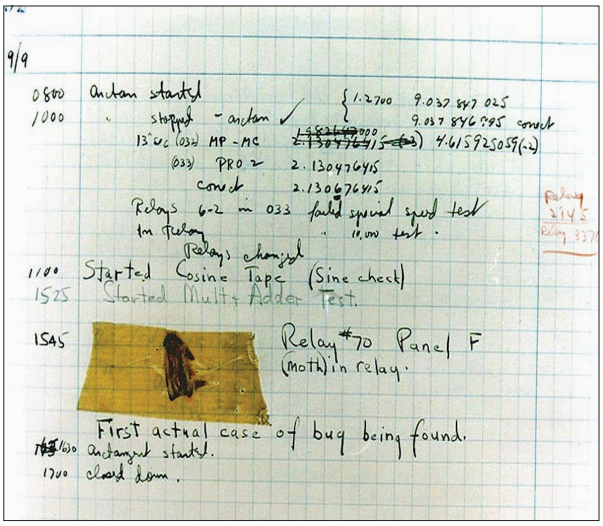
*Geoff Dutton*

**There Is a Bug**




I was one year old when America nuked Japan and sixty-six when Japan nuked itself. In between, I had a love affair with technology that sort of soured. Let this baby boomer tell you, if you will, a cautionary tale as he licks his wounds.

The children of my generation received the first doses of Polio vaccine, watched the first network television programs, and witnessed the dawn of the space age. The ongoing and predicted parade of miracles of technology enthralled me. As a teen-aged nerd, I built electronic gizmos with vacuum tubes, resisters, capacitors and transformers, and marveled at the first Earth satellites, transistor radios, nuclear power ("too cheap to meter," its boosters predicted), and silent timepieces driven by the inaudible hum of tiny quartz crystals. And computers—hulking, humming, blinking behemoths that some said would soon be able to think. I decided I had to be an electrical engineer.

In high school, I neglected English assignments to read every science fiction story I could find, speculating how we would live in a future in which robots and other machines produced our goods, served us, and even healed us. Would we converse with them? What would socializing with robots do to us? Would human nature change? I sensed that it would, even though at that tender age my historical perspective was pretty limited.

The summer between high school and college brought a cool minimum wage job as a gofer at a nicely air-conditioned university computer center. I found a lot to like about it beyond following around the guys posted there by IBM as they replaced failed vacuum tubes in the 709 mainframe, maybe a dozen a day. In a big room filled with rows of softly humming grey cabinets, I received stacks of punch cards wrapped in rubber bands or in oblong brown boxes from programmers to feed into the mainframe's voracious maw. Several hours later, if they were lucky, I would pass back to them stacks of fan-folded paper full of code and tables of numbers that chattered out from a printer the size of a chest freezer.

By far, the best part of my internship was learning how to code. I keypunched and submitted my first program—in cutting-edge FORTRAN—which tabulated values of the Fitzgerald-Lorentz transformation coefficient [2] across a range of velocities, taking care not to divide by zero, convinced I was destined for geekdom. How proud I was of the neat columns of numbers that unfurled from the chunking line printer, having made a huge, mysterious machine obey my commands. I was hooked. That first summer job probably sealed my vocational fate.

My little program didn't work the first several times my cards fluttered down the hopper. I sought the aid of a systems programmer (to my surprise, a woman—but most of the first generation of programmers were, I later found out). She parsed my code and found errors, which she called "bugs." The word puzzled me. Much later, I learned that it's an old term (even Edison used it) brought into computing just after World War II at Harvard, where a group led by Howard Aiken built a large computer called the Mark II. On that team was a pioneer programmatrix, a Navy Ensign named Grace Murray Hopper. The Mark II was making errors, and she and their team set out to determine why. This machine was electric, not electronic: it computed digits using banks of electromechanical relays organized into logic circuits. Eventually, Hopper or a colleague found the problem: a moth had alighted on a relay and got its wing caught in one of its contacts, preventing it from conducting electricity. The moth was tweezed out of the works and taped to a duty log, with the note "First actual case of a bug being found." [2] Now they are everywhere.

I entered college hell-bent on engineering, but a liberal education that exposed me to history, literature, philosophy, music, art, and social science—not to mention D's in science and math—persuaded me otherwise. To rescue my self-esteem, I took a course called Science and Government. I found myself in a seminar room with three other students and a gentle former physicist, who at my age had dropped out of Harvard to volunteer for the Manhattan Project, doing his part to build the A-Bomb. Mixing it up with those high-powered physicists and engineers, he said, piqued his curiosity about the human and institutional dimensions of science—what social arrangements make it tick. Years later, he came to establish a tiny think tank on campus to study the culture of science and its support systems. He wanted to know what determines which research gets promoted and funded, who wins, who loses, and why—in essence, the politics and sociology of science.

My teacher's obsession infected me and I did well in his course. He noted my interest and asked me to become his assistant, a job I gladly accepted (I was really broke). Fresh from a philosophy class or a history seminar, I would trudge to his cramped office and morph into a private eye, sleuthing the connections of scientists from the pages of newspapers, journals, *Who's Who*, and *American Men of Scienc*e (as it was called then). All this career data I poured into holes punched into cards. Each notable had a card or two that summarized his specialty, degrees, professional societies, workplaces, committees, and so on with an ID and name spelled out in the first two fields.

Periodically, we dumped the cards into what was called an accounting machine—basically a card sorter we had to "program" by plugging jumper cables into holes in what looked like a frame from a miniature beehive. The sorter read the cards and spat them out into a dozen or so bins based on how certain columns were coded. (Those columns would now be termed database keys.) After punching up a card as a descriptive header for each pile of cards, I loaded them back into the keypunch machine (programmed by a punch-card wrapped around a spindle) that scanned the columns and clattered out their content an electric typewriter hooked up

to it. The reports went into binders that my boss pored over, to what end I was never apprised.

And suddenly it was my senior year and I still didn't know what I wanted to do with my life. One thing I was sure I *didn't* want was to throw it away in Vietnam, and that focused my faculties on getting in to grad school, but in what field? Though I continued to study science (without ever doing any), that fall my interests gravitated toward the pastiche of habitats and technologies we call The City.

Coursework in urban history and architecture focused my attention on the field of city planning. Against my advisor's recommendation, I accepted an offer from Harvard's School of Design to pursue a professional degree. He warned me its planning department had fallen on bad days, but when I arrived the profs were collegial and convivial, and my fellow students were raring to go. But as it turned out, the department's worst days were still to come.

With the military nipping at my heels, I emigrated to Cambridge, but a letter with the salutation "Your Government sends you Greetings!" never came. I married my college sweetheart and tried to focus on academics. Drawing lines and applying colored overlays onto maps to reconfigure urban neighborhoods in studio courses was sort of fun, but the more I learned about the political futility and flimsy methodologies of city planning, the less I was motivated to practice it. To add to my existential despair, undergraduates called a strike after Harvard called in the cops to drag off students who had occupied the administration building. It spread quickly to my school and broadened its demands to insist that the university reform its governance and give back to the community. Between April and the end of the semester, almost nothing beyond debating and organizing got done. A number of my comrades fled to other schools, but out of inertia I hung in. Of course, all that resistance and change-agenting didn't matter. When students returned at the end of summer, little about the institution had changed.

Nevertheless, it changed my life. While classes were suspended that spring, I holed up in the bowels of a building housing a new lab that was developing software to make maps with computers, a novel idea at the time. There, a new mentor materialized to alleviate my despair, the lab's director. This professor, a learned (rare in my department) theoretical geographer (yes, that's a thing) shared my distain for the faculty's know-nothing approach to urban and regional analysis. He gave me an assistantship, and together we pored through stacks of geographical socioeconomic statistics that his models cranked out. We mapped them by hand and with the new software to detect trends and anomalies and analyze the relief of our abstract terrains.

My renewed contact with computing mesmerized me with its possibilities. I became a cardholding member of the World Future Society and tried to forecast how things digital would influence the shapes of cities. I worshipped at the alter of the Whole Earth Catalog [3] and tried to understand what the hell Buckminster Fuller was saying, to dope out what the future would do for us, let us do, make us do. I didn't get very far, but believing that the future would be a lot more digital, I got with the program and started coding FORTRAN again. After my mentor left the lab, I

continued on, inventing data visualization software centered on map displays. My *pièce de resistance* was a cylindrical hologram animating American population as a 3-D terrain that morphed across 180 years. [4] It put me on the cutting edge of mapmaking, but now our browsers show us far cooler stuff on demand (such as this elegant map of current US wind conditions [5]). My R&D career culminated with a useless PhD in Geography in the late 90s, just when corporate forces and the Internet was taking over cartography. Sensing impending irrelevance, I quit the geospatial game to pick up work in technical communications, a euphemism for instructing computer users how to be digital and work around bugs.

And so, now I live in the future I tried so earnestly to imagine, full of wonders like Dick Tracy's wrist radio, paperless newspapers (but not offices or bathrooms), video telephony, a pharmacopeia of wonder drugs, and Mars missions, with computers everywhere and the wisdom of the ages at everyman's fingertips. And everyone—especially young people—seems to take them for granted as entitlements of material progress. We still haven't gotten our jetpacks, gyro-cars, food pills, robot butlers or moon colonies, but if we did, we would take them for granted too. Is it just I, or do others hunch down when they hear glib expectations of scientific progress, technological abundance, long, carefree lives served by obedient robots? It's not so much the gizmos themselves as the nonchalant air of inevitability that they will be only good for us that unnerves me.

Most people probably think that socializing with robots is fairly far out, but is it? They've actually been here a while, but we don't notice them because they just don't look like we imagined. Place a call to any corporation or government agency, and one will almost surely answer it. We know they work in factories and that the military—not to mention Google, Uber, et al.—compulsively propagate driverless vehicles. Our Apple and Android (great name, eh?) cell phones speak to us and proffer advice, and when we're not talking to them they enthrall us with light entertainment. You might even own a robot that sweeps up your quarters, mercifully without trying to converse. But pretty soon they will, and we will talk back and chuckle when they diss us. ("Hal, sweep up in the closet." "I'm sorry, Dave. I'm afraid I can't do that.")

The most troubling aspects of all this are the "unanticipated consequences" of material progress (which technologists now call "innovation"). Hydrocarbons and heavy metals in drinking water. Air pollution alerts and oil spills. Disease-inducing processed food and untested frankenfood, much of it contributing to endemic obesity, heart disease, diabetes and cancer clusters. Species of fish and wildlife winking out, replaced by out-of-control exotic pests. Nuclear and polar meltdowns. Entire nations under surveillance as malware filches our identities. Yet, its seems that when news outlets report on such ill-advised phenomena, people get upset for a while, only to walk away muttering "What you gonna do," without taking time to consider what spawned them or why. No one steps up to take responsibility or charge or goes to jail, no matter how dire the disruption and destruction. Since forever, it seems, technologists (including me) have earnestly tried to remediate their inventions' side effects in an infinite regress of fraught fixes. While today's fixes may be more effica-

cious than yesterday's, so many more of them are needed that, like drug interactions, we can't quite be sure the interventions won't crash the system, a Rube Goldberg [6] world I willingly admit I was complicit in creating.

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Once, back in my lab days, when I was struggling with some code that wasn't working, a buddy told me, "The first law of computer programing is: *There is a bug*." That's even truer now than it was for me or for Grace Murray Hopper, and it applies to all technologies. The more intricate and embedded they become, the harder they are to understand and the more ways they can fail. Even back in 2002, a Federal Government study [7] estimated that "software bugs, or errors, are so prevalent and so detrimental that they cost the US economy an estimated $59 billion annually, or about 0.6 percent of the gross domestic product." Today, just the cost of dealing with consequences of hacks that exploit software bugs to crash sites and steal sensitive data must be at least as high, not counting the ensuing unemployment, pollution, biological harm, and climate disruptions.

Nevertheless, many of us accept new technologies with grim fascination, like moths darting around a porch light. Perhaps the bug is us.

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[1] image: The First "Computer Bug" – a moth found trapped between points at Relay # 70, Panel F, of the Mark II Aiken Relay Calculator while it was being tested at Harvard University, 9 September 1947. The operators taped the moth to the computer log, annotating it: "First actual case of bug being found". U.S. Naval Historical Center Online Library photograph, from wikimedia.org. https://commons.wikimedia.org/wiki/File:H96566k.jpg

[2] Wikipedia article: Length Contraction; https://en.wikipedia.org/wiki/Length_contraction

[3] Web page: *History of Whole Earth Catalog*, at wholeearth.com: http://www.wholeearth.com/history-whole-earth-catalog.php

[4] Online PDF: Geoffrey Dutton, unpublished. *American Graph Fleeting: An Integral Hologram Depicting U.S. Population Growth from 1790-1970*, 31 May 2016. http://www.spatial-effects.com/Hologram/AGF%20Data%20Sheet.pdf

See also Geoffrey H. Dutton, *American Graph Fleeting: a Computer-Holograph Map Animation of United States Population Growth 1790-1970*, in Computer Mapping in Education, Research and Medicine, Cambridge, Mass., Harvard University, Laboratory for Computer Graphics and Spatial Analysis, 1979, pp 53-62, https://iiif.lib.harvard.edu/manifests/view/drs:48805565$55i

[5] Visualization: Real-time online map of wind speeds and directions across the United States, created by Fernanda Viégas and Martin Wattenberg, at http://hint.fm/windmap

[7] The syndicated cartoonist Rube Goldberg (1883-1970) delighted readers with his insanely complicated contraptions for accomplishing simple tasks like sharpening a pencil or pulling tissues from a box. Even

today, young people are instructed to think like him by building kits that animate those sorts of silly things. See Rube Goldberg, Inc. https://www.rubegoldberg.com/

[7] Government document: NIST News Release 2002-10, *Software Errors Cost U.S. Economy $59.5 Billion Annually: NIST Assesses Technical Needs of Industry to Improve Software-Testing*. Department of Commerce, National Institute of Standards and Technology, 28 June 2002. http://web.archive.org/web/20090610052743/http://www.nist.gov/public_affairs/releases/n02-10.htm