Viewing the world systemically.

Analyses of "Complex Systems"

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Critique of: *Making Things Work: Solving Complex Problems in a Complex World*[1]

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This report on Complex Systems starts with a critique of the work by Yaneer Bar-Yum, *Making Things Work: Solving Complex Problems in a Complex World*. This critique is restricted to Chapter 9: *Military Warfare and Conflict*.[2] However, before considering the current text, some background is required as founded on other research, and, in particular, we will review *Dynamics of Complex Systems*.

Dynamics of Complex Systems provides a more in-depth analysis of the basis for the theory upon which *Making Things Work* relies. In view of that analysis, it will be seen that there are major differences in perspective between *Complex Systems Theory* and *ATIS*. There are also avenues for compatibility between the two theories. However, the fundamental differences must first be recognized and explored.

Complex Systems Theory

The fundamental distinction between the two theories is that Complex Systems Theory (CST) relies on a statistical/information base, whereas *ATIS* relies on an axiomatic/property base.

On page 1 of *Complex Systems Theory* it states:

> Qualitatively, to understand the behavior of a complex system we must understand not only the behavior of the parts but how they act together to form the behavior of the whole. It is because we cannot describe the whole without describing each part, and because each part must be described in relation to other parts, that complex systems are difficult to understand.

Possibly there is a misunderstanding here of what is meant by being able to "understand the behavior of a complex system." One platitude comes to mind: *The whole is more than the sum of its*

[1] Bar-Yam, Yaneer; *Making Things Work: Solving Complex Problems in a Complex World*. NECSI Knowledge Press, 2004.

[2] As background, Captain Thompson is very familiar with the Viet-Nam War, both in Viet-Nam and in Laos. As a Herb and Raven FAC he has over 1800 First Pilot Combat Hours, 2 DFCs, 31 Air Medals, and a Bronze Star for Valor. In addition, he has a Senior Pilot Rating and was the Counter-Insurgency Tactics Officer for USAF TAC, and initiated the development of the counter-insurgency program for USAF TAC.

In addition, Captain Thompson initiated and developed the *Weapons and Counter-Tactics Program for Aircrew Members* and the *Tactical Air Command Instructor Orientation Course* for the U.S. Air Force Tactical Air Command.

parts. This assumed truism has been around for well over 50 years now, and yet CST seems to be reverting to a time that predates this truism. Of course, this platitude may not be accurate.

So, we must visit, once again, whether or not the understanding of the behavior of a complex system is dependent on an understanding of its parts. It seems to be obvious that the platitude is far truer than the alternative. Do we have to understand the functioning of a human appendix in order to understand the behavior of a truant student? It would seem not save *reductio ad absurdum*. While the appendix is certainly a part of the human body and, therefore, a part of the system comprising a human being, it is beyond the realm of comprehension that such appendix has anything to do with the choice that a student makes to be truant from school.

Therefore, either a student is not a complex system, or system behavior is not dependent on understanding the workings of the subsystems, or at least not just any subsystem, and especially not "all" subsystems.

Therefore, our first observation is that only certain subsystems are relevant to the understanding of the behavior of a complex system.

Now, there is no assertion that complex systems are not entities that deserve our attention, since they do. But, our concern here is with respect to properly defining a complex system and defining the relevant subsystems. And, the emphasis on "relevant" is important. Contrary to the reductionist perspective, not everything will rely on the atoms that comprise the physical universe. Whether or not "intent" is dependent upon the organization of the atoms that comprise the physical body is questionable.

On page 5 of *Complex Systems Theory* the "Central Properties of Complex Systems" is discussed. There it states:

> After beginning to describe complex systems, a second step is to identify commonalities. We might make a list of some of the characteristics of complex systems and assign each of them some measure or attribute that can provide a first method of classification or description.
>
> - Elements (and their number)
> - Interactions (and their strength)
> - Formation/Operation (and their time scales)
> - Diversity/Variability
> - Environment (and its demands)
> - Activity(ies) (and its [their] objective[s])
>
> This is a first step toward quantifying the properties of complex systems. Quantifying the last three in the list requires some method of counting possibilities. The problem of counting possibilities is central to the discussion of quantitative complexity.

In fact, quantifying diversity/variability, environment, and activity does not *require* "counting possibilities." That is one way to do it, but such a quantifying technique is not inherent in these types of

properties. That is, 'Diversity', 'Environment', and 'Activity' can be considered properties of a system, which is consistent with *Complex Systems Theory*. Then, the question is how to define and quantify these properties, rather than asserting such as being inherent in the concepts themselves.

When a system is analyzed at its most refined level, or at the most elementary scale, then it may be that statistical/probabilistic quantification is all that can be obtained. But, such precision not only may not be required, but it may be counterproductive to a proper analysis of a system. For example, if a biological system had to know everything that was going on in order to function, it would not be able to function due to conceptual overload. The point is that a quantification perspective is being assumed that in fact may not be appropriate for the analysis of a specific system.

What is the "diversity" of a system? It's whatever is required to answer the questions being asked. And, the diversity may very well be countable. But, not all systems have countable diversities, which is true. But, so what? If a statistical measure of diversity is appropriate, do so. But then, in *ATIS* that statistical answer will just be called "good enough" and it will be used as though it is an accurate measure of the number of diverse options without any degrees of freedom. In the analysis of a very complex system, it really will not make any difference.

As for "environment," the environment is whatever is related to the system components. If they are not related, then they are not part of the environment. If we do not know which components are related, then they remain unknown. More important, if they have no effect, it will not make any difference anyway. If they do have an effect, then they are not *unknown* they are just *unrecognizable*.

For example, concerning the discovery of Neptune and Pluto, it was known before they were ever seen that they were there, but could not be recognized. We could, however, proceed with our calculations as though we knew exactly where and what they were, even if we could not see them. They were *unrecognizable* but they were not *unknown*. If they had remained unknown we would never have found them except by an accidental observation. And so with "activity."

It is now seen that, contrary to the assumption being made for complex systems, "counting possibilities" is not at all "central to the discussion of quantitative complexity." To the contrary, while "universal laws and phenomena are essential to our inquiry and to our understanding" (p. 1) is an accurate assertion, those universal laws are not dependent on statistical observations.

Now we turn our attention to the discussion on *emergence*. As discussed on page 5, there are two emergent complex system behaviors—*emergent complexity* and *emergent simplicity*. *Emergent complexity* occurs when a system composed of simple parts results in a collective behavior that is complex. *Emergent simplicity* occurs when a system composed of complex parts results in a collective behavior that is simple.

With respect to the second concept of emergence, the following example is given:

> A useful example [of emergent simplicity] is a planet orbiting around a star. The behavior of the planet is quite simple, even if the planet is the Earth, with many complex systems upon it. This example illustrates the possibility that the collective system has a behavior at a different scale than its parts. On the

> smaller scale the system may behave in a complex way, but on the larger scale all the complex details may not be relevant.

To the contrary, this is an example of a *confusion of system types*. Here, a "system" is being "observed" where in fact no "system" exists.

That is, the earth revolving around the sun has absolutely nothing to do with a frog jumping in a pond. The frog's jumping will not affect even the rotation of the planet, let alone the orbiting of the planet around the sun. An earthquake may have an effect on the planet's rotation and therefore all earthquakes are legitimate components of the "orbiting system." But to suggest, as another example, that the blood flowing in a person is somehow part of that "orbiting system" is to refine the observation of the "system" to the point of absurdity. Other than to suggest that the entire universe is part of every system that must be considered, in which case the notion of system is meaningless, then there must be some other criteria that must be used to properly restrict the concept of 'system' even if that system is "complex." "Complex" does not mean all encompassing; and well-defined boundaries of a system must be obtained in order to reasonably discuss that complexity.

The criteria for subsystem inclusion in the *blood-flow/orbiting complex system* could be stated as follows: "Is there a relevant question that can be answered only by including the blood-flow in an analysis of planet rotation or orbiting?" While such a question should not have to be asked for this particular "complex system," it may be appropriate when considering other systems where the subsystems have more relevance to the behavior of the whole system.

And, this criterion for subsystem inclusion is frequently applied in science. For example, this is the same type of reasoning that has to be asked when deciding whether to use Newtonian or Einstein Physics. If Newtonian Physics cannot answer questions relating to atoms, then do not suggest that "atom-physics" is somehow a part of the systems with which Newtonian Physics is concerned. Blood flow in humans and frogs jumping in a pond have no relevance to the orbiting or rotation of the planet Earth and, therefore, are not part of the simple Earth-orbiting system; that is, they do not make this simple system complex.

Now, to understand why blood flow and planet orbiting are considered as part of the same system, we have the following statement concerning the definition of 'complex system'.

> A complex system is a system formed out of many components whose behavior is emergent; that is, the behavior of the system cannot be simply inferred from the behavior of its components. The amount of information necessary to describe the behavior of such a system is a measure of its complexity.

The first sentence of this definition is accurate as initially stated, and is consistent with the precepts of *General Systems Theory* and other theories dealing with complexity. The second sentence of this definition may or may not be acceptable. Since it is a definition, of course, it must be taken at face value. The question then is, does it lead to relevant analyses that answer relevant questions. Two sentences that follow this definition, however, put this definition into perspective:

> It is impossible to understand complex systems without recognizing that simple atoms must somehow, in large numbers, give rise to complex collective behaviors. How and when this occurs is the simplest and yet the most profound problem that the study of complex systems faces.

This assertion seems to be stating the utopia of the physicist in reverse; that is, instead of trying to find the unifying theory of physics, the complex system theorist is trying to discover how atoms and their parts result in the emergent behaviors of all existence.

However, it is one thing to try to obtain a comprehensive unifying physical science that can be reduced to whatever it is that physicists are reducing it to in terms of quarks and whatever someone else had for lunch, but it is another for behavioral scientists to then start from yesterday's lunch and assert that it determines the collective bargaining practices of the AFL-CIO. That this reductionist vision can even be proposed, however, results from the assertion that complex systems can only be viewed in terms of "collective behaviors"; that is, by statistical analyses dependent on probabilities and information theory. Fortunately, such is not the case. There is another approach that does not reduce orbiting planets to yesterday's lunch and digestive processes.

From the preceding analysis, it will be seen in what follows that the problems with properly analyzing the Viet-Nam War; for example, relate directly to the belief that a fine-scaled analysis is appropriate when in fact it but distorts the results.

Introduction

An excellent presentation has been made concerning the relation between system complexity and scale. Probably one of the more important concepts provided is that of a *complexity profile*. Such a profile will assist in evaluating comparisons of systems as well as selecting the appropriate complexity-to-scale required to properly analyze a system.

However, knowledge of such a profile does not provide a basis for deciding which profile is most appropriate for a system's analysis that will be responsive to answering relevant questions. If the system is viewed at too fine a scale, the details may be irrelevant to the questions of concern. If the system is viewed at too large a scale, the relevant details may be missed. In fact, it is due to just such a lack of a decision-procedure for selecting the complexity profile that the analysis of the Viet-Nam War was misapplied in the discussion on "*Military Warfare and Conflict*."

In order to properly analyze the import of complexity on warfare, the basis for comparison between conventional and complex warfare needs to be properly grounded.

While it is customary to view the loss of the Viet-Nam war in terms of the type of warfare, it is suggested that such is not the case. Viewed at the proper scale, there is no confusion or mystery as to why the U.S. lost this war. As will herein be seen, the loss was due to political considerations and not at

all due to a military defeat. Possible contrary analyses at the War College or other research studies can be attributed to the scale of the war being viewed rather than portraying an accurate analysis of the *Viet-Nam Warfare System*. Although an analysis similar to the one herein described has been issued by the War College.

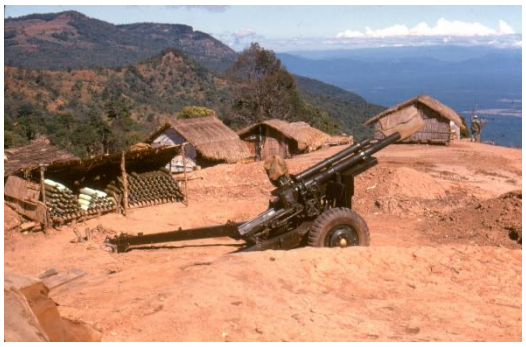

Figure 1: PS-26 above Attapeu, Laos

That is, if one wishes to restrict the scale of analysis of the war at the battlefield level, then results will reflect the fine-grained observations that are made. However, the war for the U.S. was not lost on the battlefield, it was lost in Washington, D.C.

In fact, Captain Thompson participated in an operation, *Operation Honorable Dragon*, which was being controlled from Washington, D.C. This was a CIA Special Guerilla Units Operation on the Bolovens Plateau in Southern Laos. Each evening, following the day's activities, a report would be sent to the CIA Headquarters in Washington, D.C., and then the Country Team would await instructions as to how to proceed. And, all of this control was directed at attempts to retake PS-26, a very small outpost overlooking Attapeu, Laos, shown in the photo at the left. This represented micro-managing to the extreme. In fact, the outpost was so secure that 4 North Vietnamese soldiers were able to hold off a battalion of Special Guerilla Unit soldiers. Even T-28's dropping napalm on the outpost did not dislodge the North Vietnamese soldiers. This was a ludicrous military tactic, but a required political tactic designed to support a claim that the Bolovens was secure. In fact, it resulted in the loss of the Bolovens.

But, to believe that the Bolovens was lost as a result of an analysis at the battalion-level would be to totally misunderstand what actually happened.

This is an important distinction when recommendations for military restructuring are founded on this false premise. In fact, it can be easily argued that the current difficulties in Iraq are due to the very same shortsightedness. By focusing on the military structure as the cause, the U.S. is, once again, caught up in a military operation experiencing far more casualties than it should, and even now warnings are being given that a civil war may be eminent. [This is now updated, in 2015, to the current conditions in Iraq with the advent of ISIS, and the existing "civil war" or "ISIL invasion" from Syria.]

It is suggested that a new perspective needs to be taken concerning the Viet-Nam War so that a proper analysis may be made of the Iraq War. This is essential as pointed out in *Making Things Work* where it is emphasized that the correlation between the complexity and scale of a military operation must be recognized if a war is to be won. If the premise is false concerning the Viet-Nam War, then the results of the current military actions in Iraq are also flawed [as we now know]. Consider the following discussion.

It is important to recognize that many systems have great complexity. And yet, such systems are manageable and they do work. Biological systems, in particular, do function in spite of their great complexity. By recognizing this fact, one can get a better grasp on managing other such complex systems. That is, if the biological system had to actually recognize each and every "communication path"

required to sustain the system, it would not be able to function as it would experience sensory or information overload. This is an important fact emphasized by *Making Things Work*.

This same strategy of selecting the appropriate complexity profile must be employed when defining any complex system. That is, the system must be defined at a *level of least refinement* required for desired predictive results. This is an important concept in *ATIS* (Axiomatic Theory of Intentional Systems) and is inherent in *Making Things Work*. This principle will be cited as the ***Least-Refined Definition Principle***. Any system can be viewed with greater refinement, but the level of refinement must be minimized to obtain the greatest predictive results—a view that is possibly counter-intuitive, and has certainly been counter-intuitive when analyzing the Viet-Nam War.

Least-Refined System Object-Set/Relation-Set Definition Principle

The object-set and relation-set of a system must be defined with the least number of elements required to define the system.

Or, in terms of the complexity profile:

Least-Refined System Complexity Profile Definition Principle

The complexity profile of a system must be defined so that the largest scale is viewed that will result in a description of the system appropriate to the required analysis.

That is, what is the largest scale at which answers to the relevant questions are obtained? With these preliminary observations, *Making Things Work* can now be critiqued.

Critique of *Making Things Work*

At 97 of *Making Things Work*:

> "There are many arguments for why the U.S. was unsuccessful in Vietnam: …"

It is suggested that with an application of "complexity and scale," the answer can be reduced to: Political considerations. The importance of recognizing "scale" in the analysis of this problem is most important. Further, such a response is not whimsical. The same reason can be recognized, as discussed below, for the current problems in Iraq. All other responses are but excuses for failure and misdirection from responsibility. There is no question as to why we were unsuccessful in Viet-Nam, since in fact, in hind-sight, we had "won" following the Têt Offensive—but were unaware of such. The consequences were the result of political abdication.

And, the final fall of South Viet-Nam was the result of a tactical error resulting from the lack of U.S. advisors in place at the time. On April 1, 1975, Thompson recognized, from the evening news, that South Viet-Nam was being overrun. He and his wife went immediately to Viet-Nam to rescue their children, entering Viet-Nam on April 10th. The children were at that time behind enemy lines (in Luong Phuc, 200 miles northeast of Saigon), but a rescue was successful and they were brought back and entered the States on April 29th, the day South Viet-Nam fell. But, why did it fall?

The general at Pleiku saw the same thing that Thompson had seen, but made the wrong choice (pursuant to complexity)—hence, failure. That is, while the army of the South Vietnamese general and the North Vietnamese army were conducting a conventional war, the scope of the general's immediate vision was reduced to the Pleiku-Qui Nhon corridor resulting in a more, and unnecessary, complex picture for him. His vision resulted in his having several choices to make and he made the wrong one. What did he do?

When he learned that the North Vietnamese were moving on Qui Nhon he became concerned that he was going to be cut off from the Saigon government. As a result, he pulled his troops out and started down the road toward Route 1 along the coast. When the civilians saw the military leaving, they immediately started to follow the troops. Then, the commanding general at Saigon ordered him to return to Pleiku. But, by then the roads were muddy from the rain, the civilians were in the way and causing deep ruts in the road, and the army was unable to return to Pleiku. They got caught out in the open and were destroyed by the North Vietnamese Army in a conventional attack.

Had the general remained at Pleiku until the North Vietnamese had extended their lines well south of Qui Nhon, he could have made a coordinated move with the army in the south to cut the North Vietnamese lines in half, and caused heavy losses on their side. Choice, determined by perceived scale, was the factor that lost this particular battle, and the war. But, a proper analysis of that loss is required if it is going to be used as a basis for analyzing the complexity of the war. South Viet-Nam was in fact lost as the direct result of conventional warfare and a misjudgment concerning that conventional warfare—a misjudgment by a general who viewed the war not as conventional but on the scale of his battalion and the Pleiku-Qui Nhon corridor.

The same could be said for the loss by the United States. That is, the U.S. did not lose due to the complexity of the war, but because of the lack of information concerning the Têt Offensive and the resulting "poor choices" made by the commanders. The lack of information can be blamed on lack of proper technology as much or more than on anything else. In this case, a more technologically complex military could have resulted in differing decisions being made. Again, however, it was not the complexity of the war, but the lack of information and the capability to obtain that information.

That the loss was more a result of political choices rather than a non-recognition of the complexity of the war is further seen by the actions taken by the military that were obstructed for political reasons. A U.S. general stationed in Udorn, Thailand, initiated his own "war" against North Viet-Nam to destroy their military capability. He was stopped due to political reasons. Again, this defeat was not due to the complexity of the war, but due to decisions that were made that compromised the ability to conduct war. This should not be confused with losing the war because the U.S. did not comprehend the characteristics of a complex system.

Further, the Viet-Nam War was in fact a combination of conventional warfare and guerrilla warfare, hence in fact recognizing the complexity of the war. The Phoenix Program was well targeted toward the insurgency, a well-planned counter-insurgency program at a very small scale, independent level.

The point is that the Viet-Nam War was lost, not due to non-recognition of the complexity of the problem (although such "recognition" may not have been stated), but due specifically to political choices that compromised military capabilities. Whether these political reasons were due to "lack of will to win, ambiguous objectives," etc. (page 97), is irrelevant to understanding the reason for the loss. When properly considering the complexity and scale criteria, the reason for the loss is clear. Choice of scale is very important to the understanding of this problem.

At 98:

> "U.S. forces retreated from Vietnam after many years of unsuccessfully grappling with difficult terrain and climate, the difficulty of distinguishing friend, enemy, and bystander, and the inability to locate and target the many nearly independent parts of the enemy."

Whether or not this assertion is oversimplified due to the nature of the book, or is actually intended is not known. Therefore, it will be taken at face value.

It is questionable whether or not U.S. troops could not successfully grapple "with difficult terrain and climate." If so, then the U.S. has far greater problems than recognizing the "complexity" of military conflicts.

However, it is not so that we had an inherent problem with "distinguishing friend, enemy and bystander." It may be that current events have tainted our view of Viet-Nam. While there were a few bombings in Saigon and other cities, there was not the daily onslaught of "suicide bombers" and other such targeting that we have seen in Iraq. Prior to 1968, the war had not reached Saigon. Buddhist monks burning themselves up in the streets did not directly affect any of the "bystanders" and the intent was to overthrow President Diem and not to assist the North Vietnamese.

In fact, most often in the countryside it was quite easy to determine the enemy—for example, any person who was west of the canal in the Tuy Hoa valley was enemy. The rationale is quite clear for anyone who knows the war zone. Further, if the person crosses the canal from west to east, then anyone or any group of people who protect that person's movement into the local villages are also enemy. Again, the reason is quite clear when the war zone is known.

The problem in Viet-Nam was the same as it is for any military action where the intent is to fortify and protect an area rather than taking the war to the enemy. As it is currently being recognized in Iraq, defense is extremely difficult. But, this lack of action of taking the war to the enemy should not be construed as resulting from not recognizing the complexity of the war, or believing that if the complexity had been recognized that a different outcome could have been achieved. No different outcome could have been achieved when the political constraints preclude taking the war to the enemy and a fortress strategy is pursued.

Why is all of this important? If the basis for comparison between complex and conventional military systems is not properly recognized, then the argument for "complexity/scale" is flawed.

In fact, the same argument can be made for Iraq. That is, the current problems have nothing to do with recognition of the complexity of the problem as it does to very poor choices being made [as was done in 2011 with the pull out of U.S. troops]. The problem is suggested at pages 97-98: In the 1991 Gulf War, the U.S. assembled "a large-scale allied force of over half a million troops" in the region.

In the buildup for the current campaign, the administration was informed by a leading general that 300,000 troops would be required for the current conflict. Instead, the U.S. went in with about 1/3 of the recommended force. Even with that force, however, the conventional war was quite successful. Current difficulties in Iraq are distinctly different from the conventional part of the war. In fact, the entire conflict can be viewed as but one of "poor choices" being made time-after-time, whether those poor choices were made at the large- or small-scale level.

Soon after the initial thrust into Iraq, an Iraqi general surrendered along with his troops. Rather than integrating that force into an allied force, the soldiers were disarmed and disbanded. Now, such troops are being recalled—confirming the initial poor choice.

Without enough troops, the looting is looked on by the administration as but the normal results of a new developing nation.

These are not the results of a failure to recognize the complexity of the war, but a political philosophy that is flawed. "Poor choices" were made, not due to the complexity or lack of complexity of the war, but because a President took the U.S. to war without a clear vision of what was required and failing to listen to the general who was in a position to properly advise. Since the *modus operandi* of any military general throughout history has been that an army never has enough troops, it is nothing but self-serving to suggest that the generals in the field did not want and did not request more troops. And, then to suggest that such was due to lack of recognizing the complexity of the war environment is to fail to properly evaluate what has actually happened. It is not good politics to assert that 300,000 troops could have helped to avoid many of the current problems, but it is not good science not to recognize that politics is exactly the reason for the current military problems.

Now, however, a new conflict has in fact occurred—an Iraqi Insurgency. And, this insurgency needs to be distinguished from the Terrorist War. And, as stated at 99, it is true that "Complex warfare is characterized by multiple small-scale hidden enemy forces. Large-scale warfare methods fail in a complex conflict." This is true. But, in this case, the need for converting to a complex conflict has its roots in the failure to properly carry out the initial large-scale warfare.

This complex warfare applies to both the Iraqi Insurgency and the Terrorist War. The Iraqi Insurgency, however, is characterized by geographical boundaries. The Terrorist War does not have any such boundaries. The distinction is significant. As a result of the geographical boundaries, the war has more well defined targets—police stations, foreign civilians, oil pipe lines, etc.

To properly analyze the Iraqi Insurgency, let us take a look at just one of these targets—police stations. If it were not for the attacks on the police stations, one might be more convinced that the problem is due to the lack of recognizing the "complexity" of the war zone. However, this one target argues against any such conclusion.

It must be that there is a reason that Iraqi police do not take initiatives to protect themselves. However, let's take a look at this situation:

1. Police stations are hard targets.
2. Police stations can be fortified.
3. It is known that police stations are targets due to the months during which they have come under attack.
4. 50-cal turrets have not been placed in fortified bunkers or towers surrounding the stations, or on the roofs of the stations.
5. There are no guards in fortified bunkers surrounding the stations.
6. Apparently, there are no guards even standing watch. Etc.

Now, is this a "complexity/scale" problem? Not in the least. Whatever the problem, it simply begs for someone taking the initiative to fortify the stations in a manner commensurate with the very obvious threat. It is one thing for someone to trigger a car bomb along a highway, it is quite another for a cadre of insurgents to be able to storm a police station and systematically kill everyone inside (up to 40 being killed) with no shots fired in response that results in the killing of any of the insurgents. The lack of any apparent effort to fortify hard targets suggests a problem that is endemic to the culture or to the Iraqi leadership or the Americans advising them.

The "police station problem" suggests that a more careful analysis needs to be made concerning the nature of the actual military problem in Iraq.

None of this suggests that complexity/scope is not important, since it is. But, its application is not quite as obvious as one may think. When police are systematically shot on a continuing basis in their own stations, there is a far greater problem than not recognizing the complexity of the war zone.

The problem here is that recognizing a complex task does not indicate what needs to be done. This is possibly a question of available individual talent. While it is true, as addressed repeatedly in this text, that complex problems must be addressed by more than one individual, the Iraqi problem suggests that there is not even one individual who either knows or can implement a solution to the killing of Iraqi police—and the tactics to prevent such killings are known.

At 101:

> When the units at a particular level of organization are more independent, the complexity is higher at that scale, but as a result, complexity at the larger scale is lower because it's more difficult to carry out coordinated actions. The dependence of the complexity on the scale, i.e. the complexity at the individual, fire team, squad, company, and battalion levels of organization, is the complexity profile of the entire military force.

Is the first sentence in the above paragraph accurate? At 110, the concept of "distributed control with central command" is introduced. This seems to contradict the above conclusion. In fact, as analyzed below, it will be seen that the two are not necessarily related. That this is recognized is due to a clear, formal definition of complexity and independence that is lacking in this text.

First, the last sentence of this quote is a definition of 'complexity profile'. This can be defined in terms of *ATIS* as follows:

Complexity profile $=_{df}$ $(\mathcal{X}_I, \mathcal{X}_T, \mathcal{X}_S, \mathcal{X}_C, \mathcal{X}_B)$;

where $\mathcal{X}_I$ is "individual complexity", $\mathcal{X}_T$ is "fire team complexity", $\mathcal{X}_S$ is "squad complexity", $\mathcal{X}_C$ is "company complexity", and $\mathcal{X}_B$ is "battalion complexity".

At any particular time, this profile could be determined by an APT (Analysis of Patterns in Time) Score and defined as follows:

Complexity profile $=_{df}$ $\mathcal{A}(\mathcal{X}_I, \mathcal{X}_T, \mathcal{X}_S, \mathcal{X}_C, \mathcal{X}_B)$; where $\mathcal{A}$ is an APT measure.

How 'complexity' is defined will determine the appropriateness of these definitions. Without further discussion at this time, the APT Score, $\mathcal{A}$, would be an appropriate measure for this 'complexity profile'. Also, 'complexity' as defined in *ATIS* may be used, or an alternative definition could be developed that may be more appropriate for a specific military system. In general, 'complexity' is a measure of the number of connections in an affect relation. As defined, we have:

Complexity, $\mathcal{X}$, $=_{df}$ number of connections.

$$\mathcal{X} =_{df} \mathcal{M}(\mathcal{A}_m \in \mathcal{A}) \mid \mathcal{M}: \mathcal{A}_m \rightarrow \mathcal{R} \wedge \mathcal{M}(\mathcal{A}_m) = |\mathcal{A}_m|;$$

where $\mathcal{A}_m$ is the affect relation for "m", $\mathcal{A}$ is the family of affect relations, and $\mathcal{R}$ is the Reals.

Complexity is defined as a measure of an affect relation; such that the measure is a function defined from the affect-relation set into the Reals, and the measure is equal to the cardinality of the affect-relation set.

It is noted that there are various results that can be obtained from this definition, including one dependent on a statistical analysis of a very large system where the actual number of affect relations is unknown. The need for such statistical analyses is not yet known, however, as it may be that a system of concern has a recognizable and manageable number of components. The value used for complexity will depend in part on the intended use of such measure. Regardless of the actual measure used, the intent of the notion of 'complexity' is inherent in the above definition.

Now, let's consider the first assertion stated above; that is:

> When the units at a particular level of organization are more independent, the complexity is higher at that scale, but as a result, complexity at the larger scale is lower because it's more difficult to carry out coordinated actions.

It is suggested that what is required is a means to analyze a system to determine with respect to that particular system the appropriate design that will optimize desired outcomes. The assertion presented here is a conclusion about systems that may or may not be warranted. Is the following possible?

> Given a hierarchy with heterarchy subsystems, or an otherwise structured heterarchy, can there be increasing independence within the subsystems while maintaining hierarchical or central heterarchy control of the system?

The answer to this question is dependent on the definitions of the respective concepts and their interrelatedness.

We begin with the definition of 'independent affect relation':

Independent affect relation, $_{I}\mathcal{A}$**,** $=_{df}$ an affect relation comprised of independent components.

$$_{I}\mathcal{A} =_{df} \mathcal{A} \mid \forall(x,y)[x \in_{I} \mathcal{C}]$$

Independent affect relation is defined as an affect relation; such that, the unary component contains an independent connected component.

Then, we will need the definition of 'independent components':

Independent connected components, $_{I}\mathcal{C}$**,** $=_{df}$ a set of system components that do not have connections to them.

$$_{I}\mathcal{C} =_{df} \mathfrak{X} = \{x \mid x \in \mathbb{S}_0 \wedge \exists y[(x,y)_c \boldsymbol{E} \supset x \in_{pi} \boldsymbol{E}]\}$$

Independent connected components is defined as a set of components of the object set; such that, if the components are connected, then they are primary initiating.

> Disconnected components are not considered as being "independent" in this definition. By the definition of the object-set, being derived from the relation-set, if a component is not related to any other component, then it is not part of the system, and, in fact, cannot be known.

To this point, the *ATIS* definitions seem to be consistent with the intent of complexity; that is, that independence at various levels of the hierarchy or subsystems of the heterarchy are dependent on how much "freedom" they have from being controlled by upper level or other command subsystems. Freedom from control; that is, independence, is determined by the initiative the components (military personnel) are allowed—the independence of each subsystem is determined by the extent of primary initiating personnel at that level.

This is where the analysis breaks down and greater clarification is required. The reason is that if 'complexity' is simply the "number of connections," then it has nothing to do with the extent of the primary initiating components, the determining factor for independentness.

The conclusion at this point is that there is nothing to indicate that the complexity at the higher levels or other command subsystems, or larger scale, will actually be lessened by greater independence within any subsystem.

This may be counterintuitive, but suggests that a more formal approach is required with respect to the analysis of military systems, as well as a review of the basic assumptions of Complexity Theory.

In fact, what is being suggested is that it is possible to design a system that has the attributes of subsystem independence while maintaining desired large-scale complexity.

While complexity profile provides an excellent measure of a system that may be used for a variety of analyses, it does not determine the complexity level that would provide the desired answers for complex systems.

That this is so, is confirmed by the analysis taken with respect to the Viet-Nam War.