Coping With Complexity
Understanding and managing our complex public-private systems

BY DR. WILLIAM B. ROUSE

It seems that we currently face a rather amazing range of complicated problems in the U.S. The costs of healthcare continue to escalate. Growing costs of higher education makes healthcare look like a success story. Energy independence seems within our grasp if we are not too worried about the environment. National security no longer involves pitched battles but instead concerns the globalization of technology and cybersecurity. More recently, of course, we have faced the complexities responding to a natural disaster, followed by a blizzard.

The systems that cause and perpetuate these problems—and are simultaneously taxed with solving them—have two things in common. First, they are complex public-private enterprises. The private enterprises involved can no longer act independently of public interests. They must care equally about quality of care, graduation rates, environmental impacts and job creation as they do about profit-making, competitive advantage and return on investment.

The second thing common across these systems is that they are all “complex adaptive systems”—a highbrow way of saying that these systems have six characteristics in common.

First, these systems are nonlinear and dynamic. In other words, the responses of these systems are often disproportionate to their inputs. Thus, the few feet of recent floodwaters yielded enormous consequences. In such situations, system behaviors may appear to be random or chaotic.

Second, these systems are composed of independent agents whose behavior is based on physical, psychological or social rules rather than the demands of system dynamics. The recent election, hurricane and snowstorm did not result in everyone responding in the same ways. National security no longer involves pitched battles but instead concerns the globalization of technology and cybersecurity. More recently, of course, we have faced the complexities responding to a natural disaster, followed by a blizzard.

Those needing generators saw the situation quite differently from those selling generators.

Third, agents’ needs or desires, as reflected in their decision rules, are not homogeneous. Consequently, their goals and behaviors are likely to conflict. In response to these conflicts or competitions, agents tend to adapt to each other’s behavior. In other words, the fact that you boarded your windows will increase the chance that your neighbor does the same. On the other hand, if you bought a chainsaw, he may just ask to borrow it.

Fourth, agents are intelligent. As they experiment and gain experience, they learn and change their behaviors accordingly. If disaster warnings are seen as excessive, people will discount future warnings. On the other hand, they will not get caught without flashlights twice. Thus overall system behavior inherently changes over time.

Fifth, adaptation and learning tend to result in self-organization. Behavior patterns are not designed into the system. They emerge over time. The neighborhood groups working to help each other recover from the floods—including the sharing of their charcoal grills and beer kegs—emerged from such self-organization. In general, the nature of emergent behaviors may range from valuable innovations to unfortunate accidents.

Finally, there is no single point of control. System behaviors are often unpredictable and uncontrollable, and no one is “in charge.” For example, people may flee the floods or hunker down. Consequently, the behaviors of complex adaptive systems can usually be more easily influenced than controlled.

The mission of the recently formed Center for Complex Systems and Enterprises (CCSE) at Stevens Institute of Technology is to enable understanding and management of such complex public-private systems. Domains of interest to CCSE include healthcare delivery, sustainable energy, financial systems, and national security. Sponsors range from large aerospace and defense companies (e.g., Lockheed Martin), to smaller high-tech software system providers (e.g., Northern Light) to government agencies (e.g., Department of Defense).

CCSE draws upon expertise in systems science and engineering, economics and management, and behavioral and social sciences to develop fundamental understanding of these complex organizational systems, as well as develop methods and tools for addressing policy and management issues in these systems. Solutions range from advanced data analytic characterizations of “what is” to policy flight simulators that enable explorations of “what if.” In this way, enterprises can both assess how they are currently performing and project how they would likely perform if organized and incentivized differently.

CCSE refers to this as “driving the future before you write the check.” Decision making groups gather around large interactive displays and choose the settings of interest, for example, for patient demographics, consumer energy preferences, or investors’ risk appetites. They then “fly” the simulator into the future to see how these settings play out. In the process, many bad ideas are weeded out while good ideas are refined for empirical evaluation.

Recent explorations have focused on employer-based prevention and wellness programs, chronic disease management programs, consumer preferences for energy management, and predictors of corporate performance. Decision makers have identified what things will not work, the conditions under which some things could work, and the impacts of scaling up their ideas to the whole organization. Because they were able to try out the future, these decision makers were much more confident of their plans for moving forward into that future.

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