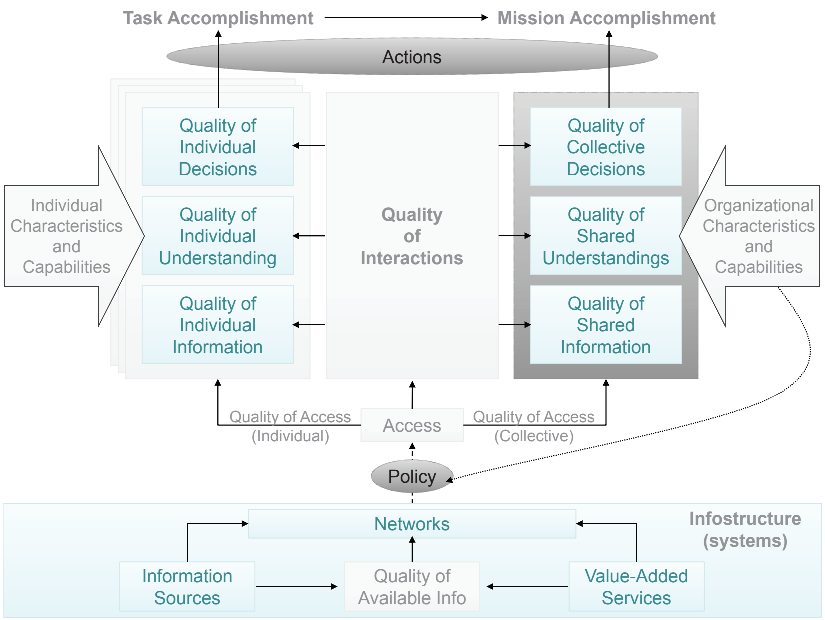

Figure IV-17: Integrated Process-Value Model

It is not by accident that the quality of interactions has been placed in the center of this integrated process-value model. This is because I believe that agility is, in large part, determined by the interactions that are enabled as a result of both investments in infostructure and appropriate policy or approach. Each approach is associated with a set of policies that incentivize and facilitate some interactions while disincentivizing or inhibiting other interactions. The set of interactions translates into processes and behaviors that possess a given agility potential.

Figure IV-17 leaps directly from information to understanding without depicting a number of important intervening steps along the way. This part of the model will be enriched during the discussion of the agility experiments in part V of the book. Figure IV-17 depicts some important interactions between and among the variables depicted. For example, the quality of available information is not only a result of the nature of information sources and value-added services but is also affected by the interactions that take place between and among individuals and organizations. These interactions make it more likely that incorrect or outdated information will be identified and updated or corrected. Readers should note that policy affects the quality of access to the information and services provided by the infostructure. Access is additionally dependent on the condition and performance of the communications networks and the value-added services provided.

This integrated process-value model can be used to identify individual variables or sets of variables that are candidates to be tested to see if they can be used, are positively or negatively associated with agility, and thus, as markers or indicants of potential agility.

Chapter 17

Agility Related Hypotheses

Looking at the conceptual model of agility from its value view identifies the links in the value chain that connects the characteristics and behaviors of entities to measures of mission outcome as a function of circumstances. This allows us to construct an agility map for the entity in question. This value view provides a point of departure in the search for markers of agility. The search for markers involves an exploration of self. Within self, in our case a collective engaged in a complex endeavor, the process view identifies the relationships and interactions that exist between and among individuals, organizations, and infostructure, and suggests that the agility of one entity depends on the agility of other entities.

The statements above about the nature of agility (whether about the links in the value chain or the relationships between and among the agility of entities) are testable hypotheses. To begin with, these hypotheses can be expressed in generic form (without the specification of specific variables to be manipulated or observed). A set of these generic hypotheses are presented below, grouped by whether the independent variable is a characteristic or capability of a system, individual, or organization (group, team, or a collection of organizations).

Generic hypotheses are, in fact, conceptual templates that need to be instantiated in the context of a specific experiment or analysis. As evidence from different experiments and analyses accumulate, these generic hypotheses can be tested and a general theory of agility can be developed. Given the complexities that exist, particularly in the context of collectives in complex endeavors, it will be important to understand not only that a particular hypothesis is supported by the evidence, but under what conditions and circumstances. A number of these generic hypotheses have been instantiated in a set of experiments involving both human participants and agents with a set of context-specific independent variables (the treatments in an experiment) and a set of dependent variables (the measures of value). The results of these experiments will be reported in the next part of this book.

Infostructure (System) Agility

The mission of the infostructure is to collect, process, and provide secure and appropriate access to quality information in a timely manner. The potential agility of the infostructure depends on its characteristics and capabilities. The first two infostructure hypotheses listed below can be used to explore the link between infostructure characteristics and capabilities, infostructure performance, and infostructure effectiveness and efficiency. The agility-related impacts of a variety of infostructure design, implementation, and investment decisions can be ascertained by looking at their immediate consequences in terms of network connectedness and performance. The third hypothesis involves the identification of infostructure-related markers of agility—variables that are links in the value chain that connect infostructure effectiveness/agility to task accomplishment.

Infostructure Hypothesis 1: Network Connectedness Impacts Infostructure Performance

Connectedness is a characteristic of a network and is a property of the links between and among the nodes. As the ratio of links to nodes in a network increases, connectedness increases. A minimum of *n*-1 links is necessary to ensure that each node is connected to every other node either directly or indirectly. Networks in which there is a path between every node and every other node are called *connected*. Less than *n*-1 links means that at least one node is not connected to another node. In this case, the network is called *disconnected*. Thus, networks with less than *n*-1 links must be disconnected. However, simply having n or more links does not mean that a network is connected because some of these additional links may simply create additional paths between and among nodes that are already connected. As the number of links increase,[123] the number of nodes that are directly connected increases.[124] In addition, a connectedness ratio greater than 1 means that, for at least some nodes, there are multiple paths

123. Assuming they are unique links, not simply additional links between two nodes that are already directly connected.
124. Different paths are not necessarily independent—that is, they may share a link in common. In graph theory terms, this is referred to as edge independent.

between them. Therefore, connectedness is related to redundancy and therefore, resilience. Connectedness is also related to average path length—the higher the connectedness, the lower the average path length. This could have an impact on network performance in a number of ways. While this hypothesis may seem obvious or even tautological, except in extreme cases, the impact on agility of increased connectedness may be difficult to quantify and will certainly vary as a function of other individual and organizational characteristics and capabilities and approach. To illustrate the impact of connectedness, a series of experiments were conducted that varied in their connectedness. These are reported on in the next part of the book.

To explore this hypothesis, one needs to specify both a quantitative measure of connectedness and a measure of infostructure performance. There are a number of measures that reflect the degree of connectedness. One measure takes into consideration extra links. This measure is called the *edge cut* and is simply the minimum number of links (called edges in graph theory) that if removed makes a connected network into a disconnected one. Another measure is the maximum number of links that could be removed without the network becoming disconnected (this would be the number in excess of n-1). A third measure, and the one I will use later in the analysis of experimental data, is the ratio of links to nodes. I choose this measure to use because it normalizes the measure of connectedness to the size of the network and also captures the degree to which there are extra links and hence duplicate paths without being complicated.

Infostructures can vary in capability and sophistication and provide a variety of information and communications related services. In addition to providing basic communications connectivity, infostructures may provide a number of value-added services that either enhance the quality of available information or the nature of the interactions between and among individuals or organizations. Various measures of infostructure effectiveness reflect the degree to which these services are provided. In figure IV-17, there is a box labeled *access* that serves as a bridge between the infostructure and the value model whose output is a measure of task accomplishment. Therefore, one measure of infostructure effectiveness that should be developed is the degree to which the information available was in fact available to the individuals and organizations that needed the information. There are a number of factors that can affect this, for example, the degree to which information is discoverable. Given that the quality of available information is both a direct and indirect function[125] of infostructure capabilities, this would also be a useful measure, although some care needs to be taken to identify the reasons for observed changes in this measure. The ability of an infostructure to enforce policy is also an important measure.

125. Direct because it is a function of collection and analysis capabilities. Indirect because it is a function of both access to information and the interactions between and among individuals and organizations.

Infostructure Hypothesis 2: Network Performance Impacts Infostructure Agility

Network performance measures include throughput, latency, delay, and jitter.[126] Throughput is a measure of how much information can transit the network while the other measures are related to the time it may take for a signal to go from one node to another and the variations in the time delays. Network performance can be adversely impacted in a number of ways. For example, if the network is overloaded or is degraded by conditions or has suffered damage, throughput will be reduced and delays increased. Uncertainty regarding the probability of messages getting through will also increase. When there are long messages involved (many packets of data), it is possible that a large variation in the delays (jitter) can result in out of order packets (or even short messages) that can have an impact in its own right. Clearly, network performance is also related to connectedness as a function of the alternate paths available. Given that the performance of a network can vary considerably over time and that its performance is related to task-generated activity, it requires extensive network data collection (instrumentation) and understanding of the tasks that load a network to be able to predict the relationship between performance and task accomplishment.

Having developed measures to quantify network connectedness, network performance, and infostructure effectiveness, all that remains is to identify the ways in

126. For a discussion of network performance and design there are any number of textbooks. One can be found online at Purdue.edu: http://www.cs.purdue.edu/homes/park/cs422-intro-2-06s.pdf.

which circumstances should be varied to ascertain if these changes in circumstances have a significant impact on infostructure effectiveness and hence, by definition, on infostructure agility. Included in the experiments discussed in the next part of this book are experiments that, to illustrate a change in circumstances, varied the amount of noise in the available information (signal to noise ratio). It was found that the relationships between measures of infostructure characteristics and performance and task accomplishment did indeed depend on circumstances.

Among the circumstances of interest is the loss or degradation of a link(s) or node(s) either permanently or temporarily. Infostructures that degrade gracefully and/or can recover quickly from such events clearly are more agile than those that cannot. The loss of links or nodes can be represented by different degrees of connectedness, while the degradation of these can be represented by reduced levels of network performance. Experiments in which links or nodes went down were conducted to illustrate the characteristics necessary to recover from this kind of loss.

Infostructure Hypotheses 3: Infostructure Effectiveness/Agility Affects Shared Information and Information Quality (Individual)

With the exception of the engineers that design and develop infostructures, the performance of these infostructures is not an end unto itself. These infostructures exist to support individuals and organizations in the performance of a variety of tasks. This hypothesis links information effectiveness and agility to a mission value chain based on the network-centric value chain that expresses the tenets of net-centricity. If this link and the other links on the value chain are supported by empirical evidence then we would conclude that shared information and information quality (individual) are markers of agility.

Individual Agility

The tasks taken on by individuals reflect their assigned or self-assigned roles, responsibilities, interests, experience, and expertise, as well as their personalities. Virtually all these tasks involve sensemaking. The first of the generic hypotheses listed below focuses on the link between infostructure effectiveness and agility and individual effectiveness and agility. The second hypothesis focuses on the relationships between and among individual characteristics and cognitive capabilities and their effectiveness and agility. The third hypothesis involves the identification of markers of agility—variables that are links in the value chain that connect individual effectiveness/agility to task accomplishment.

Individual Hypothesis 1: Infostructure Effectiveness and Agility Impacts Individual Effectiveness/Agility

The most obvious measures of individual effectiveness in the context of a set of sensemaking-related tasks are the correctness of the individual's perception, the time required for an individual to develop the correct understanding, and the resources utilized. In some cases, an individual's role and responsibilities will involve more than just reaching a correct conclusion. For example, it may also involve being a team player. Thus, an additional measure of effectiveness, one dealing with the degree to which an individual shares information and interacts in an appropriate manner with others, should be included in agility-related analyses. Otherwise, one may reach the conclusion that an individual is effective when that individual hoards information and/or passes bad or irrelevant information to others.

Individual Hypothesis 2: Individual Characteristics and Cognitive Capabilities Impact Individual Effectiveness/Agility

To explore the relationships between individual characteristics and capabilities and individual effectiveness, variables that represent specific characteristics and circumstances of interest need to be identified. Some of the characteristics and cognitive capabilities of interest include: propensity to share, task versatility, and cognitive bandwidth. To explore individual agility, variables related to key changes in circumstances that promise to have a significant impact on individual performance need to be identified. These include variables related to the nature of the task (task difficulty, time pressure, and task criticality). It is possible that problematic infostructure performance can be compensated for by certain individual characteristics and capabilities or that desirable infostructure performance levels can be negated by some individual propensities and behaviors.

Individual Hypothesis 3: Individual Agility Impacts Quality of Understanding (Individual), Information Quality (Average), and Shared Information

Given that individuals have historically been the component of organizations that have exhibited the agility required to compensate for the shortcomings of formal structures, processes, and other capabilities and/or unanticipated events, it seems clear that individual agility and organizational agility are closely related. Clearly, individuals that can maintain high levels of awareness and develop correct understandings under a range of circumstances (agile individuals) make a significant contribution to individual effectiveness. However, it is probable that individuals who are agile contribute not only by being more effective themselves, but also by making others more effective as well. Therefore, this hypothesis links individual agility not only to the quality of understanding (which should contribute to individual effectiveness) but also to the quality of the information that is available to others and the extent to which this information is shared. Both these measures are key links in the network-centric value chain and have been shown to create the conditions necessary for self-synchronization. If this hypothesis can be supported by analysis and empirical evidence, then we could conclude improved quality of information and a higher degree of shared information are markers of agility.

Organizational (Collective) Agility

The missions taken on by organizations and collectives are often not a matter of choice but a matter of necessity. As is the case with the tasks taken on by individuals, virtually all of these involve individual sensemaking. For organizations and collectives, they also involve shared sensemaking. The first of the generic hypotheses listed below focuses on the link between the approach and policies that can be employed by entities to shape and constrain individual roles, responsibilities, and the interactions permitted on the one hand, and organizational effectiveness and agility on the other hand. The second and third hypotheses focus on the interrelationships between information, individual, and organization agility. These generic hypotheses also address the relationship between organizational and collective agility.

Organization Hypothesis 1: Approach/Policy Impacts Organizational Effectiveness/Agility

The location of the organization within the approach space is a matter of policy, although it may be constrained by infostructure capabilities. Organizational effectiveness can be measured by whether or not the mission or task was accomplished and by how long it took to accomplish the mission. If the mission is accomplished, the efficiency with which the mission was accomplished is also of interest. This can be measured by how many resources were required.

Organizational agility is a reflection of the relative effectiveness of different approaches (set of policies) under different circumstances. Circumstances of interest include: the difficulty of the mission or task and the mix of individual characteristics.

Organization Hypothesis 2: Infostructure Agility Impacts Organizational Effectiveness/Agility

Using the same measures for organizational effectiveness just mentioned, this hypothesis explores the combination of variations in infostructure agility (and hence effectiveness) and approach. To determine the sensitivity of combinations of approach and infostructure agility, both should be varied.

Organization Hypothesis 3: Individual Agility Impacts Organizational Effectiveness/Agility

This hypothesis explores the mix of individuals with different levels of agility.

Entity Relationships

Organizations and collectives are composed of a set of entities (individuals, teams, and systems), each of which has a set of characteristics and behaviors that determine its potential and manifest agility. However, the agility of an entity or set of entities (e.g., an individual or a set of individuals) can enhance or constrain the agility of other entities. It is important to understand these interdependencies. The following generic hypotheses address some of these relationships.

Relationship Hypothesis 1: Individual Agility Can Compensate for a Lack of Organizational Agility

Organizational agility is directly related to the organization approach that has been adopted and the policies and processes being employed. The organization approach selected determines how decision rights are allocated, what interactions are prescribed or permitted, and how information is distributed. These serve to constrain the actions of individuals and teams in organizations and organizations in a collective. However, depending on a number of factors, entities have some degree of discretion that they can use to find a way to get things done. For example, an individual could decide to do a job not assigned or assigned to someone else if necessary, share information with someone who is not on the normal distribution list, try a nonstandard approach, or consult the informal organization. At times, these actions may not be explicitly sanctioned or even explicitly prohibited. In these cases, individuals may risk punishment to get the job done. There is an old Navy saying that *it is better to beg forgiveness than to ask permission*. These behaviors are manifestations of initiative (innovativeness) and without them many organizations would suffer immeasurably. Thus, the willingness of entities to take initiative when necessary could make up for the lack of agility associated with specific organizations' approaches.

Relationship Hypothesis 2: Individual, Organization, Collective Agility Can Compensate for a Lack of Infostructure Agility

A lack of infostructure agility translates into degraded performance under some circumstances and conditions. This generic hypothesis focuses on whether, and under what circumstances, the agility of individuals, organizations, and collectives can compensate for the degraded performance of the infostructure. This generic hypothesis can be instantiated by a set of treatments where one or more of the entities possess one or more of the components of agility (e.g., flexibility). There are numerous possibilities to explore. For example, if a particular mode of communications goes down, interrupting the flow of information between a given pair of entities, one or more of the affected entities could compensate by taking one or more of the following actions:

- Revise the objectives of their assignment;
- Temporize (delay);
- Choose another course of action;
- Change their decision/decision process to account for increased uncertainty;
- Find a workaround or alternate mode of communication; and
- Change their organization/approach.

Relationship Hypothesis 3: The Agility of One or More Entities in a Collective Can Compensate for a Lack of Agility in Other Participants

The maturity of an entity's approach to collective action is a function of how much of the approach space is available to the entity. That is, how many different ways can an entity organize, work with, and interact with, others. The ability of a collective to effectively function is directly related to the combination of approaches adopted by participating entities. Some combinations of organization approaches can lead to dysfunctionalities (an inability to connect the dots or develop shared awareness and shared understanding); while other combinations simply constrain effectiveness or efficiency (serve to constrain the pace of operations), and others get the most out of the capabilities possessed by participating entities (enable synergies).

Given that complex endeavors are both dynamic and complex, the effectiveness/efficiency of each of these combinations may change as the situation changes. This could make what was an acceptable combination at time t unacceptable at time $t + \Delta t$. This then requires that one or more entities switch organization-approach options to create an acceptable effective-efficient combination in current circumstances and conditions.

Chapter 18

Measuring Agility

Concepts are not operationally defined until the definition(s) provide for observation and measurement. Without measurement, it is impossible to ascertain progress or improvement. However, experience has shown that one must take great care in the development and application of appropriate measures to avoid potential counterproductive behaviors and undesirable outcomes. However, to simply avoid measuring the capabilities we wish to achieve, the effectiveness and efficiency of the processes we design, the potential and actual contributions of the products we produce, and the capabilities of individuals and organizations is a prescription for failure.

In my efforts to facilitate and encourage appropriate measurement in a variety of organizational settings, I have observed far less resistance in cases where the measures were well established and the object of measurement was not an individual or an organization. For example, military organizations all have a tradition of *readiness* reports—reports in which an assessment of a platform or unit is made, usually in accordance with well-defined criteria.

However, there is always the problem of *gaming the system*, which can produce some very pernicious effects. One such case of counterproductive gaming involved the readiness of Navy ships. In this case, the level of readiness was related to parts on order. If one or more parts were on expedited order, then it was assumed that the ship was not ready. This conclusion was based upon the assumption that if you needed a part urgently it must be critical to operations. Fearing that having an unready ship would be held against them, the ship's captain made it a practice not ask for expedited parts. As a result the average readiness scores received hovered around 90 percent. Aware of this gaming behavior, their admiral decided to find out how ready his ships really were and ordered them to participate in an exercise. Far less than 90 percent were able to do so. The admiral, believing that it was important to have an reliable indicant of readiness (it would not be good to count on ships that in fact were not mission capable in planning an operation), changed the behavior of ship captains not by changing the metric or how its value was determined but simply by saying that if a ship was reported as ready and if it could not perform an assignment when ordered to, the ship captain would be fired (thus effectively ending his career). Almost instantly the average readiness dropped to about 80 percent. Knowing what real readiness is has a number of benefits. These include not only more feasible operational planning but also the benefit of providing a foundation upon which plans for improving readiness can be formulated and their progress measured.

Measuring agility is as important, if not more important, than measuring readiness. A measure of agility incorporates into a coherent assessment the performance, effectiveness, and efficiency of a system, piece of equipment, process, organization, or individual. Performance, effectiveness, and efficiency are all measures of merit, but they differ in important ways. Measures of performance are absolute measures that are relevant to the accomplishment of the task at hand. The actual value of a performance measure is independent of the requirements of situation. Thus, a given level of performance can be compared to a level of performance achieved by an entity with different characteristics or by the same entity under a different set of conditions, but it is not a measure of success.

Success requires that we compare the measure of performance to the levels required. Making this comparison between required and achieved provides us with measures of effectiveness that are designed to reflect the degree of successful accomplishment of the task at hand. While performance measures are independent of context and provide an objective measure of accomplishment, effectiveness measures are contextual and subjective. Effectiveness measures thus reflect fitness for use. They are subjective because they reflect a level of satisfaction as seen by a particular entity. Thus, if a measure of performance provides an answer to the question, “How well did a system, individual, or organization behave?” then a measure of effectiveness is a response to questions like, "What difference did it make (in terms of accomplishing the task)?" or, "Was the task accomplished (at a given level of satisfaction)?" The same level of performance may be more than adequate for some tasks and less than satisfactory for others. Effectiveness is viewed from an entity's perspective and reflects an entity's perceptions and values.

Efficiency measures are about the return on investment and the resources it takes to attain a given level of performance or effectiveness.

The measures that are appropriate to use depend on the nature of the problem. To illustrate the differences among these different types of measures of merit and when they are appropriate, let us begin by considering the relatively simple problem of assessing two designs for a given sensor.

Sensors provide information, in this example, information about the location and speed of an object at a given point in time. Assessing the relative performance of two sensor designs involves comparing a set of measures of sensor performance, including the degree of accuracy associated with the location of an object reported. For the sake of this example, let us say that the first sensor can provide the position of a particular object within 25 feet, while the second sensor can provide the position within 50 feet. Clearly, in this case, the first sensor performs better than the second sensor.

If the problem were simply to select the sensor design with the best location performance, then one could skip to a consideration of how these sensors performed given different types of objects (e.g., small vs. large or slow vs. fast) and different environmental conditions (e.g., clouds, rain, and temperature). The performance of these sensor designs could then be compared under different conditions. If both sensors maintain their performance for a set of different types of objects and different environmental conditions deemed relevant or if their relative performance was maintained across the set of objects and conditions, then an assessment of overall location performance would be straightforward. The first sensor would be said to perform better. If, however, the relative performance of the sensors changed with the nature of the object or with environmental conditions, then the assessment becomes more challenging. We will discuss this situation later when we discuss the results of experiments with different approaches in the context of different mission challenges and circumstances. Note that throughout this analysis we are working with absolute measures of performance that map linearity to utility.[127] This is not always the case.

The design and development of sensor systems and the analysis of related investments require that sensor performance be put into an operational context. The additional question, "What level of sensor location performance is

127. Utility is inherently a subjective judgment that may not be a linear function of a measure of performance. In the case where a certain threshold needs to be reached for a task to be accomplished, performance values lower than the threshold do not have any value and at some point more performance does not result in more value.

good enough?" also needs to be addressed. Of course, the answer to this question depends on what the location information is going to be used for. It may be that both of these sensors are up to the task at hand (provide comparable utility) or the performance of both may not be satisfactory (they do not meet the minimum threshold) or that only the first sensor performs adequately.

This is a form of the so what question. In fact, there may be a series of so what questions that form a value chain that ultimately leads to a measure of task effectiveness. Sensors are components of information or command and control systems, and as such, enable the performance of the functions we associated with management or command and control. But, neither the sensors, the information provided, nor the C2 systems they are a part of are ends unto themselves. Their value is directly related to their ability to contribute to endeavor success…and this depends on the situation. Thus, the ability to successfully cope is situation dependent. This dependence is going to present us with some difficulties we will need to overcome when we try to measure agility.

Getting back to our example, the position information provided by the sensor could be used to accomplish a number of different tasks. In fact, the same information could be used by different individuals and organizations for different purposes at the same time.[128] The task at hand could be to intercept a moving object, simply to

128. This is part of the logic that leads to the power-to-the-edge approach to information dissemination—post before process, or as some would say, post in parallel. See *Power to the Edge*, p. 82 (http://www.dodccrp.org/files/Alberts_Power.pdf).

see if the object is on a collision course with the earth or another object, or any of a long list of possibilities. In these cases, several time-stamped reports of the object's position would need to be combined to track the object and predict the location of the object at a given point in time. The accuracy of this prediction (within *x* feet with probability *p*) is also a measure of performance—not of sensor performance but the performance of the *prediction system*. Whether the prediction system is performing well enough depends on whether an intercept is desired or simply a heads-up on a possible collision. In each case, a decision will need to be made and action taken or not taken. Thus, the prediction system supports decision-making and subsequent action. This chain of performance measures (sensor, prediction system, and decision-making system) ultimately lead to a measure of effectiveness. However, the appropriate measure of effectiveness will depend on the task or mission to be accomplished.

Each link in this value chain determines whether or not an entity has *successfully coped* as evaluated from the perspective of the next link in the chain. The sensor is evaluated by its contribution to the prediction system, and the prediction system is evaluated based on its contribution to decision-making. Each successive link introduces new entities and variables into the analysis. For example, the quality of decision-making depends not only on the quality of information available but also on the manner in which this information is distributed and on the skills, knowledge, and experience of those empowered to make decisions. Experts may be able to perform acceptably with less accurate and less timely information than non-experts who may require more accurate information and more time to perform acceptably.

As stated earlier, resources are never unlimited and thus they need to be allocated among competing needs. Time is one of the most limited of resources and in many cases a response to a change in the environment needs to be taken within a certain window of opportunity. Actions taken outside this window may have greatly reduced value, no value, or actually have negative value. Thus, a more efficient system, process, or organization will not only generate more value directly, but also indirectly, by leaving more time for other related activities. Efficiency is a measure of the resources required to perform at a given level or attain a given degree of effectiveness. Efficiency can ultimately translate into more effectiveness for a fixed level of resources. For a system, one measure of efficiency is its throughput (the ability to handle workload). For a person, one measure of efficiency is the time it takes to reach a decision. For an organization, one measure of efficiency is the time it takes to act once a decision has been made.

Determining whether or not an entity can successfully cope in a given circumstance is a three-step process. The first step involves determining what the appropriate measures of performance, effectiveness, and efficiency are. The second step is to ascertain what the values for these variables are. The third step is to determine whether or not these values translate into success. Having determined whether or not an entity can cope or has, in fact, successfully coped with a given circumstance, it is then necessary to determine how the entity will cope with changes in these circumstances.

Part IV Review–Part V Preview

In this part of the book we have finished our theoretical preparations and are now ready for the empirical part of our journey. These preparations included a definition of agility, a set of agility-related metrics, a conceptual framework that includes both a process model that can yield measures of manifest agility, and a causal model of potential agility that predicts what manifest agility will be under a given set of circumstances. In addition, components of agility have been identified and will guide us in our search for indicants or markers of agility—both enablers and impediments. Finally, a set of agility-related hypotheses have been offered. In the next part of this book, I shall report the results of a campaign of experiments designed to see if 1) the definition of agility can be *operationalized* (observed and measured), and 2) to test a number of the hypotheses offered.

Part V

Agility Experiments and Analysis

Part V

Agility Experiments and Analysis

In this part of the book, I shall report on and analyze, from an agility perspective, a collection of experiments that were conducted in a number of different countries, some with human participants, others using agents in a simulated environment. The first set of human experiments was originally designed to explore the relative effectiveness and efficiency of the two corners of the C2 approach space (the hierarchy at the low front left and the edge at the upper back). These results provided a solid point of departure for a series of human experiments that explores a number of different organization-approach options (regions of the approach space), as well as a series of agent-based experiments specifically designed to explore the agility of different organization-approach options.

My first objective is to provide readers with the results of these experiments, and the findings and conclusions of an agility-related analysis based on the experimental results to improve our understanding of the relative agility of different archetypical organization-approach options. For the most part, the experiments reported on in this book focus on two of the organizational hypotheses posited in part IV. The first of these hypotheses asserted that organizational performance (effectiveness and efficiency) and agility were a function of approach and policy, while the second of these hypotheses asserted that organizational performance and agility were a function of the performance and agility of the infostructure. My second objective is to provide readers who are interested in pursuing their interest in agility, whether by considering changes to their organizations, exercising agility-related capabilities, or performing agility-related research and analysis, with a template and a set of tools that can be adapted to explore agility in a variety of entities and circumstances.

The first part of the conceptual and analytic template was introduced in part IV (figure IV-15). This figure depicts models of manifest agility and potential agility, and the relationships between these two models. In this, part V, I will provide, and illustrate with the results of a campaign of agility-related experiments, an approach to experimental design, several ways to visualize the results of agility-related experiments, in the form of agility maps and impact graphs, and I will introduce two agility metrics and apply them to the data created by these experiments.

The first step in any effort to understand and explore agility is the establishment of a baseline, that is, a measure of mission or task success (effectiveness and efficiency) under normal or baseline circumstances and conditions. This is accomplished here by reporting on the results of a set of matched ELICIT experiments in which participants were placed in either a hierarchy or an edge and asked to find the correct solution to a problem.

The next step is to consider mission or task performance, under a variety of circumstances and conditions. This involves constructing a multidimensional endeavor space. Since the possible variations in circumstances are virtually infinite, agility-related analyses that rely on observing or estimating entity performance in different parts of endeavor space can only focus on a small subset of possible circumstances. Defining the endeavor space (the dimensions of endeavor space and the ranges of the variables involved) to be employed is a critical analytic task, and one that ultimately determines the success of the analysis. Ultimately, there is no guarantee that this task will be done appropriately and therefore, we will need to complement this analytic approach with one that takes a different approach (presented in part V of this book).

Chapter 19
Experimental Campaign Framework

The framework of the campaign of experiments undertaken for this exploration of agility consists of: 1) a scoping of the endeavor space, the set of circumstances deemed relevant, 2) a model that defines the variables of interest (including the *treatments* and measures of merit), and 3) an experimental environment.

The Endeavor Space

The endeavor space defined for the campaign of experimentation conducted for this book has five dimensions. These dimensions and the ranges of the variables involved are:

- Nature of the Mission Challenge
    - Four mission challenges (from industrial age to complex endeavor)

- Mission Requirements
  - Three levels of required shared awareness (low, medium, and high)
  - Three levels of required timeliness (low, medium, and high)
- Level of Noise in Available Information
  - Three signal to noise ratios (no noise 1:0, normal noise 1:1, and twice the noise 1:2)
- Problem Difficulty
  - Three levels of cognitive complexity (low, medium, and high)
- Infostructure Characteristics and Performance
  - Three levels of network damage (none, 1 link down, and 2 links down)

This five-dimensional endeavor space has 972 distinct circumstances (combination of mission/requirements/conditions). The ability of an organization-approach option[129] to maintain its effectiveness/efficiency in the face of these variations in circumstances and conditions provides us with some insights into the components of

129. A number of different organization-approach options were considered in these experiments. These are described later in this part of the book. For each of these options, different information-sharing policies were considered.

agility and the factors that enable or inhibit these components. For example, the ability or inability to successfully deal with different types of mission challenges is a result of the degree to which an entity possesses the component versatility. The ability to continue to be effective/efficient in light of damage to the network demonstrates the component of agility called resilience. The components of agility called flexibility and adaptability are related to the ability of an entity to dynamically change information-sharing behaviors as a function of the condition of the network. To be perfectly agile, an entity would need to be successful in all of these 972 distinct circumstances.[130]

In order for readers to be able to judge for themselves the significance of the experimental findings reported on here, some basic information about the nature of the experiments that were conducted is needed. This section addresses the capabilities of the experimental laboratory, the methodology used to explore and compare the agility of different organization-approach options, and the specific measures employed.

ELICIT: The Experimental Laboratory

The series of agent-based experiments designed and conducted for this book is based on and extends a series of human experiments that have been conducted using ELICIT. ELICIT stands for the Experimental Laboratory for Investigating Collaboration, Information-sharing, and Trust. This CCRP-sponsored environment has been used extensively by a number of researchers and institutions in

130. This is a simplified view of a measure of agility that will be discussed in greater detail later in chapter 28.

the United States and abroad, including Portugal, Chile, Singapore, and the United Kingdom. There is a growing body of ELICIT-based literature and empirical data. Interested readers should begin by exploring ELICIT-based research papers and the ELICIT Community of Interest webpage at www.dodccrp.org.

ELICIT[131] is an instrumented environment in which humans or agents try to discover the who, what, where, and when of a planned terrorist attack. In the context of these experiments, *mission accomplishment* equals the development of shared (correct) understanding among a set of participants. A correct understanding requires the accomplishment of a set of four interrelated tasks with each task involving the correct identification of one aspect of the attack (e.g., who) within a specified time period. Individuals and organizations may be assigned the entire problem (the mission) or one or more of the aspects of the problem (a task or set of tasks). Furthermore, they may be assigned priorities (e.g., first find the *who*, next find the *what*). These individuals can be assigned a variety of roles. Also configurable in these experiments are communications connectivity, network performance, and information accesses. In human experiments, participants can be conditioned by instructions and/or incentives. In agent experiments, the personalities and cognitive capabilities of individual agents are configurable.

Because experiments such as these with human participants are time consuming and relatively expensive to arrange and conduct, the CCRP sponsored the

131. The ELICIT environment was first introduced to the research community in 2006.

development of agent software that could take the place of one or more human participants. These software agents were designed to be able to represent a number of behavioral and cognitive capabilities. When all the participants are agents, the ELICIT experiments (runs or trials) can be accomplished in compressed time. The all-agent capability is called abELICIT. abELICIT facilitates the systematic exploration of sensitivities to a range of values for selected variables that represent not only assigned roles and responsibilities but also individual characteristics and capabilities.[132]

A major focus of ELICIT-based experimentation has been to explore the effectiveness of various approaches to command and control and organizational archetypes. Given that no single approach is most effective under all circumstances, these experiments and related analyses have begun to explore the region of the approach space that is most effective under different circumstances, as well as the relative agility of these various approaches.

Methodology

Since agility is the capability to maintain acceptable levels of effectiveness and efficiency over a range of conditions and circumstances, exploring the agility of an individual, system, organization, or collective requires that an entity's effectiveness and efficiency be observed under a range of conditions. This requires the ability to conduct a large number of experiments varying one and only one variable at a time. Agent-based simulations are

132. More information about abELICIT, the agent-based version of ELICIT, can be found at http://www.dodccrp.org/html4/elicit.html.

a cost-effective approach to conducting the large number of experiments needed if they can be shown to produce valid results.

The first step in our experimental exploration of agility was to validate the behavior of the agents that would be used. There are a number of approaches to validation. These include construct validity, face validity, and empirical validity—with empirical validity being the most rigorous approach. The initial agent design, programming, and testing involved efforts at construct and face validity. As part of this phase of the validity-testing effort, a number of organization archetypes were developed to see if agent behaviors were consistent with those that were specified and expected in each of these archetypes. These archetypes included: industrial age hierarchy, information age hierarchy, industrial age hierarchy with coordination, information age hierarchy with coordination, and an edge organization. Initial runs turned up a number of coding errors and indicated that some rethinking about parameters and their settings were required.

Having been satisfied that the agents were performing as expected, attention was focused on the next phase of the validation effort, that of establishing empirical validity. The human first approach taken by DoD's CCRP ELICIT initiative provided the empirical data needed to tune agents and compare their behaviors to that of a large number of human participants.

Having been satisfied that the agents displayed reasonable humanlike behaviors, the next step was to provide a point of departure or baseline for the exploration of the relative agility of various approaches to C2, organization, management, and governance. A target of opportunity was to instantiate a set of approaches to collective action defined by NATO Research Group SAS-065 that were thought to possess different degrees of agility. These approaches included: conflicted, de-conflicted, coordinated, collaborative, and edge. Fortunately, these approaches had been instantiated in a series of ELICIT experiments with human participants that could be used as a basis of comparison.

A set of abELICIT runs for each of the organizational archetypes and approaches to collective action created the baseline necessary for the exploration of the relative agility of these organization/approach options. Each of these runs produced observable measures of effectiveness and efficiency that could be compared to the results of later runs in which a selected characteristic or condition was varied.

By comparing these baseline results to other runs in which selected variables take on a range of values, it is possible to measure manifest agility and gain insights into developing indicants of potential agility. My exploration of manifest agility involved comparing measures of effectiveness and efficiency over ranges of conditions (e.g., problem difficulty). This set of experiments also generated data that was analyzed in an effort to identify indicants of potential agility.

Measuring Manifest Agility

The ability to measure both effectiveness and efficiency is essential to determine the agility that an entity manifests. The ELICIT and abELICIT findings presented in this book utilize a set of measures that relate to: 1) the accomplishment of assigned tasks (aspect(s) of the problem) and the accomplishment of the organizational or collective mission (the solution to the whole problem), and 2) a set of measures related to the links in the value-chain that link network characteristics and performance to the quality of shared understanding.

The following effectiveness and efficiency measures were developed[133] for and used here as a basis for determining the relative agility of individuals and organizations.

133. ELICIT experiments have been conducted with a variety of measures for several years. When it came time to write this section of the book, it became clear that these measures did not provide all the information that I desired to explore agility and that even the individuals involved in these analyses had different perceptions of the concepts (e.g., correctness) This, in large part, was due to the fact that many abELICIT runs were made to validate the agent software—not to systematically explore hypotheses. In July 2010, I sought an agreement on the set of measures presented in this section and insisted that these be used in projects funded by the CCRP to promote clarity and consistency (although researchers were free to use additional measures that they felt were appropriate).

For an individual:

- Quality of Individual Understanding (Correctness). The identification score at the end of the trial, where if the individual correctly identifies the who, what, where, and when of the attack the score = 1; otherwise the score is 0.

- Time Efficiency of Individual Sensemaking (Timeliness). The time required for a correct solution relative to the window of opportunity. Timeliness is calculated as a function of the time period. Timeliness scores range from 0 to 1, where if the individual does not correctly identify within the period available, timeliness = 0; if the individual correctly identifies, the timeliness = (1 – t_{id}) / t_{trial}, where t_{id} is the time that the individual first correctly identifies and t_{trial} is the total time available in the experiment or trial. The above assumes that the individual does not subsequently re-identify incorrectly. In cases where individuals identify multiple times and misidentify after they first correctly identify, t_{id} is determined in the following manner. First, all repeated identifies are disregarded (e.g., the identification sequence I C C I I C C becomes I C I C because I C ∈ I Ɨ C ∈). If their last identification is correct, then t_{id} = the time of the last C.

- Reserve (Opportunity). The available time remaining after the individual first correctly identifies. To normalize runs with different time periods, reserve is calculated as a function of the time period and ranges from 0 to 1, where if the individual does not correctly identify the score within the period available reserve = 0, and if the individual correctly identifies, the reserve = $(1 - t_{id}) / t_{trial}$. For individuals that misidentify after their first correct identify, the adjustment is the same as for speed. For individuals speed = reserve.

- Process Efficiency of Individual Sensemaking. The amount of effort expended to reach a correct solution, where the efficiency score = 1/(number of actions taken/correctness score) if the individual has a correctness score of 1 and = 0, otherwise. In these experiments the actions that are counted include the interactions with other individuals or Internet sites and identifications.

Figure V-1 presents a graphic representation of these individual measures and the interpretation of the end points on each scale.

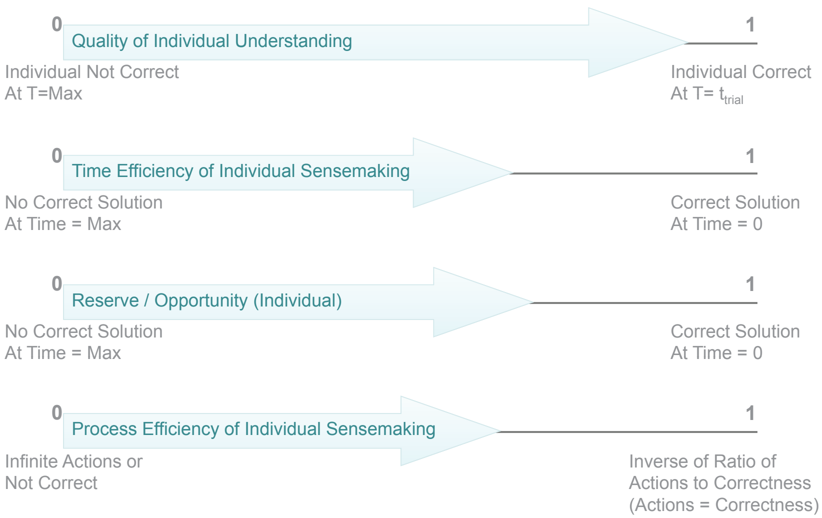

Figure V-1: Individual Measures of Effectiveness and Efficiency

The mission of the organization or collective is to solve the entire problem. A measure of correctness must reflect this fact.

The following measures of effectiveness and efficiency were developed and used for organizations and collectives:

- Quality of Shared Understandings (Average Correctness).
  - Mean of individual correctness scores.
- Time Efficiency of Collective Sensemaking (Maximum Timeliness).

   - The time to first correct and complete identification by any participant relative to the time available. This metric uses the same approach to multiple identifies as timeliness (individual).

- Average Reserve/Opportunity.
   - Mean of individual reserve/opportunity scores.

- Average Process Efficiency of Collective Sensemaking.
   - Mean of individual efficiency scores.

Maximum timeliness is determined by the earliest correct identify, the time that at least one individual has the correct solution. Translating this event into an action scenario will require a better understanding of the processes associated with each specific organization/collective.

Figure V-2 presents a graphic representation of these effectiveness and efficiency measures as they apply to group, organization, and a collective, and the interpretation of the end points on each scale.

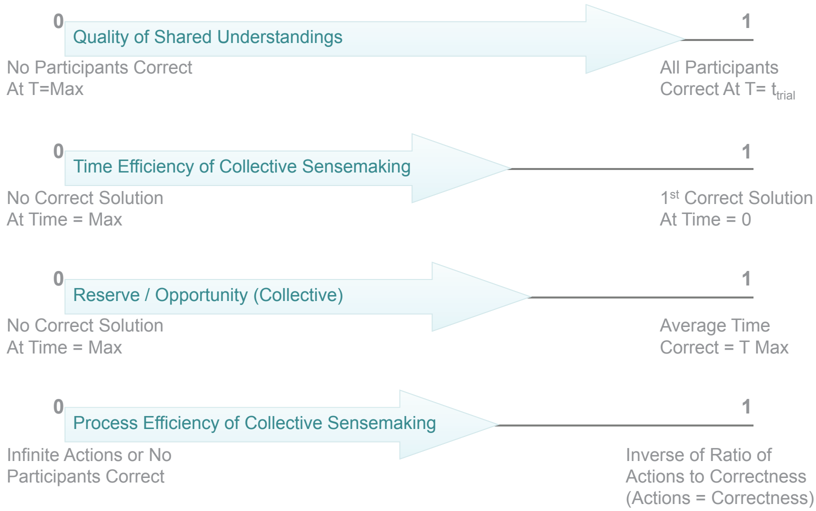

Figure V-2: Group / Organization / Collective Measures of Effectiveness and Efficiency

In these experiments, as in real world organizations and situations, individuals have been given or have chosen to tackle the complete problem (who, what, when, where). If an individual is a member of a group or organization, the individual may have been given a less ambitious assignment, may have decided to specialize on a part of the total problem (mission), or, in the case when self-synchronization occurs, may make a choice depending on what information the individual has and what the individual knows or perceives others are doing. In such cases, a task performance measure would be appropriate to see how well the individual (or set of individuals) performs with respect to the task(s) taken or assigned. Task performance is thus, a function of the focus of an individual. The value of an individual's task performance measure would be 1 if the tasks taken on are fulfilled and 0 otherwise.

Average task performance would be the corresponding collective measure. When used in the context of groups and organizations with differing approaches to the allocation of decision rights, average task performance may present interpretation challenges. In some organizations and approach options it is not only important for individuals to get the correct answer, it also matters that selected individuals get the correct answer. If, for example, only one person gets the correct answer (all parts correct and all tasks accomplished), is it the same if this person is the overall leader or a member of one of the teams? Therefore, in order to get a complete picture of the functioning of an organization or collective, average task performance should be calculated by role. For example, average task performance (team leaders) would be a reflection of how well the set of team leaders performed, while average task performance (overall leader) would, assuming that the overall leader's assignment was to solve the complete problem, be a measure of whether or not the hierarchy ultimately functioned as intended.

Given the large number of ways roles and responsibilities can be assigned, readers should note that task performance is not a mission-effectiveness measure and the relationship between average task performance and effectiveness (average correctness) is not a simple one. This relationship depends on how responsibilities and decision rights are allocated (assigned or self-selected). It is quite possible to have everyone accomplish their assigned tasks and for the organization or collective to still not accomplish the mission. In fact, the relationship between average task performance and average correctness will tell us quite a bit about an organization or collective.

Since individuals may take on or be assigned more or less ambitious tasks (e.g., to tackle only one area vs. tackling two areas), the interpretation of these results needs to be approached with some care. To solve this problem, another measure, one that gives partial credit for partial results is needed. In the case of a four-part problem (assuming that the parts are equally difficult and significant), that would amount to assigning a value of .25 for each area or part solved. This partial credit approach provides a measure of progress, something that is in widespread use in the application of PERT[134] to project management. Average progress should, as is the case with average task performance, also be measured as a function of role or assignment.

While at this point we have quite of few metrics to use to help us understand the performance and effectiveness of individuals, organizations, and collectives, there are two more metrics that are needed to assess how well individuals and organizations are performing. In the experiments that will be discussed below, the solutions that individuals offer may not be correct. Not being correct

134. PERT (program evaluation and review technique) is a tool used to manage large and complicated projects that identifies the tasks required, their interdependencies, the resources available, the assignment of resources to tasks, and progress made (task accomplishment) vs. resources utilized. It can, if used properly, provide an early warning of possible problems.

is not the same as being incorrect. That is, the lack of an identify action in these experiments can reasonably be interpreted to mean that the individual did not have sufficient information to feel certain enough of the solution to identify. Different individuals have different thresholds or confidence levels. Some are more prone to guess while others want to be sure of themselves. However, even the most confident individuals can be wrong. They may be wrong for any number of reasons, including misperceptions, miscalculations, faulty logic, or misinformation. To put correctness into perspective, a measure is needed that reflects the frequency (and timing) of incorrect answers. Let us call this measure, *error rate* and calculate it by taking the number of mistakes in identification made and dividing it by the number of identifications that are made. Since individuals can make more than one identify, the error rate may change over time. The error rate at any point in time represents the most recent identification made by the individual.

Individuals can also identify solutions in areas that they are not assigned. A measure of this behavior, *initiative rate*, can be calculated in this series of experiments by looking at the number of areas for which an individual provides a solution (whether or not correct) divided by the number of areas assigned. Initiative may, in certain situations, have a positive impact (increasing average correctness) or it may have an adverse impact (increasing average error rate). In some cases it may increase both. These metrics provide practitioners and analysts with insight as to how well individuals, organizations, and collectives are performing, as well as providing information for forensic analysis that may permit us to understand not only what happened, but also why it happened.

Comparing Disparate Organizations and Collectives

The above measures of individual and organization (collective) effectiveness and efficiency provide the basic tools necessary to measure and compare their relative agility. When comparing organizations and collectives that employ different approaches, it is important to distinguish between an organization functioning as intended and mission success. The former is a reflection of looking at progress and task performance, while the latter involves looking at mission performance—in this case, their correctness scores. Scoring an organization on performance alone measures the input to a value proposition, not the outcome.

In addition to using these summary statistics, it will be useful, at times, to look at some of these measures over time. For example, a graph of average correctness over time for an organization shows the extent to which the correct solution is proliferating across the organization, that is, whether or not increasing numbers of individuals are coming to the correct solution over time. Given that the mission at hand was defined as a correct understanding of the situation, average correctness in this instance is a measure of shared understanding.[135] When average correctness increases, clearly more individuals have the correct understanding of the situation. However, one also needs to factor in the average error rate when making an assessment of effectiveness. Clearly, it will depend on how an incorrect understanding (misunderstanding) ultimately affects the actions taken and the results of these actions. In some cases, individuals with incorrect understandings may, in addition to simply wasting resources pursuing unneeded actions, detract from the overall effort by getting in the way.

135. The metric quality of understanding is defined in terms of correctness, completeness, relevance, and timeliness. Shared understanding inherits these measures. As a result it makes no sense or is at best confusing to say that shared understanding is high when many members of a group share the same misperception. In such cases it would make more sense to refer to this situation as *shared ignorance*.

Chapter 20

Establishing a Baseline

Since agility is a relative measure, a baseline needs to be established before we can proceed. This baseline is critical since the agility demonstrated by an entity depends on a comparison between performance under normal circumstances (the baseline) and performance under changed circumstances.

Several years of ELICIT experiments with human participants have provided us with the empirical results we need to establish a baseline of performance for both an information age hierarchy and an edge organization option. These human participant runs were used in a series of analyses comparing the behaviors and performance levels associated with edge and hierarchical approaches, and to validate and tune behaviors of the abELICIT software agents.

Since we are interested in exploring a wide range of organization-approach options and since experiments with human participants are fairly time-consuming and expensive, the baseline for other organization-approach options was established using an agent-based simulation built on the ELICIT platform. After the presentation of the baseline results for the hierarchy and edge options, the results for these other options are provided.

A graphical depiction of each of the information age hierarchy and the edge organization-approach options, along with a brief description, is provided below. This is followed by a comparison of the observed values of effectiveness and efficiency measures.

Information Age Hierarchy

The organizational archetype information age hierarchy, hereafter referred to simply as *hierarchy*, consists of four teams, each of which is assigned a different area of interest (e.g., who). Each team has three members and a team leader. In addition there is an overall leader. Each team has a website that may be accessed by team members and the team leader. Team members may share with others on the same team and the team leader. Team leaders may share with the overall leader. The overall leader is assigned all areas of interest and may share with team leaders. The overall leader also has access to all the team websites.

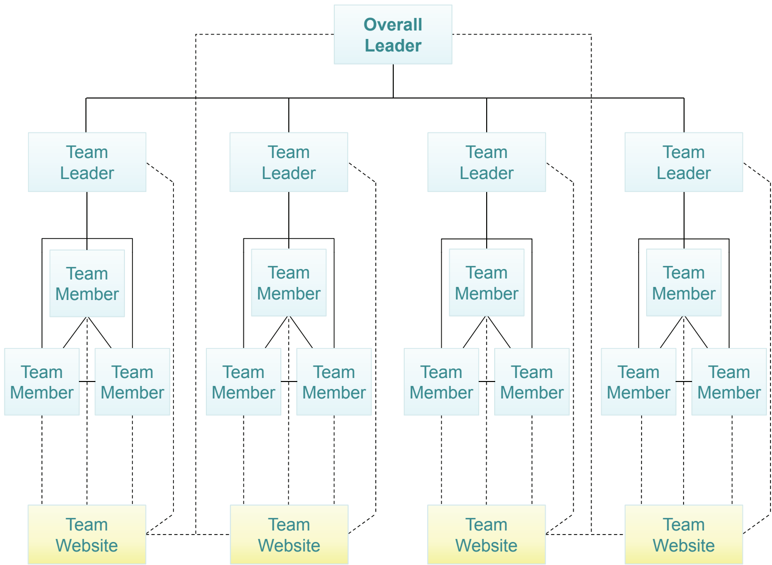

Figure V-3: Hierarchy

Edge

The edge consists of 17 individuals and four area websites. Individuals are not assigned specific areas of interest. They may share with all other individuals, and they have access to all the websites.

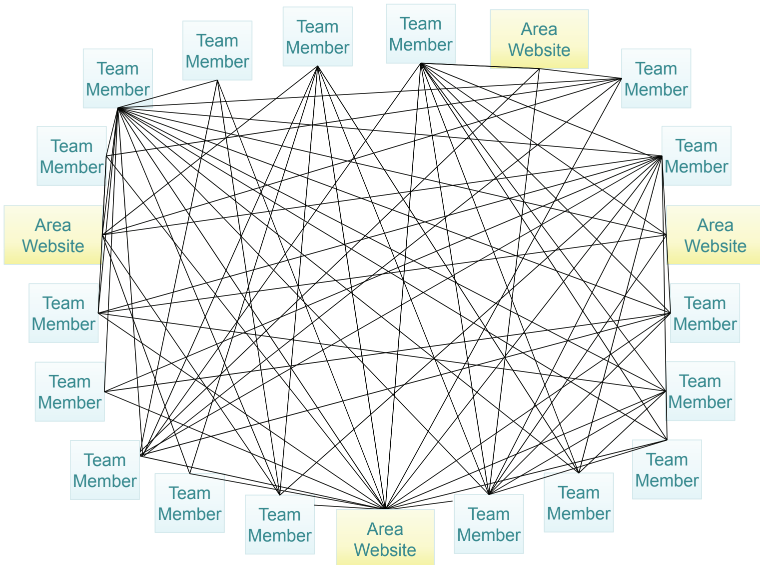

Figure V-4: Edge

Hierarchy vs. Edge: Baseline Effectiveness and Efficiency

Figure V-5 consolidates the results from 14 comparable experimental trials in Canada, Chile, Portugal, the United Kingdom, and the United States.[136] The results were consistent across a wide set of participants.

136. The experiments included in this analysis were conducted by and at the following institutions: U.S. Naval Postgraduate School, U.S. Military Academy, Portuguese Military Academy, Boston University, Defence Research and Development Canada (DRDC), Military Polytechnic Academy (Army of Chile), and Cranfield University (UK). The consolidated results were taken, in part, from analysis conducted by McEver and Wynn, and, in part, from additional analysis of the transaction logs undertaken at the author's request by the EBR ELICIT team (see acknowledgments).

	Average Correctness	Average Timeliness	Average Efficiency	Average Error Rate
Hierarchy	.025	.013	.011	.549
Edge	.193	.080	.044	.426

Results from 7 matched sets (14 human trials)

Figure V-5: Hierarchy vs. Edge: Measures of Effectiveness and Efficiency, Results of Human Trials

Human participants in edge organizations correctly found the solution far more often (by a ratio of almost 10 to 1), far more quickly (by a ratio of more than 6 to 1), and had lower error rates than those in a hierarchy. The combination of higher correctness with low error rates is significant because it means that the higher correctness scores cannot be simply attributed to a greater willingness on the part of participants in edge organizations to risk a guess. Nor is the supposition that participants in hierarchies are less willing to guess supported by the facts. Human participants in edge organizations were involved in a greater number of transactions (experienced a greater workload) on the order of 4 to 1, as reflected in the efficiency scores, than participants in hierarchies. While at some point this higher workload may become problematic, at the level observed in these experiments, this was not the case.

At this point in the discussion it should be pointed out that, in these experiments with human participants, although the participants were informed about the nature of the organization, certain constraints related to hierarchy were not enforced. While team members had no access to websites other than their own, they were not prevented from working on aspects of the problem which they were not specifically assigned and were not prevented from sharing information with participants in other groups. This is important to remember when the results of agent-based runs are presented and discussed, since in later agent runs, task assignments and position-related rules were enforced.

Hierarchy vs. Edge: Baseline Measure of Task Progress

Correctness, that is, getting the correct solution to the problem is, of course, a bottom-line measure of accomplishment. To fully understand the results of this set of experiments, it would be useful if one could know what progress had been made by those individuals that did not get the correct solution by the end of the available time. This would tell us if for some reason the time that was selected to end the experiment unfairly affected one of the groups. That is, they were just on the verge of getting the correct solution when time ran out. Therefore, a measure of task progress was also calculated. Figure V-6 presents a comparison of task progress as a function of approach.

	Average Task Progress
Hierarchy	.351
Edge	.498

Results from 7 matched sets (14 human trials)

Figure V-6: Hierarchy vs. Edge: Measure of Task Progress, Results of Human Trials

These results indicate that individuals in the hierarchy were making more progress than was apparent by simply looking at the correctness scores. It highlights the failure of the hierarchy to connect the dots, that is, to put parts of a solution together to get the whole solution.

Hierarchy vs. Edge: Baseline Results by Role

There is a set of assumptions that attend hierarchies. One of these is that hierarchical organizations are designed to inform their leadership, who are expected to make decisions and tell subordinates what to do. It could be argued that in a hierarchy, the only person who needs to solve the problem is the overall leader. Putting aside the long list of problems associated with this view of how to organize, this characteristic of a hierarchy begs the question "What is the probability that the overall leader in an information age hierarchy solves the problem?" In order to answer this question in a more general manner, correctness (total solution) and progress (partial solution) as a function of role (hierarchy team member, team leader, overall leader, and edge team member) was calculated. The results of this role-based analysis are summarized in figure V-7.

	Average Correctness	Average Progress	Average Timeliness	Average Efficiency
Overall Leader	.000	.393	n/a	n/a
Team Leader	.000	.464	n/a	n/a
Team Leader Hierarchy	.036	.310	.018	.015
Team Leader Edge	.193	.498	.080	.044

Results from the 7 Hierarchy trials in the matched set of 14 human trials

Figure V-7: Measures as a Function of Role, Results of Human Trials

Based on the design of a hierarchy and its information-sharing behaviors, one's a priori expectations would be that if anyone solved the entire problem, that person would be the overall leader. However, in these experiments, this was not the case. In the small number of instances where someone in a hierarchy got the correct solution, it was not the overall leader nor a team leader, but a team member. Readers may wish to recall their own experiences and see if this initially counterintuitive result is consistent or inconsistent with situations that they have experienced in their organizations. The progress scores indicate that there is an enormous difference between the ability of the hierarchy and edge to complete the shared sensemaking task. Individuals in both groups made progress, but only in the edge was this progress translated into bottom-line results (the correlation between progress and correctness scores).

I developed the initial problem challenge to be representative of what I thought were the characteristics of real world connect-the-dots problems. Our experience has been that various institutions have had considerable difficulty in dealing with these connect-the-dots problems and that suggested fixes or improvements in their ability to share information (and in fact increase information sharing) have not been sufficient to ensure success. These institutions and the approaches they are utilizing are still not up to the task. These experimental results show that even adopting what is considered a fairly mature collaborative approach is not, in and of itself, a guaranteed solution. This will be explored later when I look at varying the nature of the mission challenge.

Hierarchy vs. Edge: Baseline Measure of Initiative

Humans, as we all know from experience, vary greatly in the degree to which they follow instructions and show initiative. In the context of these experiments, initiative in a hierarchy equates to solving parts of the problem that were not assigned to an individual. Innovation scores reflect the degree to which humans, when placed in hierarchical organizations, take on work not specifically assigned to them. Since edge participants in these experiments were not assigned specific tasks, it was reasonable for them to assume they were assigned the entire problem, and thus this measure is not applicable to edge runs. In this set of experiments, the average innovation score for participants in hierarchies was .218. When these results were examined to consider the assigned role (team leaders, team members), no significant difference was observed.

Exploring an Expanded Organization-Approach Option Set Using Agents

While the hierarchy and edge approaches provide a stark contrast (opposite corners of the approach space) that serves to illustrate the implications of organization-approach on mission performance, being able to obtain experimental results for a variety of regions in between these two extremes is needed so that we can explore the relative impact of the dimensions of the approach space and to ultimately design an approach that has the characteristics that are most appropriate for a given situation and/or environment.

Human trials are both time-consuming and very expensive. This limits the number of organization-approach treatments and the variety of conditions that can be investigated. For this reason, the remainder of experimental results reported here come from abELICIT, the agent-based version of ELICIT. As explained earlier in the section on methodology, abELICIT runs on the ELICIT platform but uses software agents in place of humans. These agents are provided a set of factoids expressed in the form of logical statements. Agents build up understandings from the factoids they receive in the form of logic tables. The agents possess a number of cognitive capabilities and personalities that determine their information sharing and processing behaviors, and their willingness to share their conclusions (identifies). In abELICIT the constraints associated with each of the organization-approach options are enforced.

An initial set of abELICIT runs were made to create a baseline. The results for the baseline provide a set of values for the measures of mission effectiveness and efficiency that can be used to see how each of the different organization-approach options and variations on these options (e.g., mix of individual characteristics, policy) respond to various changes in circumstances. That is, how agile they are.

Approach Space

In addition to the hierarchy and edge approaches that are used in the both the human and agent experiments discussed above, four more organization-approach options were simulated.

Figure V-8 is a graphical representation of the approach space.[137] The regions in this space occupied by each of these organization-approach options described below are depicted in this figure.

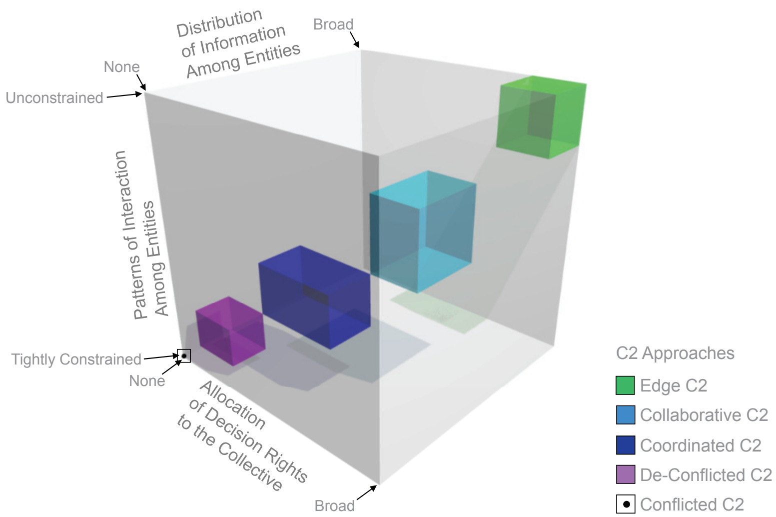

Figure V-8: Approach Space

An organization-chart depiction of each of these additional organization-approach options, along with a brief description, is provided below. This is followed by a comparison of the observed baseline values of effectiveness and efficiency measures.

137. The approach space was introduced to the community by the author during SAS-050 in 2003. More recently it appeared as the C2 Approach Space (*NATO NEC C2 Maturity Model*, pp. 63–66). Readers should note that the dimensions are not orthogonal in practice and thus this space is not really a cube.

Conflicted

The approach to collective action, conflicted, consists of independent teams, each of which is assigned a different area of interest (e.g., who). Each team has three members and a team leader. There is no overall leader. Each team has a website that may be accessed by team members and the team leader. Team members may share with others on the same team and the team leader.

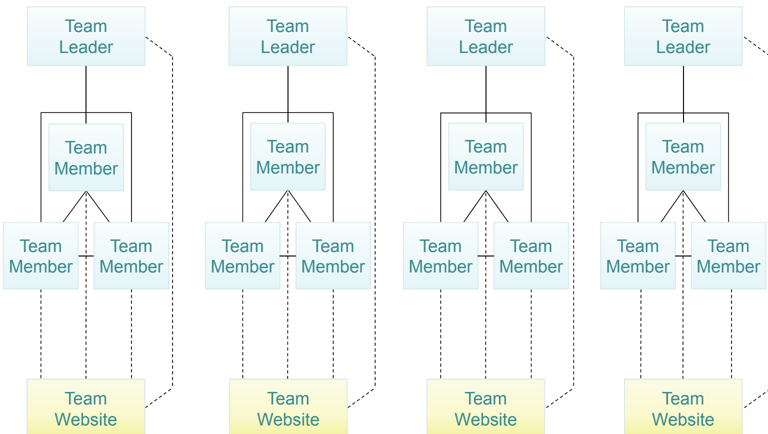

Figure V-9: Conflicted

De-Conflicted

A de-conflicted approach to collective action consists of four independent teams, each of which is assigned a different area of interest (e.g., who). Each team has three members and a team leader. There is no overall leader. Each team has a website that may be accessed by team members and the team leader. Team members may share with others on the same team and the team leader. Team leaders are assigned one additional area of interest and may share with the team leader of that area. Deconfliction is accomplished by sharing of factoids between pairs of team leaders.

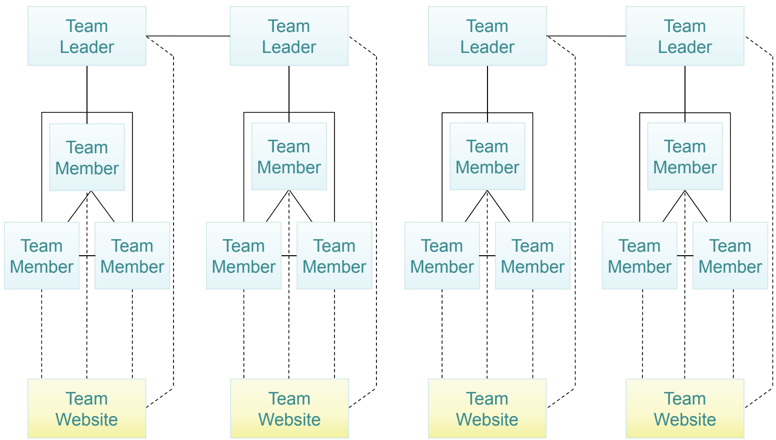

Figure V-10: De-Conflicted

Coordinated

The coordinated approach to collective action involves four independent teams, each of which is assigned a different area of interest (e.g., who). Each team has three members and a team leader. In addition, there is a coordinator. Team members may share with others on the same team and the team leader. Each team has a website that may be accessed by team members and the team leader. Team leaders are assigned one additional area of interest and may share with the team leader of that area and access the website associated with that area. The coordinator may share with team leaders and also has access to all the team websites. Coordination is accomplished by the sharing of factoids between the coordinator and team leaders, sharing between pairs of team leaders, and providing appropriate website access to team leaders as a function of their assigned areas.

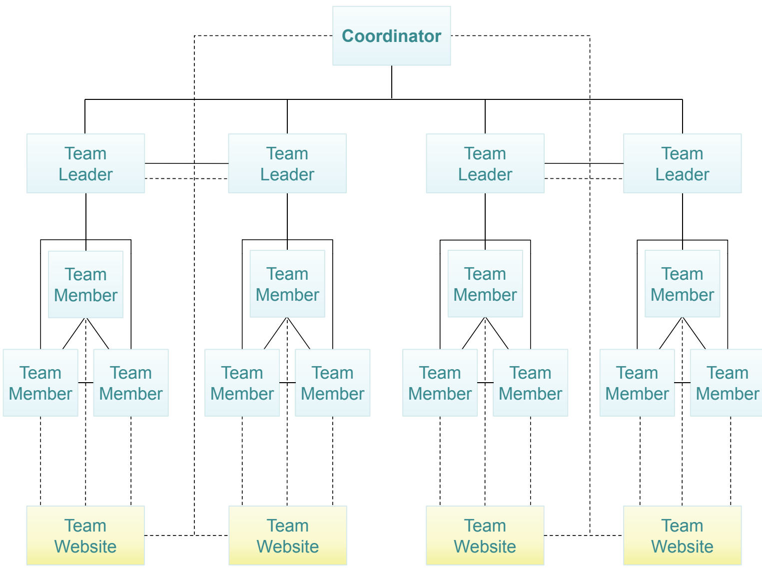

Figure V-11: Coordinated

Collaborative

The collaborative approach to collective action consists of four independent teams, each of which is assigned a different area of interest (e.g., who). Each team has three members and a team leader. Team members may share with others on the same team and the team leader. Team leaders are assigned all areas of interest and may share with other team leaders. Each team has a website that may be accessed by team members and any team leader. In addition, there is a coordinator. The coordinator is assigned all areas of interest, may share with team leaders, and has access to all websites. In addition, there are two cross-team members on each team. They each are assigned an additional area of interest, may share with the corresponding cross-team member on the other team, and have access to the other team's website. Coordination is accomplished by the sharing of factoids between and among the coordinator and team leaders, sharing between cross-team members, and relatively widespread access to websites.

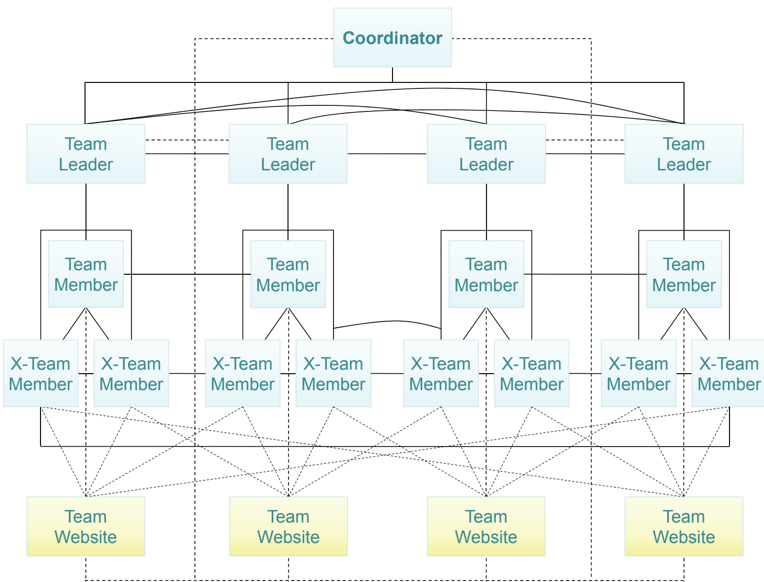

Figure V-12: Collaborative

Baseline Results for Expanded Organization-Approach Options

The different organization archetypes and approaches to collective action defined above are expected to produce behaviors that differ significantly with respect to the set of measures that have been established for mission effectiveness and efficiency. These results create the what-would-have-happened baseline that will be used to determine the relative effectiveness and efficiency of these approaches as a function of a number of different stresses and changes in circumstances. This baseline, a prediction of normality, is an estimate of mission performance had the event in question not occurred. This baseline needs to be compared to a second line that reflects what actually happened (the observed) when the altered condition or circumstance was represented in a second series of experiments.

During each run, one for each organization-approach option, information was collected to determine the values for the measures identified in figure V-13.

abELICIT Measures	
• Average Correctness – over time – at the end of the run	• Task Progress – average – by role
• Timeliness – maximum – average	• Error Rate – average – by role
• Task Performance – average – by role	• Initiative – average – by role
• Average Efficiency	

Figure V-13: abELICIT Measures

In the initial set of results for the complex endeavors challenge, only the participants in the edge approach were able to correctly solve the problem (see figure V-14).

	Average Correctness	Overall Leader Correctness	Average Task Performance	Maximum Timeliness	Average Timeliness	Average Efficiency
Hierarchy	0	0	0	n/a	n/a	n/a
Coordinated	0	0	0	n/a	n/a	n/a
Collaborative	0	0	.176	n/a	n/a	n/a
Edge	1.000	n/a	1.000	.311	.180	.016

Figure V-14: Comparison of Organization-Approach Options, Complex Endeavors Challenge

In fact, everyone in the edge was able to find the correct solution (average correctness = 1). The other organization-approach options did not exhibit sufficient information sharing and this lack of information sharing prevented participants in those other organizations or collectives from correctly identifying all aspects of the who, what, when, and where of the attack.

Readers will remember that in the human runs, behavior was shaped only by instructions, and it was participant perceptions of what it means to be on a team, be a team leader, or be an overall leader, that shaped their behaviors. The restriction that team members not share with members of other teams or work on aspects of the problem that were not assigned to them was not enforced. Upon reflection, the result of the abELICIT hierarchy runs is close to that of the hierarchy trials with human participants where only 2.5 percent of the participants were able to correctly solve the problem. The perfect score of 100 percent for the agents in an edge was also to be expected in abELICIT, since the agents will correctly solve the problem if they have the information, while human participants may, for any number of reasons, not solve the problem despite having access to the information required. An attempt was made to insert delays at appropriate junctions in the agent code so that agent time approximated human time. If we compare the timeliness scores between human and agent runs, we see that agents in edge runs have higher average timeliness scores and lower average efficiency scores. This means that agents are not only getting the correct answers faster but also doing more (shares, posts, etc.) in the same amount of time. Since we will be comparing agent runs to other agent runs, not to human runs, this difference is not important. When, in the future, we wish to compare agent results to human results, this time-related issue will need to be addressed.

This stark result (hierarchy vs. edge) is directly related to the mismatch between the nature of the complex endeavors challenge and the characteristics of the organization-approach options. Later, in the section that explores organization-approach agility, the results of experiments with other mission challenges are presented. These other mission challenges were formulated in a manner that made them more amenable to one or more of the non-edge organization-approach options.

The all-or-nothing results for correctness hide the fact that, at least, in the collaborative hierarchy, some individuals are successfully completing their assigned tasks. The measures of task performance and task progress were designed to track this. Figure V-15 presents the task performance and task progress scores for the collaborative hierarchy by role for the baseline challenge. Readers should note that in the edge approach, all the participants were able to solve the complete problem (hence all of these scores would be 1.000).

	Average Correctness	Average Task Performance	Average Task Progress
Leader - Coordinator	0.000	0.000	0.500
Team Leader	0.000	0.000	0.500
Cross Team Member	0.000	0.250	0.375
Team Member	0.000	0.250	0.250
All Roles	0.000	0.176	0.382

Figure V-15: Collaborative Hierarchy, Baseline Challenge

This result shows that while no one in the collaborative hierarchy was able to meet the challenge, the overall leader or coordinator was able to get the correct answer for two of the four areas (the overall leader is assigned all four parts of the problem). Team leaders in a collaborative hierarchy are also assigned all four parts of the problem and, on average, were able to solve two of the parts. The results above show that one of four cross-team members and one in four team members successfully accomplished their tasks. The task progress scores for cross-team members show that while some cross-team members completed their assignments, some got only one of the two areas assigned to them correct. It is important to note that in a collaborative approach, two of the three team members are designated as cross-team members and are assigned two areas each, while the remaining team member is assigned only one area. Since other team members are only assigned one area, their progress and performance scores are the same.

Chapter 21

Looking Beyond the Baseline

The results for the measures of effectiveness and efficiency for the different organization-approach options to collective action provided by the baseline experiments reported on in figures V-5, V-6, V-7, V-14, and V-15, may change when the embedded constraints are relaxed, when the underlying assumptions are challenged, and/or when circumstances change. While these changes may impact all the different organizations and approaches, their relative effectiveness and/or efficiency may also change. That is, a relaxed constraint may benefit one organization-approach option more than it benefits another, and a particular stress could adversely affect one more than another.

Experiment Constraints and Assumptions

This section lays bare the constraints and assumptions that are embedded in the initial set of abELICIT or baseline runs, and it identifies a series of sensitivity analyses that explore the relative agility of each of these organizations and approaches to collective action.

The baseline cases all involved the same specific problem, that is, the same set of factoids that are distributed to participants in the same way (order and timing). Furthermore, these experiments share the following characteristics:

- Characteristics of the Problem (Challenge)
  - The information (factoids) provided is all true.
  - Half of the factoids are not relevant (normal noise).
  - The set of information available to the organization or collective is sufficient to solve the problem.
  - Factoids can be processed quickly (low cognitive complexity).
  - Sharing of information is required to solve the problem.
- Characteristics of the Infostructure
  - The network is operating normally (no damage).
  - All messages get through without error.
  - Communication network performance delays are insignificant.

- Characteristics of the Agents
  - The agents behave as instructed, that is, they follow specified roles, assignments, policies, and practices.
  - The agents do not make mistakes in information processing and logic.
  - All agents have high trust in one another.
  - All agents have high trust in the information sources (websites).
  - The agents must wait until they have a minimum of *x* factoids to identify.

Manifestations of Agility

Agility is not about being effective in one or a small number of circumstances or under ideal conditions. In fact, it is often the assumptions or conditions that we take for granted that ultimately result in failure. In large part, this is because organizations, approaches, systems, and indeed individual behaviors are optimized for a given set of circumstances. Since they are so finely tuned, they tend to be most vulnerable when circumstances change. Many assumptions about how an individual or an organization should behave are made because the doctrine writer or analyst was unable to envision any other way of working. These unnecessary assumptions can contribute to a lack of agility.

The set of abELICIT baseline runs for the different organization-approach options were not meant to be the end of the analysis, rather they were intended to serve as a point of departure for determining when entities manifest agility by observing:

- How these organizations and approaches deal with a multitude of different conditions and problem challenges.

- How the effectiveness, efficiency, and agility of these organizations and approach options vary as a function of the characteristics of individual members and the infostructure.

The remainder of this part of the book is devoted to presenting the findings of a series of experiments designed to explore the impacts to organization-approach effectiveness and efficiency that result from changes in the nature of the fact set provided or the manner in which it is distributed (the mission challenge) and/or changes in one of the characteristics of an organization, its members, or the supporting infostructure.

These experiments explore the impact of changes in workload levels, cognitive complexity, and cyberattacks that damage infostructure. They also look at a variety of mission challenges.

Impact of Workload

Previous work[138] has indicated that a particular approach to command and control (management) involves the accomplishment of a specific set of tasks. This translates into the ability to handle a certain transactional and cognitive workload. Success depends on the capacity of the entity to handle the required workload. Being able to explore the impact of varying workload on the performance of organization-approach options under different circumstances and conditions is essential to apply the concept of agility to real world entities. This section provides an example of a set of experiments in which workload is varied and the performance of two organization-approach options is compared as a function of workload.

In these experiments, changes in both cognitive and task workload were investigated. In both the human and agent-based baseline experiments a total of 68 factoids were distributed. Each of these factoids consisted of one or more pieces of information. This information needs to be cognitively processed, and information-seeking and sharing tasks need to be performed. In these experiments, the level of work required was varied by changing the total number of factoids provided. This was done by simply adding different amounts of *noise* factoids to the set of available information. A noise factoid contains information that is not necessary to reach a correct

138. Different militaries have taken different approaches to organizing and staffing headquarters. Each approach requires a certain capacity (the ability of a headquarters to do the tasks required by the approach) and each has been successful under some circumstances. See Alberts, D. S. et al. *Understanding Information Age Warfare*, chapter 7, specifically pp. 169–184.

solution. This variation in workload is not accompanied by any adjustment in resources. This enables us to see how each of the different organization-approach options performs as workload changes.

Organization-approach options that were able to deal with the increased number of factoids distributed without suffering a significant reduction in effectiveness *and/or* were able to increase effectiveness and/or efficiency when workload was reduced were exhibiting agility. Different organization-approach options can be expected to exhibit different behaviors as workload changes, and thus they vary in their relative agility.

From the results of the baseline experiments, it is clear that the complex endeavors challenge problem posed to both human and agent participants could only be solved by an edge approach. For this reason, in the workload analysis that follows, I shall begin by looking at how edge organization-approach performance varies with workload. This will serve to illustrate how one can measure manifest agility. In this case, how to measure the agility of an entity that has adopted an edge approach with respect to changes in workload.

To begin our examination of the impact of changes in workload on effectiveness and efficiency, I ran three different abELICIT complex endeavors challenge runs for the edge organization-approach option. These three runs differ in the total number of factoids distributed to the agents. Anchored by the standard factoid set containing 68 factoids, half of which are noise (normal noise), two other factoid sets were created. The first of these variants simply eliminated all the noise factoids resulting in a no-noise set of 34 factoids. The second variant doubled the number of noise factoids by introducing 34 additional noise factoids for a total of 102 factoids (twice the noise). These runs range from a 33 percent to 100 percent signal. Figure V-16 presents the results obtained for correctness, timeliness, and efficiency.

	Average Correctness	Maximum Timeliness	Average Efficiency
Twice the Noise	.059	.004	.001
Normal Noise	1.000	.311	.013
No Noise	1.000	.479	.019

Figure V-16: Impact of Workload on Edge, Complex Endeavors Challenge

The edge approach was able to improve its performance[139] (timeliness) and its efficiency with the elimination of noise factoids (thus being able to take advantage of an opportunity). In the case of a doubling of the noise, the increased workload had a deleterious effect on average correctness—reducing it to the point where only one participant was able to completely solve the problem. Timeliness and efficiency were adversely affected as well. In fact, the one individual who did manage to get the correct solution only got it at the very end of the time

139. Readers should note that the edge's correctness score was the highest possible and thus could not be increased.

period with less than 1 percent of the time remaining. While the edge, when faced with a significant increase in workload, still managed to have at least one participant develop a complete solution, the hierarchy could not take advantage of a no-noise situation to improve its correctness score.

Chapter 22
Exploring an Expanded Challenge Space

The results of these baseline experiments strongly suggest that the initial formulation of the ELICIT challenge is simply beyond the abilities of hierarchies as they are traditionally structured. This complex endeavors challenge was not created to make hierarchies fail, rather the challenge was crafted to reflect the reality of many of our current mission challenges that have been characterized as complex endeavors. By their very nature, complex endeavors require information and expertise that is widely dispersed. As a result, organic information is insufficient and information sharing is needed to construct an accurate picture of what is occurring. In complex endeavors it is not sufficient for just one person (the head of an organization) to have the answer. Rather the development of an adequate level of shared understanding is a prerequisite for a coherent and effective response. Average correctness, a measure of shared understanding, will be used to see the extent to which different organization-approach options develop shared understanding when given problems of different types and under different conditions.

As has been previously observed, these variants of hierarchical organization-approach options were designed or have evolved to deal with problems and information environments that are to a large extent decomposable and well-behaved. Major changes in the way decision rights are allocated, the nature of the interactions that take place, and the flows of information are needed if these entities are to solve these new and more challenging problems.

However, there are problem challenges that can be successfully tackled by hierarchies and even by conflicted approaches. A basic premise of agility is that there is no one-size-fits-all solution. Approach agility demands that an entity understand the characteristics of a situation (endeavor) in terms of what would be the most appropriate organization-approach option (from the set of available options) and then adopt that approach. An entity's agility is a function of its organization-approach tool kit and its ability to understand the approach implications of the situation and adopt to an appropriate approach.

Therefore, it is important to understand the characteristics of the endeavor (the nature of the challenge posed), its associated information environment, and what the implications are in organization-approach terms. That is, we need to create a mapping from regions in the endeavor space to associated regions of the approach space (see figure V-17). These mappings represent, at least in theory, assessments of which organization-approach option(s) would be most appropriate for which types of endeavors.

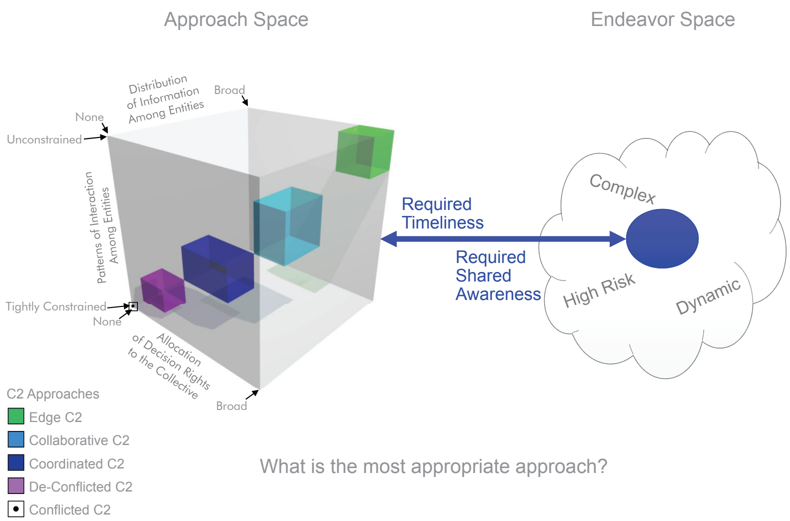

Figure V-17: Finding the Appropriate Organization-Approach Option

One can imagine coloring different regions of the endeavor space with different colors, where each color represents the organization-approach option best suited for the endeavors represented by this collection of points or region of the space. In fact, later in this part of the book, comparative agility maps, maps with colored regions of endeavor space that signify the most appropriate organization-approach option for that region, are introduced. These are based on experimental results. The relative sizes of the areas for each color would provide a visual measure of the relative agility of each organization-approach.

To explore the relationship between endeavor space and approach space, we need a variety of different kinds of challenges that represent different regions of endeavor space. To orient ourselves, the baseline ELICIT challenge needs to be mapped to a specific region of endeavor space. Having done this, a set of new challenges needs to be defined to represent other regions of endeavor space.

The ELICIT baseline results presented earlier showed that the who, what, when, and where problem posed was solvable (if not easy) for edge organization-approaches and difficult, if not impossible for hierarchies. Clearly, the different organization-approach options vary in important ways in their problem-solving capabilities and thus in their ability to tackle endeavors located in different parts of endeavor space. The complex endeavors challenge clearly occupies a corner of endeavor space that maps to the area of approach space occupied by edge organizations-approaches.

An Industrial Age Challenge

To explore challenges that would be located in other regions of endeavor space, I began by crafting a problem challenge that I expected to be more amenable to industrial age organizations—organizations that, to varying degrees, stovepipe assignments and information flows.

The nature and difficulty of the ELICIT challenge can be varied by changing the set of factoids and the manner in which they are distributed to participants. The baseline factoid set and its variants have the following properties:

> *Sixty-eight factoids (50 percent relevant and 50 percent not relevant). The problems that need to be solved are not independent. Some factoids contain information about more than one area. Some factoids need to be known by individuals in more than one area. Each factoid was distributed to only one individual. The set of factoids distributed to a team was not sufficient to solve their assigned problem.*

Each of these characteristics can be varied to make the problem more or less difficult (relative to a particular organization-approach option). The lack of independence among the tasks means that either the solution to one or more areas or the information required to develop the solution (e.g., who and what) is required to complete an assigned task (e.g., when). This both increases the complexity of the task and creates more work because an individual or a team needs to share information in order to solve more than one task and to solve the tasks in a specific order. These challenge properties, taken collectively, mean that a significant amount of sharing of information is essential.

Having found a problem that is appropriate for only edge-organization approaches, the next step was to identify changes in the factoid set and/or its distribution that would make it suitable for an industrial-age-organization approach. Given that industrial age hierarchies, to varying degrees, are composed of specialized components with stove-piped information flows, an industrial age problem would differ from the baseline problem in that the information distributed to each team needs to be sufficient to solve their assigned problem. The only information sharing that would be required would be to enable the overall leader (if there is one) to obtain the correct solution. A factoid set was created and the manner of distribution was designed to satisfy these industrial age assumptions. While I did not expect that only hierarchies would be able to solve this problem, I did expect that this organization-approach option would do the best job in terms of timeliness and efficiency relative to other organization-approach options. Hence, this industrial age challenge occupies the corner of endeavor space that is opposite to the baseline ELICIT challenge.

Figure V-18 presents the results of abELICIT runs for four[140] of the organization-approach options when faced with an industrial age challenge.

	Average Correctness	Overall Leader Correctness	Average Task Performance	Maximum Timeliness	Average Timeliness	Average Efficiency
Hierarchy	.059	1.000	1.000	.809	.048	.006
Coordinated	.059	1.000	1.000	.783	.046	.005
Collaborative	.294	1.000	1.000	.730	.193	.017
Edge	1.000	n/a	1.000	.200	.169	.016

Figure V-18: Comparison of Organization-Approach Options, Industrial Age Challenge

140. Given the nature of the problem of interest, neither a conflicted or de-conflicted approach would be viable.

Since hierarchies generally are not designed to disseminate information widely or to create shared understanding (measured by their information positions and average correctness), but rather to inform the chain of command, the correctness score of the overall leader or coordinator, where applicable, is provided. Average task performance speaks to how well each participant performed the duties assigned. Maximum timeliness is a key metric because it provides the best case for the development of a correct understanding. If the first entity to discover the correct solution can quickly distribute the solution once it has been discovered, it provides some information regarding the timely development of shared understanding. Since the goal of military and civilian organizations has been moving toward shared understanding rather than simply leader awareness/understanding, a good measure of shared understanding is provided by average correctness and average timeliness, while average efficiency (number of transactions per correct solution) provides a measure of relative productivity. As can be seen from these results for the industrial age challenge, all participants, regardless of organization approach, successfully completed their assigned tasks and at least one participant in each of the organization-approach options was able to solve the problem. In the case of the hierarchy and the coordinated-organization-approach options, only one person, the overall leader or coordinator, was able to correctly identify the who, what, where, and when of the attack.

As expected, the hierarchy received the highest score in terms of speed with a maximum timeliness of .809. The coordinated (.783) and collaborative (.730) options received good scores as well. The edge, however, takes considerably longer to develop the correct solution. On the other hand, the ability of these different organization-approach options to develop shared understanding is inversely related to their timeliness. That is, in the edge approach everyone (all 17) gets the correct solution as opposed to the hierarchy and coordinated options where only one person gets it. In the collaborative approach the overall leader and all the team leaders (5) get the correct solution. This shared understanding-timeliness trade-off is depicted in figure IV- 19.

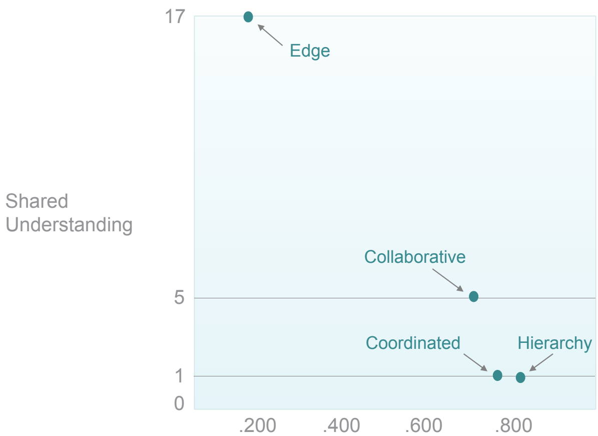

Figure V-19: Shared Awareness vs. Maximum Timeliness, Industrial Age Challenge

Coordination and Collaboration Challenges

Having developed two challenges, one suitable for edge and one for hierarchy, I turned my attention to developing a *coordination challenge* and a *collaboration challenge*. These two challenges were designed to require levels of information sharing that were thought to be consistent with the way hierarchies have implemented coordination mechanisms and collaborative processes and environments. Two sets of abELICIT runs yielded the following results.

Figure V-20 presents the results for the coordination challenge.

	Average Correctness	Overall Leader Correctness	Average Task Performance	Maximum Timeliness	Average Timeliness	Average Efficiency
Hierarchy	0	0	.706	n/a	n/a	n/a
Coordinated	.059	1.000	1.000	.782	.046	.005
Collaborative	.294	1.000	1.000	.722	.189	.017
Edge	1.000	n/a	1.000	.213	.162	.016

Figure V-20: Comparison of Organization-Approach Options, Coordination Challenge

The first thing about the coordination challenge results to note is that no one in the hierarchy was able to solve this problem. The three other approach options scored the same as they did on the industrial age challenge with respect to these various measures.[141] Changes made to the

141. There are in fact slight differences (e.g., for collaborative—maximum timeliness .730 vs. .722), but these are not significant.

factoids used in the coordination challenge themselves or in the way these factoids were distributed adversely impacted the performance of the hierarchy.

Figure V-21 presents the results from the collaboration challenge.

	Average Correctness	Overall Leader Correctness	Average Task Performance	Maximum Timeliness	Average Timeliness	Average Efficiency
Hierarchy	0	0	0	n/a	n/a	n/a
Coordinated	0	0	0	n/a	n/a	n/a
Collaborative	.294	1.000	1.000	.726	.188	.017
Edge	1.000	n/a	1.000	.291	.222	.017

Figure V-21: Comparison of Organization-Approach Options, Collaboration Challenge

These results show that none of the participants in the hierarchy or coordinated organization-approach options could solve the collaboration challenge. While all participants in the collaborative approach option successfully accomplished their assigned tasks, only 5 of 17 participants (the overall leader-coordinator and the team leaders) were able to completely identify the who, what, where, and when and receive a correctness score of 1. Thus their average correctness score (shared understanding) = 5/17 or .294. All participants in the edge organization-approach option were successful. Of note was that, even as the problem became more challenging (in terms of information sharing), the edge improved its timeliness scores, while the timeliness score of the collaborative organization-approach option remained constant.

Organization-Approach Versatility

One of the components of agility is versatility. Versatility is the ability of an entity to maintain acceptable effectiveness (or to improve effectiveness and/or efficiency) when faced with significantly different tasks (challenges). The results for each of four different mission challenges presented above provide us with the data we need to look at the relative performance (correctness, timeliness, and efficiency) of the organization-approach options as a function of mission challenge. The extent to which a particular organization-approach option is successful over the challenge space determines its versatility.

Clearly, the edge, when judged only by the standard of shared understanding, was the only approach that was completely successful (figure V-22) across all of these challenge problems, and thus, exhibited the greatest versatility.

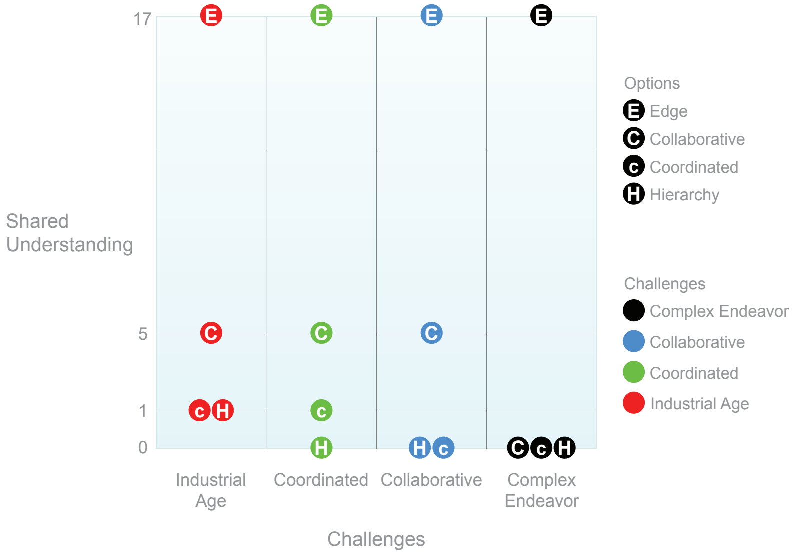

Figure V-22: Versatility of Organization-Approach Options

There are situations that may be effectively dealt with by organization-approach options that are designed to function without very high levels of shared awareness and/or understanding. In some cases, it may be more important to minimize the time it takes for someone or just a few individuals to correctly understand the situation than to have high levels of shared understanding. In these cases, the primary measure of interest is timeliness, specifically maximum timeliness, which is the time it takes for the designated decision-maker(s) to obtain the correct solution. When this occurs, other processes take over—processes that translate these decisions into plans, orders, instructions, and/or incentives as appropriate. Figure V-23 looks at the relative versatility of the organization-approach options with respect to maximum timeliness.

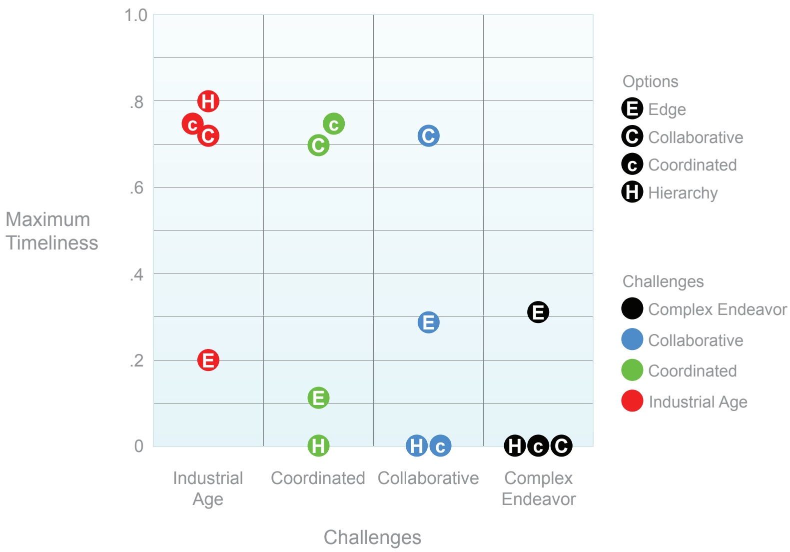

Figure V-23: Relative Timeliness of Organization-Approach Options

Each of the organization-approach options does best with respect to maximum timeliness when dealing with the problem challenge that has been designed for them. Readers will note that in reality it is not the problem challenge that has been designed, but rather the organization approach has been designed or has evolved over time to be optimized for a particular type of situation. These results also show that the collaborative approach works relatively well for all but the complex endeavor challenge. While in the case of the industrial age challenge, both the hierarchy and the coordinated approach options have higher maximum timeliness scores, and in the case of a coordination challenge, the coordinated approach has a higher timeliness score. However, the differences are not that great. There may be an advantage (less investment in training and practice) for an entity not to have to learn several approaches. If properly selected, having fewer approaches makes it easier to master the approaches and to learn to transition from one approach to another. If this is the case, an entity may wish to focus on only two organization-approach options—in this case, a collaborative and an edge.

Impact of Workload on Versatility

The above results compare the performance of different organization-approach options across the set of mission or problem challenges. These results are for a situation with normal levels of noise. Noise can vary. Increases or decreases in noise translate into corresponding increases and decreases in workload. To see if the amount of noise has any impact on the *relative* ability of each of these organization-approach options to deal with these different types of challenges, four sets of abELICIT runs were made, each of which varied workload as was previously done in our examination of the edge.

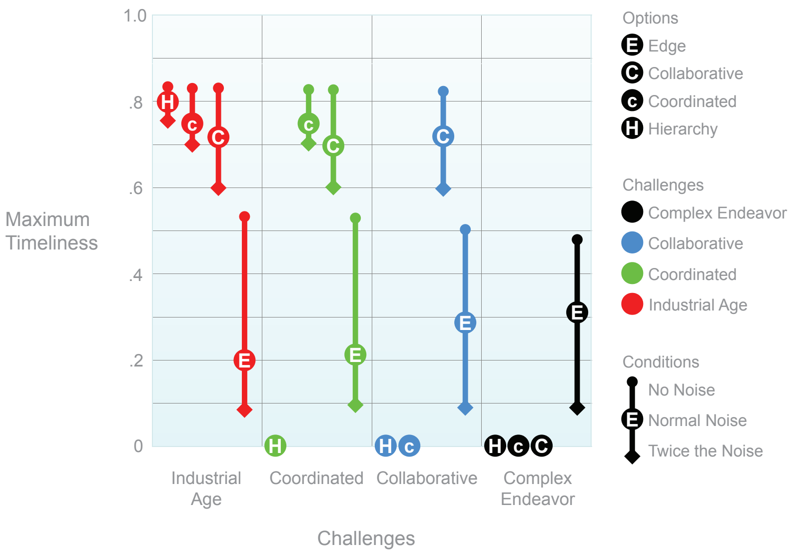

Figure V-24: Impact of Workload on Option Versatility

Figure V-24 is what I call a *relative impact diagram*. It presents the results of these runs in a manner that facilitates visual inspection of the relative impact that a given variable (in this case the level of noise) has on the experimental treatment (in this case a set of organization-approach options). Note that a timeliness score of zero means that no one found the correct solution. When the noise level doubles, with the exception of the edge option, all of the organization-approach options were able to maintain their previous levels of correctness (e.g., only the overall leader or coordinator gets the solution for the hierarchy and coordinated options; the overall leader and all the team leaders get the solution for the collaborative option). The presence of this level of noise makes the edge fail across the mission challenges. On the other hand, reductions in noise levels did not result in any improvements in correctness scores for any of the organization-approach options. This means that the pattern of interactions associated with an approach option constrains the option's correctness score.

Reductions in noise levels did universally result in improvements in timeliness. The sensitivity to noise (graphically depicted in figure V-24 by the size of the vertical lines) was found to be related to the patterns of interactions exhibited by the different organization-approach options. The hierarchy has the sparsest set of interactions and was relatively unaffected by increases in noise, while the edge has the densest pattern of interaction and was affected the most by noise.

Figure V-25 compares the correctness and timeliness scores for each of the options under different noise conditions for the industrial age challenge.

	Hierarchy		Coordinated		Collaborative		Edge	
	Correctness	Timeliness	Correctness	Timeliness	Correctness	Timeliness	Correctness	Timeliness
Twice the Noise	.059	.746	.059	.698	.294	.598	.000	n/a
Normal Noise	.059	.809	.059	.783	.294	.730	1.000	.200
No Noise	.059	.831	.059	.831	.294	.831	1.000	.522

Figure V-25: Impact of Workload, Industrial Age Challenge

It is important to note that the critical trade-off between timeliness and shared understanding persists at all levels of noise. Outcomes with higher shared understanding (average correctness scores) are, in general, accompanied by lower timeliness scores. In all case, timeliness scores increase as noise goes down.

Which organization-approach option makes sense depends on mission requirements and circumstances. Specifically, it depends on the levels of shared understanding and timeliness that are required, and the level of noise present. If high levels of shared understanding are required, only the edge option satisfies this requirement and only when the noise level is not high. If moderate levels of shared understanding will suffice, then the collaborative option makes sense. This is because the collaborative approach is the only approach that develops sufficient shared understanding when the level of noise is high, and when the level of noise is either low or normal, the collaborative approach is more timely than the edge option. In situations where the level of noise is high, and when timeliness is critical (a high degree of timeliness is required), the hierarchy is the only option that can satisfy this timeliness requirement; however it can only generate a low level of shared understanding.

These results indicate that there is no best or one-size-fits-all choice of an organization-approach option.

Impact of Mission Challenges on Organization-Approach Options

Agility is, as previously discussed, the ability to be successful over a set of circumstances and conditions. This set of requirements and conditions of interest form the endeavor space. The size of the region in this space where an option can operate successfully is a measure of its agility.

Figures V-26 through V-29 are entity agility maps that depict, for the industrial age challenge (the only challenge where all of the options can achieve a measure of success), the regions in endeavor space where each of these organization-approach options can successfully operate. This example of endeavor space considers required shared understanding, required timeliness, and the amount of noise present. Each of these four figures consists of three matrices each—one for each level of noise. Each matrix looks at nine different combinations of required shared understanding and timeliness. Low shared understanding equates to an average correctness score of .2 or less, while high shared understanding requires a score of .8 or above. Similarly, low timeliness equates to a timeliness score of .2 or less and high timeliness requires a score of .8 or more. To determine the entry in a particular cell, I looked at whether or not the correctness and timeliness scores satisfied the shared understanding and timeliness requirements. If the requirement was satisfied, the cell was filled in, and if not, the cell was left empty. For example, if the correctness score received was .059, then only the row that corresponds to low shared understanding is applicable, and the cell(s) to be filled in depend on the timeliness score received.

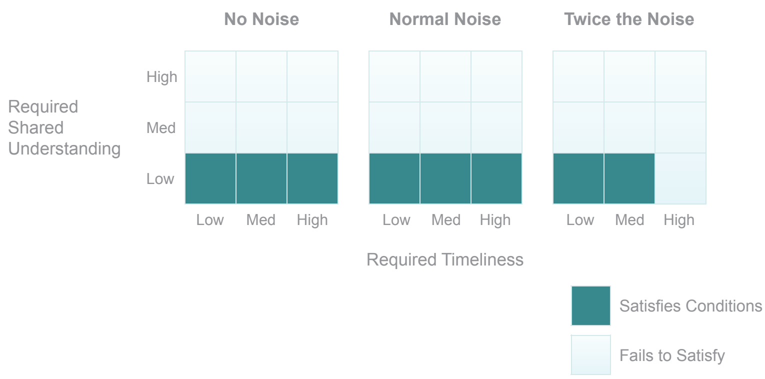

Figure V-26: Hierarchy Agility Map as a Function of Required Shared Awareness, Timeliness, and Noise, Industrial Age Challenge

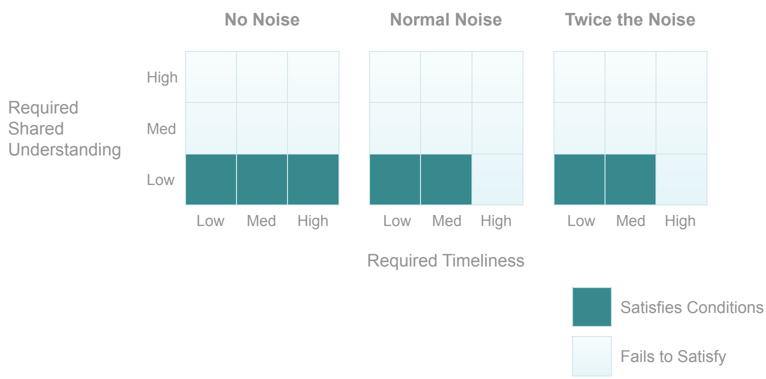

Figure V-27: Coordinated Agility Map as a Function of Required Shared Awareness, Timeliness, and Noise, Industrial Age Challenge

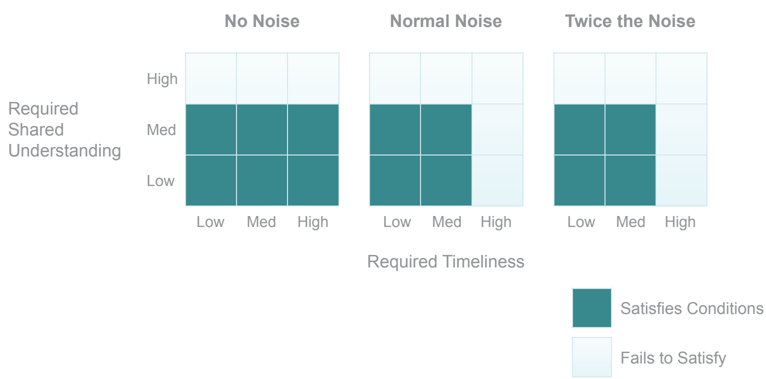

Figure V-28: Collaborative Agility Map as a Function of Required Shared Awareness, Timeliness, and Noise, Industrial Age Challenge

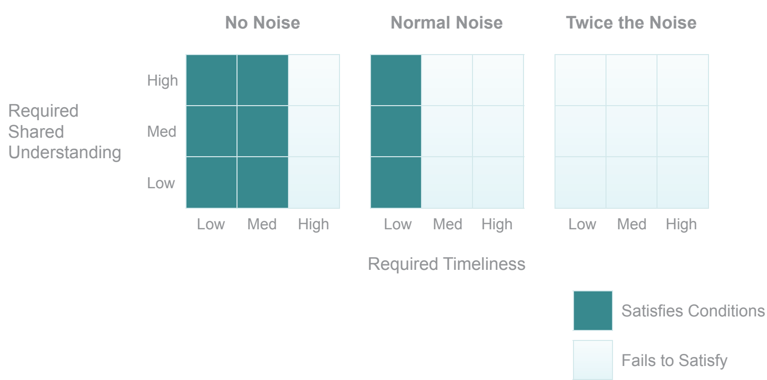

Figure V-29: Edge Agility Map as a Function of Required Shared Awareness, Timeliness, and Noise, Industrial Age Challenge

There are several immediate conclusions one can draw from this set of four entity agility maps. First, the size of region is a function of the amount of noise—the higher the noise, the smaller the region. Second, the size of the region differs over organization-approach options. While hierarchy and coordinated have the same total area (in fact cover an identical region, the collaborative and edge options cover more of the space). Third, the shapes of the regions associated with these two options differ. The edge extends to cover higher levels of shared understanding, while the collaborative option extends by being able to successfully operate in situations where more timeliness is required. Fourth, there are areas of the space where only one of the four options can successfully operate (e.g., hierarchy—normal noise, low shared understanding, and high timeliness) and other areas where all four of the options may be used (e.g., no noise and normal noise, low shared understanding, and low timeliness). There are also certain situations and conditions where a particular option is inappropriate (e.g., the edge in high noise situations or the hierarchy in other than an industrial age challenge.

One can also look at the agility of a particular option under a variety of mission challenges. Figures V-30 and V-31 allow us to compare the performance of the edge option for the industrial age and complex endeavors challenge.

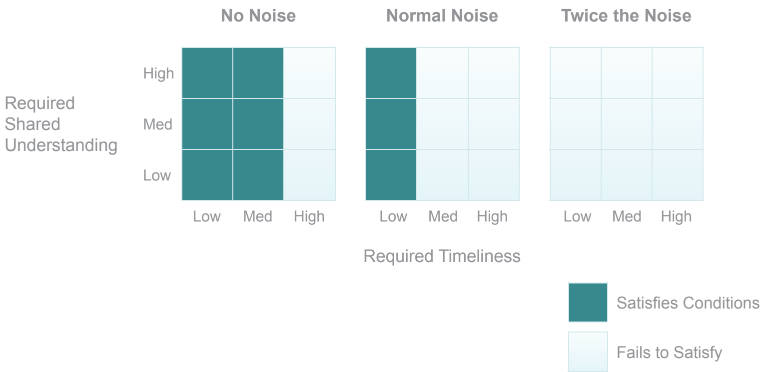

Figure V-30: Edge Agility Map as a Function of Required Shared Awareness, Timeliness, and Noise, Industrial Age Challenge

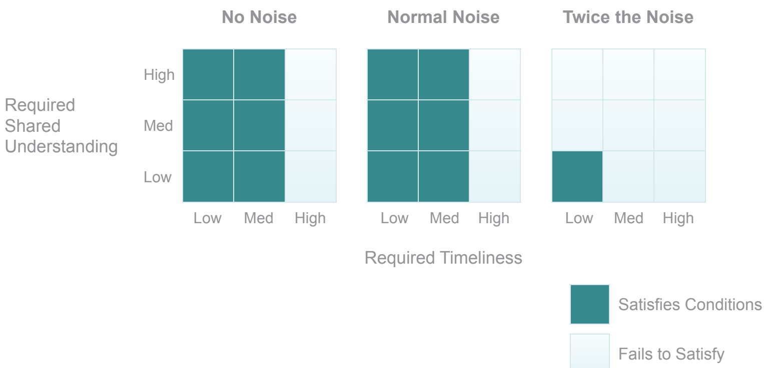

Figure V-31: Edge Agility Map as a Function of Required Shared Awareness, Timeliness, and Noise, Complex Endeavor Challenge

Readers will note that it appears as if the edge has a larger region of success in the more challenging mission. In reviewing the results of these experimental runs, it was found that under conditions of high levels of noise, the length of the trial was such that the first correct identify takes place right at the end of the trial. In the industrial age challenge run it occurred right after the end of the trial, and in the complex endeavors run it occurs just before the end of the trial. The difference depicted here looks larger than it is in reality.

Chapter 23
Picking the Most Appropriate Option

While it is obvious that one can quickly recall one or more situations where a particular option is suitable or inappropriate, it is far more difficult to recognize which one of the organization-approach options is best in a given situation. That is, given the challenge at hand (a particular region of endeavor space), what option should be adopted? Figure V-32 provides, at a glance, the answer to this question over a multidimensional endeavor space. The option to adopt is the one that performs best over a range of required levels of shared understanding and timeliness, as well as under a set of conditions (e.g., with varying levels of noise) that correspond to the nature of the endeavor. To illustrate how one could look at and compare the relative merits of the different organization-approach options (or for that matter any type of entity), I will examine the experimental results for the industrial age challenge under varying noise levels.

I picked this example because, at least under some conditions, each of the organization-approach options has 1) some level of success (at least one participant gets the correct solution), and 2) a relative or comparative advantage, that is, each option is, in at least one part of the endeavor space, the best of the available options. I used only one condition—normal level of noise—simply because it makes it easier to visualize the results.

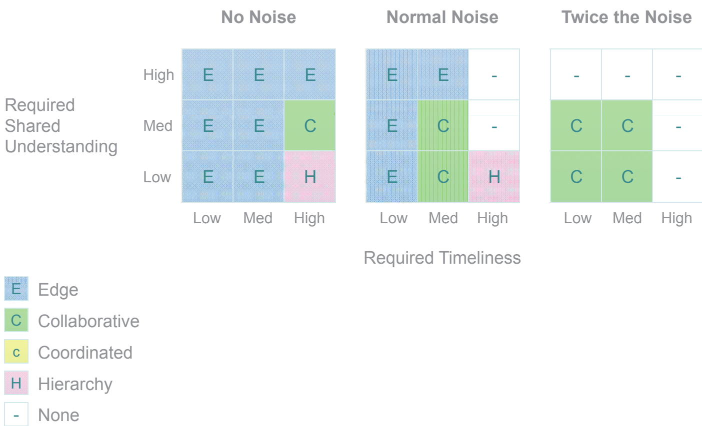

Figure V-32: Comparative Agility as a Function of Correctness, Timeliness, and Noise, Industrial Age Challenge

Figure V-32 follows the design of the previous set of figures. In this case, to determine the entry in a particular cell, I first looked to see which organization-approach options *satisfied both* the shared understanding and timeliness requirements. For example, all four options satisfied the requirements of low shared understanding and low timeliness for the situation with no noise. If, as in this case, more than one option satisfied both requirements, then the option with the best efficiency score was selected. In some cases, none of the options satisfied both requirements and a hyphen was put in the cell. It is of note that the coordinated option was never the most efficient of the feasible options. Also, of note was the fact that when there was twice the noise, none of the options could satisfy either a requirement for high shared understanding or a requirement for high timeliness. It is important to remember that these are the results for the industrial age challenge, the challenge that requires only sharing within stovepipes. As the problem gets more challenging, it becomes increasingly difficult for these options to satisfy requirements. Readers are reminded that in the case of the complex endeavors challenge with twice the noise present, only the edge was able to be successful and then only when both the requirement for shared understanding and timeliness was low.

Figure V-33 provides a more complete picture of the comparative advantages of the different organization-approach options by including consideration of other mission challenges.

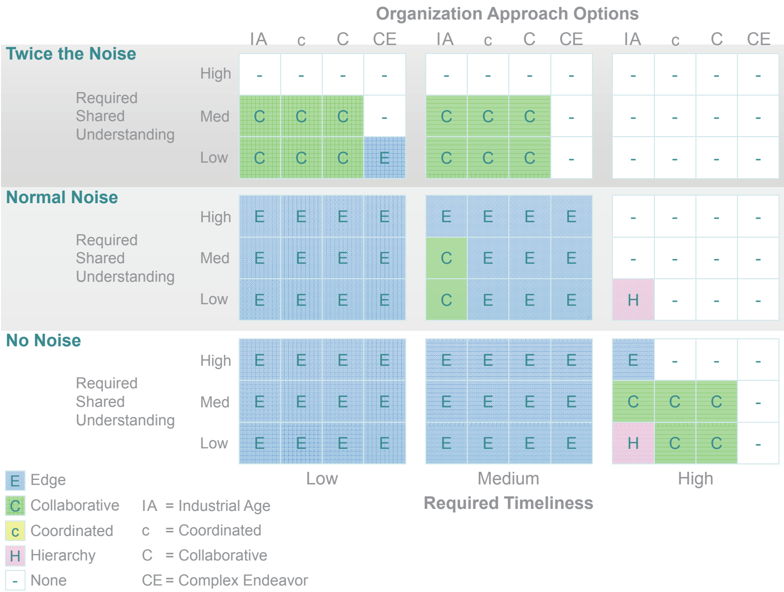

Figure V-33: Agility Map of Organization-Approach Options

Agility maps provide an easy-to-understand visualization of the relative agility of various organization-approach options by comparing the areas covered by the different colors associated with each of these options. Furthermore, one can see at a glance which sets of circumstances are beyond the capabilities of all the options. This agility map also provides a way of visualizing the benefits associated with being able to dynamically adapt one's organization approach by being able to employ more than one of these options. For example, if an entity is capable of adapting, as appropriate, either an edge or a collaborative approach, it can increase the size of the region where it is a best efficient fit—in this case from 48 cells to 67 cells out of a possible 108 cells.

Readers need to be reminded that this map depicts the most *efficient* option that also completely *satisfies* both the shared understanding and timeliness requirements for the circumstances associated with each particular cell. There may be a second organization-approach option that is slightly less efficient but that would be more timely or result in a higher level of shared understanding than the option identified in this map.

While the agility map can be used to get a good overview of the agility landscape, those involved in making these decisions should dig deeper to make sure that they fully understand the trade-offs being made. For example, the entry in the cell that corresponds to an industrial age challenge—no noise, medium shared understanding, and medium timeliness—is edge. In fact, this particular case resulted in the following scores for shared understanding, timeliness, and efficiency: 1.000, .522, and .019. In other words, it overachieved in shared understanding and received a middle-of-the-road timeliness score that was good enough, but not great. In this same set of circumstances, the collaborative option received the following set of scores: .294, .831, and .014. It barely satisfied the shared understanding requirement, overachieved in timeliness, and earned a slightly lower efficiency score than the edge. This result illustrates the need to really understand the relative performance of the available options and the break points used to specify requirements.

Chapter 24
Information Sharing Behaviors and Policy Choices

The behavior of agents (individually and collectively) is subject to a number of constraints. Individuals or agents cannot directly share information without the existence and availability of a *path* between them. Even if a path exists, individuals may be constrained and/or deterred by, for example, policy, cultural norms, language barriers, and/or access constraints. Some of these constraints may be a direct consequence of the adoption of one of the organization-approach options. In addition to constraints, there are also imperatives that *force* certain sharing behaviors and interactions. Other factors at work also collectively determine the nature of information flows and the total number of transactions that take place. These factors include individual (or agent) preferences for sharing modalities (direct person-to-person communications vs. posting/pulling to or from websites), the degree of trust that an individual has in an information source or other individual, and an individual's assessment of the relevance and value of a particular piece of information. Trust values depend not only on individual characteristics but also are related to the nature and culture of the organization, *team hardness*, and the nature of the situation. In addition to individual modality preferences, organizations or collectives can establish different policies that can determine or influence information sharing behaviors (e.g., whether to post before processing the information). Finally, the total number of factoids distributed and the signal-noise ratio of a factoid set will impact the total number of transactions.

For the runs reported on so far, the agents' parameters for trust were all set to high, the agents' modality preferences were set to both (share and post-pull), and all factoids were processed before they were shared (or posted). As a result of these settings, the information-sharing behaviors of each of the organization-approach options were 'maxed out.' In other words, if an agent determines the information in the factoid is relevant, the agent will share this factoid with all the other agents with whom the agent is directly connected, and if the agent has website access, the agent will post the factoid.

Looking at the total number of transactions in this set of ELICIT runs, there is a huge difference (20 to 1) between the number of transactions logged in hierarchy and edge organization-approach options. This ratio does not vary a great deal from problem challenge to problem challenge. In addition to a particular organization-approach option's access rules, the total number of transactions is a function of the number of factoids distributed, the trust values assigned to agents (that represent the trust they have in each other and in their sources of information), and the settings of agent-sharing modality parameters. For these runs, with the exception of the approach-option-related parameters (e.g., access to a website), the values for the other variables that can impact the total number of transactions were held constant. Therefore, the differences observed are a consequence of the organization-approach option.

A Shift to a Web Culture

The maxed out sharing-posting behavior of the agents has consequences. This is the reason that the edge approach in general has lower timeliness and efficiency scores and fails in high noise level situations. Fortunately, this maxed out mode of behavior is not the only way these organization-approach options could be implemented. Entities may adopt different policies and processes that affect information sharing and information seeking behavior with corresponding impacts on entity effectiveness and efficiency. At least theoretically, this would increase the regions covered on their agility maps.

If, for example, an entity adopts a post-only practice, that is, it limits all its information-sharing behaviors to posting to or pulling from websites, the entity can significantly reduce the number of actions and interactions involved. In doing so, the entity may achieve efficiencies that translate into a significant increase in its correctness score. Even if correctness is not increased, if the entity can maintain its correctness score when employing this policy, the entity will improve its efficiency, and perhaps it can also improve its timeliness.

	Average Correctness		Maximum Timeliness		Average Efficiency	
	Share/Post	Post Only	Share/Post	Post Only	Share/Post	Post Only
Twice the Noise	.059	1.000	.004	.656	.001	.088
Normal Noise	1.000	1.000	.311	.768	.013	.125
No Noise	1.000	1.000	.479	.831	.019	.190

Figure V-34: Impact of Policy and Workload on Edge, Complex Endeavor Challenge

As a first step in an effort to quantify the impact of the adoption of a post-only policy, the abELICIT runs done to explore the impact of workload on the edge organization-approach (complex endeavor challenge—34, 68, and 102 factoid sets) were rerun with a post-only policy in effect. The results, presented in figure V-34, show that the adoption of such a policy not only dramatically improves edge timeliness and efficiency, but it also serves to avoid the adverse impact on correctness that was previously observed when the noise level was high. Before the adoption of a post-only policy, only one of seventeen participants in the edge got the solution, while with this policy in place all the participants were able to get the correct answer. Furthermore, as workload increases, the improvements in timeliness and efficiency increase. For example, in the case of a no-noise situation, the adoption of a post-only policy improves maximum timeliness by 73 percent while for the normal-noise case the improvement is 147 percent and for the twice-the-noise case, the improvement is 16,300 percent. The noisier the information environment, the greater the relative advantage gained by an edge-organization approach with the adoption of a post-only policy.

Clearly, a post-only policy works well for the edge organization approach, as it attempts to deal with increased noise levels in the context of the complex endeavor challenge. But does this policy work as well for the edge when dealing with less challenging problems? If so, does it work as well as it did for the more challenging (complex endeavor) problem? Will this policy option work for the other organization-approach options? If so, in what circumstances does this policy work? Under what circumstances does it work best? To answer these questions, a series of abELICIT runs were made.

The first of these looked at the impact of a post-only policy for an edge across the set of mission challenges (with the noise level set to normal). Figure V-35 presents the results of these runs.

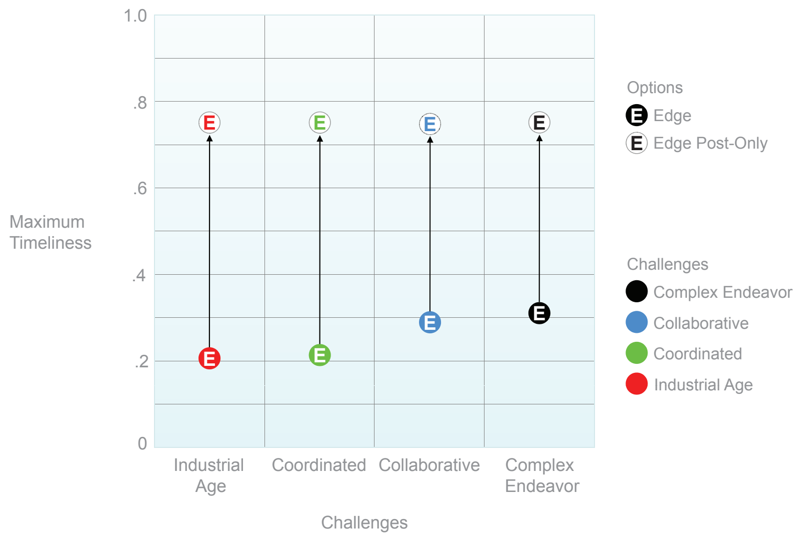

Figure V-35: Impact of Post-Only on Timeliness of Edge

Dramatic improvements in timeliness were observed for all mission challenges. These improvements in timeliness can be traced to the even more dramatic reductions in unproductive information sharing transactions. With a post-only policy in effect, the number of transactions is approximately 5 percent of the number observed when sharing-posting behaviors are maxed out. However, it should be noted that a post-only policy increases single points of failure in contrast to the maxed-out case where there is a very high level of redundancy. These results look only at the extremes. It seems reasonable that there would be a sweet spot in which unneeded information sharing is greatly reduced without at the same time creating single points of failure.

The next set of runs was designed to examine how the adoption of a post-only policy impacts the performance of other organization-approach options. As expected, a dramatic reduction in the total number of transactions was experienced. While this reduction was seen for all organizational-approach options, the edge experienced the largest reductions both in absolute and relative terms.

The next question to be addressed was whether or not the adoption of a post-only policy or practice adversely affected an edge approach's correctness and timeliness. Figure V-36 compares correctness, timeliness, and efficiency scores for each of the organization-approach options with and without a post-only policy for the industrial age challenge. The adoption of a post-only policy does not, in fact, impact the correctness scores of the various organization-approach options, but it does have a significant effect on both timeliness and efficiency scores. The edge approach gains the most from the adoption of this policy, improving its timeliness score fourfold. While the hierarchy-organization approach still performs the best with respect to maximum timeliness, the edge almost closes this gap while maintaining its shared understanding (average correctness score.) As for relative efficiency, while both the coordinated and edge options gain substantially, the edge approach gains the most.

	Average Correctness		Overall Leader Correctness		Average Task Performance		Maximum Timeliness		Average Efficiency	
	Both	Post Only	Both	Post Only	Both	Post Only	Both	Post Only	Both	Post Only
Hierarchy	.059	.059	1.000	1.000	1.000	1.000	.809	.831	.006	.028
Coordinated	.059	.059	1.000	1.000	1.000	1.000	.783	.831	.005	.028
Collaborative	.294	.294	1.000	1.000	1.000	1.000	.730	.821	.017	.144
Edge	1.000	1.000	n/a	n/a	1.000	1.000	.200	.768	.016	.534

Figure V-36: Adoption of Post-Only Policy, Industrial Age Challenge

These results change the agility maps for each of the organization-approach options and thus their comparative agility. Figure V-37 depicts the changes in a comparative agility map that take place when the organization-approach options adopt a post-only policy. The adoption of this policy makes it possible for at least one option to be successful in areas of the endeavor space where previously none of the options were able to operate successfully. For example, the collaborative approach can successfully satisfy the requirement for medium shared understanding and medium timeliness under conditions of high noise, by selecting a post-only policy.

Figure V-37: Comparative Agility with/without Post-Only Policy, Industrial Age Challenge

A more dramatic change can be seen when the noise level is twice the normal level. The edge becomes the preferred option and extends its ability to successfully operate in situations that require high levels of shared understanding. It is important to note that even though the edge runs involved far more transactions than the other organization-approach options, it was still able, albeit with comparatively lower timeliness scores, to turn in a perfect correctness score. This raises a set of questions regarding the ability of various organization-approach options, particularly the edge, to effectively deal with larger factoid sets. It is notable that with the adoption of post only as the policy choice, there is no longer any region of endeavor space where the hierarchy option dominates.

A Caution Regarding Post Only

As previously noted, adopting a post-only policy increases single points of failure. If one or more websites go down or even if one participant cannot gain access to one website, key information may be denied to those who need it. There is a trade-off that needs to be understood and the consequences assessed in light of circumstances before a decision is made to adopt policies that severely constrain the number of paths available and restrict information-sharing behaviors.

In the ELICIT experiments, each individual or agent is the first to see some information not unlike in the real world. Of course, not all this information is relevant, and some of the pieces of information are unimportant. Even if there is a failure that creates a disconnected network, that is, a network where at least one node (individual or website) is isolated from the rest of the organization or collective, it does not necessarily result in a failed mission (no one gets the correct solution). Failure will occur if, and only if, some key piece of information fails to get to the individual(s) that require it. The probability of failure thus depends on which link or links are down. In the case of an edge that strictly enforces a post-only policy, the probability of failure in abELICIT for an industrial age challenge is 8.82 percent if just one link goes down and not much higher at 9.09 percent if two links go down. These probabilities would be far too high in many, if not most, real world situations. By contrast, taking just one link down in a hierarchy run will not cause a failure, while taking two links down guarantees failure with a probability of 1.95 percent. All these probabilities are best-case scenarios since the agents are perfectly behaved and never make cognitive mistakes.

Impact of Post Before Process Policy

There are a number of policies that can significantly affect the degree to which and the time required to develop shared understanding, whether at the individual, organization, or collective level. These policies include those that determine access to information and those that specify required information-sharing behaviors. The book *Power to the Edge* asserted "To make this new information dissemination strategy work, organizations need to adopt a policy of *post before processing*. Such a policy serves to make certain that the network is populated with information in a timely way."[142] Also known by the acronym TPPU (task post process use), TPPU replaced a long-standing practice of TPED (task process exploit dissemination). Such a strategy was introduced by the U.S. Department of Defense and has been instantiated to varying degrees by different organizations. The adoption of this policy was based on the belief, supported by deductive reasoning, that the above assertion in the book *Power to the Edge* is valid.

142. *Power to the Edge*, pp. 82–83.

To test this experimentally, a policy flag in abELICIT, when set to post before process, causes an agent to post some of the factoids received to appropriate websites before the information is processed and evaluated. Post before share means that information is shared before an agent can update its own understanding. Additional sharing/posting of factoids may also occur after the information is processed, based on a number of parameters and accesses. This stands in contrast to the baseline case, process before post, where a decision to share or post is made after an entity has evaluated the information in question. Given that policies are not always followed by everyone, this flag applies to individual agents and runs can be configured with an arbitrary number of agents that follow or do not follow this policy.

Each of the organization-approach options was run with a post-before-process policy and a process-before-post policy in effect. All agents were assumed to follow this policy. The results showed that simply instituting such a policy did not improve average correctness scores. The only discernable impact was to slightly improve the average timeliness of the edge approach.

A look at these runs in detail identified the impediment to information sharing that prevented this policy from achieving its objectives. The impediment was the fact that individuals' access to websites was not altered as part of an adoption of this policy. Therefore, while agents wanted to post all the information they received, if they received information outside one of the areas to which they were assigned, they did not have access to the appropriate website and could not post the information.

Furthermore, agents worked on information relevant to their assignments and hence did not process this information. Consequently, they did not have an opportunity to share it. In the actual implementation of this policy, major gains have been made within communities of interest (COI) where members have reasonable access to websites of mutual interest. Even with this policy in place, information sharing between and among disparate COIs is not effected significantly.

If the information needed to connect the dots is widely dispersed and unlikely to be accessible by a particular COI, then it is unlikely that the information will be shared widely enough to connect the dots. The edge approach, as it is conceived and implemented in these experiments, does not limit the interests or accesses of participants. Therefore, the information that gets stuck in non-edge organization-approach options gets shared, and as a result, the edge succeeds.

This result suggests that hierarchies, even those with coordination mechanisms or collaborative processes, still limit individual initiative and information flows in ways that reduce the probability of success.

Chapter 25
Impact of Problem Difficulty on Organization-Approach Agility

Problem difficulty, as the term was defined earlier, is a function of the nature of the problem, including the environment in which the problem exists, and the characteristics of the entity seeking to solve the problem. There is both an absolute and relative aspect to problem difficulty. Some situations are objectively more difficult with which to deal than others and some entity characteristics make dealing with a particular situation more or less difficult. In the final analysis, Agility requires that an entity be relatively insensitive to variations in problem difficulty. The agility an entity possesses is manifested by its being able to find a way to successfully cope with problems that have different time pressures, amounts of complexity, levels of uncertainty, or degrees of risks.

The ELICIT and abELICIT results reported on above illustrate how a particular condition (e.g., the level of noise) affects the ability of the different organization-approach options to meet the challenges posed. The level of noise present was reflected in the number of factoids made available. As the number of factoids increased, the workload of individuals who had to process and share more factoids increased. Since abELICIT runs were made not only for combinations of noise levels and organization-approach options, but also for the different problem challenges, these experiments also provided some insights into the ability of the different organization-approach options to tackle different types of problem challenges (e.g., complex endeavor vs. industrial age) with different requirements for shared understanding and timeliness. Finally, the combination of both noise and problem challenge were explored. Here I extend this initial look at problem difficulty by looking at the complexity or perceived complexity of the problem itself.

The first ELICIT experiments to offer some insights into the relative ability of different approaches to deal with problem difficulty caused by complexity were serendipitous. Four data sets were developed so that human participants could play the game multiple times without profiting from information obtained in previous runs (although they might learn how to approach solving these sorts of problems). Analysis of runs by participants from different institutions, levels of experience, nationalities, and backgrounds clearly indicated that the edge approach outperformed the hierarchy in both correctness and timeliness but resulted in more transactions during the course of the experiment.

There were reports that one of the datasets seemed to be more difficult to solve. This report came as a surprise because these datasets were initially considered to be of equal difficulty since they were all simply variants on the first factoid set that was developed; each had a similar structure and the same number of relevant and noise factoids. An analysis of the findings from a matched pair of experimental runs[143] confirmed that indeed one of the data sets was empirically harder to solve than the others (fewer people were able to correctly solve the problem). The results of this comparative analysis are presented in figure V-38.

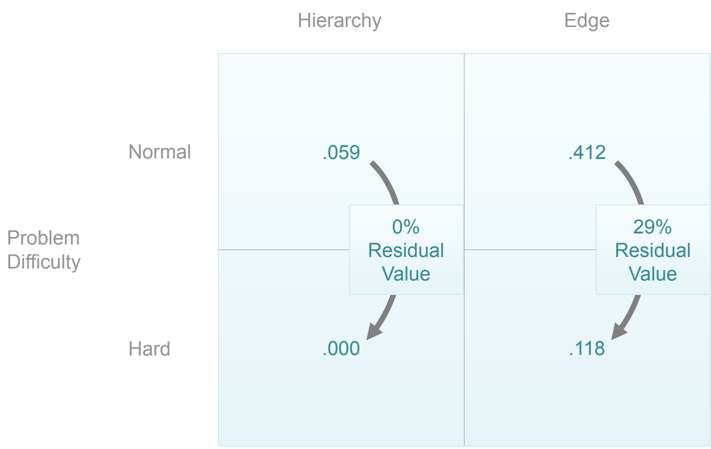

Figure V-38: Correctness as a Function of Organization and Problem Difficulty

The results from this matched set of experiments were as follows:

- Edge outperformed the hierarchy for both the normal and hard problems.

143. These experiments were conducted at the Naval Postgraduate School (NPS). A more complete analysis of runs conducted at NPS can be found at http://www.nps.edu/Academics/Centers/CEP/work.html.

- Both the hierarchy and edge groups were adversely affected by the increase in problem difficulty.

- The edge group was relatively less adversely impacted.

In this matched set of experiments, the performance of both types of approaches when given normal problems to solve was found to correspond closely to the results from the much larger set of experiments. The results in both cases were significantly different when they were given the harder problem. In the case of the hierarchy, no one found the correct solution to the more difficult problem; thus this change in circumstances resulted in a 100 percent degradation of performance. The edge group faired better, maintaining 29 percent of its level of performance. Even at 29 percent of its performance under normal circumstances, the edge performed better in this more difficult circumstance than the hierarchy performed with the normal problem. In fact, the edge performed twice as well (.118 vs. .059).

Figure V-39 presents a different way of presenting these results.

Impact of Problem Difficulty on Organization-Approach Agility

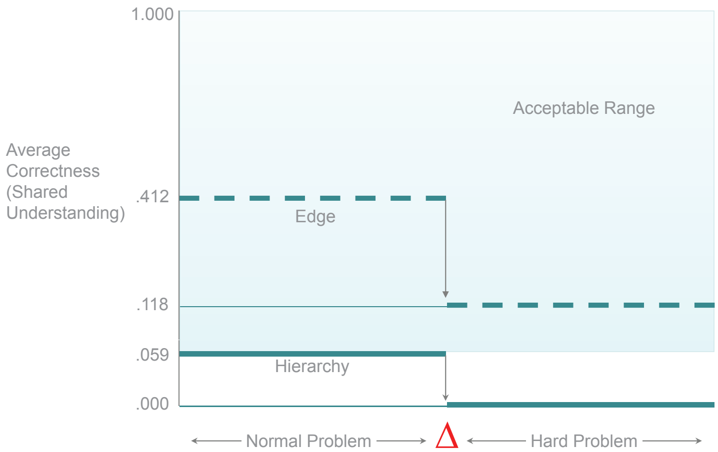

Figure V-39: Relative Sensitivity of Options to Problem Difficulty

The minimum acceptable value for shared understanding (average correctness = .059) is set at a value of average correctness that translates into one person with the correct solution. Readers should be mindful that the acceptable range is a subjective judgment. The most reasonable argument for setting the minimum value to .059 is that in a hierarchy only one person needs to get it right if this person is the overall leader since the correct solution will be conveyed in various forms to the rest of the organization.[144] The story of this chart is rather compelling. Given normal problems, both approaches perform acceptably, but when the problem is a hard one, the hierarchy is unable to cope with this change in circumstance, while the edge, although degraded, remains in the acceptable range.

144. I do not agree with this line of reasoning for a variety of reasons which I previously expressed in *Power to the Edge* and other books.

If these results hold up in repeated experiments that explore problem difficulty, the edge approach could be said to be more agile than the hierarchy with respect to problem difficulty.

The above results illustrate how the comparative agility of various approaches can be ascertained. In this case, the circumstance involves an increase in cognitive complexity. Specifically, the solution to one of the problems required a more involved description of the target (multiple adjectives).

Problem difficulty, as discussed in part I and depicted in figure I-6, is a function of a number of characteristics, including time pressure, uncertainty, and risk.

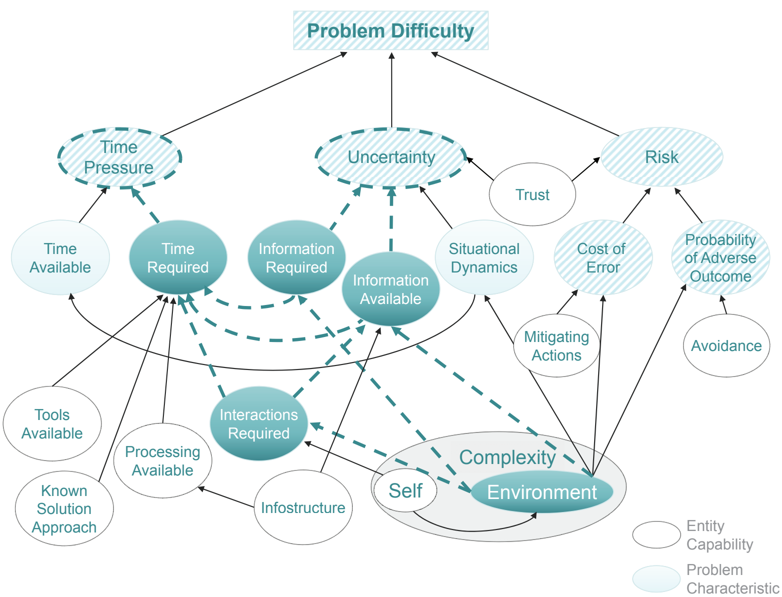

Figure V-40: Sources of Problem Difficulty

Figure V-40 highlights the ways in which the need to know more about the characteristics of a target in order to solve the problem contribute to the problem's level of difficulty. Specifically, how this need for more information increases both the workload required and the uncertainty involved. When looking at the transaction logs for these experiments, it is clear that increased workload was not a factor. Rather, the difficulties arose from confusion about what it took to sufficiently describe the target.

The above results are from human trials. To further explore the impact of problems that increase cognitive load and variations in the ability of individuals to handle a given load, a set of abELICIT experiments was conducted. In these experiments, the complexity of the problem is related to the cognitive tasks that agents perform as they process factoids. In abELICIT agents think by creating truth tables. Processing factoids involves one of more cognitive tasks as a function of whether or not the factoids results in the creation of a new table, a change to an existing table, or the linking of one or more tables.[145] The ability of an individual to handle these tasks is represented by a parameter that governs the delay associated with the performance of these tasks. Cognitive complexity is a function of the problem challenge, the level of noise, task assignments, and the ability of individuals to handle given cognitive tasks.

145. The ability of abELICIT to deal with conflicting, out-of-date, and/or misinformation will be added in the next major release of ELICIT. The introduction of conflicting, out-of-date, and/or misinformation will greatly increase complexity and hence, problem difficulty.

Figure V-41 depicts how increased cognitive complexity affects the ability of the hierarchy and the edge to satisfy shared understanding and timeliness requirements for the industrial age challenge.

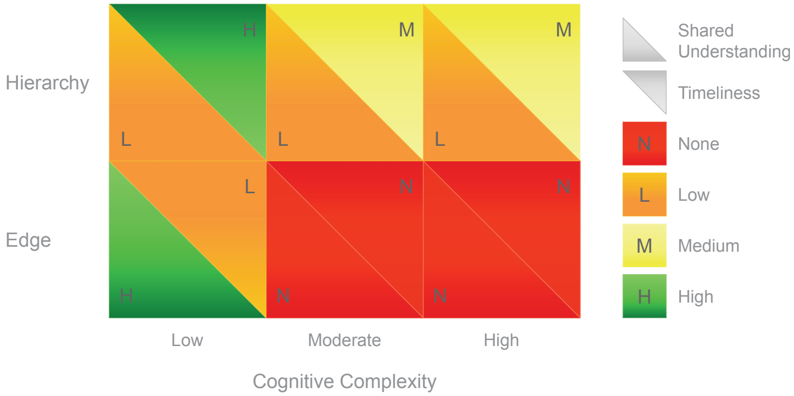

Figure V-41: Impact of Cognitive Complexity, Hierarchy vs. Edge, Industrial Age Challenge

Both the hierarchy and edge have relative advantages when cognitive complexity is low in that the hierarchy provides more timeliness, while the edge provides greater shared understanding. The edge option is unable to function successfully with increased cognitive complexity. On the other hand, the hierarchy, which can only develop a low level of shared understanding even with low cognitive complexity, is able to maintain this level of performance and suffers only a modest loss of timeliness as cognitive complexity increases.

This is the result for the maxed-out edge, and in real situations, it is highly unlikely that all individuals would share with all other individuals all the time. In fact, the human experiments show that in many edge trials, the participants relied on websites rather than sharing with one another and, as a result, had very low sharing rates. Figure V-42 adds the results for a post-only edge.

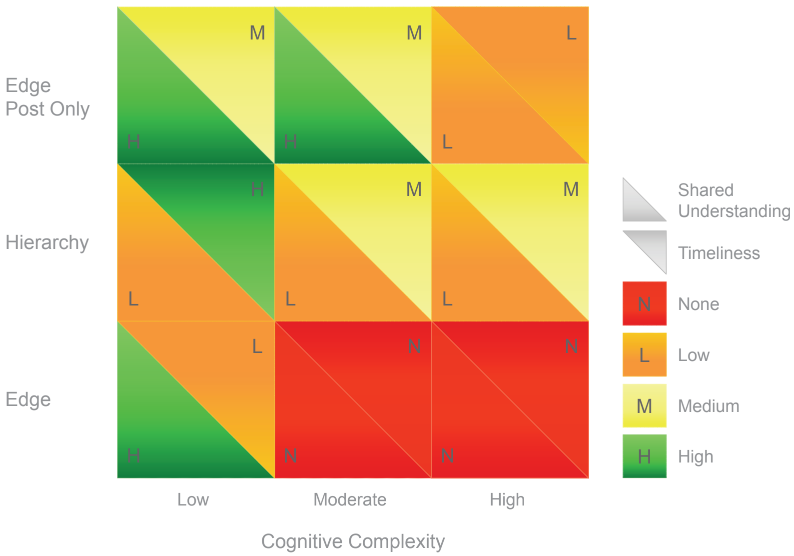

Figure V-42: Impact of Cognitive Complexity, Post-Only Edge vs. Hierarchy vs. Edge, Industrial Age Challenge

The post-only edge covers more of the endeavor space (has more agility) than either the hierarchy or edge when cognitive complexity is low. The post-only edge also has an advantage over the hierarchy when complexity is moderate, while the reverse is true when cognitive complexity is high.

These results show the ability of these different organization-approach options to maintain effectiveness over a range of mission requirements (shared understanding and timeliness) for one mission type (industrial age challenge) in the face of one stress (cognitive complexity). If, however, multiple stresses were present, how would that affect the agility maps associated with these entities? Figures V-43 and V-44 look at the ability of the hierarchy and the post-only edge to maintain effectiveness as both the levels of cognitive complexity and noise are varied.

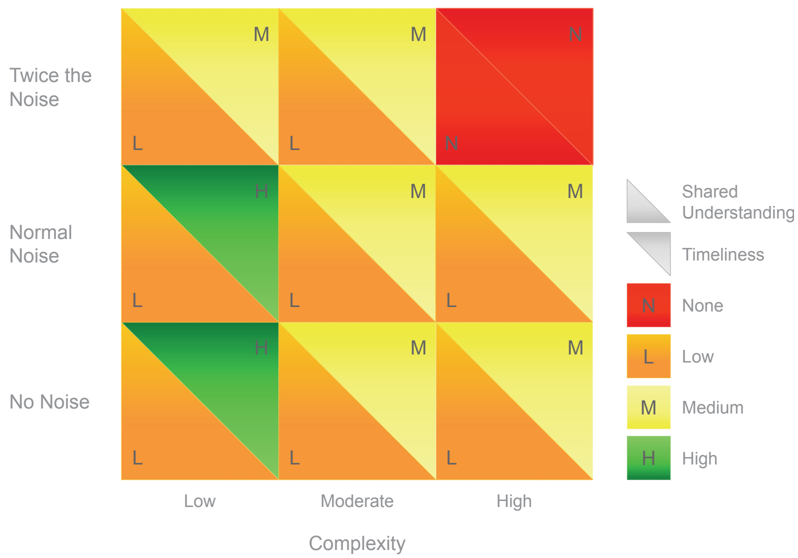

Figure V-43: Hierarchy Agility Map, Complexity and Noise, Industrial Age Challenge

In the case of the hierarchy (see the hierarchy agility map, figure V-43), when the level of noise is reduced, no improvements in performance are noted. When the level of noise is increased, the performance under conditions of low cognitive complexity is degraded and, for conditions where there is high cognitive complexity, the hierarchy is no longer able to function successfully.

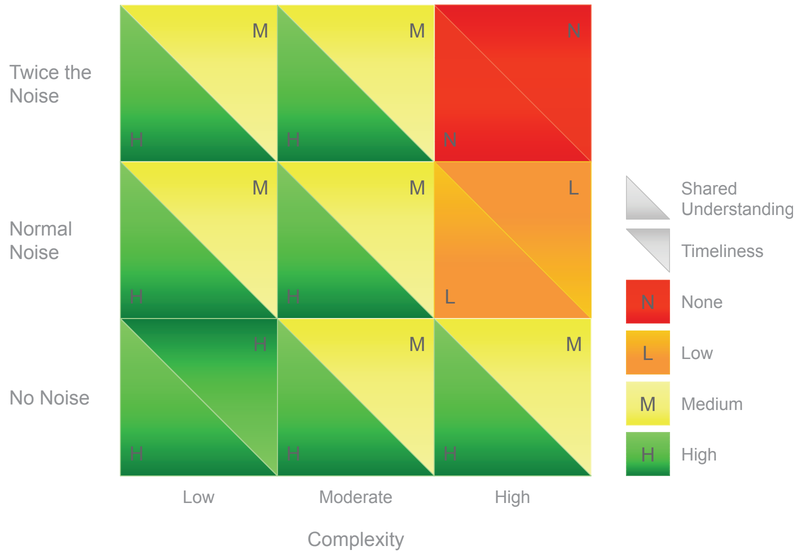

Figure V-44: Post-Only Edge Agility Map, Complexity and Noise, Industrial Age Challenge

The agility map for the post-only edge (figure V-44) shows the ability of this organization-approach option to take advantage of reduced noise. When there is no noise, and when cognitive complexity is low, the post-only edge can be successful when both the requirement for shared understanding and timeliness are high (increasing its timeliness when compared to a situation when the noise level is normal). When there is no noise, even when the level of complexity is high, it is able to increase both its shared understanding and timeliness.

When we compare these two agility maps, we see that the post-only edge has a competitive advantage over the hierarchy in most of the regions of the endeavor space. There are three exceptions. First, when the level of noise is normal and complexity is low. In this case, both organization-approach options have some advantage with the post-only edge developing a higher degree of shared understanding, while the hierarchy is more timely. Second, when the level of noise is normal and complexity is high, the hierarchy has the advantage. Third, when both the noise and complexity levels are high, neither can function successfully.

Impact of Problem Difficulty on Organization-Approach Agility

Chapter 26

Agility and Cybersecurity

The critical role that information sharing and collaboration play in enabling individuals, organizations, and collectives to meet the challenges they face in the 21st century has become a given; yet entities remain reluctant to share the information they have or to depend on information that originates elsewhere. Culture, confidence, and trust lie at the heart of the matter. Asking individuals to change their behaviors or trying to influence their behaviors simply by extolling the virtues of information sharing may be necessary, but it will not be sufficient. Trust in others to use and share the information appropriately; trust in the correctness, timeliness, and accuracy of information whose sources are unknown; and confidence that the network will be there when it is needed must be developed if we are to expect increased information sharing and collaboration.

Given that there is ample evidence that trust can be misplaced, information can be misused, and the network can be down or severely degraded at the very moment one needs it, cyberspace is far from a well-behaved and benign environment. With this realization, entities, both private and public, have begun to step up their investments in information assurance and more recently in what is called *cybersecurity*. In doing so they are making trade-offs, many of which may not be explicit, and most of which are currently not well understood. Specifically, they are making trade-offs between increasing access and maintaining or increasing security (or at least, perceived security), between being more effective over a larger region of the problem space, and being more efficient in terms of costs and timeliness.

A recent advertisement in the *New York Times* by Cisco[146] (figure V-45) seemed to promise that if one switched to the *cloud* some of these trade-offs would not be necessary.

Figure V-45: Promises, Promises, Promises

146. *New York Times*, January 29, 2011, p. 9.

Perhaps this is true or maybe one day technology will be able to ensure openness, security, agility, and efficiency. The revolution we have witnessed in military affairs (network-centric warfare), in business affairs (e-business), and in the provision of governmental services (e-gov) was made possible by advances in technology that changed the shape of curves that defined trade-offs between and among information richness, reach, and the quality of interactions.[147] Previously, if one wanted to increase one of these three dimensions, one had to reduce another of these dimensions or incur significantly increased costs. With current telecommunications costs and networking and computer capabilities, one can both reach more individuals and provide increased information richness without incurring significant additional costs. It remains to be seen if similar progress can be made in the trade-offs between and among openness (access), security, efficiency, and agility. This book provides readers with both the conceptual framework and metrics to test claims of this sort.

To properly make these trade-offs, or to test espoused claims, one needs to be able to quantify impacts and consequences. For example, how available does a network need to be to accomplish the mission? What is the impact of a degraded (less bandwidth or paths available)? What is the impact of having a piece of information corrupted or replaced by misinformation? Of course, the answers to these and other similar questions are situation dependent. But by looking at a range of situations and seeing

147. This observation is discussed in Alberts, D.S. et al., *Understanding Information Age Warfare*, pp. 44-49. See http://www.dodccrp.org/html4/books_downloads.html.

the impact on effectiveness and efficiency and by calculating the probabilities, we can make better-informed trade-offs.

Agility is about maintaining acceptable levels of effectiveness and efficiency in the light of changes. Actions taken to enhance agility include those taken to recover from damage to, and/or degradation of network availability and performance, as well as those actions taken to protect communication and information-related infrastructure (infostructure).

In abELICIT experiments reported on earlier, some light has been shed on the relationships between and among organization-approach, information-sharing policy, and characteristics of the challenge. This section takes a look at the impact that a damaged or degraded network and/or loss or corruption of the information it carries can have on the effectiveness of the organization-approach options. We would expect that in some cases these impacts are independent of other circumstances and conditions, while in other cases they are codependent on circumstances and conditions. These dependencies or lack thereof will be discussed in the context of specific experiments.

Impact of the Loss of Connectivity

Although the word network is used by many people to refer only to a communications or computer network, it is used here to include social and process networks as well. While these networks usually depend on a communications/computer network to support interactions between individuals and processes, there is not a one-to-one relationship between the links or connections in these different networks. For example, in a social network a direct interaction between two individuals can be represented by a signal link. The characteristics of this link, including its existence at any point in time, depend on the status of the communications and/or computer networks involving a large number of nodes and links. That is, the virtual interaction between the two individuals in question might involve multiple paths transversing multiple networks. In today's sophisticated communications and computer networks, if one of these paths is not properly functioning, another path will be automatically tried. A lost link in a communications network, although it may adversely affect network performance, does not necessarily translate into a loss of connectivity from a social network perspective.

Our analysis of the impact of a damaged network views the loss from a social network perspective. That is, does the damage sustained prevent individuals from directly interacting with one another? Figure V-46 presents the probability of certain failure as a result of a loss of just one direct connection (one specific pair of individuals or an individual and a website) for each of organization approach as a function of the information-sharing policy they adopt when faced with an industrial age problem. In this case failure equals an outcome where no participant is able to obtain the correct solution.

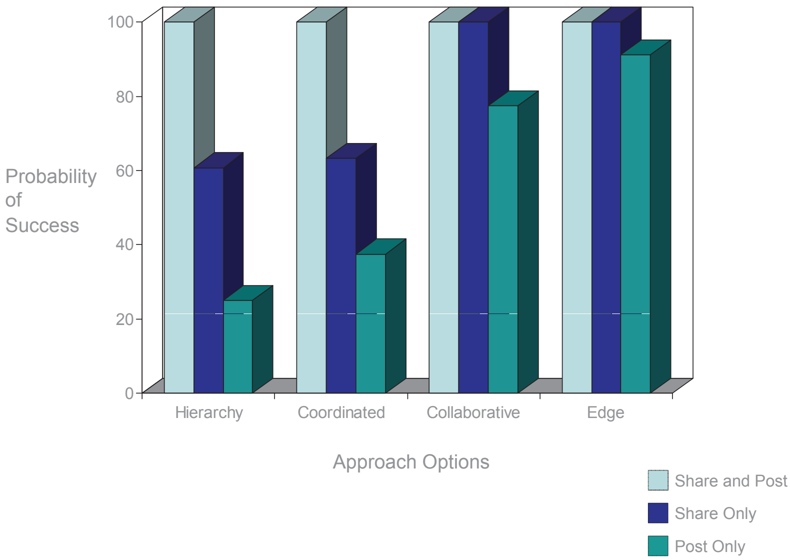

Figure V-46: Impact of Loss of One Connection

As would be expected, as more restrictive sharing policies are put into effect, the adverse impact of a loss of just one connection increases. The amount of information sharing that takes place is both a function of organization-approach and the permissible sharing modalities (e.g., share and post, share only, or post only). It should be noted that in hierarchies the limited organizationally determined paths (in the social network) available for information sharing have little reason to adopt modality restrictive sharing policies unless their communications/computer network resources cannot provide adequate bandwidth. The same is true to a lesser extent for coordinated and collaborative approaches. On the other hand, we saw earlier that maxed-out edges can result in extremely high bandwidth requirements and place very high sharing-related workload demands on individuals. The adoption of a post-only policy for edge organization-approach options may be required in some cases.

One could reasonably compare post-and-share hierarchies, coordinated, and collaborative options to a post-only edge. In doing so, the edge experiences an 8.8 percent failure rate when only one link is randomly lost or compromised as compared to no loss of effectiveness experienced by the other options. It should be noted that, in cases when the loss of a single connection results in failure because vital information is not made available, these results are independent of other conditions. That is, for example, having a cognitively easier problem or less workload cannot compensate for the loss of a link in this case.

Figure V-47 provides the results of these calculations for a loss of two connections.

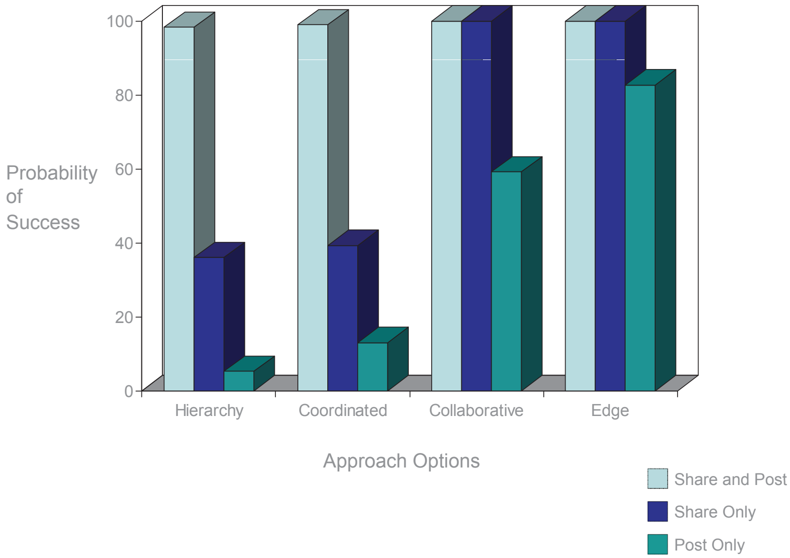

Figure V-47: Impact of Loss of Two Connections

A loss of two connections results in failure for hierarchies and coordinated approaches with probabilities 1.3 percent and 1.0 percent respectively, even when they both post and share. This is far better than a post-only edge, which would be expected to fail 17.3 percent of the time.

Clearly, the loss of connectivity is related to an entity's or collective's (set of entities) social and process topologies, as well as, their cybersecurity capabilities and the design and performance of their infostructure. As we all have seen, network failures (social, process, information, and communications) are bound to happen whether they are the result of an adversary attack or as a result of some other cause.

Impact of the Loss of a Website

Figure V-48 presents the results of two series of abELICIT runs. In the first series, a website is taken down at the start, while in the second series, there is no attack. Cognitive complexity was varied.

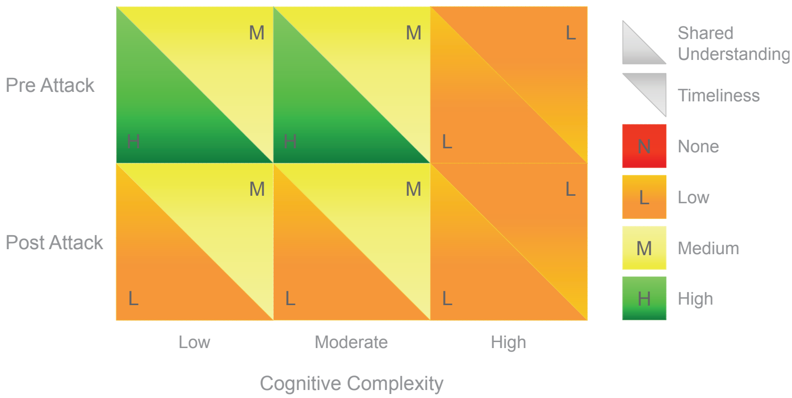

Figure V-48: Impact of Website Attack, Post-Only Edge, as a Function of Cognitive Complexity, Industrial Age Challenge (color coded)

These results show that such an attack has a significant adverse impact on shared understanding, reducing it from high to low when cognitive complexity is low or moderate. When cognitive complexity is high, the entities can only achieve low levels of shared understanding and timeliness, with or without an attack.

A more granular analysis of the results, one that also takes into consideration cognitive complexity (presented in figure V-49), provides additional information.

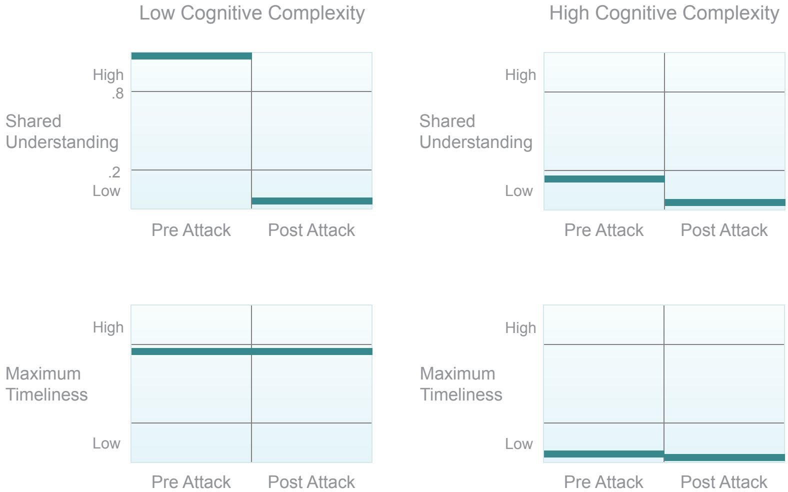

Figure V-49: Impact Analysis of Website Attack, Post-Only Edge, as a Function of Cognitive Complexity, Industrial Age Challenge

In figure V-48, where low, medium, and high were simply color coded, it was not possible to distinguish between the magnitudes of the impacts within bands of performance. For example, when cognitive complexity was high, both shared understanding and timeliness were low both pre- and post-attack. Figure V-49 shows that while they may be both *low*, the attack does indeed substantially degrade the level of shared understanding (from 176 to .059), while it has a smaller impact on timeliness (from .046 to .015).

Impact of Information Corruption/ Misinformation

Adversaries may not want to take down a link, but rather they may wish to destroy information to deny the information required to accomplish a task or mission or to corrupt or change information to mislead. The impact of lost information has been previously explored since the impact of the availability of information is independent of the cause of its lack of availability. If data is corrupted so that the information it contains is no longer available, the impact is the same as that of lost information.

The alteration of information or the insertion of misinformation is another matter. Misinformation can have a number of different results depending on the nature of the misinformation itself and the ability of the humans or agents to recognize incorrect information when they see it.

Currently abELICIT agents do not have the capability to deal with conflicting information, that is, to resolve conflicts by discarding the least trusted information based on agent assessments of the trustworthiness of information sources, other participants, websites, and the communications network itself. These capabilities have recently been incorporated into the ELICIT platform and should become available to researchers late in 2011. Readers may wish to acquaint themselves with the latest research results by visiting the CCRP website (www.dodccrp.org).

Chapter 27
The Advantage of Being Adaptive and Flexible

Entities can improve their agility by increasing the degree to which they possess one or more of the capabilities associated with the components of agility. That is, an entity can take steps to be more responsive, versatile, flexible, adaptive, innovative, or resilient. This chapter takes a look at the impact that degrees of adaptability and flexibility have on an entity's agility.

The difference between flexibility and adaptability is somewhat arbitrary. Flexibility is about being able to have multiple ways of accomplishing something—ways that do not involve an entity changing itself. Adaptability is about being able to change self. In the first example, we are considering an entity's ability to adopt different organization-approach options. This is an example of adaptability, since a change in approach requires a change to the basic structure of an entity (a change to the allocation of decision rights). In the second example, we are looking at the impact of an entity's being able to select from among at least two different information-sharing policies. Although this is a change of behavior, it is not considered to be structural change (a change to self), and thus, we are looking at the entity's flexibility. In both cases, the choices available are not the only important thing. It is also important whether changes can be made on the fly or merely prior to or at the start of the engagement.

An Example of Organization-Approach Adaptability

For example, figure V-50 shows the difference in the agility map of an entity that is capable of adopting more than one organization-approach option (provided it can also recognize in advance the option that would work for the situation at hand in time and implement that option).

Figure V-50: Impact of Adaptability as a Function of Required Shared Understanding, Timeliness, and Noise

The degree of adaptability that makes sense depends on the relative merits of the options that are added, the costs to add these options to an entity's kit, and the mappings between the approach space and the endeavor space. These mappings reflect the relative agility of each specific option and the degree to which these options overlap in endeavor space. Each of the organization-approach options possesses some agility (the shaded region of its agility map). In some cases investing in a more agile option may be better than having a set comprised of a number of less-agile options; in other cases, the reverse may be a better strategy. Being able to instantiate more than one organization approach has also been described as the ability to move around the approach space. In this case it means at the very least being able to move from a point located in the region associated with one approach option to a point located in a region associated with a different approach option.

One can also envision being able to move within a region that is associated with a given organization approach option and this local move instantiates different versions of, for example, an edge or a hierarchy. To put another way, this means not to change self, but rather to change behavior to accommodate circumstances.

An Example of Policy Flexibility

Figures V-35, V-36, and V-37 show the impact on organization-approach performance of correctly selecting the most appropriate information-sharing policy. In certain circumstances, the ability to adopt a post-only information-sharing policy can improve both shared understanding and timeliness. However, this change in policy comes at a cost. As we have seen, post only creates vulnerabilities, particularly to cyberattacks or other network connectivity or performance problems. If an entity can choose its policy in response to circumstances, then one would expect that the entity would be able to take advantage of the best of both policies.

In the experiments discussed to this point, the organization-approach options, the information-sharing policies, or other rules of the game were determined at the beginning of the run *without regard* to circumstances and/or conditions. Furthermore, these organizational or policy choices remained in place throughout the run. If an organization-approach option employed a post-only policy, this policy continued to be in effect even if the conditions on the ground made this policy ill advised. For example, if the level of noise is high, and as a consequence workload is high, one would expect (or at least hope) that in real life the participants in an edge would have recognized the situation and would have chosen their information-sharing behaviors more appropriately.

In the language of agility, if an entity's policy can be selected appropriately as a function of conditions, then the entity is displaying the ability to be flexible. Let us compare the agility maps of three entities: the first with only a post-and-share policy, the second with only a post-only policy, and the third that can adopt either policy. We should expect to see differences in these three maps. Specifically, the agility maps for the post and share and post-only entities would have areas where each was better than the other. For the flexible entity, we should see the best of both worlds, resulting in an increase in the area of endeavor space where the entity can be successful. The set of three figures (V-51, V-52, and V-53) provides these maps. This is an interesting comparison because the entity is being pulled in two directions as the conditions change. As the level of noise increases, a post-only strategy makes sense, but as the damage to the network sustained from an attack or from some other event increases, it makes sense to have the increased path redundancy that comes with a share-and-post strategy.

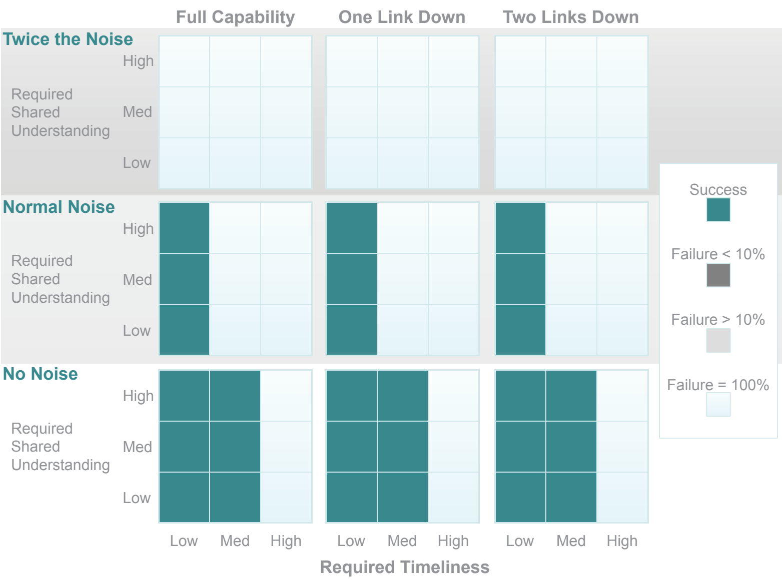

Figure V-51: Agility Map: Share-and-Post Edge Under Varying Noise and Sustained Network Damage, Industrial Age Challenge

Figure V-51 looks at the agility map for a share-and-post strategy as a function of both noise level and damage. As a rough indicant of the size of the region in endeavor space in which a share-and-post edge can successfully operate, one can calculate the percentage of shaded cells to total cells. In this case, the share-and-post edge can successfully operate in only 33 percent of endeavor space. The share-and-post edge's inability to deal with conditions of high noise results in making it infeasible for the entity to successfully operate in a large chunk of endeavor space. In addition, the region of endeavor space that corresponds to a requirement for high timeliness is also infeasible.

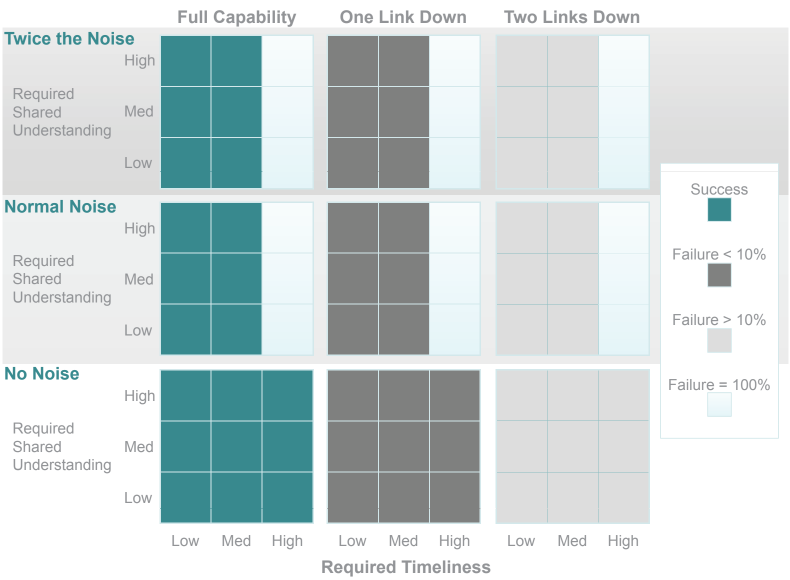

Figure V-52: Agility Map: Post-Only Edge, Under Varying Noise and Sustained Network Damage, Industrial Age Challenge

Figure V-52 presents the agility map for a post-only edge in an endeavor space that reflects different mission requirements (need for shared understanding and need for timeliness) and different conditions (level of noise and network connectivity). The adoption of a post-only policy allows the entity to successfully operate in high-noise conditions as long as there is not a simultaneous requirement for high timeliness. Furthermore, the post-only edge can satisfy a requirement for high timeliness as long as there is no noise. A post-only policy makes the entity vulnerable to the loss of one or more network links. The number of cells where the entity can operate without fear of a failure due to network damage drops from 27 (share-and-post edge) to 21. If the entity is satisfied with a 90+ percent chance of success, the percent of endeavor space covered increases to 52 percent (up from 33 percent), and if the entity finds operating with a 17 percent failure rate to be acceptable, then it can successfully operate in 78 percent of endeavor space.

Another way to calculate the coverage of endeavor space that takes into consideration the probability of failure (due to network damage) is to weigh each cell by the probability of success. In this case, 21 cells with a 100 percent success rate, 21 cells with a 91 percent success rate, 21 cells with an 83 percent success rate, and the remaining cells with a 0 percent success rate. The expected success rate for a post-only edge in this endeavor space calculates out to 71 percent as compared with the share-and-post edge region of success, which calculates out to only 33 percent.

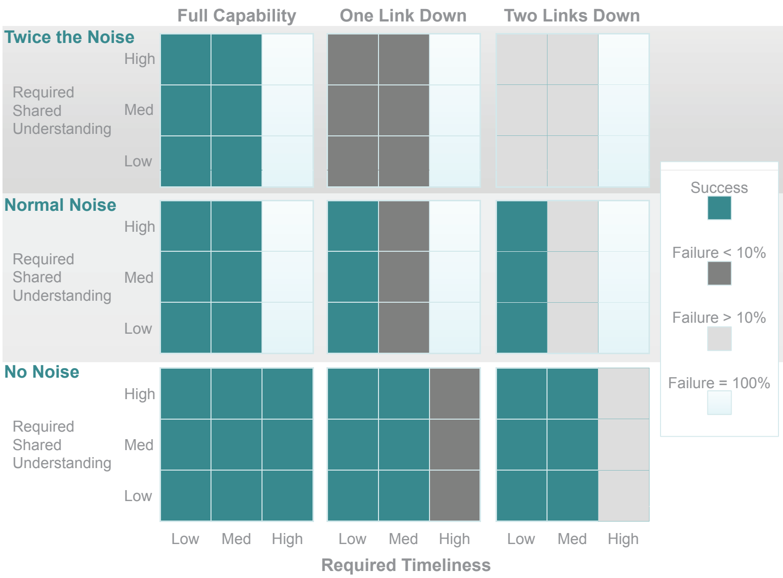

Figure V-53: Edge Approach with a Flexible Policy, Under Varying Noise and Sustained Network Damage, Industrial Age Challenge

Figure V-53 presents an edge with the capability to implement more than one information-sharing policy and where the appropriate policy is selected by participants based on conditions. Thus, the entity has policy flexibility. As previously mentioned, this provides an entity with the advantages of both policies. The expected success rate for this flexible edge in this endeavor space increases to 83 percent as compared with the 71 percent for the post-only edge and the 33 percent of the share-and-post edge. These results assume that the situations are stable during the run.

The next set of runs illustrates the power of a policy that is not only flexible but can also be changed dynamically. A dynamic capability involves an ability to choose from a menu of policies in order to cope with *changes that may take place during a run*. In this set of runs, it is assumed that participants can sense when a link or a service goes down and change behavior accordingly. Specifically, if and when an agent experiences a problem with posting to a website, the agent will begin to share as if the policy was share and post.

Responding to the Loss of a Website

As we have seen, one way to deal with increased workload (noise) or communications delays is to reduce the total number of shares, posts, and pulls. That is why the performance of an edge (an approach with the highest frequency of information sharing and seeking transactions) degrades considerably with higher noise levels (see figure V-24). In cases where there is a high level of noise, it makes sense to adopt a post-only edge. A post-only edge is vulnerable to degradation in network performance, the loss of access to a website, or a website going down completely. If under conditions of high levels of noise, the situation permits one to succeed with a low level of shared understanding, then adopting a form of hierarchy or limiting information sharing may work. In order to make an informed choice of organization approach and policy, one needs to quantify the impacts that network malfunctions, degradations, or the loss of capability may have on the ability of an entity or collection of entities to operate successfully. For example, what impact would the loss of a website have as a function of the different organization-approach and policy options and different levels of noise and cognitive complexity?

Figure V-54 compares the results of a set of post-only edge runs where one website was taken offline to results of runs where no attack took place under different noise conditions. Post-only edge was selected because, under normal network performance conditions, it has a higher agility score than a share-and-post edge. In one set of runs where an attack took place, the edge must continue with a post-only policy despite the attack, that is, it cannot dynamically change its policy choice. In the second set of runs, the entity can respond to such an attack by dynamically changing to a policy that permits selective sharing.

	Average Correctness			Maximum Timeliness			Average Efficiency		
	No Attack	Attack Post-Only	Attack Flexible Dynamic	No Attack	Attack Post-Only	Attack Flexible Dynamic	No Attack	Attack Post-Only	Attack Flexible Dynamic
Twice the Noise	1	0	1	.66	-	.62	.09	-	.08
Normal Noise	1	0	1	.77	-	.73	.13	-	.12
No Noise	1	0	1	.83	-	.83	.19	-	.19

+ Cyber attack takes down one website after first item is posted to it
+ Flexible behavior changes from Post-Only to selective sharing

Figure V-54: Impact of a Flexible and Dynamic Information Sharing Policy, Website Attack

The loss of just one website for an edge organization-approach option that adopts a post-only strategy and is unable to dynamically change its policy if the circumstances require a change, is catastrophic regardless of noise conditions. The ability of an edge to dynamically change its policy makes it possible to restore performance almost to the level experienced if there were no attack. In this experiment, when a problem is encountered with accessing a website, agents begin to selectively share. Figure V-54 shows that, as a result of being able to change information-sharing behaviors, the entity manifests perfect resiliency with respect to developing shared understanding and a very high level of resiliency with respect to timeliness and efficiency. Furthermore, these levels of resiliency are maintained under all noise conditions that were considered. While figure V-54 presents the result for the post-only edge, this result holds for the other organization-approach options. One can reasonably conclude from these results that the agility-related capabilities that an entity requires are driven by the characteristics of endeavor space.

The results of case studies undertaken by a NATO Research Group suggested that for a given endeavor space (characterized by its dynamics and complexity) there is an appropriate level of agility required. The appropriate level was called *requisite agility*. These findings support this conclusion—specifically, if there are regions of interest in the endeavor space that are dynamic, the entity must also be dynamic.

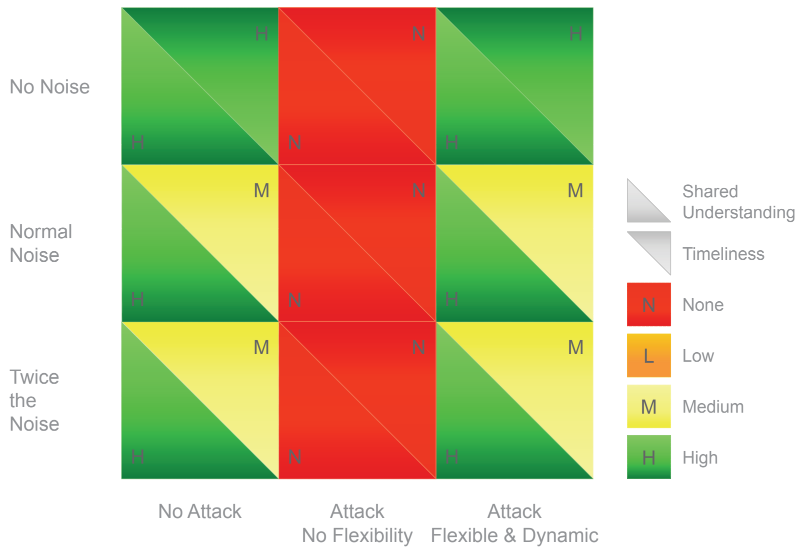

Figure V-55: Impact of Website Attack, as a Function of Noise, Post-Only Edge with/without Flexibility, Industrial Age Challenge

Figure V-55 provides a different graphical presentation of these results. This way of presenting the results shows at a glance that a flexible and dynamic policy was able to, at this level of granularity, fully mitigate the adverse effects of a website attack that took place *after* the operation began. Both shared understanding and timeliness were maintained at their previous levels regardless of noise level. While figure V-55 provides key information at a glance, since results are simply color coded, it is not possible to distinguish between the magnitudes of the impacts within bands of performance (e.g., low). For example, when noise is high, it is not clear if a flexible and dynamic policy actually fully mitigates the adverse consequences of an attack or if there remains some residual degradation in performance.

Figure V-56 provides yet another way of presenting results. In this case, instead of considering different noise levels, the results of experiments that varied cognitive complexity are presented. If these results were presented in a color-coded format (like figure V-55), one would see at a glance that when cognitive complexity was either low or medium, then timeliness was medium for the baseline (before an attack). Also under those conditions if the entity possessed a policy that was flexible and dynamic, timeliness was medium after the attack as well. If one is looking at just the color coding, one cannot tell if it makes a difference if cognitive complexity is low or if it is medium or if there is any degradation after an attack when an entity has a dynamic capability.

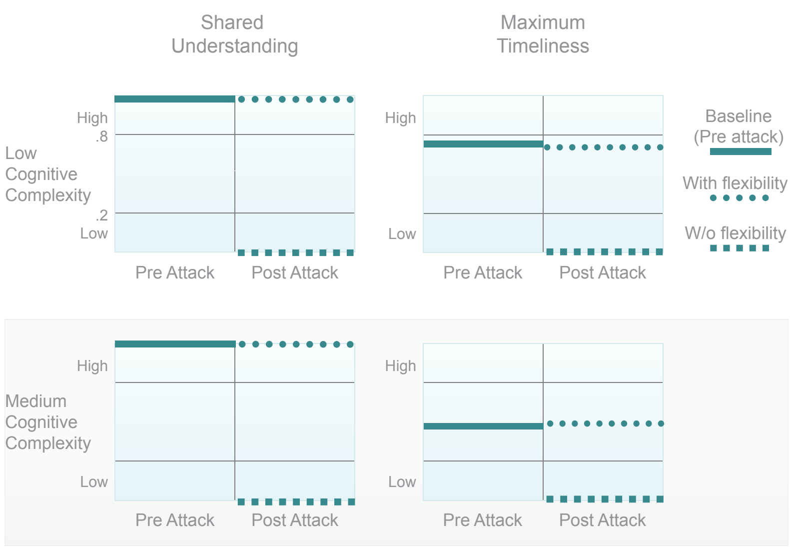

Figure V-56: Impact of Website Attack, Post-Only Edge with/without a Flexible Policy, as a Function of Cognitive Complexity, Industrial Age Challenge

Figure V-56 provides the answers. Yes, cognitive complexity makes a difference, and a flexible and dynamic capability makes entity performance insensitive to such an attack.

Recap of Agility Experiments and Findings

The exploration of agility undertaken in this book consists of four parts. The first part is the series of experiments conducted to explore mission performance as a function of organization-approach option and policy. These experimental findings have created the empirical baseline upon which my analysis of the agility of organization-approach options and associated information-sharing polices is based. The second part is the agility-related visualizations of the results of these experiments in the form of agility maps and impact graphs. The third part is the development and application of agility metrics. The fourth part involves the development of a model of potential agility that will enable us to explore agility without relying on observing manifest agility.

At this point we have completed the first two parts and are ready to embark on the third part of this exploration of agility. But, before we proceed, I think it would be useful to offer a brief review of the ground we have covered so far.

The campaign of experiments reported on here was designed to explore the agility of a set of organization-approach options for entities or collections of entities and associated information-sharing policies. These options included approaches that ranged from hierarchical to edge and information-sharing policies that ranged from a policy that encouraged simultaneous use of both peer-to-peer sharing and posting to and pulling from websites to a policy that restricted information shares to website posts and pulls. In addition, both a flexible information-sharing policy was simulated.

Each of the experiments conducted looked at a specific organization approach/ policy option under a specific set of circumstances. These experiments provided the values of a set of performance measures (shared understanding, timeliness, and efficiency) needed to populate a multidimensional endeavor space. The dimensions of this endeavor space included the nature of the mission challenge, mission shared understanding and timeliness requirements, level of noise in the available information, problem difficulty (cognitive complexity), and the condition of the network and network services (loss of connectivity or website).

The first set of experiments was designed to look at the performance of entities as a function of workload. In this case, the level of noise in the available information was used as a way of creating different levels of workload. The results showed that increases in workload had an adverse impact on performance metrics, but that some organizational approach options were affected more than others.

The next series of experiments reported on looked at the ability of these different options to be successful in different types of missions ranging from an industrial age mission, where the tasks could be completed without cross-team information sharing to a mission characterized as complex endeavor, where widespread information sharing was required to successfully complete the tasks. The results showed wide differences in the versatility of these organization-approach options. When a comparative agility map was developed, it showed that while some options were more versatile, they were not always the best choice. That is, while the most versatile options were successful under a wider set of circumstances, a less versatile option performed better in at least one of these circumstances.

Another set of experiments was designed to explore whether it made a difference if an entity had employed a post-before-process information-sharing policy. In these experiments, no significant difference was found. This result was traced to limitations in access to websites that were inherent in the definitions of organizational approaches and structures.

Another set of experiments explored the impact of problem difficulty, where the degrees of difficulty were related to the cognitive complexity of the problem. The adverse impacts observed mirrored the general pattern seen with workload changes. Individually, they each increased the time required to complete the tasks. The combined effects of increased workload and increased cognitive complexity greatly increased this effect. As a result, some options that were able to successfully complete the tasks under conditions of low workload and low complexity fail completely in conditions of medium to high levels of workload and complexity.

As was the case for increased workload, the impacts of increased cognitive complexity were more pronounced for some options than for others.

Another set of experiments looked at the impact of a loss of connectivity or a loss of a website. In some cases, a loss of some connectivity has no adverse impact, while in other cases it results in catastrophic failure. Thus, the impact of a loss of connectivity is probabilistic. As expected, options that had more social redundancy fared better than those that did not.

The advantage to be gained by a more flexible information-sharing policy was explored in the final set of experiments. A flexible policy was simulated by having an entity adopt the information-sharing policy most suitable for a particular set of circumstances. A flexible and dynamic policy was simulated by allowing an entity to sense the situation and change appropriate information-sharing policy if and when the situation changed. Significant improvements in entity agility were observed in both these instances.

The findings summarized above involved both impact graphs and agility maps. These provide useful insights, but each has its limitations. Agility maps, for example, become increasingly difficult to understand as the number of dimensions increases and/or the response surface fragments. This motivates us to develop other ways to help us understand these experimental results. Part three of our exploration of agility involves trying to quantify agility to make it easier to compare the agility of alternative organization-approach-policy options.

Chapter 28

Quantifying Manifest Agility

Measurement and hence appropriate metrics are essential to observe and quantify something of interest. Being able to observe and quantify the agility that an entity manifests with respect to an endeavor space is essential if we are to be able to compare results and make improvements in a systematic and efficient manner.

Thus far, I have introduced a way to describe and depict an entity's performance over time (responsiveness) based on an actual or simulated event. I have also provided a way to combine these individual results (for a set of specific circumstances) into an overall visualization or description of agility relative to an endeavor space in the form of an agility map. This section builds on the concept of an agility map to develop two simple measures of agility and then uses these measures to analyze the experimental results reported earlier in this part of the book. In the next part of this book, these metrics will be used in the final part of our exploration to test potential indicants of agility—the building blocks for a model of potential agility.

The agility map, as a concept and as a visualization of agility, has significant appeal. But, the construction of an agility map depends on a large number of determinations of an entity's performance under a variety of circumstances. If we insisted on waiting for actual events to take place, we clearly would have a relatively long time to wait before we had sufficient evidence to populate an entity's agility map for even a relatively small endeavor space. Without a reasonably complete endeavor space, the picture we would get of the entity's agility and any measure of agility that would be derived from it would inherit the uncertainty associated with regions of the space for which there was no data. This would make the measure less a reflection of entity agility and more a measure of the amount of missing data. The obvious thing to do when faced with a lack of data is to create the data we need by conducting a series of experiments in which we can create events, and instrument and observe behaviors. Creating data has its own set of shortcomings, but if it is done reasonably well, it can contribute to our understanding.

Having the data we need, we can then completely populate an entity's agility map or, more accurately, develop an estimate of an entity's agility map. Such a map provides us with a *visual metric* that gives us a quick sense of an entity's projected agility. As the dimensionality and complexity of the endeavor space grows, it becomes increasingly difficult to get a sense of the entire map and to visually compare the resultant agility maps, one to another.

To illustrate this point, let us consider the entity agility maps presented earlier in this part of the book. These, like all agility maps, provide a picture of an entity's degree of agility relative to a specific endeavor space. An endeavor space is a composite of the nature of the mission challenge, mission requirements, and conditions. In the set of experiments reported on earlier, four different mission challenges were considered. Mission requirements were expressed in terms of an acceptable level of shared understanding and an acceptable level of timeliness. These agility maps consider three levels of shared understanding and three levels of timeliness (measured by maximum timeliness). These independent requirements form a two-dimensional matrix with nine cells. In addition, a number of different conditions were considered, including three levels of noise (as a surrogate for workload), three levels of cognitive complexity, and three levels of damage to the social network. Considering all the combinations for a particular entity, the endeavor space used in the analysis consists of 972 cells (e.g., one cell would represent low shared awareness, low timeliness, no noise, low cognitive complexity, and no damage).

Looking at maps this large is difficult. If one could capture these maps in a single number, it would make it simple to compare to a previous state or to the agility state of another entity. What follows is the development of two such metrics.

Two Simple Agility Metrics

In this section, I propose two simple metrics. The first is simply the percentage of area in endeavor space in which an entity can operate successfully. Since agility is, by definition, related to change, this implies a baseline. The second metric incorporates a baseline into its calculation. This baseline represents what is considered to be normal conditions.

The second metric, which I call *benchmarked agility*, requires an identification of a before or baseline state. For the before I shall use the results in the form of the nine-cell shared understanding/timeliness matrix. This matrix depicts an entity's performance under what is considered to be normal operating conditions. The endeavor space is composed of a total of 108 of these nine-cell matrices. One matrix represents an entity's performance under normal conditions, and the remaining 107 represent an entity's performance under other conditions.

If an entity is able to be successful, regardless of the mission challenge faced, and in all conditions of noise, cognitive complexity, and network damage, the results recorded for the before would be repeated (or improved) for each of the other 107 matrices in endeavor space. These results, when projected to the whole of endeavor space, represent a benchmark for entity agility. Results less than this show the entity is unable to meet certain mission challenges or operate under some of the possible conditions. Results greater than this show that the entity can create and/or take advantage of opportunities as conditions or the mission challenge changes.

If an entity can successfully maintain its performance (within acceptable bounds) throughout endeavor space, then its agility score (the value of the benchmarked agility metric) should be 1, which when expressed as a percentage would be equal to 100 percent. If an entity fails to perform acceptably anywhere in endeavor space (except in the before or baseline set of circumstances), the agility metric should be 0 or 0 percent. If an entity can create changes or exploit changes that do occur and improve its performance, then we would expect the value of this metric to be able to exceed 1 or, if expressed as a percentage, exceed 100 percent. The formula for the benchmarked agility metric (see figure V-57) behaves as described above.

$$\text{Benchmarked Agility} = \frac{S_{ES} - S_{Before}}{E_{ES} - S_{Before}}$$

Where:

S_{ES} = number of cells in Endeavor Space where an Entity is able to be successful

E_{ES} = number of cells in Endeavor Space where an Entity is expected to be successful based on the “before” level of mission performance

S_{Before} = number of cells in the subset of the Endeavor Space that corresponds to the “before,” where an Entity is able to be successful

Figure V-57: Benchmarked Agility Metric

Application of the Agility Metrics

In this section, I will apply the two simple agility metrics defined above for selected organization-approach options that were previously introduced. These results will not only serve to illustrate these metrics, but will, in the next part of this book, be critical in our search for indicants of agility. These indicants will serve, individually and collectively, as measures of potential agility.

Figure V-58 presents the before matrices for each of the organization-approach options. These include the original hierarchy, coordinated, collaborative, and edge approaches. The before conditions include the industrial age mission challenge, normal noise level, low cognitive complexity, and no network damage.

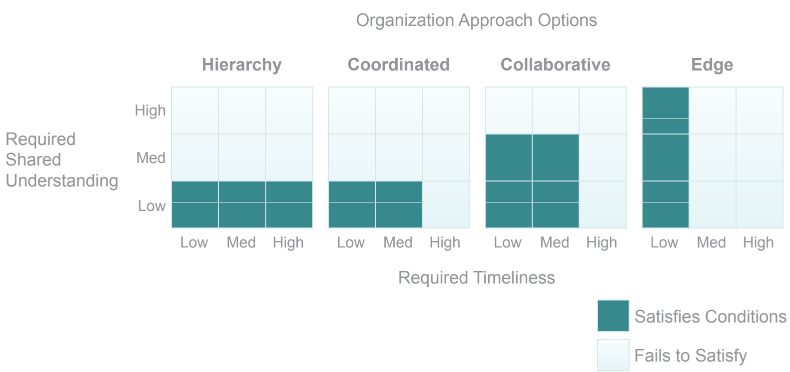

Figure V-58: Entity Before Performance as a Function of Mission Requirements, Normal Noise and Low Cognitive Complexity with No Network Damage, Industrial Age Challenge

If each of these organization-approach options were able to maintain its performance regardless of mission challenge, noise, complexity, and network damage, the total number of cells in the endeavor space in which they would be able to operate successfully would be equal to 324, 216, 432, and 324 respectively. The fact that the expectations for agile performance differ across these organization-approach options reinforces the fact that agility, while requiring success, is not the same measure as success. It is about maintaining or improving success in a dynamic environment.

In this section the results of a series of abELICIT runs that explored the agility of different organization-approach options as a function of mission challenge and conditions are presented. The entity agility maps that result are used to calculate the values of the two simple agility metrics for each of the options. These values for the simple agility metric will be used later in our search for indicants of agility.

Agility of the Hierarchy

To determine the number of cells in endeavor space where the hierarchy can successfully operate, I first looked at its mission performance when faced with different mission challenges. While the hierarchy could operate successfully in 3 of the 9 cells in the mission-requirements matrix when faced with an industrial age challenge, it was unable to duplicate this success in any of the other three mission challenges under any conditions. This inability to perform successfully in three of the four mission challenges translates into 243 cells of endeavor space where the hierarchy was not successful despite expectations to the contrary. At a maximum, the hierarchy could be successful in just 81 cells, and this would be the case only if it were successful in all noise conditions, all levels of cognitive complexity, and all network damage scenarios.

Having looked at different mission changes, the next step was to look at, for the industrial age challenge, whether the hierarchy remained successful under varying conditions of noise, cognitive complexity, and network damage.

Figure V-59 shows the experimental results when both the level of noise and cognitive complexity were varied with no network damage.

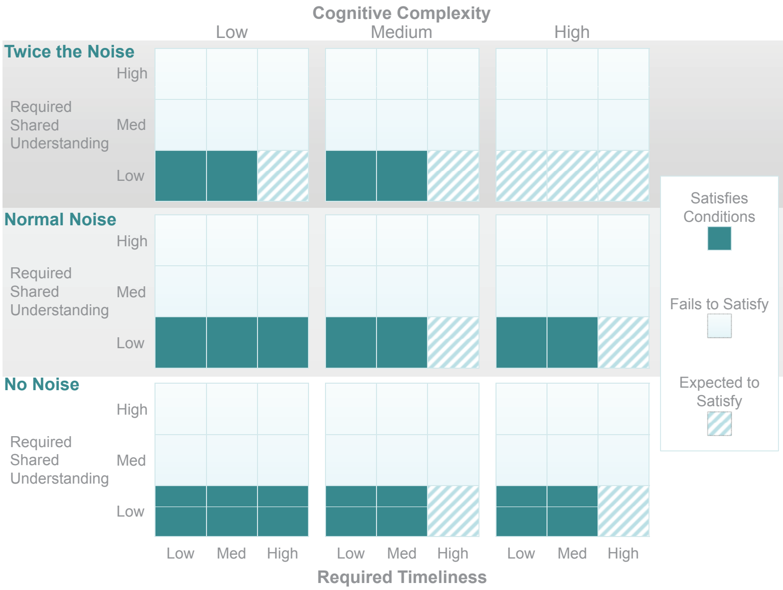

Figure V-59: Agility of Hierarchy as a Function of Noise and Cognitive Complexity with No Network Damage, Industrial Age Challenge

While the expectation here was that the hierarchy would to be able to operate successfully in 27 cells, it was only able to operate successfully in 18 of the cells when there was no damage to the network.

To complete this analysis, the impact of network damage needs to be factored in. At stake are 36 cells that correspond to the shaded cells in figure V-59 for network damage levels of 1 and 2 links down. Earlier in figures V-46 and V-47, I reported on the calculations done with respect to the impact of the loss of 1 and 2 links. The loss of 1 link by a hierarchy never results in failure, while the loss of 2 links results in failure 1.3 percent of the time. Thus in addition to the 18 darkly shaded cells that the hierarchy earns, in the case of no network damage (figure V-59), it earns another 18 cells for the condition of 1 link down, and also earns 17.8 cells for the situation when 2 links are down. Thus the hierarchy is successful in 53.8 cells compared to an expectation of 324 cells. Applying the formula for benchmarked agility [(53.8 – 3) / (324-3)], the value of the benchmarked agility metric for hierarchy = 15.8 percent. The percentage of endeavor space in which the hierarchy can operate is 5.5 percent (53.8/972). The numerical value for the second metric is less than the first because the first is relative to a baseline that consists of only a subset of endeavor space and hence has a smaller denominator.

Agility of the Coordinated Option

When faced with the industrial age challenge, the coordinated option was able to operate successfully in only 2 of the 9 cells as compared to 3 of 9 for the hierarchy (see figure V-58). This 1-cell difference can be attributed to a relatively small loss in timeliness due to the increase in the interactions attributable to coordination. This small loss of timeliness dropped its performance sufficiently to put it out of the high range for required timeliness. This performance was duplicated for the coordinated challenge. The coordinated option was unable to operate successfully in the other two of the four mission challenges under any conditions. Given this, the coordinated option could, at a maximum, be successful in just 108 cells. This would be the case only if it was successful in all noise conditions, all levels of cognitive complexity, and all network damage scenarios.

Having looked at different mission changes, the next step was to look at, for the industrial age challenge, whether the coordinated option remained successful under varying conditions of noise, cognitive complexity, and network damage.

Figure V-60 shows the experimental results as both the level of noise and cognitive complexity were varied with no network damage.

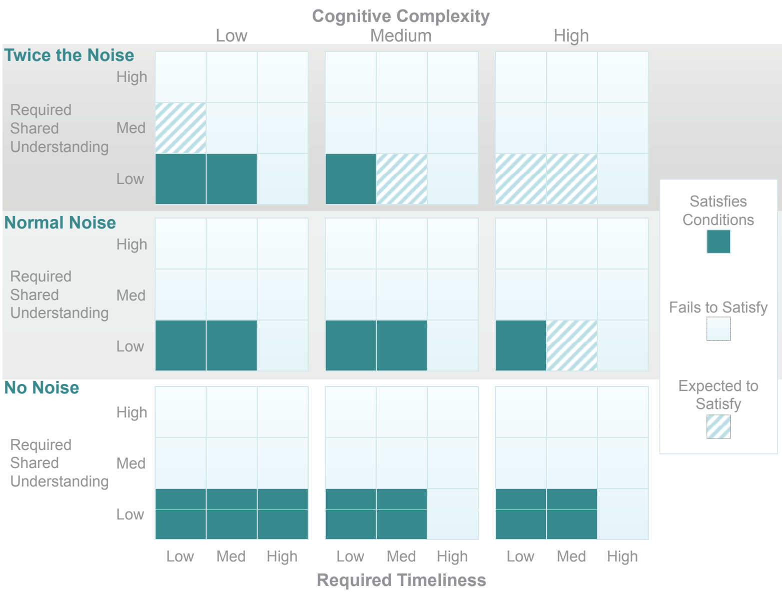

Figure V-60: Agility of Coordinated Option as a Function of Noise and Cognitive Complexity with No Network Damage, Industrial Age Challenge

The coordinated option fared well in meeting expectations, being able to operate in 15 cells versus an expectation of 18, for both the industrial age and coordination challenges, when there was no damage to the network. Of course, low expectations are certainly a factor here.

To complete this analysis, the impact of network damage needs to be factored in. At stake are 60 cells that correspond to the darkly shaded cells in figure V-60 for network damage levels of 1 and 2 links down. The loss of 1 link in the case of a coordinated option never results in failure, while the loss of 2 links results in failure only 1.0 percent of the time. To the 30 darkly shaded cells, the coordinated option earns, in the case of no network damage, another 30 cells for the condition of 1 link down and 29.8 cells for the situation when 2 links are down. The coordinated option is thus successful in 89.8 cells compared to an expectation of 216 cells. The value of the benchmarked agility metric for the coordinated option is 41.0 percent compared to the hierarchy's 15.8 percent. The percentage of endeavor space in which the coordinated option can successfully operate is 9.2 percent. This compares to the 5.5 percent for the hierarchy. The non-proportionality of the results is due to the fact that the expectation for the coordinated approach is lower than for the hierarchy. This is because the hierarchy can operate in 3 of 9 cells in the before, while the coordinated option can operate in only 2 of 9 cells due, as previously pointed out, to its timeliness being adversely affected by the larger number of transactions generated as a result of coordination.

Agility of Collaborative Approach

Unlike the hierarchy and the edge, the collaborative option was able to operate successfully in 4 of the 9 cells in the before case. The collaborative option is expected to be able to operate in 432 cells of endeavor space. When one looks at the ability of the collaborative option to maintain this expectation with changing mission challenges, we find that the collaborative option is not successful in the complex endeavors challenge. Nevertheless, given that it is relatively successful in the other three mission challenges under a variety of conditions, it performs very well overall.

Figure V-61 compares the collaborative option's performance as a function of mission challenge under before conditions.

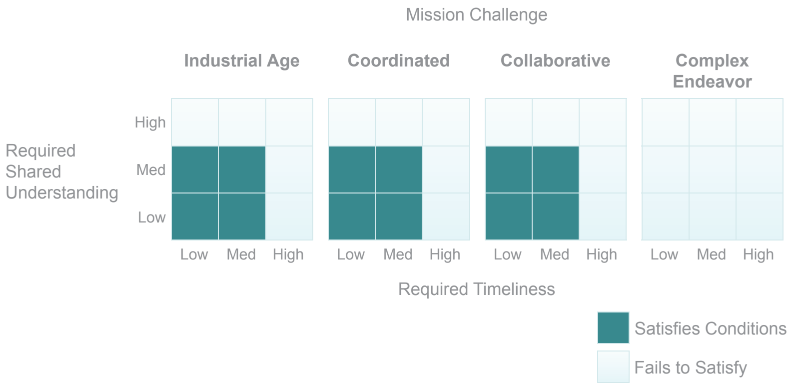

Figure V-61: Collaborative Performance as a Function of Mission Challenge, Normal Noise and Low Cognitive Complexity with No Network Damage

Having looked at the impact of different mission challenges, the next step was to look at whether the collaborative option remained successful in the three of the four challenges where it was able to perform successfully under varying conditions of noise, cognitive complexity and network damage.

Figure V-62 shows the experimental results for collaborative option operating in the industrial age challenge as both the level of noise and cognitive complexity were varied with no network damage.

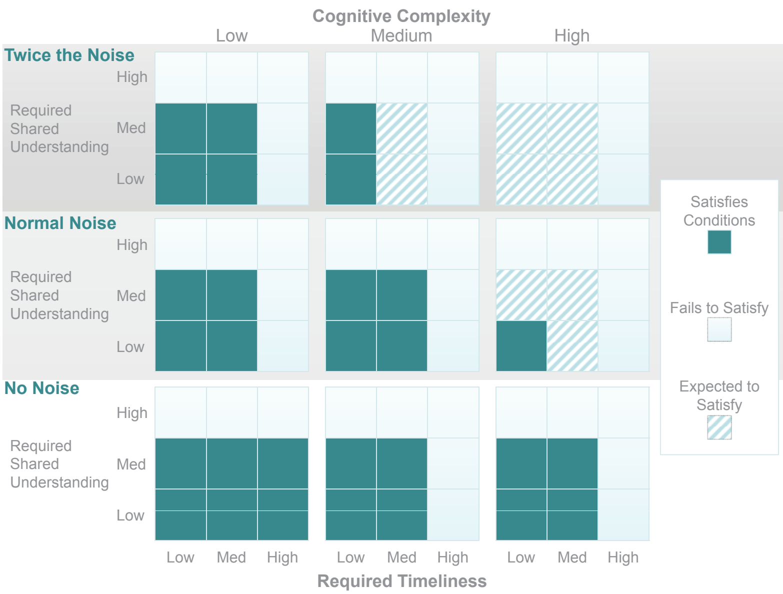

Figure V-62: Agility of Collaborative Option as a Function of Noise and Cognitive Complexity with No Network Damage, Industrial Age Challenge

Figure V-62 shows that the collaborative option, when faced with the industrial age challenge, operated successfully in 29 of the 81 cells versus an expectation of 36 cells. This result is a combination of not being able to operate in some expected cells and an ability to take advantage of circumstances to operate successfully in places where success was not expected.

This result is repeated for the coordination challenge and with the exception of one cell for the collaboration challenge. This adds up to being able to operate in a total of 86 cells when there is no network damage.

This collaborative option does not suffer any losses due to network damage in either the one-link or two-link scenarios. The total cell count (cells where it can operate successfully) for the collaborative option is 3 x 86 = 258. This translates into a value for the benchmarked agility metric of 59.3 percent. The percentage of endeavor space where the collaborative option can successfully operate = 26.5 percent.

Agility of the Edge

This analysis approach was repeated for the edge organization option to create its agility map and calculate corresponding values for the simple agility metrics. Like the hierarchy, the edge was able to operate successfully in 3 of the 9 cells in the before case (although a different set of cells). As was the case with the hierarchy, the edge was also expected to be able to operate in 324 cells of endeavor space. When one looks at the ability of the edge to maintain this expectation with changing mission challenges, we find that the edge is far more successful than the hierarchy. In fact, the edge not only maintains its performance but also improves its performance across the mission challenges. Figure V-63 shows that the edge maintains its average correctness scores across mission challenges. This figure also shows that it increases its timeliness from low to medium in the other three mission challenges. Thus the edge not only meets but also exceeds expectations.

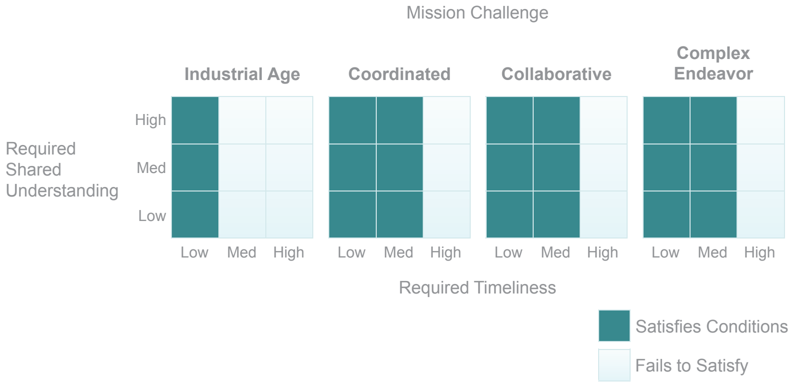

Figure V-63: Edge Performance as a Function of Mission Challenge, Normal Noise and Low Cognitive Complexity with No Network Damage

The improved performance of the edge in the other three mission challenges increases the number of cells in play as we go on to analyze the impact of various conditions of noise, cognitive complexity, and network damage. In fact, the number of cells in which the edge would be successful if it did not suffer degradation as a result of changing conditions is 561. Having looked at the impact of different mission challenges, the next step was to look at, for each of these challenges, whether the edge remained successful under varying conditions of noise, cognitive complexity, and network damage.

Figure V-64 shows the experimental results for the industrial age challenge as both the level of noise and cognitive complexity were varied with no network damage.

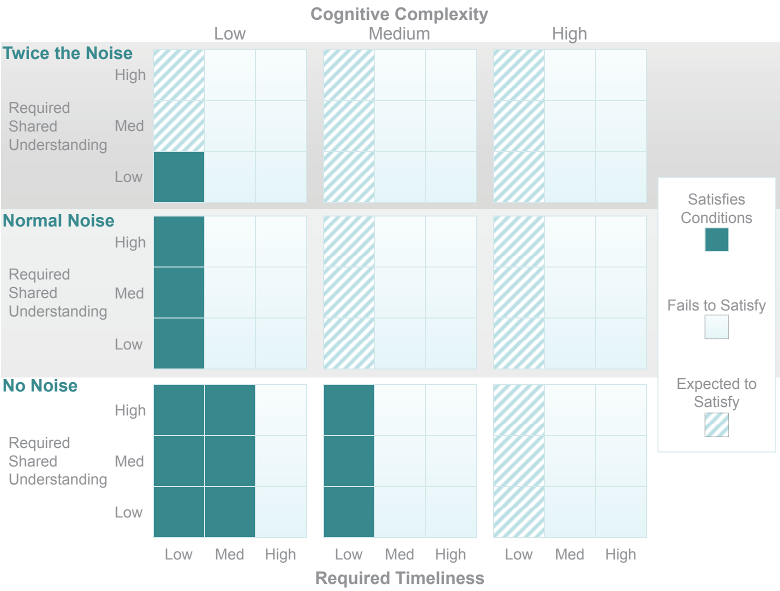

Figure V-64: Agility of Edge as a Function of Noise and Cognitive Complexity with No Network Damage, Industrial Age Challenge

The idealized edge, with its maxed out sharing behaviors, cannot deal as well as the hierarchy with high levels of noise and cognitive complexity. Both these conditions overload the participants, who as a result, are unable to complete their work. Figure V-64 shows that the edge can only operate successfully in only 13 of the cells versus an expectation of 27 cells.

The maxed-out edge does not suffer any losses due to network damage in the one-link and two-link scenarios. Therefore the total cell count for the edge in the industrial age challenge would be 13 x 3 = 39. The next step is to look at the edge in other mission challenges. Figure V-65 presents the results of the edge taking on the complex endeavors challenge.

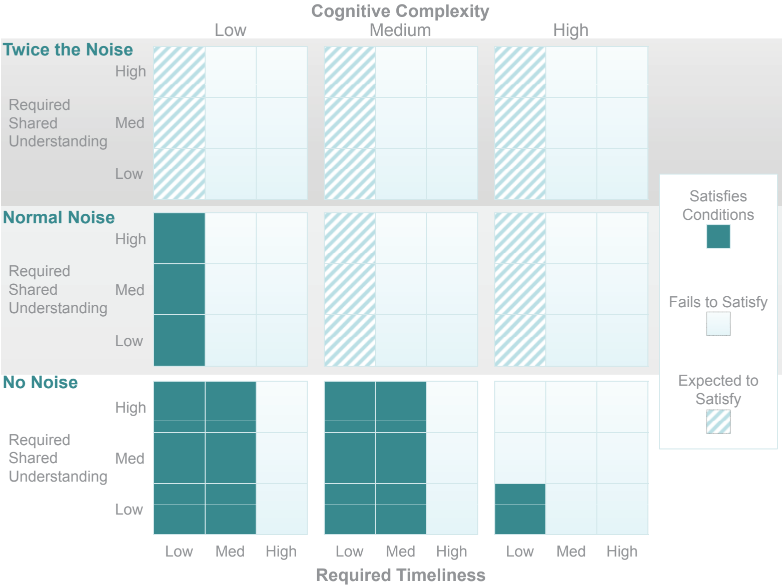

Figure V-65: Agility of Edge as a Function of Noise and Cognitive Complexity with No Network Damage, Complex Endeavor Challenge

In the complex endeavor challenge, the edge succeeds in 16 of cells versus the expected 27. These results were the same with the coordinated and collaborative challenges. The maxed-out edge was not degraded in any of the network damage scenarios. Thus the total cell count for the edge was 183.[148] This translates into a value of 56.1 percent for benchmarked agility. The percentage of

148. The number 183 was calculated as follows: 39 from the industrial age challenge (13 cells for each of the three network damage scenarios) plus 48 cells from each of the three remaining scenarios.

endeavor space in which the edge was able to successfully operate is 18.8 percent. Both these values are less than the coordinated option due to the relative inability of the edge to deal with higher levels of noise and cognitive complexity. The reason for this is the enormous number of interactions created in a maxed-out edge. This level of work adversely affects timeliness and, in some cases, correctness because the correct solution does not occur before the end of the run. (If the maxed-out edge were given more time, correctness scores would have been unaffected.)

Agility of the Post-Only Edge

The maxed-out edge serves, with the other archetypical organization-approach options to theoretically anchor the approach space. The forced universal sharing behaviors, particularly under conditions where workload increases, due to noise or cognitive complexity, do not make sense. In fact, these behaviors are not observed in human ELICIT runs. Rather, edge human participants tended to adopt a post-only policy.

In this section, I shall calculate the values for both of the simple agility metrics for the post-only edge. The post-only edge was able to operate successfully in 6 of the 9 cells[149] in the before case (compared with the 3 of 9 observed in the maxed-out edge). The post-only edge is therefore expected to be able to operate in 648 of the 972 cells of endeavor space.

149. The actual timeliness score received was .768, which was just below the cutoff for high (.800); otherwise the post-only edge would have been successful in all the cells.

Figure V-66 compares edge performance as a function of mission challenge. This figure shows that the post-only edge maintains its performance across the mission challenges.

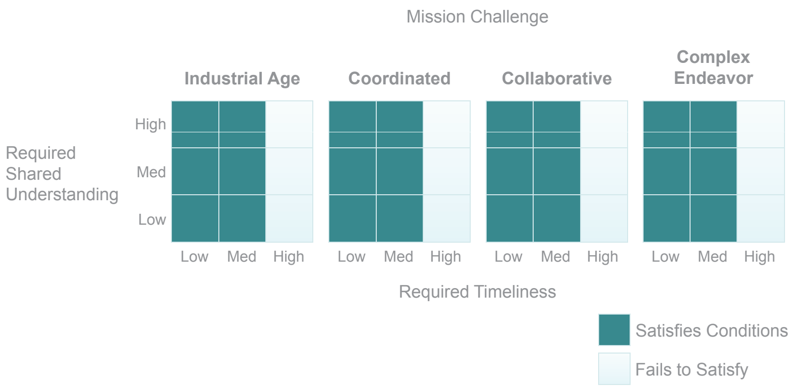

Figure V-66: Post-Only Edge Performance as a Function of Mission Challenge, Normal Noise and Low Cognitive Complexity with No Network Damage

Given this level of performance across the different mission challenges, the post-only edge still has 648 cells in play as we go on to analyze the impact of various conditions of noise, cognitive complexity, and network damage. This is greater than the standard edge (561) and far greater than the 324 cells we calculated for the hierarchy.

Having looked at the impact of different mission challenges, the next step was to look at, for each of these challenges starting with the industrial age challenge, whether the edge remained successful under varying conditions of noise, cognitive complexity, and network damage.

Figure V-67 shows the post-only edge experimental results for the industrial age challenge with no network damage, as both the levels of noise and cognitive complexity were varied.

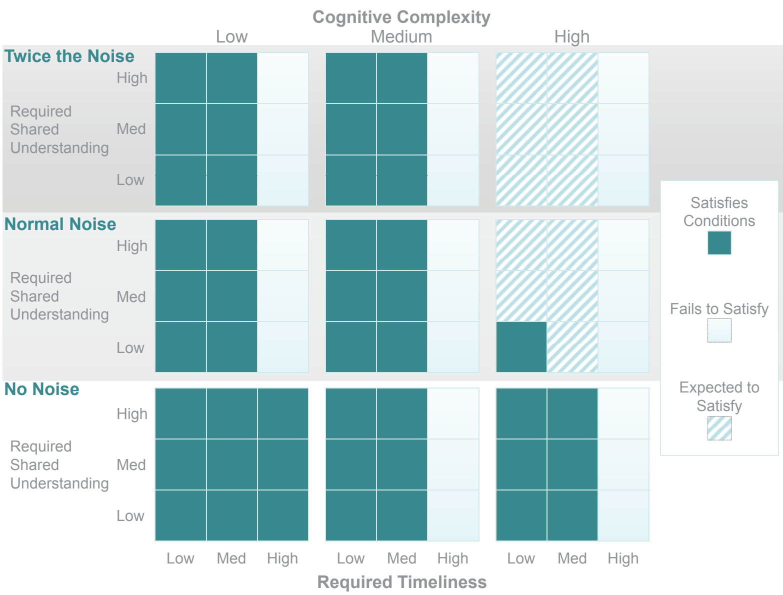

Figure V-67: Agility of Post-Only Edge as a Function of Noise and Cognitive Complexity with No Network Damage, Industrial Age Challenge

The baseline performance of the post-only edge was only adversely affected when cognitive complexity was high. Readers should note that the post-only edge was able to improve its performance when there was low cognitive complexity and no noise. As of result of these pluses and minuses, the post-only edge was able to operate successfully in 46 of the cells versus an expectation of 54 cells when faced with an industrial age challenge.

This level of performance far exceeds the other organization-approach options at this point in the analysis. The post-only edge configuration does suffer significant losses due to network damage. In the one link down scenario, the post-only edge experiences a failure rate of 8.8 percent, while in the two links down scenario it suffers a 17.3 percent failure rate. The total cell count for the post-only edge in the industrial age challenge is 46 x 1 + 46 x .912 + 46 x .827 = 125.17. This compares very favorably to a score at this point in the analysis of 39 for the standard edge.

The next step is to look at the post-only edge in other mission challenges. Figure V-68 presents the results of the post-only edge taking on the complex endeavor challenge.

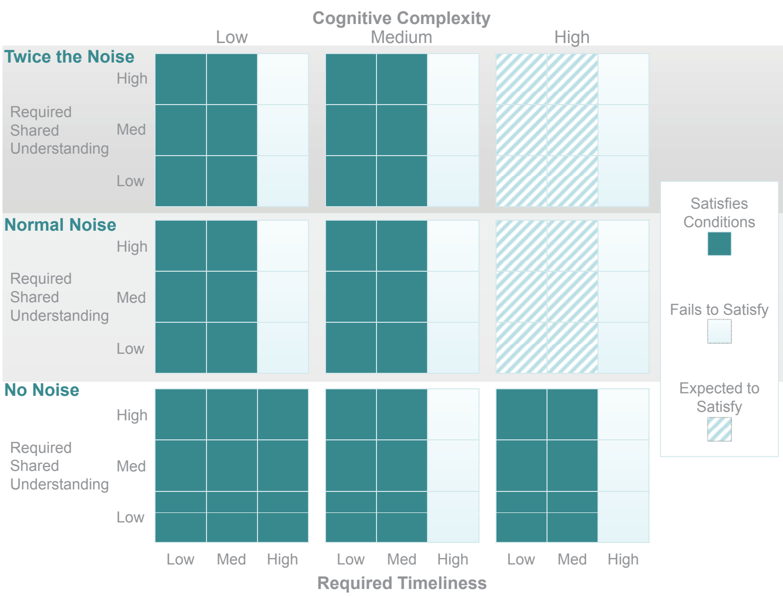

Figure V-68: Agility of Post-Only Edge as a Function of Noise and Cognitive Complexity with No Network Damage, Complex Endeavor Challenge

In the complex endeavor challenge, the edge succeeds in 45 of the cells—just one less than its performance in the industrial age challenge. These results for the coordinated and collaborative challenges did not show this slight loss of performance. The total cell count for the post-only edge across all mission challenges and conditions was equal to 501.24. This translates into a value of 77.1 percent for benchmarked agility compared to 56.1 percent for the standard edge. The percentage of endeavor space where the post-only edge can successfully operate is 51.5 percent, almost double that of its nearest competitor, the collaborative option, which covers 26.5 percent of endeavor space.

Agility Metric as a Function of Organization-Approach Option

This section summarizes the results for the values of the two agility metrics presented in the previous sections. Figure V-69 provides the values calculated for both of the simple metrics for the five organization-approach options considered.

	Benchmarked Agility Metric (relative to expectations)	Agility Map Coverage (percent of endeavor space where entity can operate successfully)
Hierarchy	15.8%	5.5%
Coordinated	41.0%	9.2%
Collaborative	59.3%	26.5%
Edge	56.1%	18.8%
Post-Only Edge	77.1%	51.5%

Figure V-69: Agility Metrics as a Function of Organization-Approach Option

Caution Regarding the Use of Simple Agility Metrics

Agility is a multidimensional concept. Boiling it down to a single value, while having obvious appeal, results in the loss of information about the agility-related behaviors of these entities. While we have a sense of overall relative agility, two options could have virtually the same value for either benchmarked agility or endeavor-space coverage, yet with quite different performance characteristics. The collaborative and the edge options, for example, received very similar scores for benchmarked agility. There is more of a difference in the agility map coverage metric values and, as readers will remember, a much greater difference in the results seen in the comparative agility map. With a concept as rich as agility, no single metric can be used to capture it. To understand and compare the agility of entities, a set of metrics and visualizations needs to be employed.

Summary of Findings and Conclusions for Agility Experiments and Analysis

This section summarizes the agility-related findings of experiments and analyses reported on in this part of the book. The substance of these findings satisfies my first objective, which was to provide readers with experimental and analytical results that will improve our understanding of the relative agility of different archetypical organization-approach options and explore hypotheses related to the relationships between and among organization-approach options and policies, performance (effectiveness and efficiency), and agility. The design and conduct of these experiments, in and of themselves, provides a *proof of concept* and satisfies the second objective that I stated for this campaign of experiments, which is "to provide readers who are interested in pursuing their interest in agility, whether by considering changes to their organizations, exercising agility-related capabilities, or performing agility-related research and analysis, with a conceptual and analytic template that can be adapted to explore agility in a variety of entities and sets of circumstances." In addition, these experimental and analytical results provide us with an empirical basis to test a series of hypotheses related to potential agility, which is the subject of part VI of this book.

Conclusions: Agility of Organization—Approach Options

Perhaps most important finding is that no single organizational-approach option is best under all missions or circumstances. This may seem to be an obvious conclusion,[150] but many organizations, both military and civilian, continue to rely on a one-size-fits-all structure and approach, whether they are operating alone or as part of a larger coalition or collective.

This general finding is enhanced with a series of specific findings that show the relative agility of different approaches and the ability of different approaches to operate successfully in different missions under a variety of conditions. These include: 1) entities that are capable of adopting more than one option (approach/policy) are more agile, and 2) approaches that are more network enabled are more agile. These two conclusions point to a way ahead.

Conclusions: Agility Metrics and the Analysis Approach

It is a basic rule of analysis that it is inadvisable to rely on a single model, a single solution approach, or a single measure of merit. The wisdom of this first principle of analysis has been supported by the findings presented here.

150. This is a conclusion that has been widely voiced. See previous CCRP publications and the management and organizational theory literature.

Agility cannot be adequately understood by using a descriptive model of manifest agility and an approach that depends on looking at the outcomes associated with a set of combinations of approach and circumstances. While such a model enables one to observe, in a real world or simulated context, the agility manifested by an entity, this type of model has a number of shortcomings. First, the agility observed is in the context of a specific instantiation of endeavor space. Given that we are dealing with complex endeavors, it cannot be assumed that anyone can foresee all the circumstances that could occur or understand all the consequences of these and the related actions that may be taken by an entity. Any endeavor space used is almost certainly to miss important circumstances, and the results observed constitute only one or a small set of possible outcomes. Thus, measures of agility that are derived using this approach, will overstate an entity's agility. If this is not properly understood, the result may give comfort and confidence where none is warranted.

As for agility-related visualizations and metrics, these results show that neither agility maps nor simple measures of agility provide a nuanced understanding of the results. This is due to the difficulty of visualizing the response surface projected on a large and complex endeavor space. Simple metrics obscure differences that result from the fact that various approaches work best in different parts of this space. The same result can be obtained from widely different response surfaces. Furthermore, the simple metrics used here did not take into consideration risk. Ideally one would like to weigh each point in endeavor space by the risk (likelihood and consequences) associated with it. Accomplishing this is not practical for reasons stated earlier. There is a real concern that efforts to manage risk in this manner will be counterproductive. Unless the shortcomings of the models, approaches, and metrics are fully understood, the results may mislead as much as they will inform.

Given these methodological shortcomings, I believe that another approach, based on a causal model of potential agility, is needed to augment analyses based on manifest agility. This approach, the fourth part of my exploration of agility, is the subject of the part IV of this book.

Part VI

Potential Agility

Chapter 29
Limits of Observation and Experimentation

The analytic results presented so far in this book have been based on experiments. As pointed out earlier, experiments provide us with a rich source of data to augment that which we can collect from our observation of real world experiences. However, both experiments and observations of reality share a major shortcoming. Both approaches to learning and knowledge creation are limited by what can be directly observed. The data obtained from instrumenting reality is further limited by what actually occurs (is manifested).

While one can create virtually any set of circumstances and response behaviors that interest one in a properly designed and conducted experiment or simulation, one is still limited by one's imagination and expectations. The design of a campaign of experiments to explore the agility of an entity involves the prior identification of one or more conditions—that is, their design involves the construction of an endeavor space and a sampling from this space. Agility is an imperative precisely because one cannot adequately identify the conditions or circumstances that will (or could) exist. Furthermore, for each specific set of circumstances, an entity could respond in a variety of ways that depend on its characteristics, capabilities, purposes, and the like. Conducting these experiments also requires setting the values of variables that represent the characteristics of the entities involved. The possibilities here are unmanageably large. Unless we know what specific capabilities to focus on, we are unlikely to find the specific set of entity characteristics that is appropriate for each circumstance. Brute force analysis, or simply guessing, is unlikely to provide us with the knowledge and understanding we need to improve agility.

The Agility Conundrum

This presents us with the following conundrum. In order for an entity to manifest agility, both an actual change in circumstances and an appropriate response are required. If a significant change in circumstances never takes place or if the entity does not recognize this change and respond in an agile manner, manifest agility cannot be observed. In order to measure or even estimate manifest agility, one needs to identify a specific set of changes in circumstances to simulate the event(s) and observe the resultant responses, effects, and impacts. If one needs to experience or simulate changes in circumstances in order to measure or estimate manifested agility, how can one account for unidentified and unanticipated events? How does one know if, when the unanticipated happens, an entity will be able to continue to successfully operate? In other words, how does one prepare for the unknown? The answer is as follows.

Entities can prepare for an uncertain future by improving their potential agility.

Potential vs. Manifest Agility

Potential agility fundamentally differs from manifest agility in that it is a function of the specific properties and characteristics of an entity, while manifest agility involves the direct measurement of effectiveness and efficiency under a set of circumstances. Manifest agility is an outcome that can be attributed to the presence of its components. A measure of manifest agility is a quantification of the impact on an entity's performance over an endeavor space. A measure of potential agility is a reflection of the degree to which an entity possesses the capability to be agile. The measurement of potential agility does not involve the specifications of an endeavor space, rather it involves the measurement of aspects of an entity that are thought to be related to agile behaviors. Potential agility is an indicant of agility rather than a measure of agility. It is a prediction of the future without knowing what circumstances will obtain.

A tall order to be sure, but I believe it is doable. The difference between manifest and potential agility is similar to the difference between training and education. Training usually involves both an explicit or implicit set of assumptions about the task to be performed and the conditions that will exist. The training objective is to improve the trainee's ability to perform the task at hand under a set of conditions. Education is different. The objective of education is to prepare one for life's vicissitudes by teaching how to approach problems and solve them.

Having explained why potential and manifest agility are different and cannot be measured in the same fashion, this part of the book provides a first cut at a model of potential agility. This model seeks to be able to predict how agile an entity will be without predicting the situations that will be faced. It is a causal model with the underlying assumption that there are certain characteristics of an entity that make it more or less agile. A model of potential agility incorporates variables that are thought to influence an entity's ability to exhibit agile behaviors. The output of this model of potential agility is a measure of an entity's potential agility. The greater an entity's potential agility is, the greater the likelihood that it will exhibit agility when required in the future. Potential agility is not a measure of manifest agility. Instead, it is an indicant of future manifest agility.

Use of Indicants

When practical, one should attempt to measure the value of a variable directly. For a variety of reasons, direct measurement may be difficult or even impossible as it is in the case of potential agility. Even when direct measurement is possible, direct measurement may prove to be too costly or the process of measurement may be so intrusive that it affects the value of the variable being measured. In the case of potential agility, direct measurement is impossible. For manifest agility, our ability to employ the measures we have is limited because of our limited imagination. Thus, there are regions of endeavor space that remain hidden from us. Due to the difficulties and costs involved, there may also be known, but inaccessible, regions of endeavor space.

In cases like this, when direct measurement is not possible or practical, indicants are often employed. An indicant is a variable or set of variables that is believed to be related to the variable(s) of interest. Knowing how the value of an indicant changes provides an indirect measure of the variable of interest. Indicants may either be variables that are affected by the variable of interest, or they may be influenced by the variable of interest.

For example, it is not practical to test for an infection at home, so we take someone's temperature. This is a case where a symptom is used as an indicant. It is not possible to get inside the mind of a decision-maker, to measure when a decision is made or why the decision was made (although with the developing science of brain scans we are getting closer to being able to do so). Even if we were able to ask someone when he made a decision and why he made the decision he did, his answers may be quite inaccurate. Instead, we observe the individual's behaviors to gain insights into his values and decision-making processes. In this case, we are using a consequence as an indicant. Many social science studies are based on experiments that infer values and perceptions from observed behaviors. For example, by observing individuals' or groups' purchases, inferences about preferences and sensitivities to costs are made. Indicants involve a conceptual model of some kind, even if such a model has not been made explicit. This model hypothesizes a link between the indicant and the measure of interest.

As indicated above, potential agility is, in fact, an indicant of future manifest agility. A model of potential agility can be considered an explanatory or causal model. This is in contrast to the descriptive model of manifest agility, which guides our observations and informs the development of a model of potential agility. The task of this part of the book involves finding an appropriate set of indicants of future manifest agility that can be used to construct a model of potential agility.

The development of a causal model of agility is a three-step process. The first step is to think about what properties or characteristics make an entity relatively more agile and how one might observe and measure those properties or characteristics. Second, having thus identified candidate indicants, the candidates need to be empirically tested, individually and in combination, to see if there is a relationship that can be observed between value ranges for these candidate indicants and the degree of agility manifested. Finally, the relationships between and among the indicants and a measure of potential agility need to be established. Data to fuel this discovery analysis can come from a variety of sources, including the experiments reported on earlier and the case studies and agility-related analyses currently being undertaken by the NATO Research Group SAS-085.

When using case studies one is always faced with the problem of determining what would have happened if the event in question had not occurred—that is, the baseline. Thus, even in the case where real world data is available, only one part of the manifest agility equation can be directly measured (what actually happened). The other part must perforce be an estimate. With experiments one can control for selected variables and thus run both cases, but the realism of an experiment clearly does not approach that of a real world case study.

Chapter 30
Developing a Model of Potential Agility

A model of potential agility is composed of indicants of agility, the relationships between and among these indicants, and their relationships to one or more agility metrics. This effort to construct a model of potential agility is informed by existing theory, experimental results, and a body of evidence from lessons learned.

Since agility is a concept that applies to a specific entity or type of entity in a particular context, the importance of a specific indicant and the nature of the relationships between and among indicants and measures of agility are context dependent. The search for indicants discussed in this section has been conducted in the context of organization-approach options and the ELICIT problem. However, the methodology used to identify these indicants and the relationships from which a model of potential agility can be developed is more generally applicable.

Building Blocks for a Model of Potential Agility

It is logical to start our search for indicants of agility by focusing on the six components of agility previously identified and the factors that are related to these components. If the theory of agility presented here is correct, hypotheses in the form of "If there is evidence of responsiveness, or if there is no evidence of the presence of another component of agility, then agility does not exist," would find support from experimental results and empirical data. That is, the available evidence would support a hypothesis that attributes the lack of manifest agility observed to a lack of either responsiveness or a lack of one or more of the other components of agility in the entity under study. Conversely, when we are able to observe agile behavior, we should be able to trace it to an entity's responsiveness and at least one of the other components of agility.

It should be noted that, while it is reasonable to conclude that if we observe agility, we should be able to trace it to a specific set of behaviors, it does not follow that if the entity exhibits these behaviors, it will always be agile. Thus, components of agility are necessary, but they are not sufficient for agility. In the case of insufficiency, it may be concluded that other factors are present that adversely affect the relationship between the components of agility and agility.

Figure VI-1 depicts the basic building blocks of a model of potential agility organized into four rings.

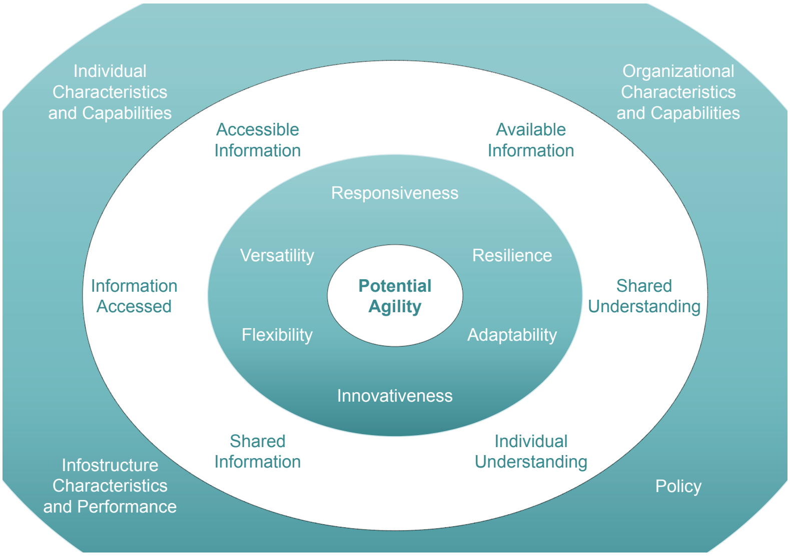

Figure VI-1: Model of Potential Agility Building Blocks

The third or inner ring, located closest to a measure of potential agility, consists of the components of agility. This reflects the belief that agile behaviors are a direct result of the presence of these components. The second ring contains a set of measures whose values are a direct consequence of the information-sharing and collaborative behaviors exhibited by an entity. It is believed that minimum levels of these are required for the components of agility. The first or outermost ring consists of the characteristics and capabilities of the entity, including the characteristics and performance of its supporting infostructure. These characteristics include an entity's ability to adopt different organization-approach options and different information-sharing policies.

The values of the variables in the middle ring of figure VI-1 are hypothesized to be the direct results of the values of the variables in the outer ring, which include an entity's infostructure, information-related policies, and information-sharing behaviors. One can think of the outer ring as placing constraints on the values of the variables in the middle ring. Removing these constraints, whether by improving infostructure or changing entity or individual characteristics, provides an opportunity to increase the values of the variables in the middle ring.

To assemble these building blocks into a useful model of potential agility, the relationships within each ring and between these rings (sets of variables) need to be further specified. In addition, there needs to be a way to determine the level of potential agility that is appropriate for a given entity over a specified time horizon. These relationships will be explored next, while the issue of requisite agility will be deferred until later in this part of the book.

Building an Explanatory Model of Potential Agility

Agility has been a continuous subtext in the CCRP literature,[151] which has offered a number of assertions regarding the relative agility of different approaches to accomplishing the functions that are traditionally associated with command and control in military organizations, management in civilian organizations, and governance in other institutions. These conjectures are

151. Interested readers can review this literature by downloading books, journal articles, and symposium presentations at www.dodcccrp.org.

contained in the body of literature that includes *Network Centric Warfare* (1999), *Power to the Edge* (2003), and the C2 Conceptual Reference and Maturity Models (2007, 2009). The first two are CCRP publications, while the later two are products of NATO research groups chaired by this author.

The theory of network centric warfare (also known as network enabled capability) implies that a robustly networked entity is inherently more agile than one that is less *network centric* and/or does not possess an approach that generates and then leverages shared awareness by self-synchronizing behaviors. The theory of edge organizations[152] holds that edge organizations, those located in and around the right upper rear corner of the approach space (see figure V-8) are inherently more agile. This is because the behaviors of these entities are not limited by preconceived and fixed problem decompositions and because they do not place arbitrary constraints on information sharing and collaboration. As a result, these entities avoid inappropriate allocations of decision rights and are not hampered by failures to connect the dots because of a lack of information sharing. The *NATO NEC C2 Maturity Model* asserts that more mature approaches are inherently more agile in and of themselves and that, as entities, they are capable of more mature approaches and are also capable of moving around the approach space, making them more agile.

152. See *Power to the Edge*, 2003.

These related theories and models posit that widespread information and collaboration are necessary to support distributed decision-making, shared understanding, and self-synchronization. As previously stated, the importance of a specific indicant and the nature of the relationships between and among indicants and a measure of agility are context dependent. This discussion focuses on the ELICIT problem challenge and uses the data generated by the abELICIT experiments reported on earlier in this book to test candidate indicants and relationships suggested by the theories mentioned above. The ELICIT problem challenge is essentially a shared understanding task. Therefore, the following links in the value chain articulated in the theories associated with NCW, edge organizations, and C2 maturity provide a starting point for a search for the relationships of interest.

- A robustly networked entity creates the conditions necessary for information sharing and collaboration.

- Information sharing and collaboration enhance the quality of information and shared awareness.

- Shared awareness is necessary to develop shared understanding.

- Shared awareness enables self-synchronization, which, in turn, enhances performance and agility.

Chapter 31
The Evidence for the Components of Agility

I will start by taking a look at the ring immediately adjacent to a measure of potential agility, the ring that consists of the components of agility. Drawing on experimental results, I shall see if there is any evidence that supports the hypothesis that the proximate cause or explanation for the agility or lack of agility observed can be attributed to one or more of these components. I shall then turn my attention to the outermost ring, the ring that contains entity and individual characteristics and capabilities to see if the evidence supports a relationship between the values of these variables and the agility observed. Finally, I shall explore the middle ring, the ring the contains a set of metrics related to the tenets associated with networked enabled capability to see if I can link the variables in the outermost ring to the innermost ring to provide an explanation of what forces are afoot that translate a particular entity characteristic to the components of agility, which I have previously shown to be the proximate cause of the agility observed.

Evidence for the Components of Agility

There is a considerable amount of evidence that suggests a strong relationship between each of the components of agility and the agility that an entity manifests. This evidence is in the form of observations of reality and case studies that attribute successful entity performance despite a change in circumstances to one or more of these six components. In this section, I will look at the results of the experiments conducted for this book to see if they support this conclusion and thereby justify the inclusion of this ring in a model of potential agility.

As has previously been noted, the components of agility are not independent. For example, versatility can be enhanced by an entity's flexibility or reduced by a lack of flexibility, and responsiveness can be enhanced by adaptability. In the discussion that follows we shall see evidence of some of these relationships.

Evidence for Versatility

The versatility of an entity is in evidence when it can be as successful in tackling mission challenges other than the baseline challenge. Since there are four mission challenges (the baseline plus three) the following versatility scale can be created:

Condition	Versatility Value
If Entity is successful only in the Baseline Challenge	0
If Entity is successful in the Baseline Challenge plus one other Mission Challenge	1/3
If Entity is successful in the Baseline Challenge plus two other Mission Challenges	2/3
If Entity is successful in all the Mission Challenges	1

Figure VI-2: Versatility Scale

Figure VI-3 compares the versatility and benchmarked agility scores for entities that do not exhibit flexible policies, or adaptive-approach behaviors, with respect to organization-approach options and policy.

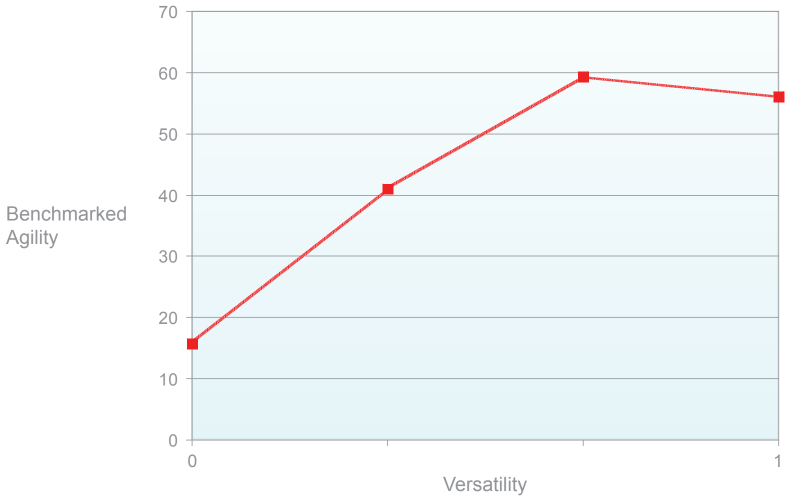

Figure VI-3: Versatility and Agility

Since these entities cannot adapt their organization approach, and they cannot be flexible with their information-sharing policy, these entities correspond to the four archetypical organization-approach options. Hierarchy has zero versatility and edge has a versatility score of 1. One can conclude that versatility contributes to agility up to a point, while a lack of versatility constrains agility. As previously observed, a more detailed look at the behaviors of the entities in these experiments found that the observed relationship between versatility and agility was due to the inability of the entity with the highest versatility score to handle circumstances that involved very high levels of workload. This was because of the time that agents devoted to information sharing (or more accurately, excessive information sharing and/or information processing). Entities with more flexible information-sharing policies were able to reduce the amount of sharing when it was not required and yet maintain their versatility. As a result, they increased their agility.

Evidence for Flexibility

The results we have seen for the edge and the post-only edge illustrate the major conclusion previously reached that there is no one-size-fits-all solution. In this case, there is no single policy option that works well, let along best, in all mission challenges and circumstances. Flexibility, the ability to accomplish a given task in multiple ways, was one of the previously identified components of agility. As discussed previously, having two or more information-sharing policy options is but one example of how an entity can be flexible. The amount of flexibility that an entity has is a function of the number of policy options available and its ability to effectively employ its options. Being able to make an appropriate policy decision requires an ability to recognize the situation and understand which policy option is best suited for the situation. Flexibility, as we will see later, can be greatly enhanced by responsiveness.

In this section, I revisit the experimental results presented in chapter 27 to provide an example. These experiments involved an edge with a fixed share-and-post information-sharing policy and an edge that could choose between a share-and-post and a post-only policy. The edge with a choice of policies chose the post-only as its default. If it recognized that the network was damaged, it switched to a post-and-share policy. Once selected, the policy could not be changed. There are, of course, far more sophisticated behaviors that could be envisioned. However, these would require more information about current network conditions, information that may not be readily available. In addition, they would require mechanisms that enabled an entity to change policy on the fly and have it appropriately implemented.

Figure VI-4 presents the results of these policy-related experiments in the form of three entity agility maps. These maps take a slice or view of endeavor space that involves the 9-cell before matrix under different levels of network damage and noise. The first is the map for an edge with a fixed post-and-share information policy. The second is a map for an edge with a choice of options but with no understanding of the situation. Therefore, that entity employs its default post-only policy option. The third map is for an edge with both a flexible information-sharing policy, and the ability to correctly understand the situation and adopt the appropriate policy option. The darkest shaded areas represent the regions of endeavor space where the entity can operate successfully 100 percent of the time, the medium shaded area represents a probability of success greater than 90 percent, while the lightly shaded area represents a less than 90 percent success rate.

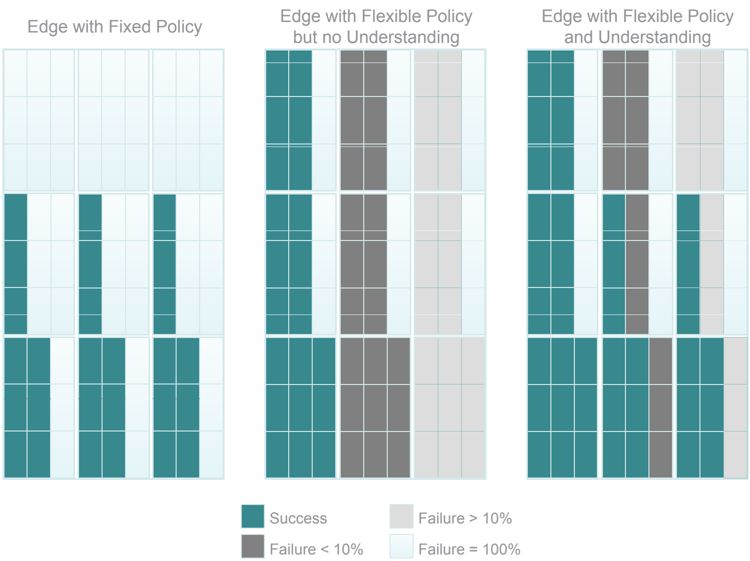

Figure VI-4: Impact of a Flexible Information Sharing Policy

Being able to implement a flexible information-sharing policy makes it possible for the entity to be certain of success under conditions of network damage, at least part of the time. Figure VI-5 shows how flexibility, with or without understanding, translates into agility as measured by the simple metrics.

	Benchmarked Agility Metric (relative to expectations)	Agility Map Coverage (percent of endeavor space where entity can operate successfully)
Edge with Fixed Policy	56.1%	18.8%
Edge with Flexible Policy but no Understanding	77.1%	51.5%
Edge with Flexible Policy and Understanding	78.1%	53.0%

Figure VI-5: Flexibility and Agility

These results support the existence of a relationship between flexibility and agility, one that depends on the ability of an entity not only to possess, but to properly employ the available options.

Evidence for Adaptability

Because it involves changes to self, one of the most difficult components of agility to build into new entities or to improve in existing entities, is adaptability. The more successful an entity is, the more it is apt to resist changes to self. However, there are sets of circumstances for which even the most successful entity is not well suited. Furthermore, a lack of adaptability constrains each of the other components of agility.

The example of adaptability presented below extends the discussion of adaptability in chapter 27. Instead of simply having the two options (coordinated or edge), I will look at the ability of an entity to adopt the full range of approach options considered in the *NATO NEC C2 Maturity Model*.[153] *The NATO NEC C2 Maturity Model* defines different five different approach options that differ in the degree to which they are network enabled. An entity's approach maturity is defined in terms of the most network-enabled approach that it can employ. However, reaching the level of maturity associated with a given approach involves more than simply being able to employ a given approach. This maturity model assumes that, in addition to being able to employ a given approach, an entity is also capable of 1) employing less network-enabled approaches, 2) recognize which of the approaches that it is capable of employing is most appropriate for the situation at hand, and 3) being able to transition from one approach to another, if necessary. Figure VI-6 depicts the five levels of entity approach maturity and, for each maturity level, the specific approaches involved, the requirement to recognize the most appropriate approach, and the transition requirements. The arrow on the left side indicates that the NATO Research Group SAS-065 believes that more mature entities would be more agile. The SAS-065 definition of approach maturity translates into more adaptability—that is, both a higher level of maturity and a higher degree of adaptability involve being able to operate in a larger region of approach space.

153. The approach space used by the *NATO NEC C2 Maturity Model* was introduced to the community by the author during SAS-050 in 2003.

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

Figure VI-6: Maturity Levels and Agility

Let us put aside the first SAS-065 level of maturity, a level that corresponds to the origin in the approach space and thus involves no delegations of authority, no sharing of information, and no interactions. As an entity moves to a higher level of maturity, it is capable of a more network-enabled approach, as well as maintaining the ability to employ an approach that is less network-enabled when appropriate. The reason this ability makes a difference in practice is that not all situations and circumstances require the interactions and information sharing associated with more network-enabled approaches. Since being more network-enabled is more costly, it makes sense to use a less network-enabled approach if it can succeed. Thus, an entity must also be able to, as was the case with policy flexibility, understand the nature of the situation it faces and pick the most appropriate approach from among the options in its tool kit; it must then be able, if necessary, to transition from one approach to another.

In terms of the ELICIT experiments, an entity that achieves a level 5 and is able to operate in any part of the approach space can appropriately adopt a hierarchy, a coordinated approach, a collaborative approach, or an edge approach. These maturity levels correspond to a scale of adaptability that ranges from 1 to 5. Figure V-50, reproduced below as figure VI-7 compares an entity that was capable of employing a collaborative approach with one, that in addition to be able to employ in a collaborative approach, is also capable of employing an edge approach.

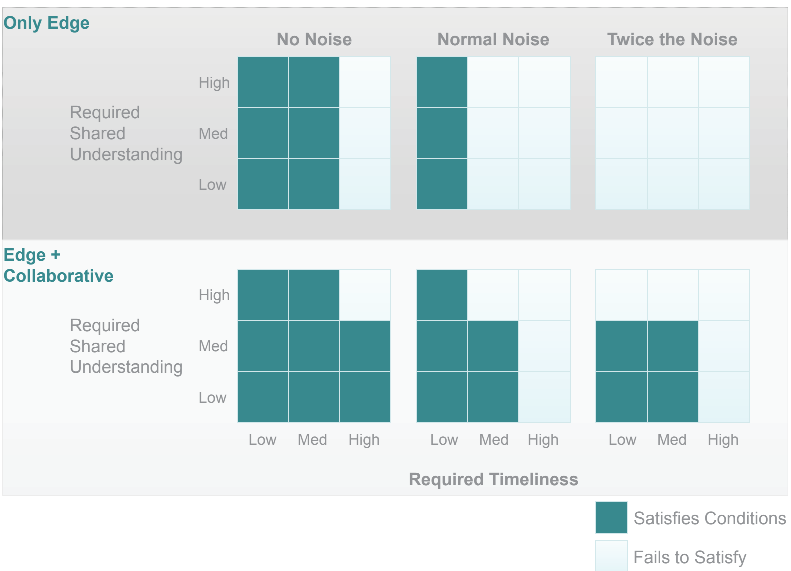

Figure VI-7: Impact of Adaptability as a Function of Required Shared Understanding, Timeliness, and Noise (Previously Seen as V-50)

Figure V-33, reproduced here as figure VI-8 is a comparative agility map that shows which organization-approach option is best suited for different regions of endeavor space. As an entity's maturity increases, it can increase its performance (correctness, timeliness, and efficiency) over a larger region of endeavor space.

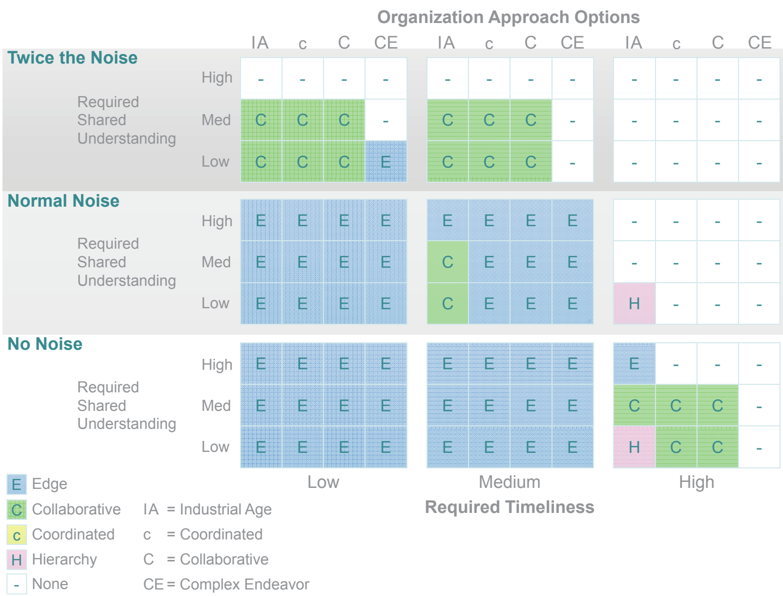

Figure VI-8: Agility Map of Organization-Approach Options (Previously Seen as V-33)

It is clear from these results that a higher level of NEC C2 maturity results in more agility. However, to develop a more complete understanding of the relationship between approach maturity and agility, a more involved analysis is required. I performed this analysis using one of the agility metrics—endeavor space coverage. The steps in this analysis and the results are provided next.

A complete analysis of the relationship between maturity levels and endeavor space coverage involves looking at the set of organization-approach options associated with each level of maturity and determining the mathematical union of endeavor space coverage. In other words, starting with the agility map of the most network-enabled option in the set, look at the agility maps of the other options to see the coverage they add.

Level 1 of the maturity model contains only one approach and this approach cannot be successful in any part of endeavor space and the value of the agility metric = 0 percent. Level 2 consists only of the hierarchy and thus its endeavor space coverage has already been calculated at 5.5 percent.

Level 3 contains both the hierarchy and the coordinated approach options. Figure VI-9 provides a slice of endeavor space that corresponds to the following circumstances and conditions: an industrial age mission challenge with no network damage. For each region in this space, one of the following four possibilities exists:

1. Neither the hierarchy nor the coordinated approach is successful;

2. The coordinated approach is successful;

3. Both the coordinated approach and the hierarchy are successful; or

4. Only the hierarchy is successful.

For the purposes of this analysis, we are not interested in the situations when both are successful because the coordinated approach is always applicable to more mission challenges than is the hierarchy.

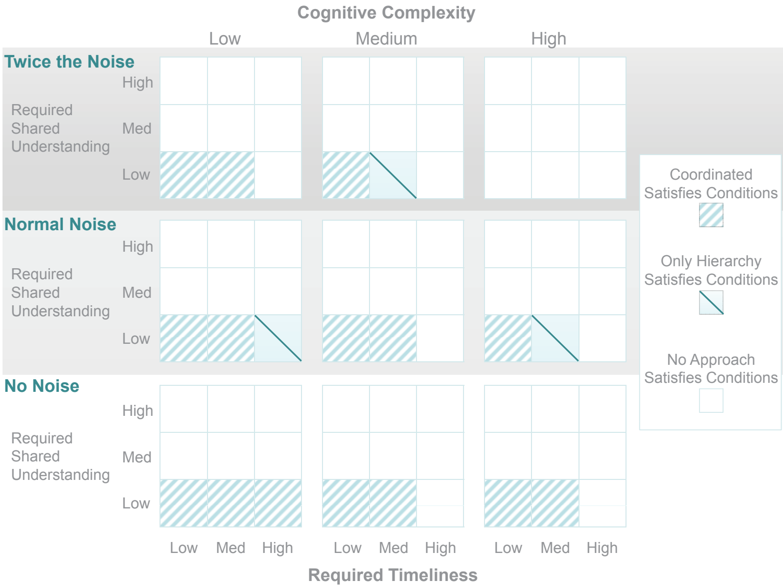

Figure VI-9: Agility Map for Maturity Level 3 as a Function of Noise and Cognitive Complexity with No Network Damage, Industrial Age Challenge

In this map there are only three instances where being able to fall back to a hierarchy adds value. In addition, the situations where the hierarchy can be successful and where the coordinated approach cannot be successful apply only to the industrial age mission challenge. From this map we can proceed to a calculation of the agility metric in the same fashion explained previously.

An entity capable of operating at level 3 can make a choice between the coordinated approach and a hierarchy option. As a result it can operate in 18 cells in figure VI-9. If we depicted the map that would correspond to the coordinated mission challenge instead of the industrial age challenge, we would see that this entity would be only able to operate in 15 of the cells. In the case of the other two mission challenges, neither of these two options (available to an entity at maturity level 3) would be successful under any circumstances.

To complete this analysis, the impact of network damage needs to be factored in. At stake are 66 cells that correspond to circumstances where the network has sustained damage to 1 or 2 links. The loss of 1 link in the case of either a coordinated approach or a hierarchy never results in failure so we can add another 33 cells to our count of the regions where a level 3 entity can be successful. The loss of 2 links results in failure only 1.0 percent of the time for the coordinated approach and 1.7 percent of the time for hierarchy. Thus, for the 30 cells that are covered by the coordinated approach, we can add 29.7 cells (30 x .99), and for the 3 cells where only the hierarchy works, we can add 2.9 cells (3 x .983). This gives us a total of 98.6 cells of coverage for an entity capability of operating at level 3, which translates into 9.9 percent of coverage.

Turning our attention to an entity that has reached maturity level 4, we start with figure VI-10.

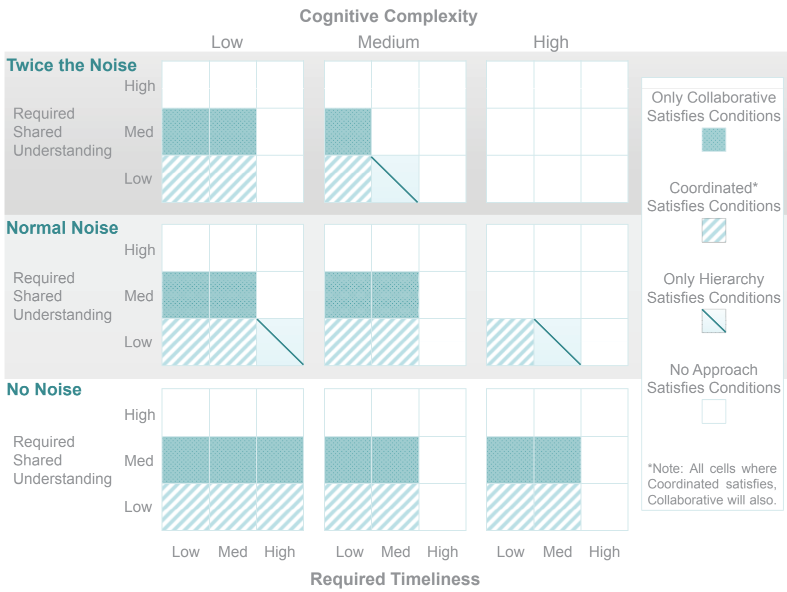

Figure VI-10: Agility Map for Maturity Level 4 as a Function of Noise and Cognitive Complexity with No Network Damage, Industrial Age Challenge

An entity capable of operating at level 4 can choose from three options: collaborative, coordinated, and hierarchy. As a result it can operate in 18 cells in figure VI-10. This map shows a total of 32 cells covered for an entity at level 4. Of these 32, 15 cells require a collaborative approach. There are 14 cells where, while a collaborative approach would be successful, it might make sense to fall back to a coordinated-approach option when faced with certain of the challenges. As in the previous case, there are only 3 instances where hierarchy adds value, and those are when the entity is faced with an industrial age challenge.

To sum up the number of cells where a level 4 entity is successful, we need to multiple the 29 cells where a collaborative approach is successful by 3, since a collaborative approach works in these regions for all but the complex endeavor mission challenge. Then we need to add 3 to this number, since the hierarchy can also be successful in one of the four mission challenges. This gives us a total of 90 cells (29 x 3 + 3).

To complete this analysis, the impact of network damage needs to be factored in. At stake are 180 cells that correspond to circumstances where the network has sustained damage to 1 or 2 links. None of the three organization-approach options available to a level 4 entity suffers as a result of a loss of just 1 link. There is no adverse impact on success for the collaborative approach, a failure rate of only 1.0 percent of the time for the coordinated approach, and 1.7 percent of the time for hierarchy. Under these network damage conditions, the entity would not choose to fall back to a coordinated option but remain with the collaborative approach. Thus, the only adverse impact suffered by a loss of two links would be when it was forced to employ a hierarchy. In this case, there are 3 regions of endeavor space where this is required. The total coverage for a level 4 entity adds up to 269.9. This translates into 27.8 percent endeavor space coverage.

I will now present the results of an analysis of an entity that has reached maturity level 5, that is, an entity that can span the whole of approach space.

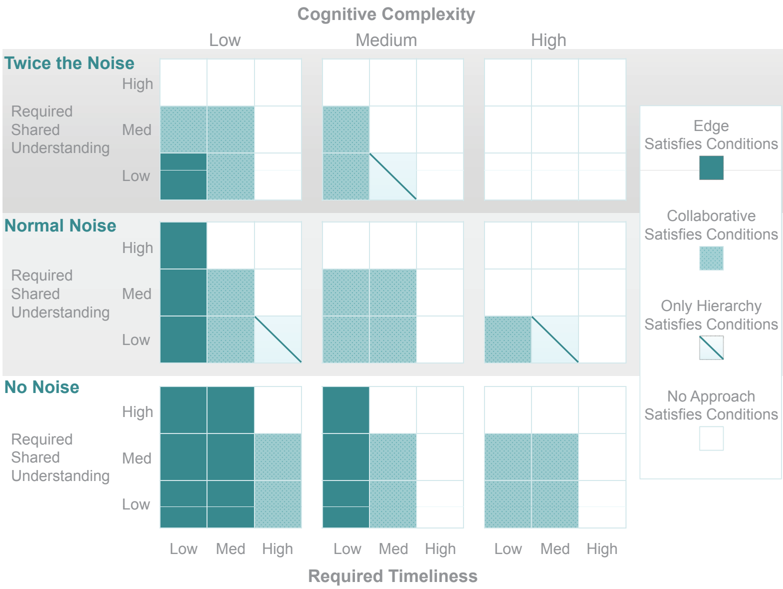

Figure VI-11: Agility Map for Maturity Level 5 as a Function of Noise and Cognitive Complexity with No Network Damage, Industrial Age Challenge

Figure VI-11 depicts the most network-enabled approach that satisfies the conditions associated with each cell. For the industrial age mission challenge, a level 5 entity can successfully operate in 36 of a total of 81 cells. If we sum across the four mission challenges, a level 5 entity can be successful in 115 of the 324 possible cells. This is 25 more cells than a level 4 entity.

To complete this analysis, the impact of network damage needs to be factored in. At stake are 230 cells that correspond to circumstances where the network has sustained damage to 1 or 2 links. None of the organization-approach options available to a level 4 entity suffers as a result of a loss of just 1 link. Thus, we are now at a total of 260 of a possible 390.

In the case where 2 links are down, there is no adverse impact on either the edge or the collaborative approach. Only the 3 cells where the hierarchy is the only approach that is successful will be adversely affected. The failure rate for a hierarchy when 2 links are down is 1.7 percent. Thus, we can add another 129.9 cells to get a grand total of 389.9. This translates into 40.1 percent endeavor space coverage.

Figure VI-12 shows the relationship between approach options, entity maturity levels, and endeavor space coverage. These results show that both approach options and entity approach maturity are related to agility. However, from these results, it appears the maturity level is a more reliable predictor than approach option. This is because there are clearly regions of endeavor space that are not appropriate for an edge. However, since higher maturity levels are not single point solutions, but rather provide a tool kit with some choice, a level 5 entity does not need to employ an edge when it is not appropriate to do so. This makes entities with higher levels of maturity more adaptable, as well as more network enabled.

To separate the effect of a more network-enabled approach from a more adaptive approach, one needs to look at the difference between the two curves. The lightly shaded area shows the relationship between the degree to which an entity's approach is network-enabled and a measure of agility, while the darkest shaded area represents just the impact that the adaptability that comes with higher maturity levels has on agility.

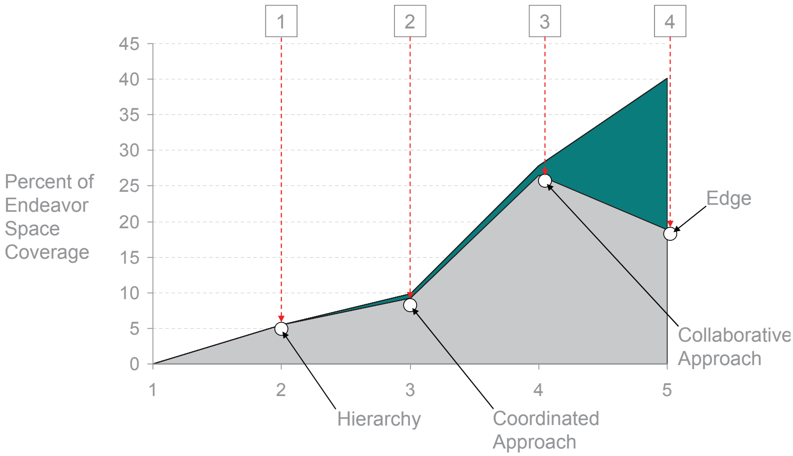

Figure VI-12: Adaptability and Agility

Evidence for Responsiveness

Responsiveness is the one absolutely essential component of agility. If an entity cannot respond in time, then nothing else matters. Even if one has a good policy response or is capable of adapting self to implement an appropriate organization-approach option, if these options cannot be exercised in time, their potential will never be realized.

In the discussions of flexibility and adaptability, it was assumed that an entity might not possess the degree of understanding necessary to make the most appropriate approach or policy choices. It was also assumed that the situation, at least for the period under consideration, was stable with respect to circumstances that would affect these choices of approach and policy. In terms of responsiveness, it was assumed that these choices would be made a priori to the experimental run. Entities that can understand the situation sufficiently to make an appropriate choice and implement that choice prior to the beginning of an operation exhibited a sufficient level of responsiveness to allow, in these cases, the potential flexibility or adaptability to be realized.

However, since the situations and endeavors of interest to us are dynamic, approach and policy choices, no matter how good they may be, at any point in time, may no longer be the most appropriate choices as the situation changes. Responsiveness, as explained in part IV, is the capability to move beyond passive agility to active agility. A responsive entity is able to anticipate and even influence, perhaps preempt, a change in circumstances. But if a change occurs, responsiveness requires that an entity recognizes that circumstances have indeed changed and that some action is necessary. Then, a decision is required. This decision identifies what action(s) is(are) necessary and for action to be taken—all in a timely manner.

There are times when an entity can anticipate a change of circumstances and can respond before the change occurs. However, this is a relatively rare occurrence. More likely than not, it will take some time for an entity to detect and understand a change in circumstances and respond to it. Figure IV-6 Anatomy of Responsiveness, reproduced here as figure VI-13, is a graphical depiction of the factors that contribute to responsiveness and the impact that responsiveness has on agility.

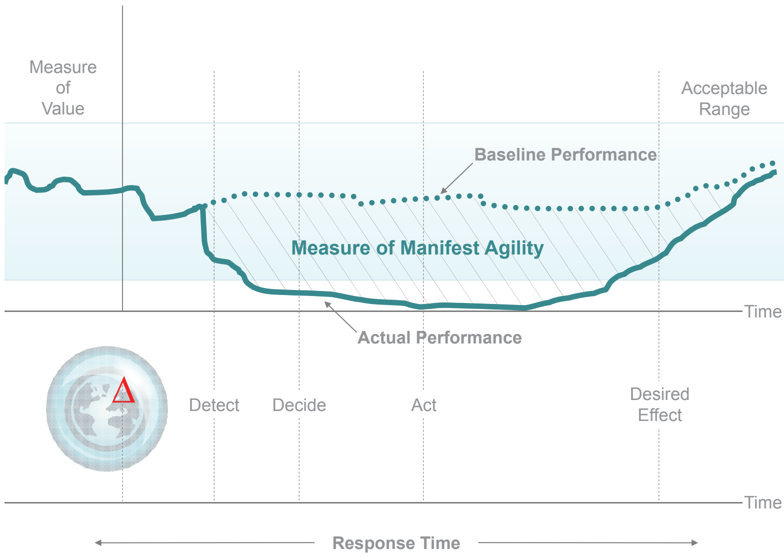

Figure VI-13: Anatomy of Responsiveness (Previously Seen as IV-6)

A set of experiments was conducted to explore the relationship between responsiveness and agility. In these experiments, a website goes down immediately prior to the start of the run. An edge with a post-only information-sharing policy in effect was chosen for these experiments because it is dependent on websites as its sole means of information sharing. Four situations are created. In the first situation, the entity (or the affected individuals) has either anticipated this event and adopted a different information-sharing policy, or has instantly detected the event and immediately implemented an appropriate change to policy. In the second and third situations, this recognition, decision, and action process takes some time. In the second run, the response occurs just prior to the second distribution of factoids (modest delay), while in the third run, it occurs just prior to the third and final distribution of factoids (moderate delay). In the fourth run, the response never occurs, or occurs after the operation is over. The results of this set of experiments show that even a modest delay results in a significant loss of capability, with average correctness dropping from 1.0 to .059. When the delay is moderate, the entity fails entirely, and receives a correctness score of 0.

Evidence for Resilience

Resilience involves the ability to avoid or mitigate the adverse impacts of damage or disruption and/or to restore functionality. This increases the ability of an entity to sustain a loss of capability without it resulting in moving the entity outside the acceptable range of performance.

In the experiments previously discussed there are two examples of a loss of infostructure capability. First, we looked at a situation where one or two links, selected at random, went down. None of the organization-approach options considered suffered a significant loss of performance when one link went down. In the cases of a loss of two links, both the collaborative approach and the edge remained unaffected. Other options, including an edge with a post-only policy, were adversely affected. The experimental results showed that a flexible edge was also a resilient edge and that an entity that possessed a high degree of adaptability proved to be resilient as well.

When it came to the loss of a website, an entity could be resilient if it possessed an adequate degree of flexibility if the entity was also sufficiently responsive. Here the degree of resiliency depends upon how quickly the loss of a website is detected and information-sharing behaviors are changed.

Evidence for Innovativeness

The creation of a new policy, the development of a new variant of organization approach, the development of a new process, or the introduction of new technology or capability all represent innovation. Innovation creates value by enhancing one or more of the other components of agility. In these examples, a new policy option could enhance flexibility, a new organization approach could enhance versatility or adaptability or both, a new process could enhance responsiveness and perhaps resilience, and the introduction of a new technology or capability could enhance each and every one of the components of agility.

These experiments did not explicitly look at innovation, but given the indirect nature of its impact, the experimental results can be used to make the case that innovation is strongly related to agility.

The Next Steps in the Development of a Model of Potential Agility

The evidence suggests a strong relationship between the components of agility and entity agility. This is not surprising. The evidence also shows the existence of interdependencies between and among these components, which is also not surprising. Based on the experimental evidence and logical arguments, the existence of a direct link between each of the components and agility has clearly been illustrated. Thus, the model of potential agility proposed has been partially supported with the evidence of the existence of a set of first order links between the components of agility (the inner ring in figure VI-1) and potential agility. The functions and parameters of interest include: 1) the degree to which an entity possesses each individual component of agility, and 2) the relationships between and among these components and the degree of an entity's potential agility.

The logical next step would be to develop measures of the degree to which an entity possess these six components of agility. However, while the various components of agility can be observed in action without too much difficulty, it is far more difficult to observe or measure them in their unactivated state. For example, flexibility can be observed when an entity, having failed to be able to accomplish something one way (the schoolbook or doctrinal solution), selects and implements a different approach to accomplish the objective. But it is not obvious how one could directly measure an entity's potential flexibility. Although one could identify how many options or ways of accomplishing key tasks are available to an entity, the number of tasks involved and the many factors that influence whether or not an entity can translate more options into flexibility when the time comes, makes this approach unattractive for our purposes.

However, this sort of metric may be very useful as part of an agility audit and can contribute to improving an entity's flexibility.

Therefore, I have chosen to take another approach. Instead of relying on direct measurement of, for example, potential flexibility, I will look at the factors in the middle and outer rings in figure VI-1 to see if there are ranges of these variables that point to more or less of a particular component of agility and/or to agility—that is, for example, entity behaviors and characteristics or the direct results of these behaviors and characteristics that would make it more likely that an entity is, for example, more or less responsive.

Chapter 32
Identifying the Enablers/Inhibitors of the Components of Agility

The final step in our search for indicants to be included in a first order model of potential agility involves working both *forward* to seek out relationships between entity characteristics and the components of agility, and *backward* from the components of agility to their proximate causes (explanations).

In situations that have changed or in a variety of situations that we have created, we can observe whether or not the entity in question did or did not manifest agility. Regardless of the particular outcome, the question of interest is "What are the reasons for the agility-related outcomes observed?" The full answer to this question requires that we identify: 1) the component or components of agility that was/were involved, 2) the reasons that one or more components was or was not present, and 3) the entity characteristics and behaviors that created the conditions responsible for this outcome. This knowledge, derived from the answers that are found, even if the answer turns out to be that a proximate cause could not be established, can be used to establish one or more links between the rings in the model of potential agility. These links can be *plus links* signifying a positive or enabling relationship, *minus links* signifying a negative or inhibiting relationship, or a *neutral link* that signifies that the relationships may depend on the particular range of values.

For example, we observe that an entity was unable to successfully operate in a particular set of circumstances. We trace this failure to a lack of responsiveness. Further analysis traces this lack of responsiveness to a failure to recognize the changed circumstances in a timely manner. Perhaps, the change in circumstances was never detected or the change was detected but the implications were not understood. Perhaps the change in circumstances was detected and understood, but by someone who did not have the decision rights to act. The next step would be to trace the reason for the lack of responsiveness to a root cause—a particular entity characteristic or behavior. For example, if the problem was that the information was not provided to the appropriate individual, it's important to ascertain why. Was it because of inexperience? Was it a result of a policy that discourages information sharing? Was it a lack of technical means? This type of forensic analysis can lead us to identify candidate indicants of agility.

Identifying the Enablers/Inhibitors of the Components of Agility

Attributing success is more difficult than finding what is broken, unless we know in advance where to look. Even then, in order to prove that a particular characteristic was, in fact, necessary for success (not mission success but agility), we would need to remove or change the characteristic in question to see if we can induce failure. If it succeeds with and fails without, we can safely conclude that we have found a necessary characteristic for agility and hence something we can use as an indicant. Readers should proceed with caution here. The indicant we have thus identified may be necessary for agility in a specific set of circumstances (region of endeavor space), but having it does not guarantee success.

However, as we continue to identify indicants that are necessary for success in a dynamic environment and work to ensure that a particular entity possesses these characteristics, it can be expected that we will be improving the potential agility of the entity.

The two analyses that follow are meant to show that it is profitable to work both backward and forward. First, working forward, I shall see if I can establish an empirical relationship between the extent to which information is disseminated and an entity's versatility. Second, working backward, I shall see if I can determine an entity's characteristics that are a proximate cause for a lack of information dissemination. If I can do both, I will have been able to establish, for the complex endeavor simulated here, a causal path from the outer ring to agility that goes through one variable in both the middle and the inner rings. This is, of course, just one of a large number of analyses that will need to be performed if we are to develop a model of potential agility that we can use for a specific entity or class of entities.

Evidence of a Relationship Between Information Dissemination and Versatility

The following analysis illustrates the process of working backward to determine a reason for the absence of a component of agility (in this case versatility). The experimental results indicate that some organization-approach options are far less versatile than others. My hypothesis is that this lack of versatility results from a failure to provide sufficient access to information. To see if this conclusion can be supported by the evidence, I looked at the relationships between a measure of the extent to which individuals had access to information for different organization-approach options.

Figure VI-14 presents the average percentage of the factoids received by individual members of an entity at the conclusion of a trial[154] and the versatility score that corresponds to the entity.

154. This was calculated using the industrial age challenge with conditions of normal noise, low complexity, and no network damage.

Average % Factoids Received	Versatility Score
97.2%	1.0
66.2%	.67
44.3%	.33
30.5%	0.0

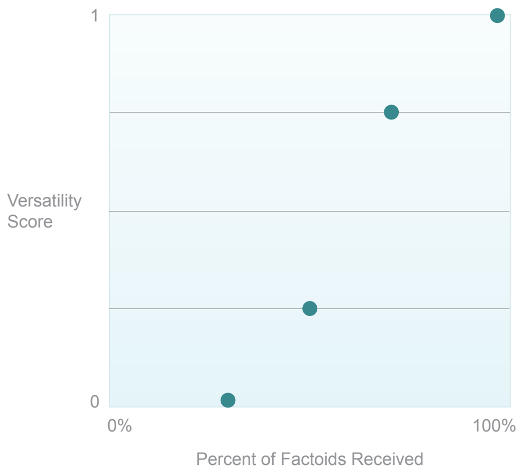

Figure VI-14: Information Dissemination and Versatility

Received refers to information brought to an individual's attention, but it does not mean that the individual actually processed this information. The strength of the relationship between what information is distributed to (received by) individuals and entity versatility appears to be a strong one. It seems reasonable to conclude that the more broadly information is disseminated within an entity, the higher its potential versatility and therefore, the higher its potential agility. However, there are many factors that also might affect versatility besides access to information. Thus, it is more accurate to say that a lack of information dissemination reduces potential agility. The experimental results confirm this inverse view. For example, as workload increases the average percentage of information actually received is reduced. Individuals in a hierarchy, for example, received an average of 30.5 percent of the total number of factoids available to the entity as a whole under conditions of normal noise, while they only received an average of 28.2 percent of the factoids when noise conditions are high.[155] This evidence supports my attributing a lack of versatility to a lack of information dissemination.

A Search for the Cause of Insufficient Information Dissemination

In figure IV-17 reproduced here as VI-15, we see that the ability of an infostructure to contribute to mission performance is determined not only by its characteristics and performance but by *access*. Furthermore, that access to the infostructure (information, services, expertise, and interactions) is constrained or enhanced by policy.

155. Not all information received is processed due to a variety of factors including simply running out of time.

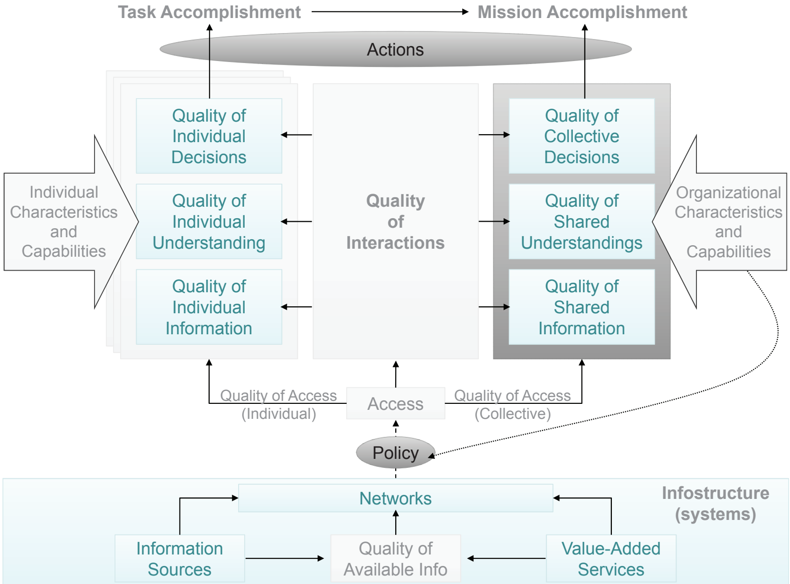

Figure VI-15: Integrated Process-Value Model (Previously Seen as IV-17)

However, the metric used in figure VI-14 did not measure access to information, but rather it measured the information actually received by individuals. In these experiments, each of these organization-approach options was a *connected network*. Therefore, it was theoretically possible for all individuals to have access to all the information. However, as is usually the case in practice, with the exception of the edge, individuals did not receive all the information they could have. This was a result of information-sharing behaviors. These behaviors were shaped and constrained by assigned roles and policy options. Thus, the access gate in figure IV-18 was open wide. Experiments should be designed and conducted to understand the consequences of access restrictions. This understanding is needed to properly balance the need to protect and the need to share.

To reiterate, in the ELICIT experiments, while there was no information that was actually restricted (access denied), there were barriers to information dissemination that varied as a function of the organization-approach option. This is another form of access denial that is often overlooked. The most notable of these was that, with the exception of the edge option, not everyone was given direct access to all websites. In cases when an individual had no direct website access (could not post or pull), the information on those websites could only be accessed if it was shared by another individual who either had direct access or received the information from another individual (e.g., a team leader). As previously noted, this form of access denial was the reason why a post-before-process policy was not as effective as expected.

To find a connection from the outer ring to the middle ring, specifically from a characteristic of an entity to the resulting information dissemination results, I hypothesized which entity characteristic I believe may have been the cause of a lack of information dissemination. One explanation for the differences in information dissemination seen among the organization-approach options that were considered is the extent to which an entity is *networked*. Each of these organization-approach options consists of nodes and links. The nodes include individuals, processes, and services (e.g., data sources, websites, and information-related services). The specific characteristics of different organization-approach options will determine the degree to which the entity is robustly networked. A robustly networked force was considered the *entity fee* for network-centric operations. Being robustly networked translates into a high degree of technical, informational, and social connectedness. Included in my definition of social networks are the formal and information relationships between and among individuals and groups of individuals that constitute the fabric of human enterprises. Trust is an important aspect of these networks and serves to determine the nature of the interactions that actually take place between and among the nodes. These are normally co-evolved with work processes that provide the means of value creation.

However before there can be an interaction between two nodes, they must be connected. A measure of the density of connections in an entity's network(s) is connectedness. Connected in this context means that 1) a communications path between the two nodes exists, and 2) the two nodes are permitted to directly interact. Thus, individual connectedness reflects the degree to which an individual is *plugged in*, and collective connectedness determines the number of potential interactions. Connectedness, since it is a reflection of the available pathways between and among the entities, is therefore related to the extent to which information is accessible and thus is clearly related to the ability of an organization-approach to get the information needed to make decisions to the right place in a timely manner. Connectedness enables but does not guarantee access to information or to individuals and their expertise and perspectives. Without permissions, tools, trust, and the like, connectedness is of little value. However, while the dissemination of information is a function of a number of factors, including trust, policy, and individual proclivities, it is constrained by the degree of connectedness of the entity. Therefore, in my search for an explanation for a lack of information dissemination (average percentage of factoids received), I began by looking at a measure of connectedness. Figure VI-16 provides the connectedness scores for the organization-approach options depicted in figure VI-14 and their corresponding values for the measure of information dissemination.

Connectedness	Average % Factoids Received
9.7	97.2%
3.7	66.2%
3.1	44.3%
2.9	30.5%

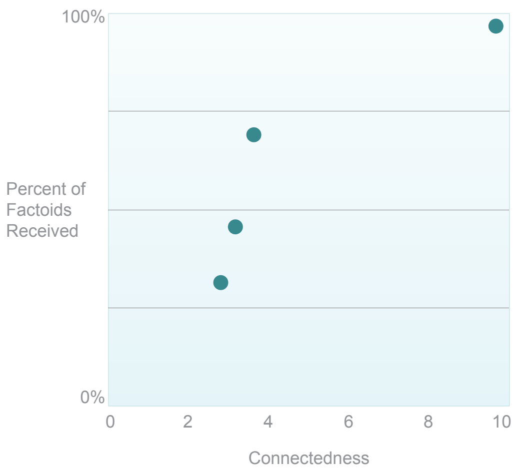

Figure VI-16: Connectedness and Information Dissemination

The results provided in figure VI-16 show that information dissemination is highly sensitive to connectedness when connectedness scores are lower than 3. A connectedness score below 3 is a significant constraint on information dissemination. As connectedness increases, information dissemination increases dramatically. As already pointed out, other factors located in the outer ring, such as policy, trust perceptions, and individual propensities to share, have a significant influence on whether the degree of information dissemination that is enabled by connectedness is realized.

Chapter 33
Toward a Model of Potential Agility

The illustrative examples provided above should be taken as only a proof of concept for the assertion that a model of potential agility can, in fact, be built. I have provided the basic ring structure for such a model and have, supported with some experimental results, established the existence of meaningful relationships between these rings. However, there is a great deal more research and analysis that needs to be done to flesh out and build upon this skeleton of a model. Thus, while this book takes an important first step on the road to a model of potential agility, much work remains to be done.

The road ahead is not conceptually difficult nor is it particularly challenging for experienced analysts in the variety of domains where agility should be of interest. What follows here is some food for thought regarding the contents of the outermost ring of the model of potential agility that may provide interested readers with a useful point of departure should they wish to embark on a journey to discover the determinants of agility.

The Outer Ring

The outer ring (figure VI-17) consists of what can be considered as a set of initial conditions (conditions that shape the individual), and entity behaviors that are measured by the metrics that comprise the middle ring.

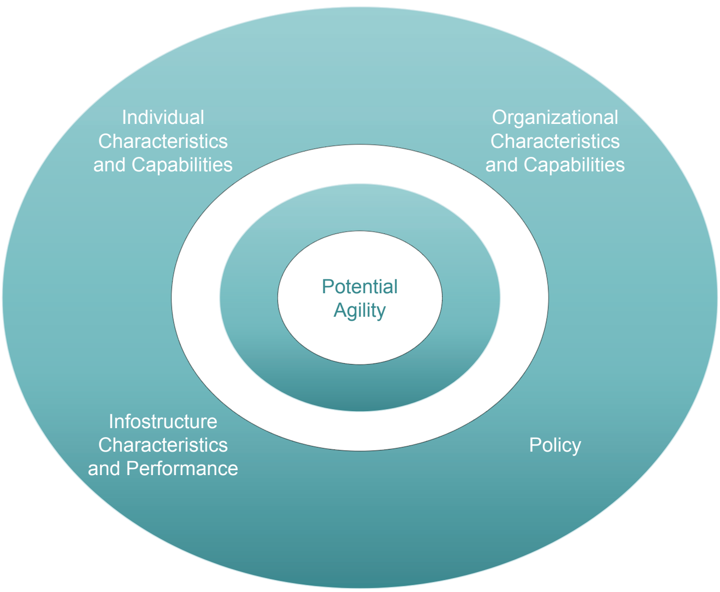

Figure VI-17: Outer Ring Model of Potential Agility

Individual Characteristics and Capabilities

It is often said that individuals are the most important investment that an organization can make. This has never been more apparent than it is today. If it were not for the inherent agility in the individuals that make up today's organizations, the complexity and uncertainty associated with today's missions and the environments in which these missions are undertaken would overwhelm them. Unfortunately, at times the agility of individuals is constrained by organizational characteristics and capabilities, policies, and infostructure. In addition to the capacity for agility that is present in individuals, many other factors such as personality, risk tolerance, cognitive skills, experience, education, and task-related competence contribute to an entity's performance. In the experiments reported on previously, these attributes and characteristics were not varied.

Organizational Characteristics and Capabilities

The organizational characteristics and capabilities of particular interest here include a key dimension of approach space (allocation of decision rights), organization culture, reward systems, and entity hardness.[156]

156. Hardness is a property of teams that reflects their knowledge of one another and their ability to work together. It has been shown to be an important factor in the ability to successfully undertake tasks. Hardness is related to trust. Hardened teams exhibit more trust in each other and/or have found ways to work with less-trusted members.

Policy

Policy, as it pertains to access to the infostructure and information, is considered separately because it is an entity design variable in its own right and can be independently controlled. It should be noted that although policy choices can be made independently of other design variables, the extent to which policy can be implemented depends upon the other characteristics of an entity, such as infostructure capabilities and culture. Thus, policy choices can be infeasible or dysfunctional. Policy choices can facilitate or inhibit access to the information and services provided by the infostructure, and can be measured by the extent of access (individual or collective) they permit. Policy consequences can be measured by the impact they have on information sharing and collaborative behaviors. The dissemination of information dimension of approach space is, in part, determined by policy. The costs of policy choices include not only those associated with the promulgation and enforcement of policy, including education and training, but also the opportunity losses associated with any adverse impacts they may have on connectedness or the limitations they place on the entity's ability to position itself in and move around in approach space. The benefits of policy can also be judged in terms of the impact it has on connectedness, access, and the size and shape of the regions in approach space where an entity can operate.

Infostructure Characteristics and Performance

Both the investments made in infostructure and its design greatly affect the ability of the technical networks (communications and information services) to support the social network and work processes. In the past, when the cost of information-related technologies and services were relatively high, the performance of this infostructure clearly constrained the flows of information, information processing, and the interactions between and among individuals. While in certain cases, the infostructures we currently have serve to constrain us, it is increasingly common that our institutions do not fully leverage the information-related capabilities that they have or could afford. The agility experiments conducted here illustrate how one could ascertain the adverse impact on agility that infostructure shortfalls (or damage to the infostructure) have. Conversely, they show how to quantify the return on investment for improvements to infostructure.

Information Quality

Infostructure is of critical importance. Without the technical ability to support widespread access to information, collaborative tools to enable individuals and organizations to productively interact with one another, and information-processing capabilities to make sense of the available information, few 21st century organizations could successfully function. The more dynamic the environment and the more geographically distributed the entity is, the more it must rely on its infostructure to function. However, all the infostructure capability in the world will not be sufficient if the quality of the information collected and developed is poor.

Information quality is a function of a number of measures (accuracy, correctness, consistency, currency, precision, timeliness, completeness, relevance, uncertainty, and ease of use). Some of these, like precision, are absolute measures, while others, like accuracy and relevance, are contextual measures—measures that reflect the nature of the task and challenge at hand.

In the ELICIT experiments reported on here, the set of information that is made directly available to the organization or collective is complete (enough to solve the problem). However, with the exception of the industrial age mission challenge, no individual or team has *direct* access to sufficient information to solve their assigned piece of the problem. Therefore, they will be unable to solve the problem unless they share information with one another, or share by posting information to websites, making it available to others.

Furthermore, all the information provided is true, although some of it may not be relevant (not needed to solve the problem). ELICIT is currently being enhanced to be able to consider the inclusion of incorrect information and even misinformation. This enhancement introduces agent perceptions of trust and associated logic that enables agents to sort out good information from bad information, based on currency and perceptions of the reliability of sources. As interested individuals and organizations seek to explore the agility of various organization-approach options and information-sharing-and-access policy options, varying initial perceptions of trust and amounts of incorrect information should be a part of these analyses.

In ELICIT not all factoids are of equal information content. Some are considered to be key or essential factoids, others are supporting factoids, and some have negative value in that they take time to deal with but do not contribute to a solution or may even be misleading.

Not all the information that eventually becomes available to the organization or collective is available at time *t*. In the ELICIT experiments, information is made available in predefined but configurable waves. In the set of experiments with human participants, the complete set of information was made available to the organization or collective within the first 10 minutes of a 60-minute experiment.

The overall quality of the information available to an entity is a significant factor that needs to be included in the outer ring. Despite the tendency to consider information quality a given in many analyses, it is a controllable variable, and not only in the proverbial long run. Significant improvements in information quality are possible in the short run. Most notably, improving information sharing between and among coalition partners presents a real opportunity to both inject *new* information (information that is not currently collected or displayed) and update or correct existing information. The greater the diversity of the coalition, the greater the potential is for improving information quality.

The Middle Ring

The middle ring, as depicted in figure VI-18, is a subset of the network-enabled value chain that measures the *outputs* of individual and entity behaviors in the information, cognitive, and social domains.

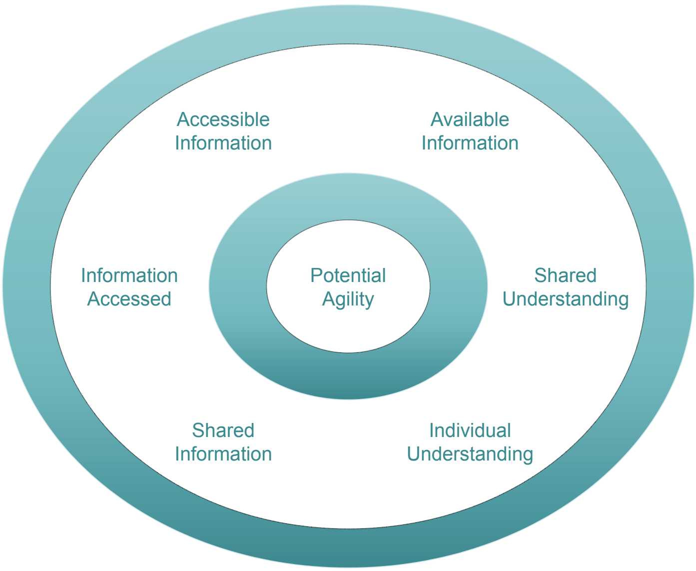

Figure VI-18: Middle Ring Model of Potential Agility

In the example provided above, I linked entity connectedness to versatility using a measure of information that was actually made available to individuals (that which was received). The relationship that was empirically established depended on the individuals' ability to utilize the information received.

In this case, not all the information received by a given individual was always used, that is, processed. In addition, not all information received was passed on to others in a timely manner. In general, information that is accessible is not always accessed and when accessed is not always shared. Individuals may not have time or may not be aware of a particular source of information. Individuals may not trust a particular source and therefore not go there. Even if an individual visits a website that contains information of interest, the individual may not *see* this information or recognize its importance.

Individuals who do not have direct access to some information rely on others to access and share it. Individuals do not always share information, they do not always share it with all the individuals that may be interested in this information, and they do not always post it to the appropriate websites. Thus, while communications pathways, access policies, and information sources may make information widely available and accessible, the information may not actually be widely disseminated.

Figure VI-19 looks at the same set of entities as figures VI-14 and VI-16 and compares entity connectedness and the average proportion of information received by an individual to the amount of information processed and the proportion of information shared.

Connectedness	Percent of Factoids Received	Percent of Factoids Processed	Percent of Factoids Shared
9.7	97.2%	97.2%	61.9%
3.7	66.2%	51.0%	31.1%
3.1	44.3%	29.3%	12.5%
2.9	30.5%	22.8%	8.8%

Figure VI-19: Information Received, Processed, and Shared

These results from runs with normal levels of noise and low-cognitive complexity highlight a number of key characteristics of the entities involved. For these organizational-approach options, connectedness is highly correlated with roles and responsibilities. In all cases, information was processed and shared to the greatest extent possible *within* the constraints imposed by role, which in turn defined access. If this were not the case, these results would not necessarily show all variables moving almost in tandem. In other parts of endeavor space, when individuals are overworked, the percentage processed and the percent shared leveled off and even fell. A variety of different information-sharing policies also had an impact on these rather uniform results. Success in this endeavor space depends heavily on how much of the available information is needed by individuals to solve the problem and how much time they have. Thus, more access to information may not result in a better outcome; however, if access is overly restricted relative to the information that is needed, a bad outcome is almost assured. Therefore, the specific parameters of a model of potential agility are domain (endeavor) sensitive.

In the abELICIT experiments reported on here, all the agents were all quite good at processing information, and their cognitive skills were excellent. In real world situations, this would not likely be the case. It is usual for individuals to be exposed to a great deal of information, and normally a lot of this information is not cognitively processed. Put another way, individuals may briefly look at a piece of information and, for any number of reasons, discard or discount the information. In abELICIT terms, agents screen the information they receive and determine whether or not to process and/or pass on this information. The percent of received information that an agent processes is a function first of role and then, of a combination of workload, time available, and agent and process speed. Figure VI-16 shows that in these experimental runs, assigned roles associated with the approach options were the dominant factor as agents in the most connected option were able to process 100 percent of the information they received (they were clearly fast enough); however, in the least connected option, the agents processed about 75 percent of the information they received. Looking at the information shared, we see that agents were also more affected by role than by workload.

Individual and Shared Understanding

Being able to develop an adequate degree of shared understanding is essential. In many cases, if not an absolute a prerequisite for entity agility, a lack of understanding constrains both individual and entity agility. Without an adequate understanding of the situation, individuals and entities cannot properly exercise whatever potential flexibility or adaptability they may possess. Without understanding, it is difficult to be responsive.

In the tenets associated with NCW, shared understanding[157] is the fulcrum that enables self-synchronization. Self-synchronization enhances responsiveness, which in the time-critical missions that are typical of national security, cyber, and humanitarian disasters is vital.

ELICIT, in its current form, focuses on the challenges associated with the development of shared understanding. Given the notable lack of shared understanding that has characterized a range of responses to 21st century challenges, considerable progress can be made simply by focusing on improving shared understanding and using this improved shared understanding to enable a variety of organization-approach and policy options that are rarely employed. However, a complete study of agility needs to look beyond shared understanding to the *execution* task. To do so will require that these experiments be augmented to simulate action and the resulting consequences.

An Assessment of Progress

We began this part of the book with the recognition that simply observing instances of agility or a lack thereof would be inadequate to develop the understanding

157. It was called *shared awareness* at the time.

necessary to systematically improve the agility of individuals, organizations, processes, and systems. While one can describe what one observes and build what is called a descriptive model, such a model does not explain why something is the way it is nor can it be used to predict what it would be if one of the conditions or controllable variables changed. Observation, however well intended or instrumented cannot provide enough empirical evidence to support the development and refinement of a causal model of agility. This is why, about a thousand years ago, humans developed a scientific method that involved experimentation.[158]

We have taken the first steps toward an explanatory model of agility that I have called a *model of potential agility*. My goal is to be able to not only assess the likelihood that an entity will be able to be successful when the unexpected happens (as is sure to be the case), but also to improve an entity's potential agility.

Figure VI-1 proposes a basic ring structure for the model of potential agility. The remainder of this part of the book is devoted to providing empirical evidence and logical arguments that support both the basic ring structure and the inclusion of specific variables and classes of variables in each ring. Previous work provides a more granular look at some of these classes.

158. There are many writings about the origins of science. An interesting website is http://www.experiment-resources.com/history-of-the-scientific-method.html.

I believe that, armed with this model, even in its current rather crude form, an entity can begin to make sense of agility as it applies to its situation. This is a significant achievement.

Part VII

Improving Agility

Part VII
Improving Agility

Agility has, until now, been admired from afar. Agility has not been consciously or conscientiously developed or nurtured. More often noticed by its absence, agility has simply not been a high priority. Even when individuals, systems developers, and organizations recognize that agility is a desirable capability to have and assert that they need to or are going to improve their agility or the agility of the products they produce, they seem at a loss to know exactly what to do or where to start.

This paralysis persists despite a seemingly never-ending stream of failures that can be traced to a shocking lack of agility. Failures are investigated and the specific assumptions, decisions, actions, and system characteristics that led or contributed to the failures in question are identified. Corrective actions are then recommended. However, these reports follow a predictable pattern in that they tend to focus on the specifics of the case and not on the systemic rigidity that is at the root of the problem. Perhaps the recommendations proffered would have, had they been put in place in time, prevented or greatly reduced the adverse consequences of the specific event at hand. But the fact remains that even if the recommendations are implemented, they do not solve the problem (a lack of potential agility) going forward.

If one looks at recent attempts to blow up airplanes in flight—for example, the shoe bomber and the printer-cartridge bomber—the countermeasures instituted have been very specific to these threats. There have been statements from officials and pundits that have even claimed that the fact that these bombs did not result in planes falling from the skies showed that "the system worked." The degree of luck involved is ignored. Thus, the knee-jerk reaction to lock the barn door after the cows have gone is still alive and well.

Clearly, we need to respond quite differently to both the continuing stream of failures we are sure to experience and those, that we manage to avoid only by chance, if we are to successfully meet the challenges that lie ahead.

In this, the final part of *The Agility Advantage*, I will briefly summarize the case for agility and why now is the time for us to embrace it. Looking ahead, I will identify a dysfunctional syndrome that will inhibit progress, and finally sketch out a way ahead.

Chapter 34
The Agility Imperative

The logical case for agility is compelling. Despite our considerable experience and our efforts to improve upon how we currently approach problems, we have yet to achieve the results we need. We can continue to depend on an approach that is based on a set of assumptions that is no longer valid, or we can adopt a new approach, one that does not rely on these outdated assumptions and thus, promises to dramatically improve our ability to meet the challenges we face.

Our current approach is based on our ability to foresee the future and adequately prepare for it by developing organizations, approaches, and processes designed specifically for the future we envision. If there are multiple threats or opportunities, then we either make the assumption that our solution for one works for all, or we develop a separate organization, approach, and process to deal with that other eventuality.

We have no illusions that we are perfect. We choose to focus on investments that are designed to improve our ability to predict and understand. We collect more information, hire more analysts, and build sophisticated tools in an attempt to reduce errors of prediction and reduce residual uncertainty. We simulate, we train, and we rehearse. As a result, we do improve, but only at the margins. We are spending more and more to get less and less improvement.

What we have not accepted is that this approach is fundamentally flawed. This is the triumph of hope over reality.

The reality is that, as a result of the complexity of the challenges and of the collection of organizations, processes, and systems that need to be assembled to meet these challenges, our ability to predict events or consequences will never be enough to rely on these predictions. In conflict situations, asymmetry is the new normal. Adversaries have proven themselves to be remarkably adaptive. They are quick to find our weaknesses and exploit them. Thus, even if we could predict initial conditions, the dynamics of a conflict remain unpredictable.

When the challenge involves managing effects in multiple domains (political, social, and economic) the prediction of cross-domain interactions defy domain experts. In cyberspace, things take place at speeds that far outpace the ability of humans to detect, understand, and respond to malfunctions and attacks. Damage to our technical networks (communications and information) affects process and social networks in ways we have yet to adequately understand.

The bottom line is that our ability to understand and predict is not getting better, but in fact is getting worse. That means that if we stick to our current approach, things will not get better but get worse. The bets we are making are not good ones as the odds are against us and continue to increase.

There is another dynamic at work that will make things worse. This is the pressure on budgets. Any student of the fiscal side of government, here or abroad, has known for some time that we are headed for a crisis of major proportions. The recent spate of sovereign fiscal crises in Europe and the U.S. national debt debate should convince planners that we will be allocated far less resources. To date, our failures, while they have had serious consequences, have not been existential. What can we expect to happen as we cut into muscle to meet our reduced appropriations? Will this be the tipping point? I, for one, do not want to find out.

It is time to get the train off these tracks and create new tracks that go in the direction we want. Specifically, we need to quickly build a new set of tracks that leads us to agility. The success of an approach based on agility does not depend on our ability to predict. It does not depend on a compliant adversary who plays by our rules. However, it requires that we are brave enough to put aside our outdated mental models and approaches.

I am not under the illusion that this will be easy, but if we know and understand the enemies of progress, that is, the impediments to improved agility, we will have a much better chance of defeating them and becoming more agile.

In the next chapter, I shall look at what I consider to be agility enemy number one.

Chapter 35

The Rigidity Syndrome

What do we need to understand and what actions do we need to take to improve our agility? What do we already understand and what understandings do we need to develop? What actions can we take immediately and which will require more preparation/investment? What do we do first? How do we measure progress? How much will this cost? How can we prove that it is worth the cost and effort?

Once the understanding that we need to improve agility sinks in, these are some of the questions that will be asked. Fortunately, at this point in our exploration of agility, we have, at least, preliminary answers to all of these questions. Actually, we know one very important thing about agility, and that is that agility is not about things. We know that significant changes in mindsets, perceptions, attitudes, behaviors, and incentives will be necessary. At times, making these changes will, in and of themselves, improve agility. However, we also know that these changes will not come easily. Understanding the obstacles we are up against in our efforts to improve agility begins with an understanding of why we or others like us are not agile enough. As it turns out, many entities seem to have a natural attraction to or a propensity for rigidity.

There are a number of words that are used to refer to a lack of agility. These include: rigid, stubborn, intransigent, willful, brittle, vulnerable, slow, and in the sense of mental agility, unintelligent or dumb. A complete list would also include the antonyms for the properties of agility (e.g., inflexible). While no single word perfectly captures the inability to be agile, I think the word *rigid* works best. Rigid conjures up a vivid picture of something that cannot move or change. Many individuals and organizations have a tendency to be rigid. The causes of these *anti-agility* tendencies are varied and include the way our brains are built and have been conditioned as we have matured from infancy, learned behaviors, and incentives. Much of this behavior is so ingrained that it is not conscious. For example, the need of humans to feel in control is widely recognized. In this case, being in control translates into a belief (hope) that one can predict.

Organizational behaviors are similarly shaped. There is a related belief that more management will lead to better results. I am sure that many of you share my bewilderment at the persistence of dysfunctional organizational behaviors, particularly when these behaviors are widely recognized. We ask ourselves "How can an organization made up of clearly bright and well-meaning people behave so stupidly?" What we are witnessing is, I believe, a systemic lack of agility.

The Rigidity Syndrome

We should consider this condition of rigidity to be an illness that can and must be treated. The first step in treating an illness is to recognize its existence. Having recognized that an illness exists, we need to be able to recognize its symptoms and understand its causes. Only then can we begin to explore treatment options.

Our propensity to rigidity has been largely unrecognized and, if and when it has been recognized, it remains untreated. In fact, the symptoms of this rigidity have often been misdiagnosed, and its root causes are attitudes and behaviors that are actually encouraged and rewarded. Encouraging these attitudes and behaviors creates negative feedback loops and results in the *patient* spinning out of control and spiraling downward toward increasing vulnerability, and ultimately toward a catastrophic event.

One of the major reasons that entities are not agile is that they have adopted an approach to the development of their core competencies that appears to increase mission performance, but in fact reduces agility. In the final analysis, this is more likely to reduce mission performance than increase it. This is because the approach to the development of competencies that they have adopted focuses on one or a small number of specific contexts (application of a mission type). It is this basic confusion between a mission capability and a specific application of that capability that creates a lack of agility.

Often entity assessments of performance are lacking in several ways. First, they usually assess their performance without due consideration to risk. For example, one can save fuel on a trip if one removes weight from the vehicle. To save weight, they choose to get rid of the spare tire. But, they do not assess the added risk associated with this decision. Doing so involves more prediction since this risk depends on the condition of the road, which greatly affects the probability of a flat. Second, they measure task accomplishment but do not put it in a larger mission context. If one successfully takes out a bridge to protect one's flanks from possible attack, that is good, isn't it? Well, it depends. There are consequences that go beyond the impact on the local battle. Suppose the bridge structure housed an oil pipeline that supplies oil to a large region. Taking out the bridge disrupts the oil flow. Who depends on this oil? How much does it cost to repair the damage and restore the flow of oil? Decision-making that does not take into consideration the cascade of consequences or relies on predictions that are subject to large error contributes to increased risk.

Entities also tend to focus on just one thing at a time.[159] Depending on the availability of resources, they either focus on, for example, perfecting or protecting themselves (trying to guarantee a minimum level of performance or trying to improve performance) or they focus on reducing costs. If not approached properly, a single focus analyses can generate solutions that are counterproductive.

Consider the difference between hiring a specialist and a generalist. There are times when each one is appropriate for a given task. A specialist can usually do the task for

159. At one point it became fashionable for organizations to pursue becoming *better, faster, cheaper*. Critics of this approach questioned the wisdom, indeed the feasibility, of doing all three at once.

which he is uniquely qualified far better than any generalist. However, the narrower the field of specialization, the fewer times that specialty is needed. In addition, the narrower specialist is less able to work on other tasks. In times of plenty, it is possible to afford ample numbers of both. In times like these, hard choices need to be made. Is it better to be able to do only one thing but do it superbly or is it better to be able to do a reasonable job on a variety of tasks? If you could choose only one doctor, who would it be? Clearly if you had a particular condition that was life threatening and only a specialist could handle it, you would choose to go with a specialist; otherwise, a generalist might be the better choice. The problem is that it is enormously expensive to develop a specialist's level of expertise in more than a small number of areas. If there is an emphasis on pushing the state of the art, this drive to excel tends to make specialists narrower, which makes them increasingly less versatile and flexible.

To be fair, many entities are aware that their prediction, with respect to a mission they need to perform, might not come to pass, and they are also aware that changes in circumstances might well occur. However, they prepare for these eventualities by generating a relatively small number of planning scenarios and developing highly focused contingency plans.

Diagnosing Rigidity

Treating an illness begins with sensing that something is wrong. Some illnesses or conditions like rigidity are difficult to observe directly since they may only cause problems under certain combinations of stresses. In the meantime, these conditions remain dormant and potentially dangerous if left undiscovered and untreated. However, there may be symptoms that, to a trained eye, can be recognized. As a result, the condition can be diagnosed and treated before it is too late.

Rigidity presents symptoms, and some of them are easy to spot. One example is that of an entity that struggles, even under favorable conditions, to accomplish its tasks, or an entity that has recently had a close call. However, in the case of rigidity, some of its symptoms are easy to misread. Take, for example, an entity that has been optimized to operate in normal conditions and currently exhibits all the signs of success. It may seem strange, but success is sometimes a symptom of rigidity. One needs to look closely at how an entity is succeeding, to see if there is a cause for concern.

A success story that has become routine in the information age is a company that has reduced costs by *just-in-time* processes. It has become quite common today for firms to keep a bare minimum of inventory on hand to satisfy the demands of their customers or to keep their production lines moving. The business reviews are populated with such success stories and tout these firms as role models—ones that are setting new standards for their competitive spaces. These are, however, examples of optimization and close coupling. In normal times, when one is able to predict demand or to quickly respond to demand, this strategy minimizes costs while manifesting no adverse affects. However, when conditions change in unanticipated ways, the adverse consequences of optimization and close coupling can be serious.

The Rigidity Syndrome

In April 2010, Eyjafjallajokull in Iceland erupted.[160] A cloud of ash containing bits of rock and glass that could be harmful to jet engines spread over Scandinavia and Europe, and resulted in the grounding of thousands of flights for almost a week. Travelers in the tens of thousands were stranded. Shipments of a wide variety of products from diamonds to flowers were suspended. The firms hit the hardest were those that had done the best job of implementing just-in-time solutions. Those role models found themselves without parts to assemble or without spares to repair broken equipment. They had to shut down.

This unanticipated event created a set of unpredicted stresses that laid bare the rigidity of individuals and organizations. Travelers found themselves with little or no money. They found themselves running out of the medicines they routinely take. The authorities responsible for air safety and traffic control were forced to make decisions in the face of uncertainty—uncertainty about the actual effects of the ash cloud on jet engines, uncertainty about the future behavior of the volcano, uncertainty about the spread of the ash cloud. Airlines that were used to dealing with weather-related problems were unable to cope with such a large number of stranded passengers. Other forms of transport were quickly overwhelmed. Almost everyone involved was slow to innovate and adapt. In retrospect, it seems that almost everyone could have been better prepared in a number of ways.

160. Many news stories have been written on all aspects of this event and its consequences, e.g., http://news.bbc.co.uk/2/hi/europe/8636439.stm.

Success that depends on stability and predictability is clearly brittle or fragile.

It may not only be how one succeeds that is a problem, but also the effect that success has on the individual or the organization. For example, the members of a very successful organization, justifiably proud of their achievements, may exude confidence. This confidence may breed complacency. Those that think they are at the top of their game may be the most rigid.

Sun Tzu referred to this weakness when he said, "Pretend to be weak, that he may grow arrogant." When you hear, as I have heard, military officers or business people opine that they are the best in the world that is a sure cause for concern. The vulnerability to what is called asymmetric warfare or disruptive competition is a direct result of optimization and arrogance.

Sometimes rigidity may be asymptomatic (not exhibiting recognizable symptoms) but can be detected by observing the entity when it is subjected to a combination of stresses. The concept of a stress test to uncover rigidity was recently applied to our financial institutions.

Countless command and control related training exercises have been conducted over the years, but few have included stressing the organization or system with cyberattacks or unexpected events. Subjecting the participants in these exercises to cyberattacks or system malfunctions is often strongly resisted. The same objections are raised when the concept of stress tests is proposed for many different kinds of organizations. Oddly enough, one of the reasons given is that such tests will expose vulnerabilities. Another objection heard is that it would disrupt training. Of course, not knowing one's vulnerabilities does not make them go away. And, failing to exercise under realistic conditions does not increase agility, but rather it reinforces rigidity.

Rigid Systems

Delays, cost overruns, and inadequate capabilities—these have been endemic problems with systems for as long as most of us can remember. A valuable lesson can be found in the radically different ways that have been proposed to deal with problematic system development efforts. One solution gives the illusion of increasing performance and lowering costs, but actually results in less performance, higher costs (due to the need to fix the system), and less agility. The other solution may increase costs initially and lower initial performance, but, in life-cycle terms, results in lower costs, higher performance, and more agility.

The year is 1982. The report of an industry task force, containing a set of conclusions and recommendations regarding the acquisition of command and control systems, has just been delivered to the Undersecretary of Defense (Research and Engineering). The authors[161] have recommended a radically different approach to dealing with problems "encountered with the acquisition of

161. This report was undertaken by a set of industry experts (including this author) under the auspices of the Armed Forces Communications and Electronic Association.

command and control (C2) systems over the years."[162] Problems, that, as this report states," are well known and have been documented in numerous studies." The problems they identified included cost growth, program delays, equipment deemed obsolete by the time it was fielded, and general user dissatisfaction with the systems when finally fielded. These problems were and continue to be a result of a mismatch between the nature of the environment (challenge) and the nature of the product that results from the way it is designed, built, and acquired. This is analogous to the poor results we saw in the ELICIT experiments for certain organization-approach options when they were faced with specific mission challenges.

As is the case with the mismatches between particular organization-approach options and specific mission challenges, the mismatch is a systemic one. Simply put, the solution approach is not well suited for the complexity and dynamics of some tasks. The Executive Summary of this report describes C2 systems as having: 1) numerous complex and changing interfaces, 2) highly interactive (read multiple, interdependent feedback loops), and 3) possessing unknown, at least in advance, requirements. On the other hand, the solution approach, systems engineering, as it was then practiced, depended on a complete and stable specification of requirements. For many, this remains best practice today. While a great deal of progress has been made with respect to the software development and testing process, and progress has been made in

162. AFCEA, *Command and Control (C2) Systems Acquisition Study Final Report*, 1 September 1982, p. I-1.

adapting system engineering to complex systems, there has not been as much progress in acquisition approaches and processes.

Specifically, conventional systems engineering wisdom holds that the success of a system engineering effort is a function of how well one specifies system requirements and that changing requirements results in the aforementioned problems. The following statement is typical of this mindset:[163]

> *Requirements must drive design and development decisions throughout the product development lifecycle. And product testing must be done against specified requirements to make sure you're not just delivering a product that works, but also the product that you set out to build.*

From a system-engineering perspective, designers and developers want to receive a *spec* and be able to go off and do their job. Nice work if you can get it, but asking someone to do something that he cannot do will not get the job done. Forcing someone to write down a set of requirements that he does not completely understand and not allowing him to change these requirements as his understanding improves or as circumstances change is not the

163. This quote is taken from an IBM website devoted to software system lifecycle management. See http://www-01.ibm.com/software/plm/pdif/solutions/requirements-engineering.html.

answer. This only results in dysfunctional behaviors and ultimately in the very problems that this solution (that is, a better specification of requirements) is meant to fix.

This *let's get a better set of specifications* approach attempts to wish away the complexity that is at the root of the problem, rather than find a way to cope with this complexity. This corresponds to a continuation of traditional (hierarchical) organization approaches to meet the challenges of complex endeavors. Both are doomed to failure.

The C2 Acquisition Study members recognized the fruitlessness of simply calling for doing a better job of requirements specification. Rather they accepted the situation for what it was and tried to find a solution that dealt with the reality of complexity and its attendant unpredictability. Their recommendations made sense then, and they still make sense today. But these recommendations were not exactly embraced. This is relevant to this discussion because, in effect, they advocated a more agile system design and acquisition process. However, accepting this solution meant accepting that one could not adequately predict system requirements. There is a related problem with accepting that one cannot adequately specify requirements and that these requirements will change over time. If there is a set of requirements that is specified, then one can be held accountable for building a system to known requirements. Accepting a *target* that is more vague involves more trust. This changes the way that participants in the process can be held accountable since there is no fixed target. This may trouble some people, but holding someone accountable to a standard that does not translate into a quality product is not an attractive option. Being able to hold someone accountable is a form of being in control. The fact that one is not controlling the ultimate value of what is being produced somehow gets lost. This is the same mentality that measures plan milestones (like holding a design review) rather than embracing measures that reflect substantive progress.

From the experimental results in part V, we saw the value of a flexible information-sharing policy. To introduce more flexibility, one needs to trust individuals and organizations to make the correct choices (or at least not incorrect ones), some of which will, of necessity, need to be made without adequate information. Mistakes will be made and, with the gift of hindsight, these mistakes will become glaringly obvious. The success of introducing more flexibility into an entity will ultimately depend on how well we educate and train those involved and how we handle mistakes and the individuals who will make them.

There is actually a fair amount of flexibility built in to the DoD's design and acquisition process. However, for the most part, fear of making a mistake prevents individuals from deviating from what is considered to be the safe choice—a choice that, if made, will protect them from receiving blame. This fear of failure and the criticism that will result is perhaps the greatest inhibitor of agility present in our design and acquisition organizations.

Rigid Individuals, Organizations, and Processes

Individuals and the organizations to which they belong develop a variety of competencies by creating and participating in educational and training programs. Teams train together and become *hardened* so that they can develop the synergies that make the whole more than the sum of its parts. While systems, with the exception of *expert systems*, are not educated and trained, they are tested and validated. All of these activities and efforts are designed to prepare individuals, teams, and the systems that support them, for the missions that they are *expected* to undertake.

However, it is important to recognize that competency building does not necessarily improve agility. In fact, many of these activities, as they are currently designed and implemented, actually result in discouraging agile behaviors and limiting entity agility. Therefore, educational and training programs and the procedures for the testing and validation of systems will need to be revisited to make sure that, while they are working to improve specific and general competencies, they are not inadvertently detracting from the agility—rather that they serve to enhance agility.

Individuals and organizations are measured and evaluated by looking at mission outcomes for specific scenarios. Failure on a training exercise can doom a career. Thus, the challenge is calibrated so that only a few, if any, fail. Anything that can result in participants not performing well is avoided. In most organizations, the scenarios must be approved. In many cases, the approval process works to ensure that these scenarios are limited in number and do not change as rapidly as conditions change. Unexpected events that challenge participants are also avoided. To make matters worse, training traditionally not only focuses on accomplishing a given task, but also on mastering a prescribed way of accomplishing the task. The emphasis is on learning and perfecting what is considered to be best practice.

In the face of perennial budget shortages, few organizations have sufficient funds to adequately train and become proficient in one way to accomplish a task under expected circumstances, let alone master a variety of ways to accomplish the task under a variety of circumstances. Thus, they are unable to learn what works under what set of circumstances and what does not. Clearly, these constraints on training and exercises do little to encourage, develop, or test flexibility. Fortunately, our men and women in uniform are able, when called on, provided that they are not unduly constrained, to exhibit agile behaviors. Just think what they could do if we enabled these behaviors.

Clearly, if it is too costly to train an individual or organization to accomplish one mission, it cannot be possible to achieve versatility by training for many missions. Thus, without being able to exercise flexibility and versatility, how can we possibly train to improve agility? This conclusion that we cannot train for agility is based on a series of faulty assumptions. First, there is the assumption that there is only one way to train. Second, there is the assumption that training for an expected mission yields good results. Third, considering the costs of training, without considering the benefits achieved, is flawed. If we are to improve agility, we must change the way we think about training, exercising, and evaluation. Changing our approach to training may seem risky, but given the complexity and dynamics of the world in which we live, continuing to train as we do is not likely to achieve the intended goals. A fresh approach at least stands a chance.

Rigidity in Problem Solving

In a similar fashion, the solutions that individuals and organizations develop in response to a problem can either exhibit agility or not. Let's take an example of a threat and a vulnerability that we have known to exist for sometime and are just recently treating with the seriousness it deserves. I am speaking of the attacks on our infostructure and our vulnerability to these attacks on our communications and information systems. I would also include a number or different kinds of systems failures that, although they are not caused by adversary action, can still have similar adverse impacts.

As a result of this growing threat, it has been repeatedly suggested that we do more about protecting our infostructure and provide mission training that includes experience with situations that involve working with systems that have suffered the effects of such attacks or disruptions. These suggestions have, until quite recently, fallen on deaf ears. Many thought the threat was exaggerated. However, organizations of all sorts have now experienced such attacks and/or disruptions, and now increasingly recognize that attacks on infostructure are no longer merely a theoretical possibility, but in fact a probability, if not an ongoing feature of the world in which we live.

In terms of the risk areas depicted in figure I-3, these infostructure risks have moved from risk areas 2, 5, and 7 to risk areas 3, 6, and 8. As a result, more is being done to prevent these attacks and/or disruptions from other causes. But, doing something to prevent or mitigate these threats may solve one problem while creating a more serious problem.

This is not just a conjecture—it is actually happening. For example, the way that some organizations have chosen to reduce their exposure to attacks is to place significant restrictions on access to and the use of the systems in question. Given what we have seen from the results of the experiments reported on in part V, restricting access to information and/or making it more difficult to share information across organizational boundaries makes it less likely that certain kinds of challenges can be successfully met. Ironically, these organizations are actually attacking themselves (degrading their own information-related capabilities) in the name of cybersecurity. In the process, they are making themselves less effective and less agile.

Readers should not draw the conclusion that it would be better to ignore infostructure attacks. However, care needs to be taken to minimize the risks and the adverse consequences of successful attacks without the solution creating adverse consequences of its own. Put another way, the cost of the solution should not exceed its benefits. One way to ensure that the solution to infostructure disruptions and performance degradations is balanced is to look at mission assurance, rather than infostructure assurance. This will avoid the tendency to implement draconian access restrictions that create collateral damage and prevent appropriate access to information that is necessary to make individuals, processes, and organizations more agile.

Agility is an appropriate response to cyberattacks in its own right. Agile individuals, organizations, and processes will reduce the return on investment that an adversary receives from these attacks. If entities are agile enough, at some point adversaries may decide that the (reduced) effectiveness of their attacks, the costs they incur by launching these attacks (including retaliatory responses to such attacks whether they are political, cyber, or kinetic), or some combination of these two make the attacks unproductive. To the extent this happens, these sorts of attacks will become less likely. Thus, increased agility can translate into reducing the probability of some kinds of attacks. Solutions that serve to limit agility thus actually increase the attractiveness of these attacks, making matters worse. Depending on circumstances then, some ways of protecting infostructure, particularly if they limit or reduce agility, can end up creating more harm than good.

Leveraging Component Agility

Enterprises, endeavors, and organizations are collections of components—individuals, teams, processes, and supporting systems. They differ in scale, diversity, and in the nature of the relationships that exist between and among their components. As such, the capabilities of organizations and collectives are a function of the competencies, capabilities, and experiences of individuals, processes, and systems. However, an organization's abilities may be either more or less than the sum of its parts. As organizations constrain or enable each of its constituent parts, they can create dysfunctional behaviors, or they can develop synergies.

In the same way that organizational effectiveness and efficiency depend on the extent to which their constituent parts are constrained or enabled, the agility of an entity depends on how much potential agility each of its components possesses and how each component's agility is constrained or enabled. One can picture agility flows coursing through an entity. The fewer barriers to these flows the better.

Agility Improvement Process

Improving agility requires a systematic and sustained effort. Having identified the general propensity for rigidity that exists in entities provides us with an initial starting point in our effort to understand and improve an entity's potential agility. An effort to improve agility should start with an identification of an entity's agility shortfalls or needs.

Figure VII-1 depicts this as part of the first phase of a coherent agility improvement process.

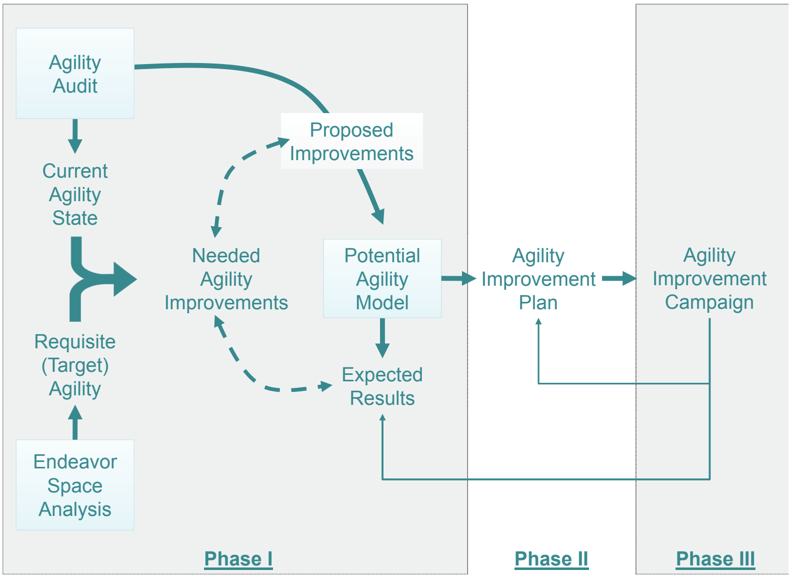

Figure VII-1: Agility Improvement Process

Phase I of this process begins with an analysis of endeavor space and an agility audit. The endeavor space defines the dimensions of interest and identifies the specific parts of endeavor space that are considered to be operationally critical. The critical regions of endeavor space constitute the target or requisite agility. An entity's state of agility is a function of the entity's current and future situation and environment. Requisite agility is dynamic and will change as the situation and environment changes (improves or deteriorates), and/or as understanding of the situation changes. The agility audit takes the endeavor space developed and creates one or more agility maps based on past experience, experiments, and analyses. These agility maps identify regions where an entity possesses sufficient capability and regions where the entity needs to improve.

The next step in the process involves an application of the model of potential agility. The analyst uses this model to identify the reasons for the inability of the entity to be successful in the regions of endeavor space where critical shortfalls have been identified. This analysis thus translates agility shortfalls (inability to successfully operate in selected regions of endeavor space) into the specific changes to entity characteristics and behaviors needed to remedy this situation. Having identified the changes needed to develop requisite agility, an agility improvement plan (phase II) can be developed and implemented (phase III).

Improving agility does not end with the implementation of this plan because the impact of the changes made to entity characteristics and behaviors need to be observed and assessed. Thus, the agility improvement process is iterative and dynamic. Even if the desired level of requisite agility is achieved, circumstances may change requisite agility and/or new opportunities to improve the agility of an entity will arise.

To many, a systematic effort to improve agility may seem to be a daunting task and even a hopeless one. However, given the understanding of the basics of agility and its measurement provided in part IV, the insights into agility obtained from the results of experimentation provided in part V, and the discussion and examples provided in part VI of this book, readers may now be better equipped to undertake such an effort.

Having a conceptual model, even a rather coarse and imperfect model as the one we have at this point in time, serves to focus attention on what is important. It helps us make appropriate observations, guides us as we develop agility-related diagnoses, and suggests ways in which we can improve entity agility.

Chapter 36
The Road Ahead

In this, the final chapter, I explain the importance of working theory and practice simultaneously, suggest some specific areas of basic and applied research, and offer some concluding thoughts regarding the road ahead.

Good Theory, Better Practice, Better Theory

Many organizations that will undertake a serious effort to improve their agility will focus exclusively on operations. This is a mistake. Organizations that do not devote an appropriate amount of attention on developing and improving theory will not benefit from the synergies that can be achieved by the interplay between theory and practice. Improving agility is, of necessity, an iterative process—a process that involves making progress in both our understanding (theory) and in developing capability (practice). Figure VII-2 depicts this interplay between agility theory and practice—that is, the relationships between improving our understanding of agility and improving our agility.

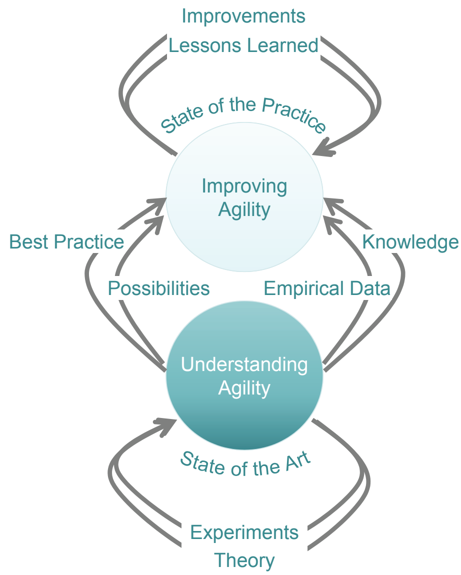

Figure VII-2: Synergies: Theories and Practice

Observations and analyses of the characteristics and performance of entities in the particular mission contexts in which they have and are currently operating provide us with an understanding of what needs to be improved and the relative priorities of these needs. These lessons learned show us what works, when it works, and what does not work.

Theory, even if it is not supported by a large body of evidence, as is currently the case here, can provide a basis for suggestions or possibilities to be explored. These suggestions, derived from theory and the lessons learned by individual entities from their experiences, can result in improvements in the state of the practice. While any improvement is certainly welcome, we need to move beyond isolated improvements in agility to the development of a coherent set of best practices. Accomplishing this requires:

1. A breadth and depth of experience that coalesces into knowledge;

2. The results of a systematic campaign of experimentation that, together with real world data, form a body of evidence; and

3. A testable conceptual framework or theory.

Figure VII-3 provides a different perspective on the interplay between theory and practice. This diagram contains two models—one of manifest agility and one of potential agility, and identifies key relationships between them.

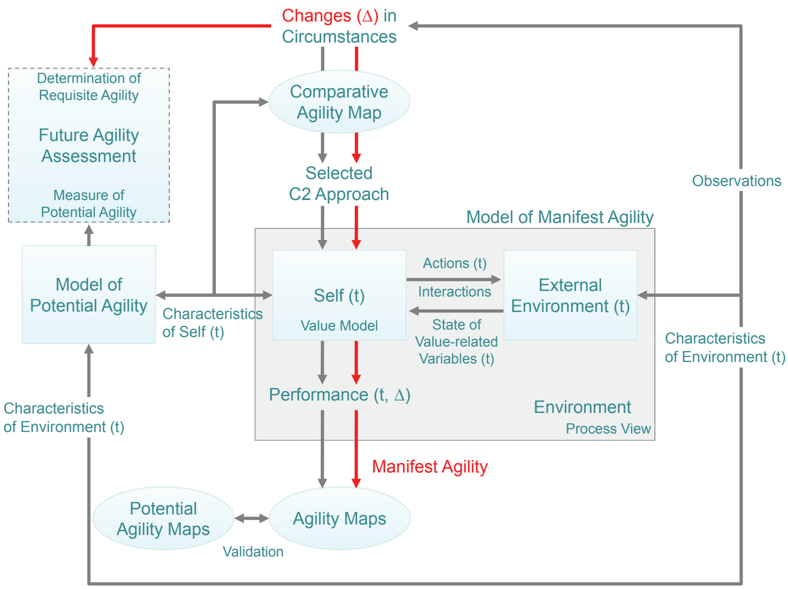

Figure VII-3: Potential and Manifest Agility Models

The model of manifest agility can be thought of as an entity or domain specific view of the state of the practice, while the model of potential agility represents the state of the theory. This is because the first is a compilation and distillation of what has been observed in practice (or in simulations), while the second is an expression of our current understanding.

When, as a result of theory, one has identified appropriate metrics and what to observe in reality, the data collected meet the standard of empirical evidence. All too often casual observation, anecdotes, and opinion pass for evidence. Best practices are not based on theory; rather they are based on an accumulation of evidence. An understanding of this evidence contributes to our ability to test and improve theory and to the development of a body of knowledge. The interplay between theory and practice serves to improve both.

This book provides enough of the ingredients required to begin to develop best practices and, thus, to systematically improve the state of the practice. This will result in making entities considerably more agile than they currently are. In other words, the theory of agility presented here is considerably ahead of the state of the practice. But this is no reason to ignore or put off efforts to improve theory, as we begin the process of applying what we already know. Better theory will allow us to improve the pace of progress by pointing us in the most promising directions. Next I will suggest some areas of research that, in my opinion, are not only well within our capability to undertake, but also are likely to yield results that can quickly be applied.

Research and Analysis Priorities and Consideration

Research priorities depend on the nature of the organization involved. In this chapter, I will identify agility-related research and analysis priorities for both basic and applied research organizations. Since I believe that agility theory (as it is articulated in this book) is currently ahead of the practice, I will turn my attention first to applying what I believe we already understand about agility to improving practice—that is, to improving the potential agility of our enterprises and endeavors. Following this discussion, I will take a look at the establishment of a multidisciplinary research and analysis community, one that can pool its collective domain expertise and experience to gain new insights into what constitutes agility and how to improve the agility of a wide variety of entities.

Applied Agility Research and Analysis Priorities

For an organization that is interested in improving its own agility or even one that is thinking about whether or not improving agility makes sense for them, the first step is undertake an analysis to ascertain how agile they currently are and how agile they believe they need to be. Although, I can see clearly how one could go about doing this, I know of no such effort that has already been done that could serve as an example. Yes, there are examples of military and business organizations that are considerably more agile than others. I believe that they developed their agility by focusing on developing the characteristics that we will find to be associated with higher levels of potential agility. Their agility improvement program was intuitive. Organizations not blessed with either a culture of agility or with inspired leadership can nevertheless improve their agility by undertaking a more scientific approach.

Thus, the first priority for a program of applied research in agility would be to identify a customer and undertake phase I of the agility improvement process for that customer. The products of such an effort include both: 1) a set of conclusions and recommendations regarding the customer's current state of agility compared with their requisite agility, and 2) lessons learned from this analysis that identify how to improve the methodology and metrics for agility-related assessments. I believe that agility assessments need to be performed for a variety of customers in order to develop the expertise and experience to perform these analyses effectively and efficiently and to maximize their benefits to customers.

The next priority is to seek to enhance the existing analysis processes, tools, and products of a set of customers by incorporating into them a consideration of agility. In some cases, one or more components of agility (e.g., resilience) may already be incorporated into existing analyses. However, it is unlikely that a comprehensive view of agility, as articulated in this book, has been employed. This effort to improve analysis methods and tools serves several purposes. First, it identifies the extent to which aspects of agility have been considered. Second, it will allow those analysts who have already given considerable thought to the subject, but were unable to find a way to fit a consideration of agility into existing processes and products, to contribute their thoughts and approaches. Third, it will provide some insights regarding the ability of our tools (e.g., simulation models) to provide agility-related results. Fourth, it allows us to learn how to express the risks associated with analyses that do not include aspects of agility into their calculus.

The above two agility-related research priorities do not constitute a coherent program of applied research in agility. Therefore, my third high-priority initiative would be to put together a group of experienced analysts working in a variety of domains that would be charged with the development of a five-year plan for applied research in agility.

Basic Agility Research Priorities

The concept of agility presented in this book is quite comprehensive. There are various aspects of agility that have received considerable attention from scholars and researchers and that have a body of literature that needs to be examined and leveraged. Thus, my first basic research priority would be to identify those scientific fields that have considered various aspects of agility (e.g., contingency theory, reliability theory), extract the knowledge they have developed, and organize this knowledge within a comprehensive conceptual framework that will be an initial expression of a theory of agility.

Another basic research priority is to focus on a better understanding of the relationships between and among the components of agility. Beginning with an effort to formulate hypotheses about specific relationships in a number of customer contexts and domains, the objective of this research area is to develop a first expression of this part of the theory of agility.

My third high-priority basic research initiative would be to focus on how the agility of collections of entities is affected by the agility of individual entities. This would include a consideration of traditional organizations which are composed of individuals, organizations, processes, and systems. The research questions would include "How, for example, do social and technical networks that are more agile affect overall entity agility?" This research initiative would also include a focus on complex enterprises and endeavors. Here the research questions would include, "What are the agility-related consequences of different approaches to collective organization?" and "How does the agility of individual entities (e.g., military or civilian entities) impact overall endeavor agility as a function of different approach options?"

Community Coalescence

There is currently no community of researchers or practitioners that has a primary interest in understanding and improving agility. One could argue that this is really everyone's job, whatever the area of interest. Thus, system engineers should be interested in improving the agility of the systems they develop and the processes they design to develop systems. Acquisition professionals should be interested in agile acquisition. Management and organization theorists and practitioners ought to be interested in agile organizations. The fact is that many individuals in these areas are interested. However, the awareness of the importance of agility has yet to translate into a focus on agility in any of these diverse disciplines or domains.

To increase awareness of the importance of agility, hasten the day when we have a better understanding of what inhibits and enables agility, and make more rapid progress in enhancing the agility of the entities of interest, we need to foster an international, interdisciplinary community that is devoted to agility research, analysis, and practice. I see this community as consisting of both members that wish to devote 100 percent of their energies to understanding agility and members that are interesting in applying state of the art ideas about agility to their specific areas of interest.

One model for such a community is the community built over time by DoD's Command and Control Research Program (CCRP). With relatively little funding, this small multifaceted program has been able to develop a vibrant international community of interest by sponsoring activities that include the creation and dissemination of a body of literature, an annual international symposium, and an academic quality journal. There are, of course, other models that could be adopted. Whatever the model, I believe that such a community will not be formed spontaneously. It will require some attention and a little investment.

An Important Agility Challenge

One of the inescapable aspects of the age in which we live is our need to assemble collections of entities (complex enterprises) in order to make progress on a variety of important social, economics, and security challenges. The stakes could not be higher, yet it is beyond the capabilities of any single entity to successfully cope with these situations. On a smaller scale, the individual systems we build cannot succeed by themselves but must rely on the capabilities of countless other systems.

I believe that improving the agility of each of these systems in a *system of systems*, while clearly helpful, will not necessarily result in success for the system of systems. Success requires that we learn how best to leverage the capabilities that each system possesses. This will, in all likelihood, involve some design changes to individual systems and establishing a set of rules that govern the relationships and interactions between and among systems. This is not a new challenge, but progress has not been sufficient to date. I would suggest that rethinking this challenge from the perspective of agility might be helpful.

If we look at the challenge of complex endeavors involving civil-military missions, this implies that we must focus on enterprise/endeavor agility. Specifically, we must concentrate on developing a better understanding of the relative agility of a variety of organization-approach and policy options and the ways in which the performance of these options can be improved. Focusing first on the enterprise/endeavor will allow us to understand how best to work with the entities that currently exist, and how to leverage the variety of agility-related attributes they possess.

A holistic focus has another advantage. This advantage is that none of us would pretend to know the best way to prepare for, organize, create, and participate in a complex enterprise/endeavor. Therefore, there is no orthodoxy to fight against. Furthermore, an exploration of the enterprise/endeavor provides all the methods and tools we need to undertake a similar investigation of more traditional large organizations. This is because large organizations (e.g., militaries, governments, or international corporations) are assemblies of the same basic building blocks that make up an enterprise/endeavor—smaller, specialized organizations, systems, and, of course, individuals. Organizations differ from enterprises/endeavors primarily when it comes to: 1) the degree to which the goals and objectives of participating entities differ from the overall goals and objectives, and the degree to which these goals and objectives are in conflict with one another, 2) the manner in which decision rights are allocated, 3) the degree of cultural diversity, and 4) the scale and complexity of their mission challenges.

In essence, both share the same model of agility (the same variables and relationships) with their differences reflected in the values of the parameters. This suggests that the organization-approach space works for both, with the locus of points that represent current organizations to be located nearer the origin than the locus of points that represent an enterprise/endeavor, which are located nearer the upper, back, right corner (see figure V-8).

Focusing on an enterprise/endeavor does not mean that one ignores the question of how we can improve the agility of individuals and systems. Rather, it means that we seek to improve their agility in the context of complex endeavors rather than when they and the organizations to which they belong are engaged in less challenging problems.

Organizations and therefore enterprises would be nothing but a collection of policies, procedures, organization charts, and incentives without the people and the systems that support them. The raison d'être of organizations is to focus the energies and abilities of individuals for a purpose that could not be achieved without their combined efforts, as efficiently as possible. However, a collection of policies, procedures, organizational relationships, and incentives can, in practice, constrain rather than enhance the contributions of participating individuals. The systems that are meant to support individuals can also constrain their efforts. The agility-related characteristics of individuals and systems can constrain, compensate for, or enhance their individual and collective contributions. It is important that we expose and better understand these interactions.

It is also important that we change our perspective in a fundamental way. This involves redefining ourselves. “Who am I?” “Who are we?” These seem like fairly simple questions. Yet, how we, as entities and system developers, answer these questions will, in all likelihood, determine whether or not the enterprise with which we identify and the endeavors in which this enterprise participates is successful. In his book *The Black Swan: The Impact of the Highly Improbable,* Nassim Nicholas Taleb speaks about the tendency of humans to focus on the specific rather than take a broader perspective. We can see this tendency in our reactions to many challenges. Perhaps this is the underlying reason why we seem incapable of creating the conditions that would allow us to connect the dots.

The Road Ahead

Agility is a new frontier. Once *the light bulb goes on* in someone’s head, I can sense their excitement. This enthusiasm for learning more about agility and applying these concepts is shared by practitioners, researchers, and analysts alike. They recognize that the study of agility and efforts to improve entity agility, particularly the agility of large enterprises, coalitions, collectives, and systems of systems, has enormous potential to provide solutions to problems that have stymied us for too long.

Simply by accepting the basic premise behind *The Agility Advantage,* imagination is unleashed. There is low hanging fruit everywhere. Agility is relevant to almost everything we design and build. Its universal application means that we will have no shortage of fine minds to work on it. Given the power of the infostructures we have at our service, agility-related ideas, experiments, evidence, and experiences will cross-pollinate at an unprecedented rate. As a result, we will make progress at a rate that far exceeds our previous experience. I look forward to being a part of this grand exploration into the power of agility.

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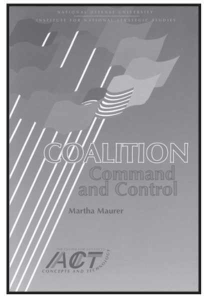
Coalition Command and Control

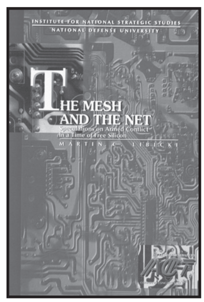
(Maurer, 1994)



Peace operations differ in significant ways from traditional combat missions. As a result of these unique characteristics, command arrangements become far more complex. The stress on command and control arrangements and systems is further exacerbated by the mission's increased political sensitivity.

The Mesh and the Net

(Libicki, 1994)

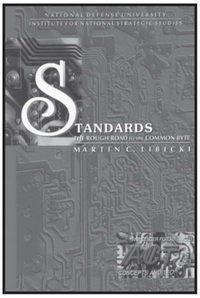


Considers the continuous revolution in information technology as it can be applied to warfare in terms of capturing more information (mesh) and how people and their machines can be connected (net).

Command Arrangements for Peace Operations

(Alberts & Hayes, 1995)

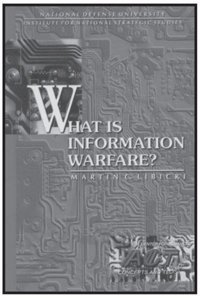
By almost any measure, the U.S. experience shows that traditional C2 concepts, approaches, and doctrine are not particularly well suited for peace operations. This book (1) explores the reasons for this, (2) examines alternative command arrangement approaches, and (3) describes the attributes of effective command arrangements.



Standards: The Rough Road to the Common Byte

(Libicki, 1995)

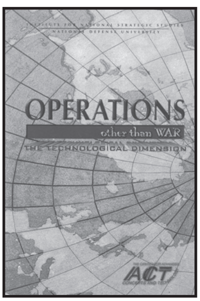
The inability of computers to "talk" to one another is a major problem, especially for today's high technology military forces. This study by the Center for Advanced Command Concepts and Technology looks at the growing but confusing body of information technology standards.



What Is Information Warfare?

(Libicki, 1995)

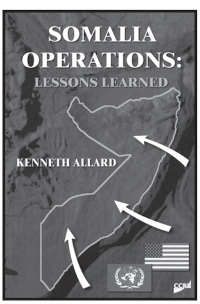
Is Information Warfare a nascent, perhaps embryonic art, or simply the newest version of a time-honored feature of warfare? Is it a new form of conflict that owes its existence to the burgeoning global information infrastructure, or an old one whose origin lies in the wetware of the human brain but has been given new life by the Information Age?



Operations Other Than War

(Alberts & Hayes, 1995)

This report documents the fourth in a series of workshops and roundtables organized by the INSS Center for Advanced Concepts and Technology (ACT). The workshop sought insights into the process of determining what technologies are required for OOTW. The group also examined the complexities of introducing relevant technologies and devices.



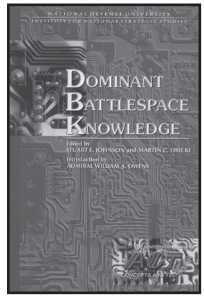
Somalia Operations: Lessons Learned

(Allard, 1995)

This book is Colonel Allard's examination of the challenges and the successes of the U.S. peacekeeping mission to Somalia in 1992-1994. Key topics include planning, deployment, conduct of operations, and support.

Dominant Battlespace Knowledge

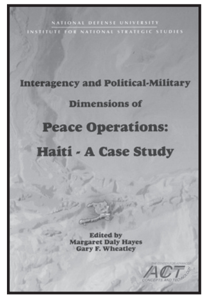
(Johnson & Libicki, 1996)



The papers collected here address the most critical aspects of that problem—to wit: If the United States develops the means to acquire dominant battlespace knowledge, how might that affect the way it goes to war, the circumstances under which force can and will be used, the purposes for its employment, and the resulting alterations of the global geomilitary environment?

Interagency and Political-Military Dimensions of Peace Operations: Haiti - A Case Study

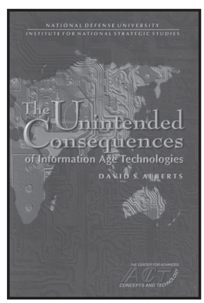
(Hayes & Wheatley, 1996)



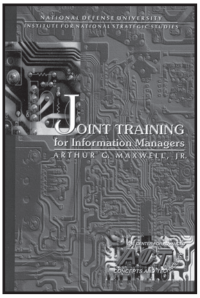
This report documents the fifth in a series of workshops and roundtables organized by the INSS Center for Advanced Concepts and Technology (ACT). Widely regarded as an operation that "went right," Haiti offered an opportunity to explore interagency relations in an operation close to home that had high visibility and a greater degree of interagency civilian-military coordination and planning than the other operations examined to date.

The Unintended Consequences of the Information Age

(Alberts, 1996)



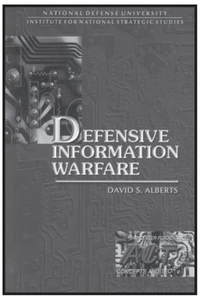
The purpose of this analysis is to identify a strategy for introducing and using Information Age technologies that accomplishes two things: first, the identification and avoidance of adverse unintended consequences associated with the introduction and utilization of information technologies; and second, the ability to recognize and capitalize on unexpected opportunities.



Joint Training for Information Managers

(Maxwell, 1996)

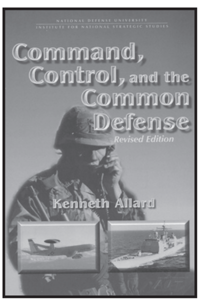
This book proposes new ideas about joint training for information managers over Command, Control, Communications, Computers, and Intelligence (C4I) tactical and strategic levels. It suggests a new way to approach the training of future communicators.



Defensive Information Warfare

(Alberts, 1996)

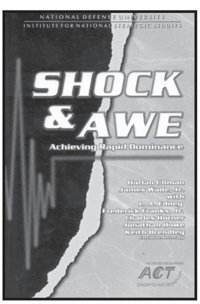
This overview of defensive information warfare is the result of an effort, undertaken at the request of the Deputy Secretary of Defense, to provide background material to participants in a series of interagency meetings to explore the nature of the problem and to identify areas of potential collaboration.



Command, Control, and the Common Defense

(Allard, 1996)

The author provides an unparalleled basis for assessing where we are and were we must go if we are to solve the joint and combined command and control challenges facing the U.S. military as it transitions into the 21st century.



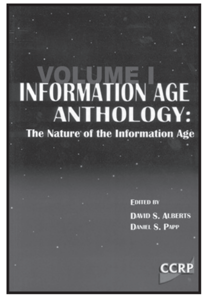
Shock & Awe: Achieving Rapid Dominance

(Ullman & Wade, 1996)

The purpose of this book is to explore alternative concepts for structuring mission capability packages around which future U. S. military forces might be configured.

Information Age Anthology: Volume I

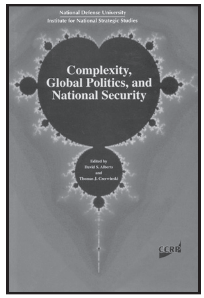
(Alberts & Papp, 1997)



In this volume, we examine some of the broader issues of the Information Age: what the it is; how it affects commerce, business, and service; what it means for the government and the military; and how it affects international actors and the international system.

Complexity, Global Politics, and National Security

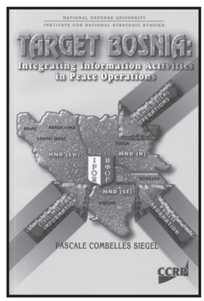
(Alberts & Czerwinski, 1997)



The charge given by the President of the NDU and RAND leadership was threefold: (1) push the envelope; (2) emphasize the policy and strategic dimensions of national defense with the implications for complexity theory; and (3) get the best talent available in academe.

Target Bosnia: Integrating Information Activities in Peace Operations

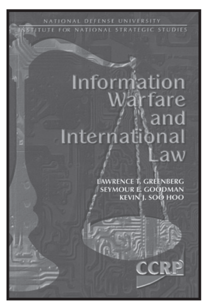
(Siegel, 1998)



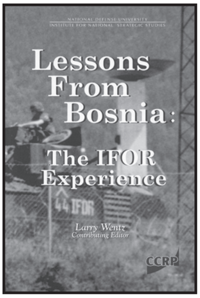
This book examines the place of PI and PSYOP in peace operations through the prism of NATO operations in Bosnia-Herzegovina.

Information Warfare and International Law

(Greenberg, Goodman, & Soo Hoo, 1998)



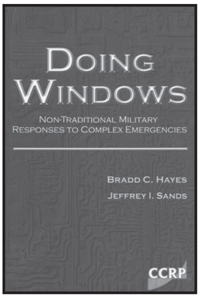
The authors have surfaced and explored some profound issues that will shape the legal context within which information warfare may be waged and national information power exerted in the coming years.



Lessons From Bosnia: The IFOR Experience

(Wentz, 1998)

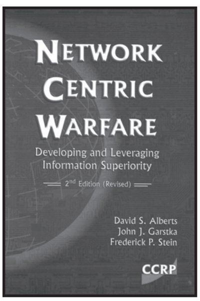
This book tells the story of the challenges faced and innovative actions taken by NATO and U.S. personnel to ensure that IFOR and Operation Joint Endeavor were military successes.



Doing Windows: Non-Traditional Military Responses to Complex Emergencies

(Hayes & Sands, 1999)

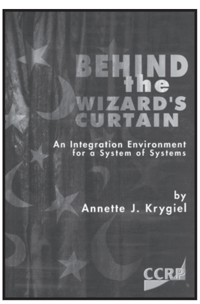
This book examines how military operations can support the long-term objective of achieving civil stability and durable peace in states embroiled in complex emergencies.



Network Centric Warfare

(Alberts, Garstka, & Stein, 1999)

It is hoped that this book will contribute to the preparations for NCW in two ways. First, by articulating the nature of the characteristics of Network Centric Warfare. Second, by suggesting a process for developing mission capability packages designed to transform NCW concepts into operational capabilities.



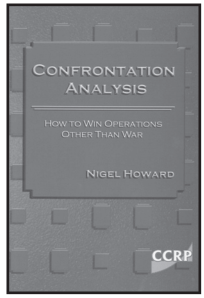
Behind the Wizard's Curtain

(Krygiel, 1999)

There is still much to do and more to learn and understand about developing and fielding an effective and durable infostructure as a foundation for the 21st century. Without successfully fielding systems of systems, we will not be able to implement emerging concepts in adaptive and agile C2, nor reap the benefits of NCW.

Confrontation Analysis: How to Win Operations Other Than War

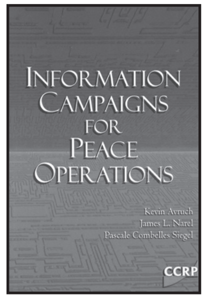
(Howard, 1999)



A peace operations campaign should be seen as a linked sequence of confrontations. The objective in each confrontation is to bring about certain "compliant" behavior on the part of other parties, until the campaign objective is reached.

Information Campaigns for Peace Operations

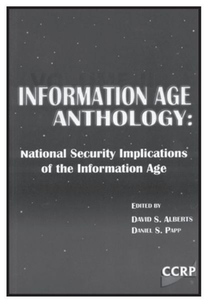
(Avruch, Narel, & Siegel, 2000)



In its broadest sense, this report asks whether the notion of struggles for control over information identifiable in situations of conflict also has relevance for situations of third-party conflict management for peace operations.

Information Age Anthology: Volume II

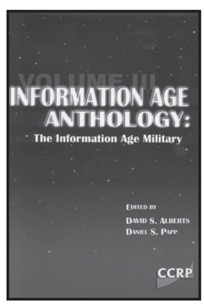
(Alberts & Papp, 2000)



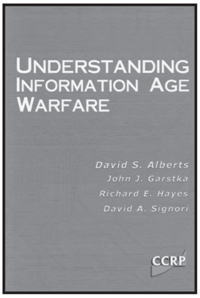
Is the Information Age bringing with it new challenges and threats, and if so, what are they? What dangers will these challenges and threats present? From where will they come? Is information warfare a reality?

Information Age Anthology: Volume III

(Alberts & Papp, 2001)



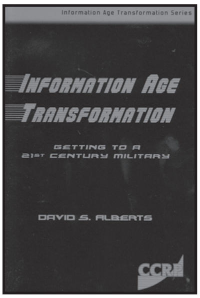
In what ways will wars and the military that fight them be different in the Information Age than in earlier ages? What will this mean for the U.S. military? In this third volume of the Information Age Anthology, we turn finally to the task of exploring answers to these simply stated, but vexing questions that provided the impetus for the first two volumes of the Information Age Anthology.



Understanding Information Age Warfare

(Alberts, Garstka, Hayes, & Signori, 2001)

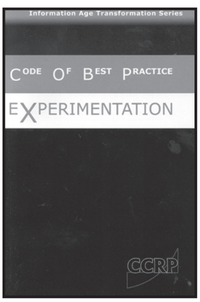
This book presents an alternative to the deterministic and linear strategies of the planning modernization that are now an artifact of the Industrial Age. The approach being advocated here begins with the premise that adaptation to the Information Age centers around the ability of an organization or an individual to utilize information.



Information Age Transformation

(Alberts, 2002)

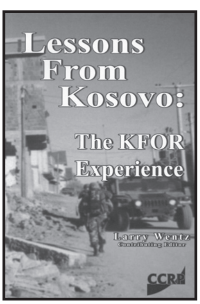
This book is the first in a new series of CCRP books that will focus on the Information Age transformation of the Department of Defense. Accordingly, it deals with the issues associated with a very large governmental institution, a set of formidable impediments, both internal and external, and the nature of the changes being brought about by Information Age concepts and technologies.



Code of Best Practice for Experimentation

(CCRP, 2002)

Experimentation is the lynch pin in the DoD's strategy for transformation. Without a properly focused, well-balanced, rigorously designed, and expertly conducted program of experimentation, the DoD will not be able to take full advantage of the opportunities that Information Age concepts and technologies offer.



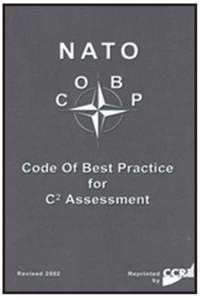
Lessons From Kosovo: The KFOR Experience

(Wentz, 2002)

Kosovo offered another unique opportunity for CCRP to conduct additional coalition C4ISR-focused research in the areas of coalition command and control, civil-military cooperation, information assurance, C4ISR interoperability, and information operations.

NATO Code of Best Practice for C2 Assessment

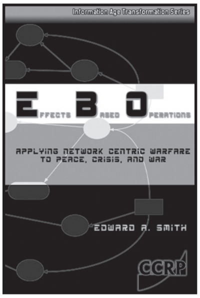
(NATO SAS-026, 2002)



To the extent that they can be achieved, significantly reduced levels of fog and friction offer an opportunity for the military to develop new concepts of operations, new organisational forms, and new approaches to command and control, as well as to the processes that support it. Analysts will be increasingly called upon to work in this new conceptual dimension in order to examine the impact of new information-related capabilities coupled with new ways of organising and operating.

Effects Based Operations

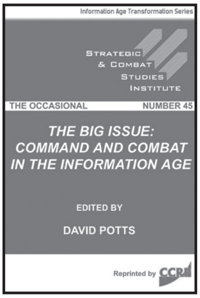
(Smith, 2003)



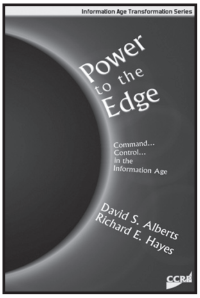
This third book of the Information Age Transformation Series speaks directly to what we are trying to accomplish on the "fields of battle" and argues for changes in the way we decide what effects we want to achieve and what means we will use to achieve them.

The Big Issue

(Potts, 2003)



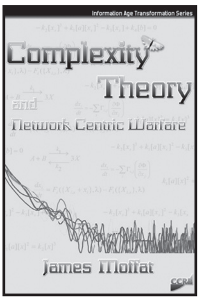
This Occasional considers command and combat in the Information Age. It is an issue that takes us into the realms of the unknown. Defence thinkers everywhere are searching forward for the science and alchemy that will deliver operational success.



Power to the Edge: Command...Control... in the Information Age

(Alberts & Hayes, 2003)

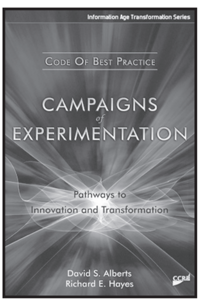
Power to the Edge articulates the principles being used to provide the ubiquitous network that people will trust and use, populate with information, and use to develop shared awareness, collaborate, and synchronize actions.



Complexity Theory and Network Centric Warfare

(Moffat, 2003)

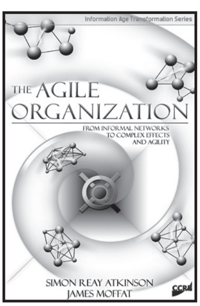
Professor Moffat articulates the mathematical models that demonstrate the relationship between warfare and the emergent behaviour of complex natural systems, and calculate and assess the likely outcomes.



Campaigns of Experimentation: Pathways to Innovation and Transformation

(Alberts & Hayes, 2005)

In this follow-on to the Code of Best Practice for Experimentation, the concept of a campaign of experimentation is explored in detail. Key issues of discussion include planning, execution, achieving synergy, and avoiding common errors and pitfalls.



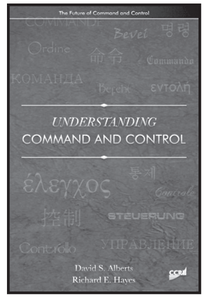
The Agile Organization

(Atkinson & Moffat, 2005)

This book contains observations, anecdotes, and historical vignettes illustrating how organizations and networks function and how the connections in nature, society, the sciences, and the military can be understood in order to create an agile organization.

Understanding Command and Control

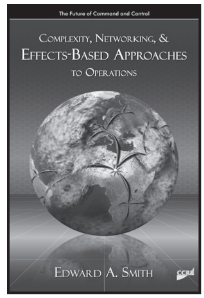
(Alberts & Hayes, 2006)



This is the first in a new series of books that will explore the future of Command and Control, including the definition of the words themselves. This book begins at the beginning: focusing on the problem(s) that Command and Control was designed (and has evolved) to solve.

Complexity, Networking, and Effects-Based Approaches to Operations

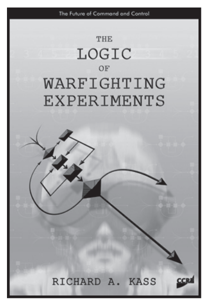
(Smith, 2006)



Ed Smith recounts his naval experiences and the complex problems he encountered that convinced him of the need for effects-based approaches and the improved infostructure needed to support them.

The Logic of Warfighting Experiments

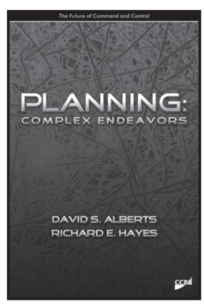
(Kass, 2006)



Experimentation has proven itself in science and technology, yielding dramatic advances. Robust experimentation methods from the sciences can be adapted and applied to military experimentation and will provide the foundation for continual advancement in military effectiveness.

Planning: Complex Endeavors

(Alberts & Hayes, 2007)

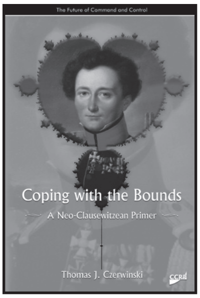


The purpose of this book is to present and explain an approach to planning that is appropriate for complex endeavors at a level of detail sufficient to formulate and conduct a campaign of experimentation to test, refine, and ultimately implement a new approach or set of approaches to planning.

The International C2 Journal

Established 2006

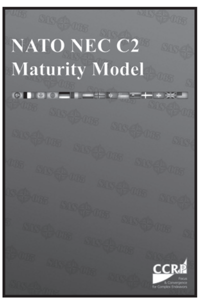
The International C2 Journal is one of the latest CCRP endeavors. This internationally directed and peer reviewed publication presents articles written by authors from all over the world in many diverse fields of Command and Control such as systems, human factors, experimentation, and operations.



Coping with the Bounds

(Czerwinski, 2008)

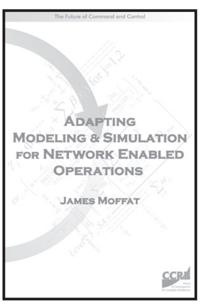
Originally published by NDU in 1998, the theme of this work is that conventional, or linear, analysis alone is not sufficient to cope with today's and tomorrow's problems, just as it was not capable of solving yesterday's. Its aim is to convince us to augment our efforts with nonlinear insights, and its hope is to provide a basic understanding of what that involves.



NATO NEC C2 Maturity Model

(SAS-065, 2010)

The NATO NEC C2 Maturity Model (N2C2M2) was developed to build on dearly won insights from the past, but goes beyond them in order that we can exploit Information Age approaches to address new mission challenges. This way of thinking about C2 is thus entirely compatible with current NATO Allied Command Transformation (ACT) thinking on Future Capable Forces which puts the emphasis on Mission Command within federated complex environments and ad hoc coalitions.



Adapting Modeling & Simulation for Network Enabled Operations

(Moffat, 2011)

The essence of this book is to describe how the UK Ministry of Defence has risen to the challenges of complex endeavors and the information age by investing in the development of new analytical tools, in particular closed form simulation modeling, in order to provide the evidence base for improved high level decision-making in government.

About the Author

Dr. David S. Alberts is currently the Director of Research for OASD (NII) / DoD CIO. Prior to this he was the Director, Advanced Concepts, Technologies, and Information Strategies (ACTIS), Deputy Director of the Institute for National Strategic Studies, and the executive agent for DoD's Command and Control Research Program. This included responsibility for the Center for Advanced Concepts and Technology (ACT) and the School of Information Warfare and Strategy (SIWS) at the National Defense University. He has more than 25 years of experience developing and introducing leading edge technology into private and public sector organizations. This extensive applied experience is augmented by a distinguished academic career in computer science and operations research and government service in senior policy and management positions.

Dr. Alberts' publications include the following books: *Planning: Complex Endeavors, Understanding Command and Control, Power to the Edge, Information Age Transformation, Understanding Information Age Warfare, Network Centric Warfare, Unintended Consequences of Information Age Technologies, Command Arrangements for Peace Operations,* and *Defensive Information Warfare*. He also led international teams whose efforts have produced the *NATO NEC C2 Maturity Model*, the *C2 Conceptual Reference Model*, the *NATO Code of Best Practice for C2 Assessment*, and the *Code of Best Practice for Experimentation*. *The Agility Advantage: A Survival Guide for Complex Enterprises and Endeavors*, is now added to this list of titles. Currently he is focused on improving the agility of organizations and systems and issues related to cybersecurity.

Recent honors have included the Secretary of Defense's Outstanding Public Service Award, *Aviation Week and Space Technology's* Government/Military Laurel, and the inaugural NCW Award for Best Contribution to the Theory of NCW presented by the Institute for Defense and Government Advancement (IDGA).

Dr. Alberts' experience includes serving as a CEO for a high-technology firm specializing in the design and development of large, state-of-the-art computer systems (including expert, investigative, intelligence, information, and command and control systems) in both government and industry. Rising from group leader to technical director at a federal funded research and development center (FFRDC), Dr. Alberts has managed organizations engaged in research and analysis of C4ISR systems focusing on their technical performance as well as their contributions to operational missions. Dr. Alberts has had policy responsibility for corporate computer and telecommunications capabilities, facilities, and experimental laboratories. His responsibilities have also included management of research aimed at enhancing the usefulness of systems, extending their productive life, and the development of improved methods for evaluating the contributions that systems make to organizational functions. Dr. Alberts frequently contributes to government task forces and workshops on systems acquisition, command and control, and systems evaluation.

Dr. Alberts' academic career has included serving as first Director of the Computer Science Program at NYU and has held professional rank posts at NYU Graduate School of Business, CUNY, and most recently as a Research Professor at George Mason University. He has chaired numerous international and national conferences and symposia and has many publications, some of which are included in tutorials given by the IEEE and other professional societies. He has served as an officer in a number of professional societies and has actively contributed to AIAA, MORS, TIMS, AFCEA, and ORSA. At the local level, Dr. Alberts has served as Assistant to the Commissioner, NYPD. Dr. Alberts received a Doctorate in Operations Research and a Masters from the University of Pennsylvania. His undergraduate work was at City College of New York where he received a BA in Statistics.

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