FROM FORECASTING TO FORESIGHT

A Complex Systems View of the Future

By T. Irene Sanders

When thinking about the future, one of the mistakes most people make—including intelligence analysts, prognosticators of all types and policy-makers—is the assumption of linearity in a world that is largely nonlinear. In classic forecasting models, the future is merely an extension of existing conditions and trends. Most forecasting models are still based on the old deterministic cause-and-effect belief that given knowledge of the past and a set of current conditions all you have to do is project those forward and with a few twists and turns arrive at a conclusion about the future.

Because the margin of error is large enough in many of the questions tackled—disease patterns, mortality rates or the motion of planets—forecasters seem to hit the mark often enough to get our attention. But when the techniques of linear extrapolation are applied to more complex questions such as the weather, politics or the current economic crisis the success rate drops dramatically. In classic deterministic models there is no room for chance, changing conditions or creativity. It's pretty much a straight line from the present to the future, but we all know from experience that the real world is far more interesting and unpredictable than this type of thinking would indicate.

In 2003, then-Fed Chairman Alan Greenspan, speaking in Jackson Hole, WY at the annual meeting of central bankers, identified complexity as one of the greatest challenges facing the Federal Reserve Board in developing effective monetary policy, "Our knowledge is barely able to keep pace with the ever-increasing complexity of our global economy." He went on to say, "Not only are our economic responses presumed to be fixed through time, but they are generally assumed to be linear. We cannot be certain that our simulations provide reasonable approximations of the economy's behavior in times of idiosyncratic shocks."

In David Faber's recent CNBC documentary on the financial crisis, *House of Cards*, and in a February 17, 2009 speech to the Economic Club of New York, Greenspan reiterated these concerns. Had Greenspan and the FRB taken seriously the challenge of understanding complexity and resolving the dilemmas posed by economic forecasting models that were clearly not related to the realities of the marketplace, the current global financial crisis may have been avoided.

What everyone knows is what has already happened or become obvious. What the aware individual knows is what has not yet taken shape, what has not yet occurred. Everyone says victory in battle is good, but if you see the subtle and notice the hidden so as to seize victory where there is no form, that is really good.

Sun Tzu
The Art of War

While it may not be possible to predict the future, it is possible to develop foresight; to see what is emerging before a crisis arises. Insights from complex systems research provide a new theory-driven framework for understanding, thinking about and influencing the dynamics of complex systems, issues and emerging situations. Complexity science is moving us away from a linear, mechanistic view of the world to one based on nonlinear dynamics, evolutionary development and systems thinking. It represents a dramatic new way of looking at things—not merely looking at more things at once. Complexity science provides new concepts, tools and a set of questions that can be very useful to analysts, prediction experts and policy-makers as they work to identify and respond to the challenges of the twenty-first century.

Stated simply, complexity arises in situations where an increasing number of independent variables begin interacting in interdependent and unpredictable ways. In the last twenty-five years scientists have learned a great deal about the structure, behavior and dynamics of change in a specific type of complex system known as *complex adaptive systems.*

Most of the world is comprised of complex adaptive systems where the components are strongly interrelated, self-organizing and dynamic. A rain forest, traffic, the stock market, our immune systems, a business, a society, the United Nations and the World Wide Web are examples of complex adaptive systems. These are open evolutionary systems that are continuously processing and incorporating or adapting to new information/feedback from the larger environment. Because the variables in a complex adaptive system are interacting constantly and changing in response to each other, the system is nonlinear.

These types of systems whether physical, biological or social share a significant number of characteristics that create a new and more realistic framework for understanding how the future emerges. Described below are a few key concepts.

The behavior of a complex system cannot be understood from one's knowledge of the parts of the system. In other words, the whole is greater than the sum of its parts. One bird won't tell you about the behavior of a flock, one car can't give you information about tomorrow's rush-hour traffic nor will one bank tell you about the economy. Only by observing the behavior of the whole system over time can you make sense of what's happening.

Complex systems evolve within a larger context with which they are interacting and responding. In our highly connected world, what goes on in Washington or Beijing quickly affects what goes on in other parts of the world. Things can change rapidly given the lightning-like speed of communications.

This requires a big picture view of situations and a synthetic approach. This is anathema to the typical analytic mindset, which reinforces the practice of studying smaller and smaller pieces of a big question. Putting the pieces together, rather than taking them apart, allows you to see connections, relationships and patterns of interaction. It quickly provides an indication of how things are changing, leading to more effective and timely responses.

This type of thinking is especially important given the global financial crisis and the world's limited supply of raw materials and natural resources. What countries are moving away from the US and the US dollar, using their wealth to lock up resources for the future?

For instance, six months ago we were comfortable thinking that China would continue to help us during this financial crisis, because our economies are so interconnected. But what if China changed its polices, as it could do, to become more protectionist or to start a hard competition for world resources? The implications of this type of shift are definitely nonlinear!

As another example, if we think of cyber security only as network security—protecting engineered systems of hardware and software, and shoring them up when a breach occurs, then our foresight is diminished and our strategies will be short-sighted and ineffective over time. If instead we think of cyber security from a broader perspective—as a complex adaptive system evolving within a changing big picture context—we will have a better understanding of the cyber security landscape or ecosystem. This will enhance our ability to protect our country's critical information infrastructure as it is evolving, identify new threats and opportunities as they are emerging and respond effectively to ongoing changes in the larger environment, before a crisis arises.

Emergence is a key concept from complexity. It refers to properties or a higher level of pattern created by the interactions of local agents in the system. What emerges does so naturally, and is not directed by a central commander or

imposed by some outside source. Local simple rules, motivations and goals create complex self-organizing global behavior.

As an example, a computer program developed by Craig Reynolds in 1986 and known as "Boids" simulates the flocking behavior of birds by programming agents, or *boids*, to follow three simple rules: 1) maintain a minimum distance from other boids; 2) match the velocity of nearby boids; and 3) move toward the perceived center of nearby boids.

What appears to be very complex emergent behavior actually arises form a set of fairly simple underlying dynamics or rules. No central boid directs this process. The boids, acting only on local information gathered from their immediate neighbors and their environment, create the dynamic, elegant flocking patterns that are entirely unexpected. They cannot be predicted by just knowing the local rules defining what each boid does.

Understanding the concept of emergence tells us what type of information we need to pay attention to and helps us ask better questions about the system being studied. As an example, listening only to the leaders or the elite components of a society will skew your perspective and cause you to miss dramatic developments among the local population. Many of the intelligence failures in the last two decades can be attributed to ignoring or dismissing the revolution taking hold on the ground and in neighborhoods.

When we think about one of the important changes made by General Petraeus in Iraq—protecting the security of Iraqi citizens—the following questions provide additional insight about the importance of understanding emergence. How could positive interactions at all levels of a system be encouraged? When negative patterns emerge, how could the interactions be influenced in a more positive direction? What are the underlying rules or dynamics that encourage interaction and positive adaptation to changes in the larger environment or context?

Complex nonlinear systems are teeming with creativity and sensitivity to new influences. Small changes or disturbances in the system can create changing conditions to which the components adapt, eventually causing dramatic shifts or unexpected consequences at a broader level sometime in the future.

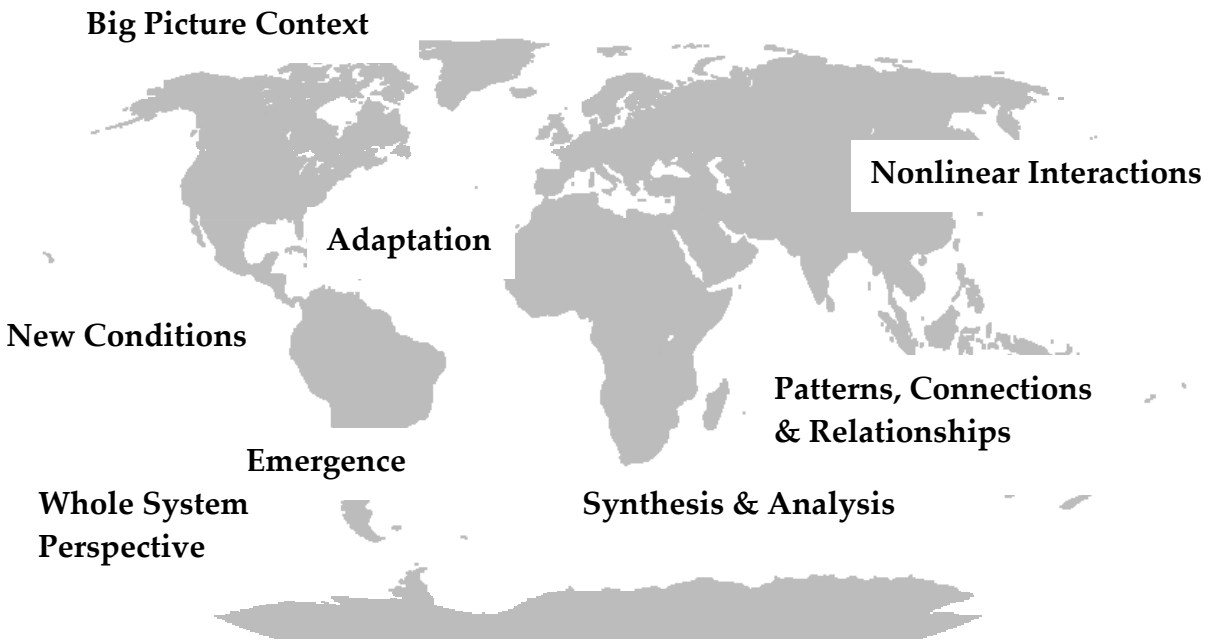
When observing a system, it's important to ask, What new initial or "perking" conditions are just over the horizon or under the radar that could dramatically influence the future of the system you're working with? What local, regional, national or international changes could go through the system like a bolt of lightning, rearranging its future overnight?

When trying to influence a system, it's important to remember that there are multiple points of influence. Small changes or inputs of resources at strategic influence points can propagate through space and time to bring about significant

shifts in the overall system. Therefore, it's important to explore or probe the system to see how it responds before creating a policy that everyone will regret.

These are just a few examples of how complex systems thinking provides insight about the system being studied and foresight about changes taking place to which the system is likely to respond. Viewing the world through the lens of complexity challenges us to review and revise our current planning, engineering and design methodologies, which in most cases reflect a more linear, mechanistic worldview. In undertaking such a review we need to ask ourselves: first, which methods recognize the properties of complex adaptive systems? Second, what kind of knowledge about the system is provided by the method?

We live in an increasingly complex world. Analysts, prediction experts and policy-makers need to know as much as possible about complex adaptive systems theory and research, and look for ways to apply the insights and thinking to their everyday work—our future depends on it.



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For those interested in learning more, here are some resources.

Complexity Digest. www.comdig.org

Gershenson, Carlos (editor). 2008. *Complexity: 5 Questions.* Automatic Press/VIP

Kerbel, Josh. 2009. "The Clash of Cognitions: The United States, China and Strategic Thinking." *American Diplomacy.* www.americandiplomacy.org

Sanders, T. Irene. 2008. "Complex Systems Thinking and New Urbanism." *New Urbanism and Beyond: Designing Cities for the Future.* Tigran Haas (editor). New York: Rizzoli.

Sanders, T. Irene. "To Fight Terror, We Can't Think Straight." *Washington Post/Outlook.* May 5, 2002, p. B2.

Sanders, T. Irene. 1998. *Strategic Thinking and the New Science: Planning in the Midst of Chaos, Complexity and Change.* New York: The Free Press.