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The Rise of the Kluges

From the electrical grid to Toyota's software to online dating sites, the systems we live by are inelegant messes that no one fully understands.

By **AMIR ALEXANDER**

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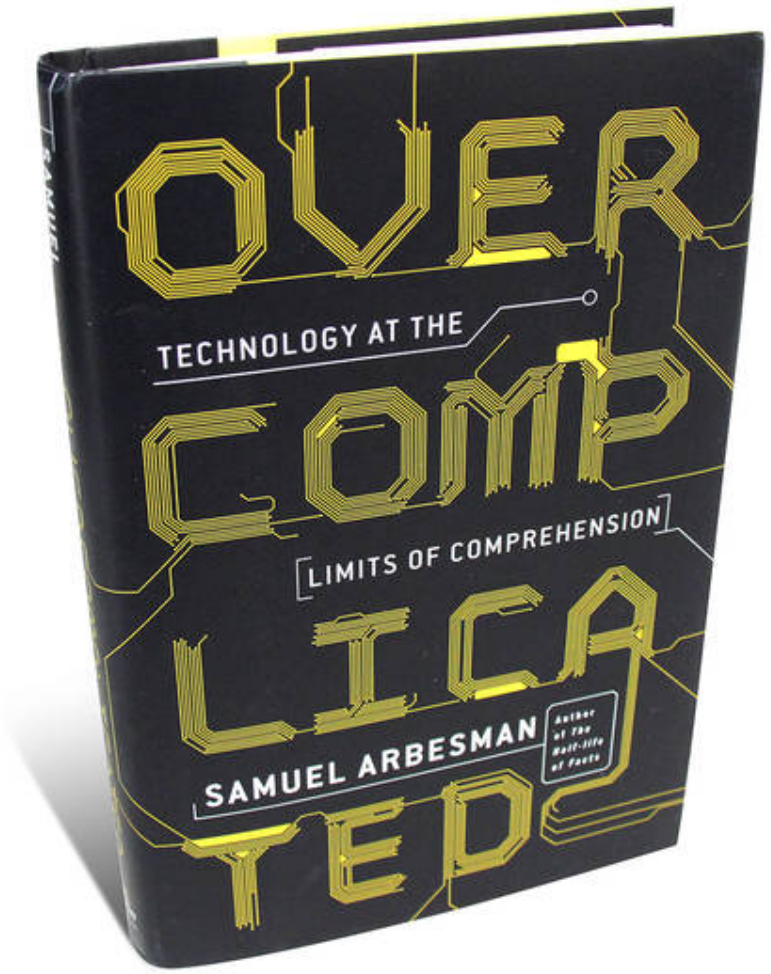
On Wednesday, July 8, 2015, the standoff between Greece and its European creditors continued; Roger Federer reached his 10th Wimbledon semi-final; and the Subway sandwich chain severed ties with its spokesman, who had been charged with possessing child pornography. It was, for most of us, just another day in an imperfect world.

But Samuel Arbesman, the author of "Overcomplicated: Technology at the Limits of Comprehension," highlights other events on that day: United Airlines grounded its flights because of a computer glitch; the New York Stock Exchange halted trading when its system went haywire; and The Wall Street Journal's website inexplicably went dark. These failures were not, as some suspected, the result of a nefarious attack by Russian hackers, but to Mr. Arbesman they were not meaningless chance either. They were an early warning of the fragility of the systems that we rely on—a possible portent of disasters that lie ahead.

The problem, as Mr. Arbesman, who trained as computational biologist, argues convincingly, is that our systems have grown too complex to handle. In the past, when a system suffered a catastrophic failure we could find the specific cause. When the Challenger shuttle exploded in 1986, a committee of experts zeroed in on the culprit: the O-rings used to seal the solid-fuel tank, which lost their flexibility in cold weather.

But two decades later, when Toyota was facing its own technological Dunkirk, no simple



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OVERCOMPLICATED

By Samuel Arbesman
Current, 244 pages, $23

answers were forthcoming. After a number of deaths were apparently caused by its vehicles accelerating uncontrollably, Toyota's software was examined by outside experts in a lawsuit against the company. Their conclusion was less than reassuring: At least some of the deaths were caused not by the failure of any particular part but by the unpredictable interaction of different pieces of software. Not exactly what Toyota owners wanted to hear.

And Toyota, Mr. Arbesman argues, is not an outlier. From the electrical grid to Internet dating sites, the systems we live by have become "kluges"—overly complicated, inelegant, cobbled-together messes. Even experts can no longer fully understand or control them. And as long as this is the case, the rate of catastrophic failures will only keep increasing.

What, then, is to be done? The obvious solution is to simplify our systems, but that is next to impossible. Once a system is in place it inevitably undergoes a process of accretion—feature is added to feature and new layers to old ones. Over time, systems are connected to other systems, and each learns to deal with an increasing number of "edge cases"—rare occurrences that barely affect the overall performance of the system but nevertheless have to be accounted for. And so, bit by bit, a kluge is born.

If this was where "Overcomplicated" had ended, it would make for a depressing read.

Driven by inexorable forces, we have become trapped in the Entanglement, an all-encompassing interconnected web that we neither understand nor control. Yet Mr. Arbesman is no doomsday prophet. While we cannot reverse the Entanglement, he argues, we can learn to live with it. The secret is to give up on the idea that we can or should fully understand a system by reducing it to an elegant model. That approach has worked wonders for physicists, as when Isaac Newton formulated the mathematical principle of universal gravity, thereby explaining everything from the fall of a stone to the motion of the planets. But for our world, this approach, elegant and powerful though it is, simply will not work.

Our only hope, Mr. Arbesman argues, is to approach the Entanglement much as a biologist approaches the natural world. Biologists do not look for grand formulations. They conduct experiments and carefully observe. Over time they learn a great deal about the natural world, which becomes more predictable and even somewhat more controllable. Yet they will never delude themselves into believing that they can completely understand biological systems or capture life in a formula.

What is true of the living world is also true for the technological world we inhabit, Mr. Arbesman suggests. Our creations have formed their own enormously complex ecosystems, and we should approach them respectfully, much as we do the natural world.

He is undoubtedly right. The dream that we can fully understand our complex man-made systems is just that—a dream. Yet as powerful as the vision of full knowledge is, the truth is that scientists of all stripes gave up on it many centuries ago. In the early 17th century, René Descartes insisted that the world could indeed be fully known through the systematic application of rigorous reasoning, leaving nothing mysterious and unexplained. For all its allure, however, Descartes's approach proved a dead end. When Newton, writing half a century later, achieved his breakthrough, he did so by abandoning Descartes's quest for omniscience and admitting that he was ignorant of the source of the central component of his system—gravity. Descartes's followers pilloried him for reintroducing magical powers into science, but no matter: It was precisely his humble admission of ignorance that allowed him to formulate his powerful mathematical system.

And whereas physicists may not be quite the proud know-it-alls that Mr. Arbesman suggests, biologists may not be simple fact collectors either. The famous 18th-century Swedish naturalist Carolus Linnaeus, for example, was an accomplished observer and collector, but he was also one of the greatest system-builders in history. His method of classification, a version of which is still used today, sought to encompass all living things in a single great tree of life. Physicists and biologists alike are both humble gatherers

and grand systematizers. Successful science, it turns out, requires both.

If we are to avoid many more days like July 8, 2015, we must approach the Entanglement like scientists: humbly, as Mr. Arbesman powerfully argues, but also without giving up on the potential grand theory. But whereas natural scientists study God's handiwork, we will study our own. And that, after all, may be cause for some pride.

Mr. Alexander is the author of "Infinitesimal: How a Dangerous Mathematical Theory Shaped the Modern World."

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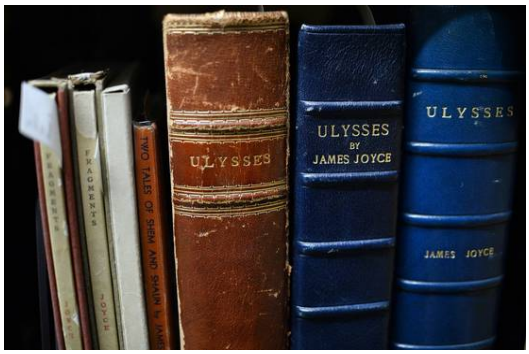

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