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A Conversation with Alan Mills, ND, FSA

By Mary Beth Moran

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Introduction: Following the Agent-Based Modeling and Simulation Workshop at Argonne National Laboratory in August 2013, I phoned Alan Mills to have a conversation about complexity science and his pioneering work for the actuarial profession in this area. Below are selected excerpts from that dialogue.

Mary: First tell us about yourself. You are an actuary and a physician. Which came first? How does one set of skills and experiences enrich the other?

Alan: Yes, I am a family-practice naturopathic physician[1] and a health actuary. Even though I have always been passionate about health and healing, actuarial work came first, perhaps because at university I was even more passionate about the beauty of mathematics. Later, as I became distressed about our health system and the poor health of people around me, I decided to try to make a difference in a more personal way, as a physician. I had lived in other countries—Germany, France and Japan—with health systems that seemed to work better than ours, and with populations that seemed healthier, so I knew we could do better.

Being a physician has enriched my actuarial work. Having first-hand experience with patients, clinicians, hospitals and other aspects of our health system helps keep my actuarial work grounded in reality. I understand how the system's players—what I call its "agents"—behave.

But more importantly: As a naturopathic physician, I see a person's body and mind and environment as one complex holistic system. To keep patients healthy, I help them address all aspects of this holistic system. Such a holistic perspective has profoundly influenced how I approach health system problems as an actuary. A health system is generally also a complex holistic system. Its major problems usually cannot be solved by addressing isolated components; rather, the system must be addressed as a whole.

Mary: I remember reading in your paper "Complexity Science: An Introduction (and Invitation) for Actuaries" about how you became interested in complexity science. Could you describe this process? What was the seed of interest that started it, and was there an epiphany that spurred you to go into it more deeply?

Alan: It was a lovely fall day in 2003, in a Barnes & Nobel bookshop in Boulder, Colo., when the seed was planted. As I often did, I browsed the nonfiction section of the store, and saw a big–very big–relatively new colorful book by Stephen Wolfram titled *A New Kind of Science*. I picked it up, started reading, and was so entranced that I sank down in the aisle and continued reading for an hour or more. In the book, Wolfram shows how the intricate behavior of complex systems—everything from weather patterns to the way shells form—can arise from very simple rules. Our intuition is that complex behavior must arise from something equally complex, but Wolfram shows that such intuition—as with so many of our intuitions—is wrong.

Complex behavior from simple rules. This is a cornerstone of the new field of complexity science. Although Wolfram didn't use the term "complexity science" in his book, he certainly helped me to see the world in a new way that I would now call the complexity science perspective.

Wolfram's book also inspired me to pursue a project that I had long pondered, namely to build a model of the U.S. health care system. It had become clear to me that to solve our health care system problems, we need to see it holistically, and to do that we need a good model of the system. We cannot solve the problems piecemeal.

To build the model, I went to work and study at the University of Michigan. There I came upon an amazing group of people with amazingly fresh perspectives about how the world works. Many of these people were part of an interdepartmental center called the Center for the Study of Complex Systems. It was there that I got to work with giants of complexity science like Scott Page and Stephen Wolfram.

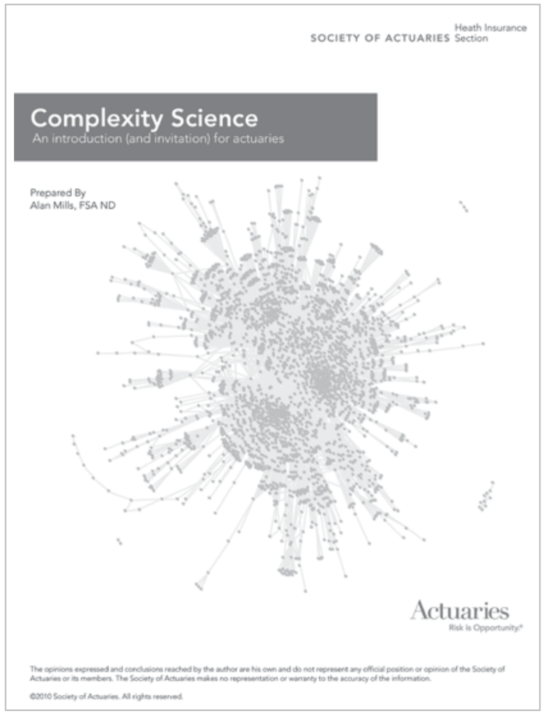
And it was there that I found another book—this time a very small book—that led me to delve more deeply into complexity science. The book is *Growing Artificial Societies: Social Science from the Bottom Up,* by Joshua Epstein and Robert Axtell. In it, Epstein and Axtell do something amazing: Using a new modeling technique called "agent-based modeling," they grow an entire economic system from the bottom up, from very simple agents and agent behavior rules, and in the process discover powerful new insights about the way that economic systems work. My epiphany was that if this could be done for an entire economic system, then surely I could do it for a health care system, perhaps even the U.S. health care system.

Mary: From there, at the University of Michigan, you were introduced to the scientists at Argonne [National Laboratory]?

Alan: Yes, Scott Page introduced me to Argonne. A student of his had attended an Argonne workshop about agent-based modeling and simulation (ABMS). He gave me a copy of the workshop notebook—another book. That inspired me to visit Argonne, attend its ABMS workshops and get to know its scientists.

Mary: When you were at the University of Michigan … did you produce [a model of the U.S. health care system]?

Alan: While people at the Center for the Study of Complex Systems were strong supporters of my proposal to build a model of the U.S. health care system (as were members of the university's governing body), the professors in the school of Health Management and Policy—my home at the university—were not. In fact, they said it could not be done. Which is understandable, because they were entrenched in the perspectives of traditional health economics and traditional modeling. Nevertheless, I hit an impenetrable wall.


SOCIETY OF ACTUARIES Heath Insurance Section

Complexity Science
An introduction (and invitation) for actuaries

Prepared By
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Actuaries
Risk is Opportunity.

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Mary: Change is difficult. One of the things I appreciated about your paper is that it is difficult to define even what complexity science is. So on the one hand, it doesn't surprise me that there can be entrenchment within a particular well-established field, but on the other hand sometimes "hitting the wall" is a sign that change is needed.

Alan: I think it was [the 19th century mathematician Carl Friedrich] Gauss who said "Science marches forward, one death at a time." The same may be true of complexity science. To step away from well-worn paths takes people with tremendous courage. When I meet them, I am extremely grateful.

Mary: That's really an honest assessment. Is it true to say that, to the best of your knowledge, before the SOA publication of your U.S. health system models that there was no agent-based model of the system available in the public domain?

Alan: There are a few other excellent agent-based models of health systems, but they are generally not in the public domain. For example, as I mentioned in my recent SOA research report, Joshua Epstein has

For more information on complexity science and agent-based modeling, read Alan Mills' two reports found on soa.org.

www.soa.org/research/research-projects/health/research-complexity-science.aspx)

www.soa.org/Research/Research-Projects/Health/Simulating-Health-Behavior-A-Guide-to-Solving.aspx

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developed wonderful models of worldwide pandemic containment strategies. Some of these models involve billions of diverse agents and reflect a wide range of agent behaviors.

But I don't want to give you the impression that I have developed a model of the entire U.S. health care system. I haven't. The SOA models are important components of the entire system, but they are not an entire system. To build an entire system will require an advanced modeling platform to which many people and organizations—such as academic researchers, health insurers, health care providers and governmental bodies—can cooperate to add vital pieces, like putting together a huge puzzle. I am working on a public-domain platform to enable such cooperation.

Mary: All of the work that you did to get the beginning of the platform built is really important. I think that the work you have done on defining a common ground, drafting a compendium of health behavior, developing an ontology—a standard language to define health behavior—and the multidimensional definition of behavior has been amazing. It's helping actuaries and others to have a common starting point.

Alan: Thank you. One of the key ingredients in modeling health systems is to better understand the behavior of the agents—the clinicians, patients, hospitals and so on—within a health system. So, in my latest SOA research paper I concentrated on agent behavior. I defined behavior (which, curiously, had never been done); started a compendium of health behavior so that actuaries and others will have a central repository to find information about health behavior; prepared a template for a health system ontology so that we will be able to discuss health system problems using a consistent vocabulary and consistent definitions of processes and interrelationships; and I developed sample agent-based simulation models to demonstrate how these can be used to help solve health system problems.

Mary: You have a vision for a new type of actuary, a complex systems actuary. Explain what it is.

Alan: Conditions are right for the rise of a second great arc of work for actuaries, particularly for a special type of actuary that I call a complex systems actuary.

The first great arc of actuarial work arose in the 1600s, and continued more than three centuries. In 1660, John Graunt—a London haberdasher in love with mortality—introduced the study of what he called "social numbers," counts of aggregate social outcomes such as death, for guiding social policy. The arc rose higher as scholars, scientists and business people nurtured the paradigm of social numbers. [In 18th and 19th centuries] the German scholar [Gottfried] Achenwall introduced the concept of "Statistik" (statistics), the French mathematician [Nicholas de] Condorcet applied the probability theory of games to social issues (just before he was guillotined), the astronomers [Adolphe] Quetelet and [Pierre-Simon] Laplace applied statistics and probability to demographic and other aggregate social outcomes, and so on through the establishment of insurance companies and the rise of actuaries to a place of prominence—prominence based on the actuary's expertise in applying the top-down paradigm of aggregate social numbers to address social problems.

The first great actuarial arc is now on its way down. Even as the number of actuaries grows, our effectiveness in the face of increasingly complex social problems declines. We cannot foresee or prevent the frequent unintended consequences of health care strategies or even effectively foretell health care expenditures, much less develop effective strategies to increase health care value. And, as harbinger of our waning prominence, we no longer sit on the boards of health care organizations, or lead health care policy. We've become a legion of highly skilled, highly paid, social mechanics in a world where social systems are more like living beings than machines. We have ridden the arc of aggregate social numbers as far as it will go.

But health actuaries—indeed, all actuaries—can now embark on what promises to be a second great arc, one that even a decade ago was hard to con-

ceive. The second arc's new paradigm, together with its enabling facts, theories and tools, arose only recently, together—not coincidentally—with the rise in computer power. The new paradigm is complexity science and one of its main tools is agent-based modeling.

A complex systems actuary is an actuary who uses this new paradigm and its tools to address problems of complex systems of all types. Not just pension, insurance and health care systems, but also financial systems, city and state systems, and corporate systems—any complex system where people, money and contingency intersect.

Now, there is a window of opportunity: Because the concept of the complex systems actuary is so new, it does not currently have significant competition. But this will surely change, and soon. The interesting question is whether actuaries and the SOA will seize this opportunity.

Mary: When we talk about this new type of actuary, a complex systems actuary, I don't think you are arguing that we should not use our old tools. It's not an either/or situation. Maybe you can talk a little bit about that. What are the similarities and differences between a traditional actuary and this new type of actuary?

Alan: Certainly. Our training regarding risk, statistics, economics, law, accounting and the like are necessary for any actuary, including the complex systems actuary. And it is likely that there will always be situations where our traditional modeling tools are appropriate. But when we address big problems within complex systems—which are most of today's pressing problems—our traditional Excel spreadsheet and micro-simulation models are often inadequate. To address such problems, we need more appropriate modeling tools and a broader modeling perspective, which agent-based modeling and complexity science provide.

One difference between the complex systems actuary and the traditional actuary is that, even though the complex systems actuary will have a field of specialty, he or she will venture beyond this into other related fields. For example, a complex systems actuary with a health specialty might also work on complex system problems related to an economy as a whole. Rather than nestle down into ever more limiting subspecialties—as actuaries have traditionally done—the complex systems actuary would continually broaden the scope of complex system problems he or she can address.

Another difference—the critical importance of which I have only recently begun to fully realize—is that the complex systems actuary must become an expert in how people and organizations behave, a topic that has been absent from our training. Complex systems are nothing but intricately interwoven relationships among many diverse agents and their behaviors. If we do not understand how individual agents behave, how can we possibly model the trajectory of a complex system as conditions in the world change? The

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complex systems actuary must master the new fields of behavioral economics and behavioral finance, and might even contribute to SOA research that elucidates agent behaviors.

A complex systems actuary is like a family-practice physician. You never know what kind of problem will walk through the door, but whatever the problem, you will address it from a holistic perspective and with the most appropriate tools.

Mary: That really leads nicely to the next question: how complexity science, or this new type of actuary you have written about, fits into the new mission statement of the Society of Actuaries, which is as follows:

> "The SOA, through research and education, advances actuarial knowledge and improves decision making to benefit society. We enhance the ability of actuaries to be trusted financial and business advisors on problems involving uncertain future events. We provide and ensure the integrity and relevance of our credentials."

As highlighted in the February/March 2013 issue of *The Actuary*, the updated mission of the SOA includes equipping actuaries to adapt and cross over into wider and more diverse areas that traditionally actuaries might not have been practicing in. SOA Past President Tonya B. Manning said, "Our profession cannot be sustained without growing and adapting as businesses and the financial sector change around us. ... Through adaption and expansion, our profession will remain relevant."

Alan: I wholeheartedly agree. If actuaries remain ensconced in traditional niches, we will become obsolete. We saw this happen with the ERISA [Employee Retirement Income Security Act] law that Congress passed in the 1970s. ERISA marginalized pension actuaries. The same could happen for health actuaries. The ACA [Affordable Care Act] may be the first step in that direction.

As the world changes, actuaries must change. The ever-more intricately interwoven complexity of our world offers untold opportunities for a complex systems actuary to address far more diverse and interesting problems than actuaries have traditionally addressed, problems that transcend traditional actuarial niches, and that even transcend traditional academic, professional and geographic borders.

Mary: People may be wondering, what do I need to do to learn the tools of this emerging new field? Is an advanced degree necessary? What is the SOA doing to help provide the education/training to fill in the skills gaps?

Alan: Although there are not yet any degrees in complexity science in the [United States], there is a lot one can do to learn more about this new paradigm and its tools. A good place to start might be my SOA research paper "Complexity Science–An Introduction (and Invitation) for Actuaries," and the list of top 10 complexity science books found at the end of the paper. Also, presentations about complexity science have become a regular feature at SOA meetings. And I hope the SOA will continue to sponsor agent-based modeling and simulation workshops such as the one held recently at Argonne National Laboratory.

Mary: Thank you for your time; I really enjoyed talking with you. So when we have the hall of fame for actuaries, you'll be in there, Alan. You have my vote! You've done some really great work to start establishing that foundational platform that you talked about, for all of us to stand on.

Alan: Mary, the work is nothing without people like you who recognize it and want to carry it further. Could we enter the hall of fame together?

END NOTES

[1] A naturopathic physician emphasizes prevention, a whole-person perspective, and minimally-invasive—and often more natural and less costly—evidence-based treatment. To achieve this, in addition to the standard medical curriculum, naturopathic physicians study non-standard subjects such as clinical nutrition, botanical medicine, psychology, and counseling. Naturopathic doctors (NDs) are generally family-practice physicians, and are currently licensed in 17 states and the District of Columbia.