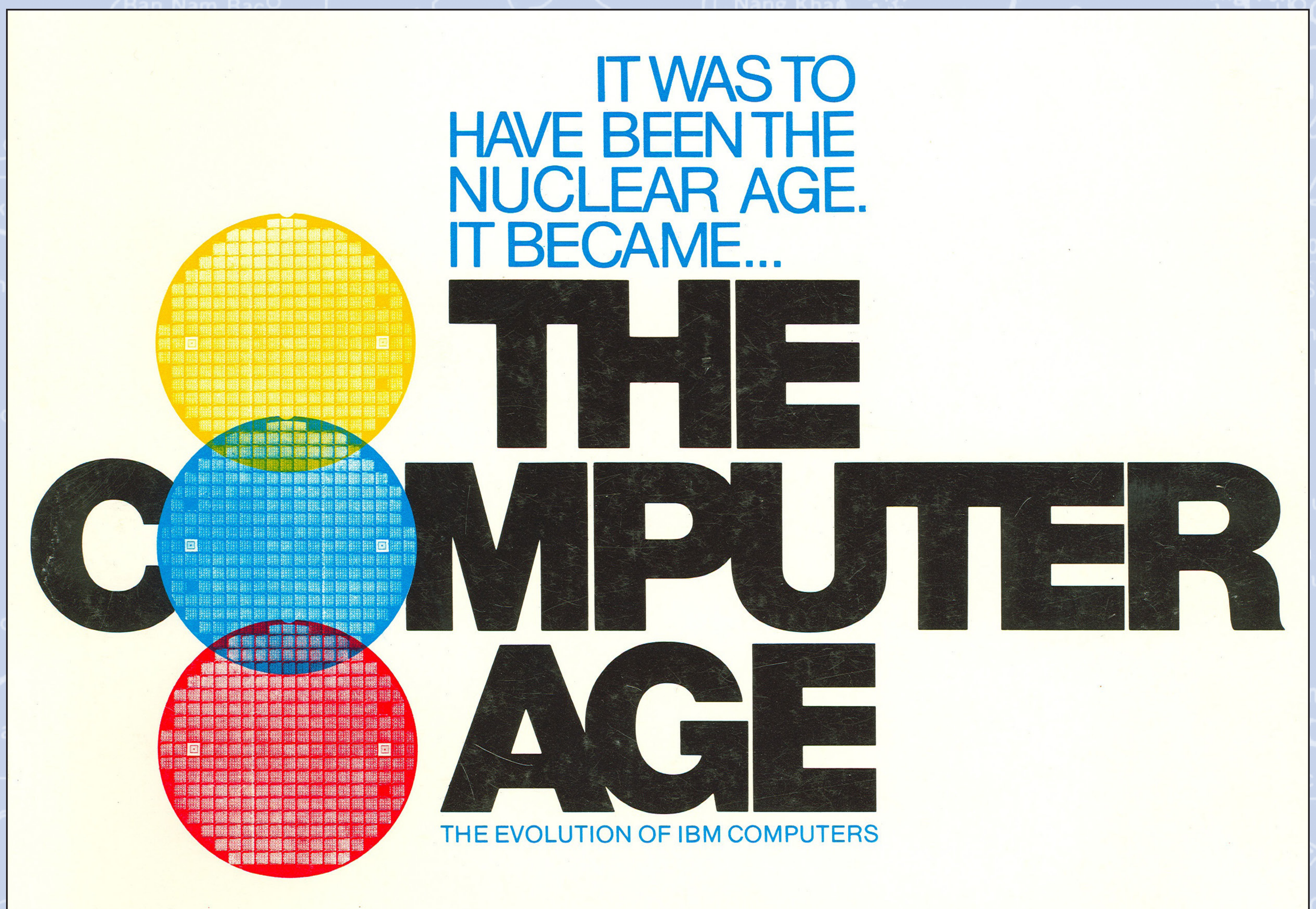
MAKING *the* MODERN WORLD

Public-Private Partnerships and Advancements in Science and Technology from 1955 to 1975

PART 1 OF 4



The front page of an IBM four panel advertisement released in 1976, highlighting computers at the expense of the nuclear age. In truth, the two were inextricably linked. Fear of the Cold War escalating into nuclear conflict led the U.S. government to exponentially advance microchip technology to gain an edge in the space race and conventional armaments. These digital advancements soon cascaded into civil society. (Courtesy of the Computer History Museum)

Public-private partnerships in medicine from the 1950s through the 1970s incentivized exchanges in science, technology, and medical practices to the great benefit of public health and private healthcare alike. Medical knowledge exponentially increased as a result and, by the 1970s, the U.S. saw the beginnings of medical centers of excellence with specialized expertise in medical research, education, and care. (Courtesy of National Museum for Health and Medicine)

In the early fifties, it was the DoD that supported transistors by buying them for the guidance systems of its rockets and missiles. The computerization of society, then, has essentially been a side effect of the computerization of war.

-Frank Rose, *Digital Anthropologist*

INTRODUCTION

In the aftermath of World War II, the United States and Soviet Union emerged as the globe's two superpowers. Locked in an ideological zero-sum game, each possessed long-range bombers, aircraft carriers, missiles, and nuclear firepower that nullified the safety once granted by the lands and oceans between them. The world shrank dramatically as a result. Armed with atomic firepower, humanity was now capable of self-destruction.

Throughout the Cold War, the U.S. made the deliberate choice to limit the size of its military, and instead depended upon allies, the nation's own economic might, and developing technological superiority in conventional armaments to limit conflict. U.S. leaders believed war would need to be tightly controlled to avoid nuclear devastation, and limiting it framed every aspect of the Cold War. Even where the U.S. engaged in military action, the nation made self-limiting decisions. For instance, during the Vietnam War, the United States made the deliberate choice not to invade North Vietnam to avoid antagonizing nuclear capable China and the Soviet Union.

Scientific learning and expertise brought the world into the nuclear age; the United States Federal Government once again turned to scientific expertise to safeguard the nation. Yet innovation alone was not enough; national defense demanded the expeditious deployment of advancements in science, medicine, and technology to enhance the nation's global readiness. Even as scientific and technological enhancements were put into operation, national security necessitated the scientific community continue to refine its work to exponentially increase the rate by which knowledge could be harnessed. To achieve this end, the Federal Government and military branches of service streamlined public-private partnerships, which are collaborations between government and non-government entities. These partnerships created a pipeline between public sector officials who funded research and experts outside of government who required only the means to realize their ideas. This arrangement established a process that minimized the time from technology's inception to its deployment.

Much of this work was performed during the Vietnam War period from 1955 to 1975. During this time, public-private partnerships advanced science, medicine, and technology in ways that profoundly shaped our modern world.

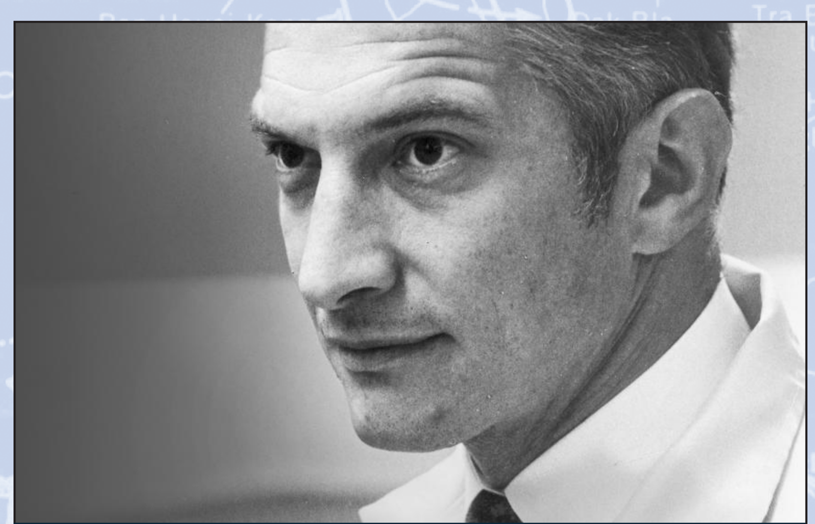
THE DIGITAL COMPUTER

The modern digital computer's development was the cornerstone upon which all future scientific, medical, and technological developments were built. Faster and more powerful computers enabled greater advances at increasing speeds in all aspects of human life. In the 1950s, digital computers began to replace their much slower and inefficient analog predecessors, which brought about the nascent beginnings of the digital, media, and information revolution.

From 1949 to 1959, nearly 60% of corporate funding in computer development came from the U.S. government. Major corporations developing computer hardware included IBM, General Electric, Bell Laboratories, the Fairchild Semiconductor Corporation, and Texas Instruments, among others. They were bankrolled by the U.S. government and tasked with developing smaller and more powerful electronics to strengthen national defense.

By the late fifties, hardware engineers Egyptian-American Mohamed Attalla and Korean-American Dawon Kahng, partners at Bell Laboratories, invented the metal-oxide-silicon field-effect transistor. This device became the basis of modern electronics. At the same time, working for Texas Instruments, American electrical engineer Jack Kilby developed the first hybrid integrated circuit from germanium. When American physicist Robert Noyce cofounded the Fairchild Semiconductor Corporation in Mountain View, California, he examined Kilby's invention and concluded the device required some refinement to be mass produced. Noyce and his team went to work creating the world's first monolithic integrated circuit chip using silicon. They drew from methods developed by Attala and Kahng. With Fairchild's development of a silicon microchip, the California valley's namesake began in earnest.

The implications of the digital future quickly became far greater than the military sphere alone. For instance, in the early 1960s, the newly formed National Aeronautics and Space Administration (NASA) attracted scientists from the U.S. military's rocketry programs to develop spacecraft capable of reaching the moon. From 1961 to 1965, NASA was the single largest consumer of mass-produced integrated circuits. In 1965, Noyce's colleague, Gordon Moore, was asked by *Electronics Magazine* to forecast the future of computers. Moore anticipated a kind of snowballing effect. He predicted electronics would exponentially increase in power. His response became the basis for what is today referred to as *Moore's Law.*



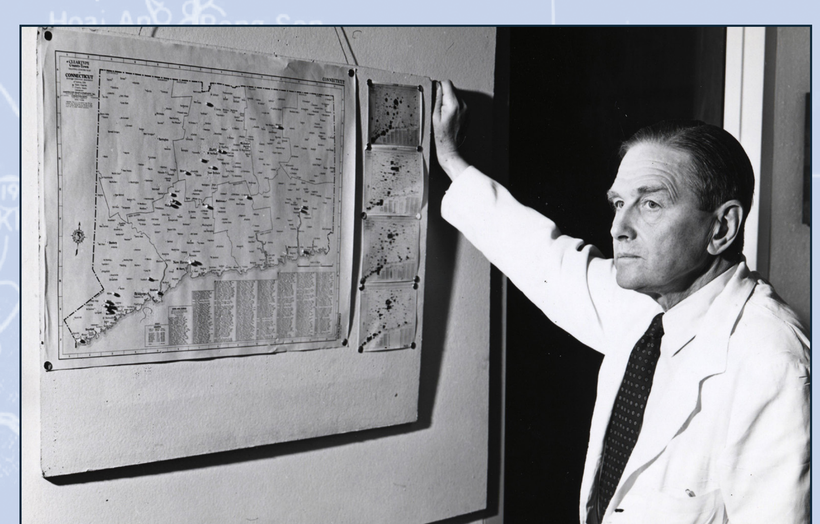
Robert Noyce co-founded Fairchild Semiconductor and the Intel Corporation in 1957 and 1968, respectively. Noyce engaged in public-private partnerships throughout his professional life, during which he co-invented the integrated circuit and used silicon to advance microchip technology. In 1987, three years prior to his death, Noyce became the first head of Semiconductor Manufacturing Technology (SEMATECH), a non-profit consortium and partnership between the U.S. government and 14 U.S.-based semiconductor manufacturers. For more than five years at the cost of $500 million, the consortium was funded in part by Department of Defense subsidies. (Courtesy of the Intel Corporation)

Moore's Law proved correct. 1950s public-private partnership successes fueled private-sector growth. Private demand for digital computers grew, and so did their reliability, intricacy, capability, and power. Hardware advancements subsequently required more powerful and complex software to run them. As a result, programming languages advanced at a remarkable pace as well. By 1972, Bell Laboratories introduced the language C, which runs many modern desktop applications, including video games, e-commerce, web searches, and operating systems.

FROZEN BLOOD

Fearing an apocalyptic nuclear war and wishing to capitalize on the growing capabilities of digital computing, experts in biomedicine sought to create repositories of human blood. With blood properly stored, frozen, and preserved, experts created an archive of humanity from which to conduct future study.

Like many of his peers in the 1930s, 40s, and 50s, Yale epidemiologist John Rodman Paul devoted his energies to the study of poliomyelitis (Polio), which is an especially virulent disease of the central nervous system that left many children temporarily or permanently paralyzed. During World War II, Paul served as director of the Neurotropic Virus Disease Commission of the Armed Forces Epidemiological Board (AFEB). The U.S. military tasked the board with studying global medical health challenges. Paul traveled to Egypt and confirmed polio infections among U.S. and British troops. Though the disease was unknown among the adult Egyptian population, Paul hypothesized that young Egyptian children had acquired immunity following an early exposure to the virus. Following the war, Paul partnered with the U.S. Navy to visit indigenous populations in outlying American regions, where he drew and froze their blood. From these studies, he discovered that a single experience with Polio resulted in lifelong immunity. His research proved essential to the development of the polio vaccine.



Dr. John Rodman Paul's global travels with the U.S. Armed Forces Epidemiological Board led Rodman to methodologically map diseases' passage through human civilization. By the 1960s, his methodology and newly acquired technologies made it possible for the World Health Organization to adopt his serological surveillance program. (Courtesy of Yale University Library)

CONCLUSION

Public-private partnerships laid the foundation for future global success. In July 1968, Robert Noyce and Gordon Moore left Fairchild Semiconductor and founded the Intel Corporation. In 1969, Jerry Sanders left Fairchild Semiconductor and founded Advanced Micro Devices, or AMD, which remains a principal competitor of Intel to this day. For his part, John Rodman Paul used his experiences with indigenous populations to justify a broader program of serological (or blood) surveillance that was ultimately adopted by the World Health Organization. From 1961 to 1966, Paul served as the director of the World Health Organization Serum Reference Bank located in the Yale Department of Epidemiology and Public Health.

A GRATEFUL NATION THANKS AND HONORS OUR VIETNAM WAR VETERANS

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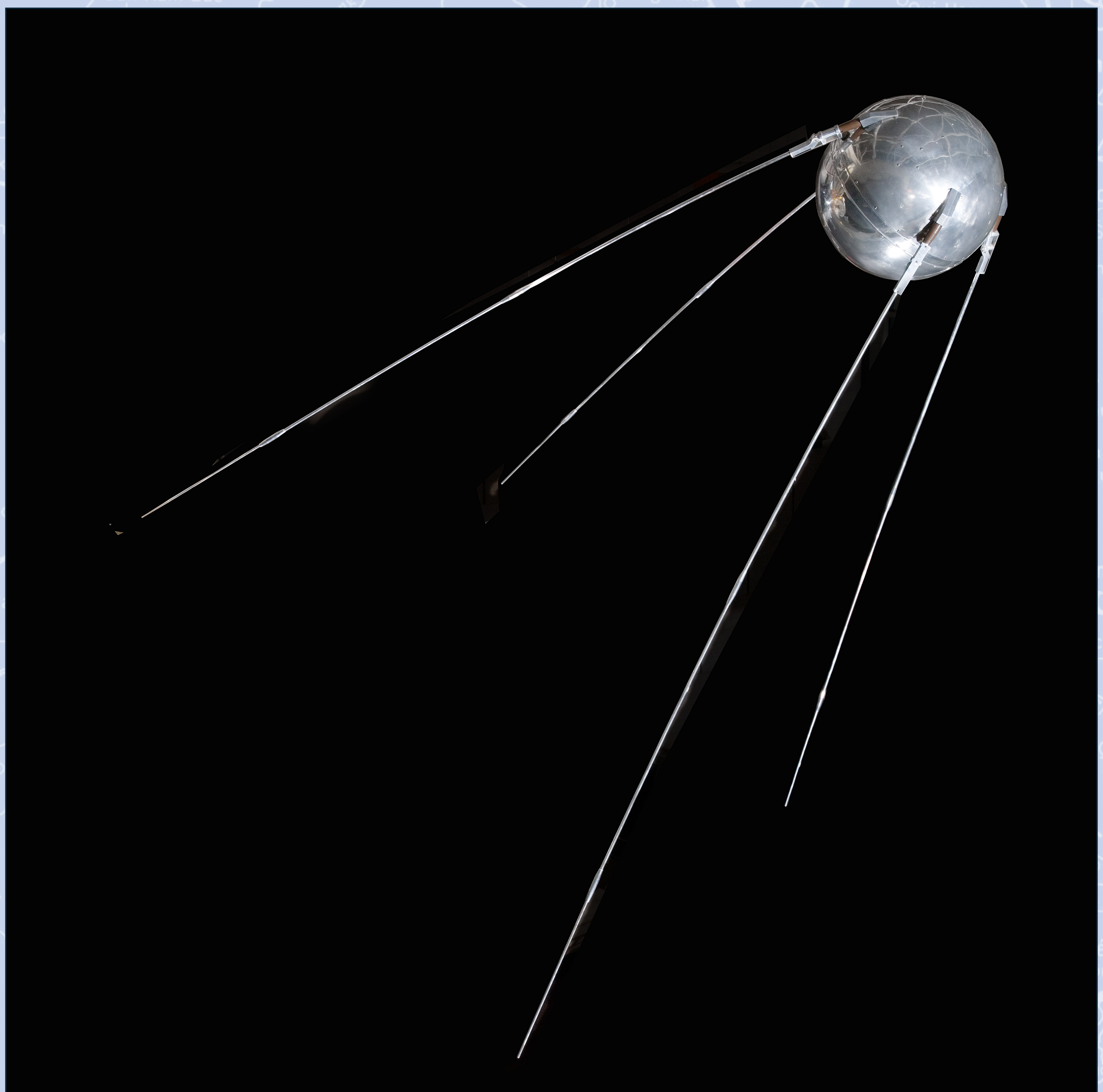
PART 2 OF 4



The Cold War was a global and political battleground that framed all aspects of civil life. When the Soviet Union launched Sputnik, *many U.S. citizens feared the nation had lost its technological edge. In his presidential campaign, John F. Kennedy seized on these anxieties. He promised to close the gap between the two nations and place a U.S. astronaut on the moon. (Courtesy of the Smithsonian Air and Space Museum)*

Oh little Sputnik flying high with made-in-Moscow beep, you tell the world it's a Commie sky and Uncle Sam's asleep.

– Gerhard Mennen Williams, *Governor of Michigan*

INTRODUCTION

On October 4, 1957, the Soviet space program launched *Sputnik 1* into Earth's orbit. The 184-pound satellite roughly the size of a beach ball shattered the globe's presumption that the Soviet Union was a technologically inept and underdeveloped state. Though U.S. officials minimized *Sputnik's* launch publicly, the Federal Government quietly and quickly went to work establishing the Advanced Research Projects Agency (ARPA) within the Department of Defense. Formed in February of 1958, ARPA was tasked with directing public-private partnerships to close the technological gap. ARPA collaborated with experts in academia, industry, and other government agencies on research and development projects to push the frontiers of technology and science.

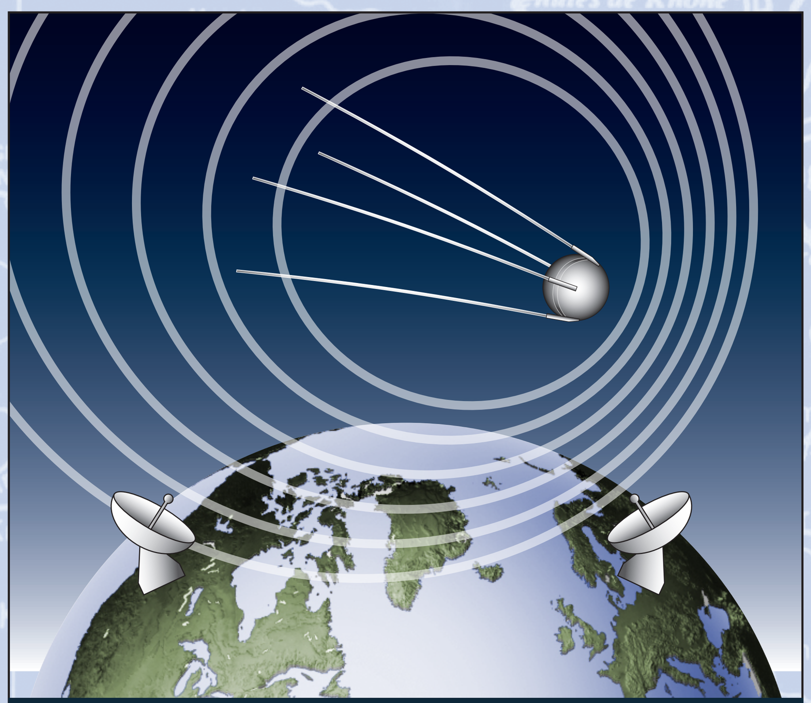
Among its many projects, the agency was particularly interested in the development and deployment of U.S. satellites. Little did ARPA know, a battery and radio transmitter inside *Sputnik 1* held the keys to realizing the agency's goals, and with them, a new way of envisioning humanity's navigational relationship to the world.

For 21 days following its launch, *Sputnik 1* transmitted radio signals. Among those listening were two American physicists, William Guier and George Weiffenbach, who worked at the Johns Hopkins University's Applied Physics Laboratory (APL).

THE GLOBAL POSITIONING SYSTEM

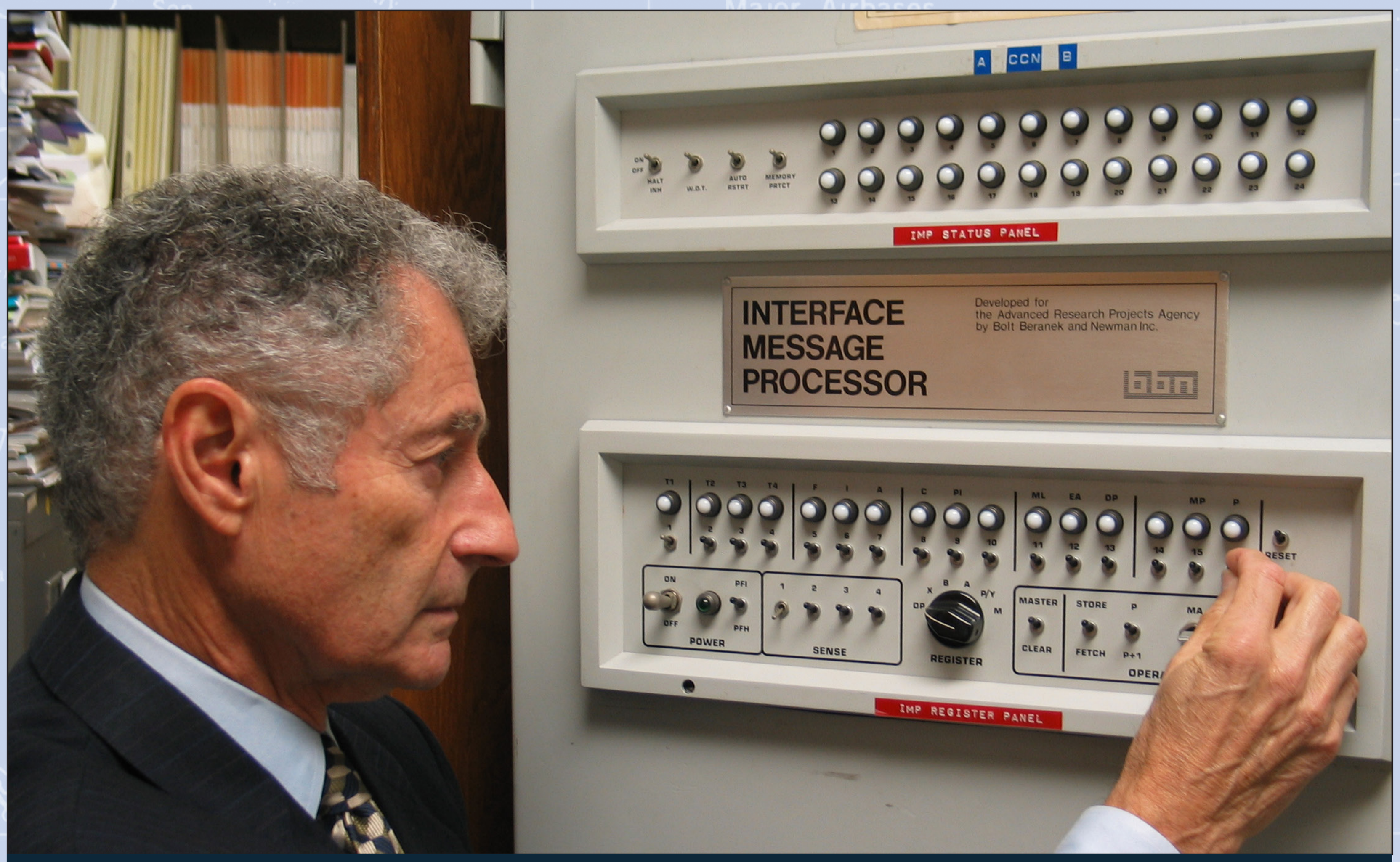
As William Guier and George Weiffenbach listened to *Sputnik 1* orbit the planet, they observed a strange phenomenon: The frequency of radio signals transmitted increased as the satellite approached, and the signal decreased as the satellite moved away. Here was the Doppler Effect in action. Listening, they tracked the satellite's movement.

The two had a moment of revelation and later wrote, "We could positively identify [*Sputnik 1*] as a near Earth satellite!" They honed their efforts, quantified the Doppler data, and, with the aid of other physicists and improvements to their equipment—to include a newly acquired UNIVAC 1200F digital computer—they were able to predict the satellite's orbit.



The Doppler effect, or the Doppler shift as it sometimes is referred, describes the changes in occurrence of sound or light produced by the emitter with respect to its observer. Waves produced by an object traveling toward the observer occur at a higher frequency than waves emitted by the source traveling away from the observer. In day-to-day life, we note this with a passing emergency vehicle's siren. (Courtesy of the Office of the Secretary of Defense)

Guier and Weiffenbach later wrote that on March 17, 1958, Frank McClure, the deputy director of APL, "called us to his office and asked us to close the door." Sensing his query, the two physicists began work on determining the inverse: Could the receiver of a signal determine its own position from a satellite signal in a known orbit?



Dr. Leonard Kleinrock at the Interface Message Processor that sent the first internet transmission in 1969. Kleinrock was instrumental in the development of ARPANET. The first message was sent by a UCLA student, Charley Kline, who Kleinrock supervised. The message text was "login;" however, the system crashed following the "l" and the "o" letters, effectively making "lo" the first message transmitted over ARPANET. An hour later, with the system restored, the full "login" was retrieved. (Courtesy of the UCLA Samueli School of Engineering).

McClure persuaded a colleague at John Hopkins, a brilliant mathematician named Richard Kershner, to design a system of satellites that would transmit navigational information to the U.S. Navy. They developed the Navy Navigation Satellite System (NNSS, sometimes called NAVSAT), which they colloquially referred to as Transit. ARPA funded the Transit program in 1958 and Transit launched its first satellite by 1960. By 1968, a fully operational constellation of 36 satellites was in place. The Transit system provided accurate, all-weather navigation to both military and commercial vessels, including the U.S. Navy's ballistic missile submarine force. Transit established the basis for wide acceptance of satellite navigation systems, yet was nevertheless limited in its capabilities.

In the early 1970s, the U.S. Air Force selected Colonel Bradley Parkinson to become director of the vaguely named Joint Program Office (JPO) to head up the equally ambiguously named fledgling project 621B (later called NAVSTAR), which was tasked with launching a more accurate system of global positioning satellites into orbit. Parkinson quickly got to work putting a team of talented military and civilian experts together. By June 1974, his office selected Rockwell International as the satellite contractor. The JPO oversaw the deployment of the first operational prototype in February 1978 at the Army's Yuma proving ground in Arizona.

NETWORKED COMPUTERS

While experts feverishly worked to create networked navigational systems from space, networking computers back on earth proved equally popular; yet ironically, networked computing came about because of two experts who independently came to the same idea during the 1960s. Welsh computer scientist Donald Davies and Polish-American computer engineer Paul Baran separately proposed "packet switching," which is a method of grouping data into packages that are then transmitted over a digital network. While working for the RAND Corporation, which is short for "Research and Development," Baran explained his vision for networked computers in *On Distributed Communications*, which he published in 1964. To provide for the defense of the United States if war ever arrived on its soil, ARPA was attempting to tie an array of defense computers together into a network called ARPANET. Yet Baran's ideas were unknown to them. In October 1967, Davies' presentation at a "Symposium on Operating Systems Principles," caught the attention of ARPA. Using Davies' ideas and Baran's direction, ARPA began the development of ARPANET in earnest. In 1969, Baran's "distributed" concept was given its first large-scale test, with the first node installed at UCLA and the seventh node at RAND in Santa Monica.

By 1972, American electrical engineer Robert Kahn joined the Information Processing Techniques Office (IPTO) within DARPA. That fall he demonstrated ARPANET by connecting 20 different computers at the International Computer Communication Conference. He later developed the TCP/IP protocols for connecting diverse computer networks. When connected, those networks formed the basis for the Internet.

The delivery of the Scientific Data Systems (SDS) Sigma 7 computer to Boelter Hall at UCLA in 1967. SDS machines were early adopters of integrated circuits and silicon transistors; yet, despite this, their machines still contained considerable heft. To deliver this unit, a hole was cut into the outside wall of the building, where a forklift elevated the machine to its destination. (Courtesy of the UCLA Samueli School of Engineering)

Fittingly, some of Baran's last communications with Davies were e-mails written in 2000, a few months before Davies' death. In the spirit of collaboration, Baran stated, "You and I share a common view of what packet switching is all about, since you and I independently came up with the same ingredient. I view your effort as totally independently coming up with the notion of packet switching, naming it and being the first to reduce it to practice."

CONCLUSION

From the U.S. military's original navigational designs for its ballistic missile submarine force and its desire to protect national security communications in the event of an attack, the ideas that drove the development of GPS navigation and the Internet surpassed military constraints and exploded onto mass commercial markets in the 1990s.

Like their creations, scientists' worldviews eclipsed the narrow confines of their immediate tasks. In considering the pursuit of knowledge, many thoughtfully drew from moral codes, beliefs, and imaginations spurred by leisure activities. For instance, the growth of science fiction during this period fascinated many scientists, and led them to make real the science and technology of fictional worlds.

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In developing a prototype video game console, Ralph Baer wrote a four-page proposal to his superiors at Sanders Associates and was given $2,500 and the aid of his colleagues Bill Harrison and Bill Rusch to develop the "Brown Box." Baer was awarded a patent for the machine on April 17, 1973 and in his filing, he defined a video game console as "an apparatus for generating 'dots' upon the screen of the receiver to be manipulated by a participant." In recognition of Ralph Baer's efforts, President George Bush awarded him the National Medal of Technology in 2006. (Courtesy of the Smithsonian Museum of American History)

From their nascent beginnings, modern video games are now a staple of global culture and feature prominently in electronic sports, literature, film, and television. Despite mainstream success, as was the case with their invention, independent developers continue to wield great influence in the industry over story-telling, graphics, and gameplay design. (Courtesy of Raccoon Logic and Neon Giant)

> *I'm in a military electronics company and I'm starting to write a document saying to myself, 'How do I write this? This has nothing to do with anything!' So, I made it sound like it applied to whatever the hell it was I was supposed to be doing. The first thing I don't do is call it a toy. But I can call it gaming.*
>
> —Ralph Baer, *The Father of Video Games*

INTRODUCTION

Physicists, computer scientists and hardware engineers invented video games during the Cold War; military concerns framed the work lives of William Higinbotham, Steve Russell, and Ralph Baer. Higinbotham had previously worked at the atomic laboratory in Los Alamos, where he designed electronics for the world's first atomic bomb. Steve Russell worked in a laboratory at MIT principally concerned with the development of artificial intelligence. Defense contractor Sanders Associates employed Ralph Baer in the construction of electronic circuit boards.

Their lives did not occur in a vacuum. Higinbotham, Russell, and Baer all let their imaginations take them beyond their immediate tasks. The three grafted interactive concepts of visual play onto hardware originally designed for military purposes. As each man built upon their predecessor's work, the progenitor to the video game and the video game console was made real.

VIDEO GAMES

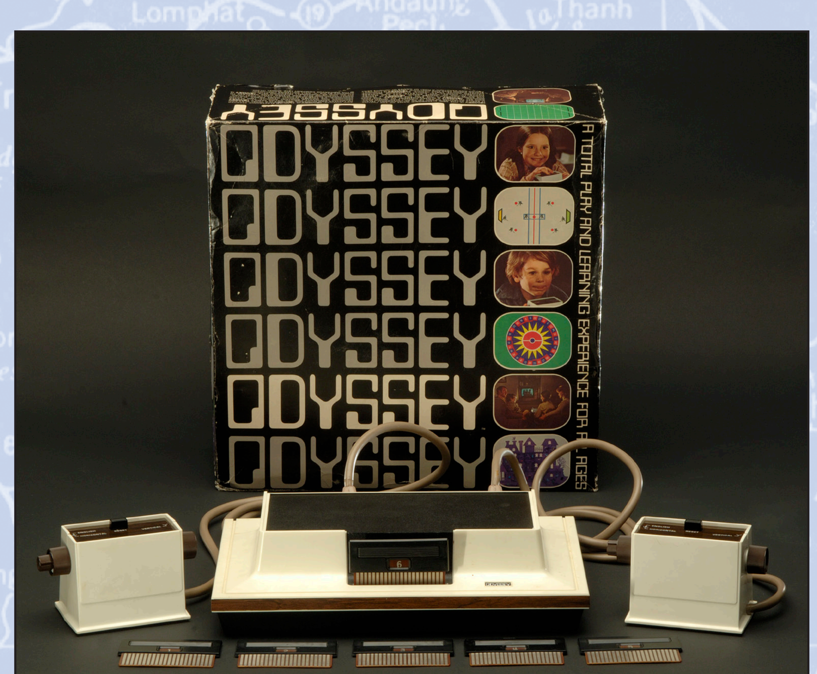
In 1958, American physicist William Higinbotham created and displayed the game *Tennis for Two* on an oscilloscope at Brookhaven National Laboratory in Long Island, New York. The laboratory was established in the 1940s under the then U.S. Atomic Energy Commission (now the U.S. Department of Energy) to conduct research in atomic energy, where it benefited from prominent public-private partnerships with Columbia University, Cornell University, Harvard University, Johns Hopkins University, MIT University, Princeton University, University of Pennsylvania, University of Rochester, and Yale University, among others. Realizing that science exhibits tended to be static and noninteractive, Higinbotham created *Tennis for Two* to showcase the power of digital computing. He stated, "[it] might liven up the place to have a game that people could play, and which would convey the message that our scientific endeavors have relevance for society."

The 1962 game *Spacewar!* is considered the originator of the modern video game. The game featured two ships fighting in outer space, which fittingly placed it at the center of the U.S. and Soviet struggle for dominance in the "Space Race." The game's 1962 release occurred five years after *Sputnik I* took orbit, and seven years before the U.S. successfully landed on the moon. In stark contrast to *Tennis for Two*, creator Steve Russell and his team at the Massachusetts Institute of Technology laboratory used technology that would be familiar to modern gamers. *Spacewar!* players used buttons to maneuver their ship and fire weapons; their physical inputs were then visually displayed on a monitor. Because Russell and his team programmed the game on a Digital Equipment Corporation PDP-1 microcomputer using a programming language called LISP, *Spacewar!* could be installed on other PDP-1 computers at other institutes, making it the first video game to become available outside a single research institute. In appearance and style of play, *Tennis for Two* and *Spacewar!* foreshadowed games like *Pong*, *Asteroids*, and *Pac-Man*, which were commercially released in 1972, 1979, and 1980, respectively.

GAMING CONSOLES

Though Steven Russell invented the first distributable video game, the computer it ran on sold for $120,000 in the 1960s, which was equivalent to more than $1,000,0000 dollars in 2020. While working for Sanders Associates, an electronics company that constructed flexible circuit boards for the U.S. military, German-American hardware engineer Ralph Baer recognized the proliferation of cheap home television sets made mass development of video games possible. He persuaded his supervisors at Sanders to grant him financial and personnel resources to develop a prototype, which the team named the "Brown Box," so-called because the brown tape that covered the console gave it a wood veneer. Sanders Associates licensed Baer's creation to Magnavox, which released the world's first video game console, the Odyssey, in 1972.

Following Magnavox's introduction to the market, the world required only three generations of video game console systems to establish the industry as a leading global entertainment medium and art form, easily rivaling that of television and film. Emblematic of the second generation of consoles, in September of 1977, Atari released the 2600 console. Across its lifetime, the Atari 2600 sold more than 30 million units worldwide. The Nintendo Entertainment System was introduced to the United States in February of 1986, and, throughout its lifetime, sold more than 60 million units worldwide.



Baer's "Brown Box" was sold for distribution to the Magnavox, a television company, which designed and released the Odyssey in September of 1972 as the world's first commercially available video game console system. Sales were initially poor due to price and consumers' poor understanding of the technology; many customers believed a Magnavox television was required to make the system function. To buoy sales, Magnavox lowered the console's price and bundled it with televisions. By the time of its discontinuation in 1975, the console had sold more than 350,000 units worldwide. (Courtesy of the Smithsonian Museum of American History)

With the ninth generation of consoles released in 2020, games have become more ubiquitous than ever before, and are available on cell phones, tablets, virtual reality systems, and home computers worldwide.

Beyond the "Brown Box's" 1970s aesthetic, the birth of video games and consoles was also indicative of their Cold War origins. Early video game design mirrored principles guiding military hardware itself: It must be simple to learn and easy to use. In designing controllers to his system, Baer drew inspiration from his work in military hardware. He used dials akin to tuning a radio, and attached metallic life-like firearms with interior electronics that communicated with the console system. Later video game consoles came with "joysticks" that mimicked the flight controls of military aircraft.

CONCLUSION

Like their colleagues developing transistors and microchips, GPS navigation, and networked computing, early game designers developed technologies in laboratories, technology, and equipment subsidized by the U.S. government that transcended their immediate Cold War purposes to shape our modern world. In the process, video game pioneers invented a novel virtual medium that fundamentally melded art and science. Yet their creation was more than engineers following their passion; video game inventors revisited existing technology with fresh perspectives to ask new questions and drive innovation. Public-private partnerships incentivized and exponentially increased the speed of scientific inquiry, modernization, and the rate with which these processes infiltrated all facets of human life.

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Wehrner Von Braun began his career in rocketry during World War Two where he developed rockets for the German Army to attack U.S. and allied forces. Following his surrender to the United States, the U.S. Army harnessed his knowledge to radically expand its rocket and missile programs. Von Braun later became a director at NASA, thus ensuring his career began under the auspices of destruction and ended under the aegis of exploration. (Courtesy of Getty Images)

Social scientists have worked for the U.S. federal government in shaping policy since the 19th century. Beginning in the late 1950s, they came to the federal government armed with digital computing power, which equipped them with large data sets. Secretary of Defense Robert McNamara was one of the earliest reformers to use digital computing and big data. Shown here pointing to a map of Laos and South Vietnam, McNamara's overreliance on data produced a complicated legacy. (Courtesy of Getty Images)

Science, all by itself, has no moral dimension. The same applies to technology. The knife may save a life when yielded by a skillful surgeon, but will kill if thrust only a few inches deeper.

—Wernher von Braun, *Director of NASA's Marshall Space Flight Center*

INTRODUCTION

Public-private partnerships were reciprocal in nature and afforded pipelines to bring private-sector expertise to government work. These individuals believed they had a role to play in national security, and they came from universities, nonprofits, and businesses to improve the function of U.S. government. By the 1960s, droves of social scientists came to work in the federal bureaucracy.

Backed by rapid growth in computing power, which afforded the opportunity to collect, store, and analyze greater amounts of data, experts applied statistical analysis to human behavior and bureaucratic systems. Practitioners were often referred to as management scientists or system analysts, and they aimed to make human affairs more efficient.

Of the many federal agencies where analysts worked, the Department of Defense presented a particularly appealing challenge. To strengthen national defense, they believed the young leviathan needed reform. When Secretary of Defense Robert McNamara arrived at the Department of Defense, he brought experts (referred to as "Whiz Kids") and a zealous belief that data-driven solutions could improve global readiness.

SECRETARY OF DEFENSE ROBERT MCNAMARA

When he accepted the position of Secretary of Defense under President John Kennedy, Robert McNamara brought to the Pentagon a team of young professionals from businesses he revitalized such as the Ford Motor Company, from universities, and from nonprofits familiar with government work like the RAND Corporation.

Following McNamara's arrival, he and his team soon installed a long-term planning system referred to as the Planning, Programming and Budgeting System (PPBS). To manage it, McNamara relied on Charles Hitch—who had come to the DoD from RAND—and who became the Assistant Secretary of Defense Comptroller. PPBS was designed to rationalize long-term planning in the Department of Defense by organizing the budget around the military's capabilities, rather than requests from the services as had been done in the past. PPBS eliminated redundant programs, lowered agency costs and granted greater budgetary flexibility. Today, the DoD refers to the process as Planning, Programming, Budgeting and Execution (PPBE).

McNamara soon encountered the limitations of data-driven solutions that, by their very definition, could not account for unknown quantities. Although decisive victory in South Vietnam eluded the U.S., McNamara remained slavishly devoted to his metrics. His ruthless adherence to this methodology reduced human beings to statistics he used to express the war's progress. Under his leadership, the U.S. adopted the grisly and morbid "body count" metric that soured civilians and military leadership on the war's handling.

Simply expressed, body counts were the number of North Vietnamese Army and Viet Cong killed by U.S. and allied forces in any given engagement. These numbers (often inflated and incorrect) were then reported up the chain of command. They were then tallied against estimated North Vietnamese and Viet Cong total strength, and by attrition, the enemy presumably weakened. McNamara believed that once enemy deaths were too great, they would have to relent. In his 1995 memoir, he admitted the U.S. "undertook [the body count] because one of [General Westmoreland's] objectives was to reach a so-called crossover point. To reach such a point, we needed to have some idea of what [the enemy] could sustain and what their losses were."

Sociologist Daniel Yankelovitch later coined this "The McNamara Fallacy." He argued it consisted of an over-reliance on measurable data and summarized it as "if it cannot be measured, it is not important." War is both an art and a science. Poetically, humans contain more variables than numbers can account for alone.

SOCIAL HISTORY

Advances in technology and data collection also fundamentally altered the way historians interpreted humanity's role in shaping history. Owing to changes to mores and norms in the 1960s as well, young historians used digital computing to build large and complex data sets of ordinary persons; from this data, they developed new questions about the past and new methodologies to explain change over time. Historians began to examine previously unexplored themes such as culture, race, gender, and more. Their answers illuminated the important roles previously non-documented persons, communities, and cultures represented in shaping the United States and the world, while also creating new avenues for historical inquiry. New inquiry then spurred further innovation, which included cross-disciplinary dialogues, and led to intersections with sociology, anthropology, ethnography, gender studies, and political science, among others.

An example of social history in action. The United States of America's Vietnam War Commemoration's History and Legacy program conducts a holistic oral history with a veteran; the interview examines veterans' lives before, during, and after the war. In addition to thanking and honoring veterans for their service, the interview generates a historical record that will be housed in perpetuity at the Library of Congress that scholars and the public may use to better understand the Vietnam War and veterans' histories. (Courtesy of the United States of America Vietnam War Commemoration)

Social historian Peter Stearns wrote, "I once argued that no aspect of human behavior should be denied to social history." This strident belief drove social historians to find new and innovative ways to document and express the past. One of the most prominent includes oral history, and it is a staple in thanking and honoring veterans at the United States of America's Vietnam War Commemoration; oral history is also used at other federal agencies, universities, and businesses. In capturing the experiences of men and women from diverse ethnic, social, and cultural backgrounds, the Commemoration and other participating programs generate a holistic view of the veteran experience so that the nation may not only thank and honor them, but better understand their role in shaping the nation and its past.

LEGACIES

Public-private partnerships lent public personnel, funds, and equipment to scientific expertise at nonprofits, universities, and private companies across the United States to place the nation at the forefront of global readiness. From 1955 to 1975, the U.S. created and deployed sensors to detect adversaries, global positioning systems to accurately navigate its own and allied forces, unmanned aircraft to safely monitor areas of national interest, networked communications systems to quickly transmit strategic information, and smart munitions to limit collateral damage. These inventions grew beyond their original purpose to become staples of modern civilian life.

Knowledge is permeable, developmental, cumulative, and advanced by asking new questions. Inquiry drives its growth from fledgling understanding to more advanced and complex states. The nature of inquiry is often fickle, and it can lead to unforeseen, unimagined, and unpredictable results. At the dawn of the Cold War, the U.S. government engaged in public-private partnerships to accomplish the extraordinary task of strengthening the nation's defense and global position. Yet, the nation's Cold War goals pale in comparison to its accomplishments. Inadvertently, scientific inquiry and technological advancement in the service of national defense combined to make the modern world. Technology, science, and knowledge now pervade every facet of human existence even as they continue to transform it and be transformed by it.

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