THE ARMY SCIENCE BOARD

A HISTORY OF ARMY–CIVILIAN COLLABORATION IN SCIENCE

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Photo by David McNally, Army Research Laboratory

Army scientists and researchers have been busy in 2019 discovering, innovating, and transitioning science and technology solutions to modernize the force and support the Soldier of the future.
(U. S. Army)

The Army Science Board: A History of Army–Civilian Collaboration in Science

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"THE HISTORY OF TECHNOLOGY IS THE HISTORY OF WAR, AND THE FUTURE OF WAR IS THE FUTURE OF TECHNOLOGY."

Michael J. Bayer

Chair, Army Science Board, 1998–2002

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FOREWORD

As science and engineering advanced during the first half of the twentieth century, the Army acquired increasingly complex weapons and equipment. Except during the world wars, however, the service during those fifty years did not make effective use of civilian expertise in its research and development efforts. By 1950, the Army understood that the Cold War required improved access to the latest scientific and industrial knowledge to maintain a qualitative advantage against the much larger Soviet army. Early the following year, the service established the Army Scientific Advisory Panel (ASAP), which in 1977 became the Army Science Board (ASB).

Since 1951, the ASAP and the ASB have been a vital conduit between the service and academia and industry. Over the decades, the organization widened its efforts from a focus on materiel issues to important work on personnel and organizational topics as the Army encountered challenges such as the transition to an all-volunteer force, the widespread use of digital devices, and the effects produced by climate change. This pamphlet highlights and honors the women and men of the ASAP and the ASB who voluntarily contributed their knowledge and skills to assist the Army in defending the nation.

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JON T. HOFFMAN
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INTRODUCTION

For more than sixty-five years, the Army Science Board (ASB) has served as the U.S. Army's leading scientific advisory body, bringing together civilian experts from private industry and the academic world to address some of the Army's most pressing research and development (R&D) challenges. Although the board received its charter in 1977 under the Federal Advisory Committee Act (FACA), the organization traces its origins to 1951, when Secretary of the Army Frank Pace Jr. approved the establishment of the Army Scientific Advisory Panel (ASAP).

The history of the ASB reveals a great deal about the Army's R&D efforts, including the evolving role of the private sector in this process. Between the Civil War and the start of World War II, the Army's collaboration with civilian scientists and engineers was cyclical in nature. During times of war, there was an urgent and intense focus on building a constructive working relationship between the Army and civilian expertise. After the return of peace, collaboration atrophied as the Army's interest in R&D declined, policymakers cut defense budgets, and civilian personnel returned to their previous positions in university and corporate labs. The Army's fundamental outlook on science was shortsighted and reactive, with civilian experts recruited only to deal with immediate problems. World War II, a global conflict in which civilian scientists and engineers played a prominent role in national defense, broke that cycle. The ensuing Cold War with the Soviet Union underscored the urgent need to develop an efficient R&D program that would be visionary, ambitious, and proactive.

The birth of the ASAP in 1951 reflected these changing priorities, helping to improve the Army's modernization program during the Cold War. In 1977, the panel evolved into the ASB, but the fundamental mission remained the same: using civilian scientific expertise to help the Army change and adapt. In the 1970s and onward, the ASB became involved in new roles, helping to shape policies related to personnel, infrastructure, and doctrine.

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THE ORIGINS OF ARMY SCIENTIFIC COLLABORATION

In 1794, Congress authorized the creation of the United States' first two national arsenals, at Harpers Ferry, Virginia, and Springfield, Massachusetts. Over the next twenty years, the federal government would build five more arsenals across the expanding country. These arsenals became key engines of American industrialization and manufacturing in the early nineteenth century. The Army's vastly increased need for equipment during the Civil War led the federal government to look to the private sector for both production capacity and independent expert advice. In 1863, Congress passed the act of incorporation for a National Academy of Sciences to produce scientific reports for the federal government and inform policymakers about scientific advancements.

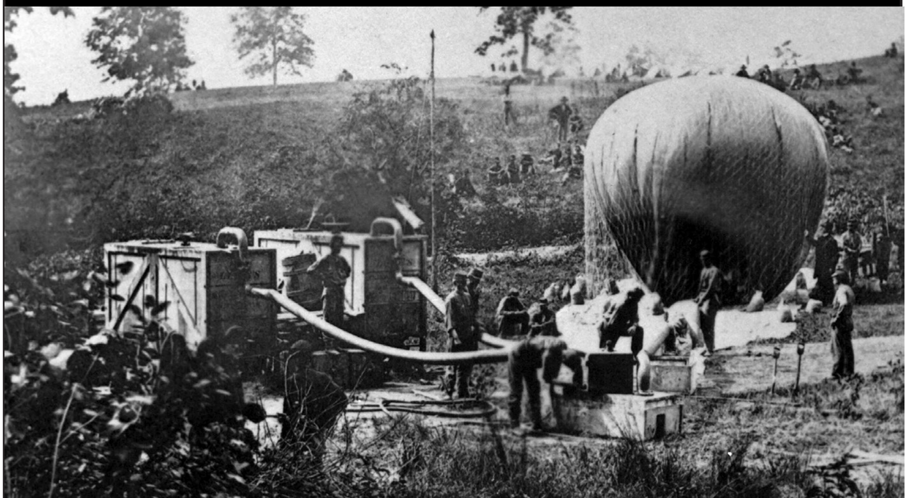
By 1914, against the backdrop of the war engulfing Europe, the small staff of the National Academy of Sciences was unable to meet the increase in requests from the armed forces for scientific advice. Though President Woodrow Wilson continued to favor American neutrality in his public statements, he requested that the Academy establish a new National Research Council to help channel civilian scientific personnel more efficiently into military R&D. After the United States entered World War I in 1917, the Army worked with civilian scientists and engineers on new technologies, such as aviation, radio, and chemical weapons, which had become important during the war.

Despite the wartime cooperation between the Army and the scientific community, in the postwar period links between civilian scientists and the service languished. The technical services were aware of the strides that civilian scientists and engineers had made in a wide range of subjects. The Army's own research efforts produced some notable advances, such as in the development of radar. The service's small peacetime budgets, however, precluded it from spending much on these efforts, and the Army lacked a mechanism for integrating civilian scientists' work with military needs.

In 1940, Vannevar Bush, president of the Carnegie Institute of Washington, met with President Franklin D. Roosevelt to discuss ways to improve cooperation between the federal government and the scientific community. Bush had worked for years to promote this cooperation and he believed that Nazi victories in Europe showed the need to better integrate scientific

Thaddeus S. C. Lowe

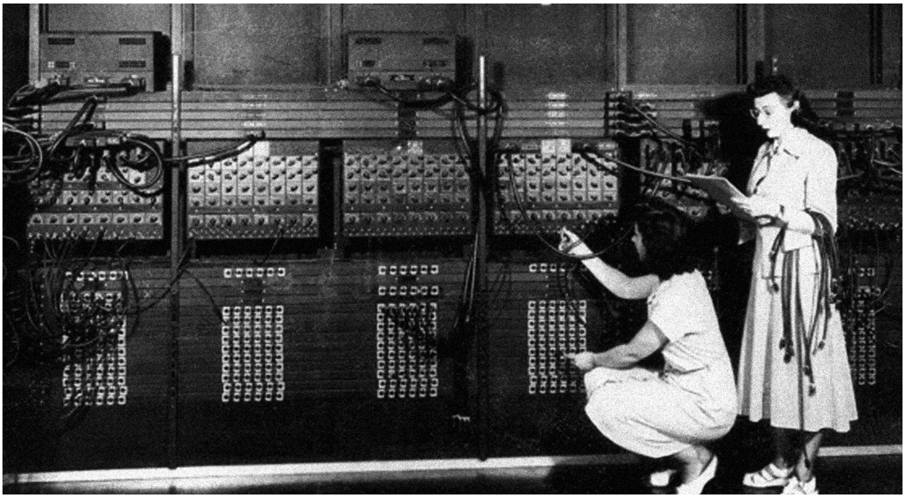
Thaddeus S. C. Lowe (1832–1913) was a scientist and inventor who became famous for building hot-air balloons in the 1850s. During the Civil War, Lowe advocated using balloons as observation posts, with a telegraph wire connected to the ground to relay information. After several attempts to use balloons on the battlefield in 1861 and 1862, the Army discontinued its use of balloons because of continuing technical issues.



A U.S. Army balloon being inflated for the Battle of Fair Oaks, 1862. *(Mathew Brady)*

expertise into American national security. Bush wanted Roosevelt to establish a new organization that could more efficiently facilitate the government's use of scientific expertise by fully embracing a partnership with private enterprise. This vision of a merger between the public and private sectors became what the political scientist Don K. Price later described as "federalism by contract." It took only fifteen minutes for Bush to convince the president, and on 27 June 1940, Roosevelt sanctioned the creation of the National Defense Research Committee (NDRC), with Bush as its director.

The NDRC did not conduct scientific research on its own, but retained experts on contract, including the services of university labs. The organization established a close, formal liaison between the military and the private sector. Such a relationship kept civilian scientists operating within the framework of official requirements, while simultaneously giving military leadership an idea of how scientific breakthroughs could help the war effort. In June 1941, Bush suggested that Roosevelt restructure the NDRC to increase its capacity to conduct medical research. The president eventually placed the committee under a new umbrella organization—the Office of Scientific Research and Development (OSRD)—with Bush as its director.



The Electronic Numerical Integrator and Computer, or ENIAC, was the world's first programmable digital computer. The Army and the University of Pennsylvania developed it during World War II.
(National Museum of the United States Army)

Over the course of the war, Bush's organization had a significant impact on the development of military equipment. On a budget of $3 million a week, the OSRD funded 6,000 scientific advisers in 300 academic and industrial labs nationwide. These resources facilitated important technological breakthroughs—from improved radar systems to the invention of the proximity fuse. The office also pioneered operations research during the war. One of its most useful innovations was allowing civilian scientists to accompany their newly developed equipment into the field to get a firsthand look at how the weapons performed.

The OSRD's most important contribution was in the effort to create an atomic bomb. In 1940, Roosevelt gave civilian scientists a mandate to study "the possible relationship to national defense of recent discoveries in the field of atomic physics, notably the fission of uranium." On 9 October 1941, the president approved Bush's plan to bring the Army into the operation. An Army officer would be in overall command of the project, and the Army Corps of Engineers would oversee the construction of the facilities necessary for the development of the atomic bomb. Civilian scientists drawn from universities and the private sector provided critical technical support, and members of the atomic bomb program, such as Crawford H. Greenewalt, would later play prominent roles in the creation of the ASAP.

In November 1944, President Roosevelt directed Bush to study how the federal government should translate the wartime system of scientific collaboration into a more enduring pattern of peacetime engagement. "New frontiers of the mind are before us." Roosevelt declared, "and if they are pioneered with the same vision, boldness, and drive with which we have waged this war, we can create a fuller and more fruitful employment and a fuller and more fruitful life." Bush's report, *Science: The Endless Frontier*, appeared four months after Roosevelt's death in April 1945. It agreed with the president, concluding that the federal government should continue generous funding of scientific research. Bush also argued that civilian scientists should remain actively engaged in the nation's defense in peacetime. "Science has been in the wings," he concluded. "It should be brought to the center of the stage—for in it lies much of our hope for the future." Nevertheless, it would take several years for him to create an organization that could translate the collaborative wartime spirit of the OSRD into the postwar period.

Bush's vision of a permanent civilian-military partnership exposed a fault line in the Army, one that centered on two questions. First, what part of the Army's organizational structure would be responsible for scientific R&D? Second, what role would civilian scientists play in these areas? In the past, logistics and production concerns had been the key factors for Army officers, and so the War Department's G–4 had overseen the technical services' R&D activities. Bush and his supporters, however, had long believed in decoupling R&D from production and procurement at the General Staff level. They argued that, when linked too closely to production, scientific research became reactive, not proactive. The response of key voices on the Army Staff dated back to the heyday of the arsenals, as they asserted that the Army must connect the development of materiel to production considerations. These individuals also viewed with suspicion the idea of a permanent role for civilian scientists in the Army.

On 30 April 1946, as part of a wider reorganization of the service, Army Chief of Staff General of the Army Dwight D. Eisenhower outlined changes to the Army's R&D program. The lessons of World War II, Eisenhower declared, "must be translated into a peacetime counterpart, which will not merely familiarize the Army with the progress made in science and industry but draw into our planning for national security all the civilian resources which can contribute to the defense of the country." His changes took two forms: bolstering the role of civilian personnel and altering the Army's organizational structure. Civilian scientists in industry and universities would assist in both the planning and the production of weapons, and have "the greatest possible freedom to carry out their research." He also directed the creation of a new R&D directorate at the General Staff level, one separate from production and procurement at G–4.

Eisenhower's decision signaled that Vannevar Bush's vision, as articulated in *Science: The Endless Frontier*, had won out. But by December 1947, in the context of severe budget cuts, Cloyd H. Marvin—one of the Army's top scientific advisers—wrote a report recommending that separate division status for R&D should be abolished. "Research and development is an attitude of mind," Marvin wrote, "not an isolated prescribed administrative activity." A March 1948 revision of Army organization abolished the separate R&D directorate and placed responsibility for R&D in the Army Staff in a new Research and Development Group in the Directorate of Logistics.

After World War II, American politicians and military planners had pinned much of their hopes for a peaceful world on the United States' singular possession of the atomic bomb. In August 1949, however, the Soviet Union successfully tested its own atomic weapon. Bush argued that the American monopoly on the atomic bomb had made military leaders blind to the real urgency in R&D: the need to develop better capacities for conventional warfare. “The result is that if war should break out tomorrow, it would be a long desperate war,” Bush wrote in April 1950 to General of the Army Omar N. Bradley, chairman of the Joint Chiefs of Staff. “We could hope to prevail,” he added, “only after a period of years by the ultimate weight of our industrial potential, and after irreparable damage.” Bush found much to criticize in the Army’s R&D program, which had all the necessary “organizational machinery” to develop great advantages against the “hordes of Russia.” Unfortunately, the Army’s research expenditure was half that of the Navy or the newly independent Air Force. “Whether we seize the opportunity or not,” he wrote, “depends upon whether we live in the past or in the future.”

In February 1951, with U.S. forces now engaged on the Korean Peninsula, Bush wrote Bradley that “we slug it out in Korea in much the same old way.” He complained that the Army did not give enough attention to preparing for future conflicts. At the root of the issue was that while the Army Staff accepted civilian oversight and control as an inherent part of the democratic system, they “resent and circumvent entrance or examination into their affairs by the civilian branch, except on the establishment of broad policies having a political or economic content.” Army leaders, Bush argued, needed to find a way to infuse the institution with civilian expertise, while not upsetting the chain of command.

Bush recommended a recent organizational innovation to smooth out the difficulties in this relationship: the civilian “advisory group.” As Bush described it: “When staffed with keen civilians in collaboration with equally keen officers, when given a free hand, and when presented with a problem that is specific rather than general, results of value can be obtained by this method.” In this way, civilians could work with the Army on the R&D programs without appearing to threaten the established hierarchy—“for they are all of a reviewing or advisory nature,” he added.

Wernher von Braun, the Nazi aerospace engineer the Army brought to the United States in 1945 to work on its missile programs, thought that it was “helpful to have a scientific advisory committee at a time when you kick the question around whether a certain proposal is sound or desirable and in the country’s interest.” Scientific advisers had great scope to provide significant assistance to the federal government. But Von Braun also offered a more cynical appraisal of federal agencies’ motivations for establishing such groups: the “prestige factor.” The collective opinions of a group of esteemed civilian scientists, well-known to the public, could add legitimacy and gravitas to any individual decision: “It helps if a man can say, ‘I have on my advisory committee some Nobel prize winners, or some very famous people that everyone knows.’” Additionally, the affirmation of the group gave senior military leaders extra confidence: “The executive feels, ‘Now if something goes wrong, nobody can blame me for not having asked the smartest men in the country what they think about this.’”

Looking at the postwar period as a whole, despite the desire of policymakers and members of the scientific community to forge closer bonds between the Army and civilian experts, the limitations of the postwar period slowed reform efforts. Rapid demobilization, as well as sharply reduced military spending, narrowed the opportunity for developing new organizations. Major reforms to the U.S. defense structure, such as the creation of the Department of Defense (DoD), also left senior policymakers little time to wrestle with other organizational arrangements. Only the pressure of rising tensions between the United States and Soviet Union would lead to a renewed emphasis on cooperation and begin a sustained engagement between scientific advisers and the Army.

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THE ARMY SCIENTIFIC ADVISORY PANEL AND THE COLD WAR

The month before Vannevar Bush wrote to Omar Bradley calling for the Army to appoint a scientific advisory group, Secretary of the Army Pace received the Kilgo Report. A formal staff study initiated by Pace's predecessor, Gordon Gray, the report focused on the Army's R&D organization. Among its recommendations was that the Army establish a scientific advisory board, composed of civilians from industry and universities who could provide specific technical guidance on national security policy. On 29 March 1951, Pace—working closely with Army Chief of Staff General J. Lawton Collins--approved the creation of the Army Scientific Advisory Panel, but on a trial basis.

The ASAP initially had ten members, with James R. Killian Jr., president of the Massachusetts Institute of Technology, acting as the group's spokesperson. The founding members represented a cross section of scientific, engineering, and management expertise. Morrough P. O'Brien, dean at the University of California Berkeley, was a pioneering hydraulic engineer widely considered the "founder of modern coastal engineering." K. T. Keller brought his administrative and production expertise as the long-serving president of the Chrysler Corporation. William B. Shockely Jr. would go on to share the 1956 Nobel Prize in physics for his path-breaking research on the semiconductor and transistor. Operating on a trial basis, the ASAP's mandate was "to assist the Secretary of the Army and the Chief of Staff in their joint responsibility to give to this country a fighting force as effective, economical, and progressive as our scientific, technological, and industrial resources permit." Though the role of civilian scientists in the military had been contested since 1945, the creation of the ASAP finally allowed them to speak from a position of relative authority within the Army establishment.

In its early days, two further reports praised the operations of the ASAP and implored the Army to make better use of its services. The first came from the Advisory Committee on Army Organization, which interviewed 129 witnesses in 1953. Many of these interviewees, including Killian, spoke with a deep knowledge of the Army's R&D program. In its December 1953 conclusions, known as the Davies Report, the committee lauded the creation of the ASAP for helping to bring the brightest civilian scientific minds into the heart of the Army.

The second report came a year later. The Military Operations Subcommittee of the House Committee on Government Operations, chaired by Representative R. Walter Riehlman, began its own investigation of the Army's R&D program.

Secretary of the Army Frank Pace Jr.

Frank Pace Jr. served as secretary of the Army from 12 April 1950 to 20 January 1953. During his tenure, he established the scientific advisory organization that would form the basis of the ASAP. As secretary of the Army, Pace's tenure was marked by large-scale combat in Korea and an extensive Army modernization program. After his service with the Army, Pace served as chair of the board of the Corporation for Public Broadcasting from 1968 to 1972, and was a member and president of the National Institute of Social Sciences.

Secretary of the Army Frank Pace Jr., by *Harrison Edward Benton Jr.*
(U.S. Army Art Collection)

In its final report, the subcommittee also praised the ASAP, but criticized the Army for making insufficient use of the panel. According to Riehlman, the Army had been too reluctant to embrace the ASAP and other civilian scientists in helping to develop a more focused R&D framework that could more directly influence policy. Riehlman and his congressional colleagues warned that if Army officers continued to resist change and innovation, "the forces of logic and civilian scientific dissatisfaction could well dictate that research and development be rightly considered incompatible with military organization." In the end, the implications of the Riehlman Report were clear: if Army leaders did not put their own shop in order, Congress would do it for them.

In response to these reports, Secretary of the Army Robert T. Stevens gave the ASAP official status as a permanent advisory board of the U.S. Army on 12 August 1954. Army Memorandum 15–435–1 specified that the secretary of the Army would directly appoint the panel chair. On advice of the chair, the secretary would then approve the appointment of members, drawn from "the nation's outstanding scientists, engineers, educators, and industrialists." They would serve two-year terms, with the possibility of reappointment. The memorandum did not specify the size of the panel, only that it would be "appropriate to its activities." Killian, who remained chair of the ASAP, later increased the size of the panel from ten to twenty-five members. In addition, an executive secretary would manage logistics, facilitating communication between members, and keep them aware of developments in the Army R&D program. Members were to meet twice annually.

James R. Killian

James R. Killian Jr. (1904–1988) was an influential scientist and adviser during the 1950s and 1960s who helped integrate scientific expertise into government policy. During World War II, Killian helped organize scientific collaboration between the Massachusetts Institute of Technology and the military. During the 1950s, Killian would help shape the ASAP into an effective and enduring part of the Army.

James R. Killian Jr. being sworn in as the first presidential science adviser.
(National Aeronautics and Space Administration)

The secretary gave the panel two functions. First, he instructed it to advise the Army on matters of a scientific nature. Drawing upon the combined knowledge of its members, the panel would highlight areas of inquiry that could prove useful to the Army. It would then decide collectively when research had reached the point where the Army could apply it to the battlefield. The panel's second function was more controversial, placing it at the heart of long-standing organizational disputes about the Army's R&D program. It would "review and evaluate the Army program, policies, and plans for research and development." It would "appraise the adequacy of research and development facilities" as well as "study and make special recommendations for the solution of special problems affecting the research and development program." In total, Secretary Stevens set out the permanent status of civilian scientific advisers in the Army hierarchy for the first time. Against the backdrop of the Cold War, the ASAP was thus prepared to play a key role in the Army's transition from a reactive R&D program to one that was permanent, proactive, and future-oriented.

With Killian in the lead, the ASAP became a firm voice in favor of separating responsibility for R&D on the Army Staff from the office responsible for logistics. Killian testified before Representative Riehlman's subcommittee and urged Secretary Stevens to make this change. In 1955, Stevens's successor, Wilbur M. Brucker, approved creation of the position of chief of research and development. The position was the functional equivalent of a deputy chief of staff, but because the Army Organization Act of 1950 limited the Army Staff to three deputy chiefs of staff, the Army could not designate it as such. For the rest of the decade, the panel would be a strong advocate for the new office.

In the years that followed, the panel continued to examine ways to improve the service's R&D organization. A major area of study in the 1950s was the lead-time in developing new weapon systems. To reduce the Army's lengthy process of fielding new materiel, the panel recommended giving the chief of research and development sole responsibility for all R&D policy and sole control of funds in this area. More successful was the ASAP's advocacy for creating an Army Research Office. Established in 1958 under the chief of research and development, this office's mission was to plan and direct the research program of the Army, make maximum use of the nation's scientific talent, provide the nation's scientific community with a single contact in the Army, and ensure that the service's R&D program emphasized the Army's future needs. Additionally, it was supposed to coordinate the R&D programs of the technical services, something the technical services continued to oppose.

The Cold War only made these internal disputes about the Army's R&D organizational structure more urgent. In the 1950s, the Soviet Union achieved a string of technological breakthroughs, fielding sophisticated armored fighting vehicles and other new weapons. In October 1957, the Soviet Union launched the first satellite, named Sputnik, into outer space. Less than a month later, it sent off a second Sputnik satellite, carrying a dog. As Sputniks 1 and 2 orbited the Earth, Americans looked to the sky with anxiety and fear. Meanwhile, the success of the Soviet space program focused minds in Washington, providing a near-constant reminder of the high stakes of science and technology. Just four months after the Sputnik launches, the Army Ballistic Missile Agency launched its own orbital satellite, Explorer 1, into space.

The ASAP's expertise would become even more valuable in the 1960s. In December 1960, the Office of the Chief of Research and Development established a monthly newsletter to better publicize the Army's increasing focus on R&D. In its first edition, the *Army Research and Development Newsmagazine* carried a message from Secretary Brucker. He framed the stakes of the R&D program in the context of the Cold War. In its quest for world domination, he wrote, the Soviet Union could "deny its people virtually every comfort and convenience of life in order to concentrate its full scientific and industrial potential." But the United States operated on a different model—one that relied on free enterprise, competition, and, in the end, "free men . . . voluntarily contribut[ing] their time, effort, and skill for the

Wernher von Braun (seated, right) displays a model of the Explorer 1 satellite to Maj. Gen. John B. Medaris, commanding general of the Army Ballistic Missile Agency.
(U.S. Army)

common good." Brucker's best example in the Army of this quintessentially American collaboration was the ASAP—an "Army-science-industry team whose combined skills, resources, and experience are unmatched in history." The same issue of the newsletter boasted about this elite group of scientific advisers, noting that "because of the urgency and immediacy of their work, the logotype ASAP has, in this case, a double meaning: Army Scientific Advisory Panel and—As Soon As Possible."

In the 1960s, the ASAP began to gain a higher profile within the Army and the wider federal government. In June 1961, the new secretary of the Army, Elvis J. Stahr, addressed a meeting of the panel. He took advantage of the occasion to urge members to supply him with a "continuous flow of new ideas and concepts" and to provide counsel on "what is best to adopt, produce, and procure as new Army material, and what should be cast aside as unpromising." Stahr's encouraging comments demonstrated the position the ASAP had reached within the Army as both the forum for visionary ideas and the vehicle for spurring their development.

By the early 1960s, the ASAP had grown to fifty-four members, and Secretary of the Army Cyrus R. Vance in 1963 approved a reorganization of the panel in order to make it "more responsive to the needs of the Army." Whereas in the past, the chair had determined the appropriate size of the panel, it would now be limited to twenty-five permanent members. The chair, however, would have the power to appoint consultants who could advise permanent members. This innovation maintained the flexibility that had made the ASAP such a benefit to the Army, creating a large, associated pool of expertise. Among the first consultants appointed were the first two chiefs of R&D, James M. Gavin and Arthur G. Trudeau. These two retired officers brought with them deep institutional knowledge of the Army and the military R&D community.

No longer composed of subgroups devoted to specific themes, the panel became a collection of ad hoc groups, designed "to review and advise on problems which arise." In recognition of the importance of the ASAP, Vance also declared the panel to be the "senior scientific advisory group of the Department of the Army." Further adjustments in December 1965 created a senior advisory committee within the structure of the ASAP and limited consultants to two-year terms. After this reorganization, the panel's membership underwent a significant turnover, with one-third of the members replaced by 1966. This transformation brought new energy to the ASAP and gave it the flexibility it would need to handle challenges, particularly when dealing with increasing requests for support from Army forces in Vietnam.

Among the ASAP's first endeavors after the reorganization was a report on target acquisition, chaired by Finn J. Larsen of the Minneapolis-based Honeywell Regulator Company. The report recommended "major efforts" to improve the accuracy of weapon systems, not least facilitating a closer relationship between R&D efforts in firepower and target acquisition. Target acquisition was especially important to combat operations in Vietnam, where frequent nighttime and jungle operations hindered visibility. Larsen's group also recommended that, as a matter of urgency, Army laboratories should focus on the development of night vision and infrared detection systems, as well as portable radar technology. In advance of the report's publication, officials at the Pentagon identified "an unusual demand for the final summary of findings."

In Southeast Asia, the Army faced a conflict without the clearly delineated front lines of World War II and Korea. This environment required new approaches and innovative technologies. In January 1966, the Army's assistant secretary for research and development, Willis M. Hawkins, wrote to ASAP chair Harold M. Agnew, suggesting the creation of an ad hoc group to focus solely on the "severe problems" facing soldiers in Vietnam. Hawkins asked the panel to study how the American scientific community could expedite technical solutions to operational problems. Hawkins also hoped the ASAP might find ways to improve upon Army officers' ability to disseminate their own experiences in Vietnam internally within the Army. Agnew agreed with the proposal and shared many of the same views. In comments to the Army R&D community, Agnew would bluntly appeal to scientists and researchers to focus on "practical results" and be more engaged with the Army. Agnew asked Jack E. Goldman, director of the Ford Motor Company's scientific laboratory, to chair this new ad hoc group.

In June 1966, the ASAP convened a meeting of eighty people at Fort Benning, Georgia, where members of the Vietnam group heard directly from soldiers about their recent combat experiences. Goldman and his colleagues received "fresh and graphic accounts" of the problems afflicting soldiers on the ground, from the threat of roadside mines hidden in culverts to the extreme difficulties in drawing insurgents out of hiding. ASAP members also took part in other activities at Fort Benning. They reviewed the night fire exercises of a combined operations team. They also visited a mock Vietnamese hamlet before viewing a film, with a special introduction by General William C. Westmoreland, who "encouraged the scientific community to increase its effort in improving technological support for Southeast Asia." After the meeting, Lt. Gen. Austin W. Betts, the Army chief of research and development, reported that "finding the enemy" continued to be the number-one problem in Vietnam. As a result, reconnaissance, surveillance, and target acquisition became the Vietnam ad hoc group's primary concern.

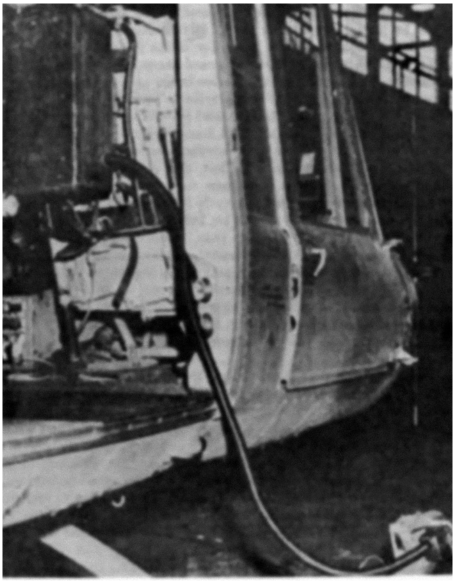
In 1966, the ASAP began to work on an ambitious Army technological project to meet the needs of soldiers in Vietnam—a chemical personnel detector. Quickly dubbed the "people sniffer," the device could detect the chemical makeup of human beings, thus alerting soldiers to the hidden presence of enemy personnel. The Navy had successfully developed similar technology in World War II to locate the diesel fumes of German submarines. In 1965, scientists at General Electric had begun to convert this technology to the effort to detect people based on humans' biological composition. Their hypothesis fell back upon basic chemistry. A byproduct of human sweat is ammonia, and when ammonia and hydrochloric acid mix in air, they produce ammonium chloride. The idea was to fill a cloud chamber device with hydrochloric acid, and if members of the Viet Cong or the People's Army of Vietnam were near the detector, the ammonia they naturally produced would prompt a reaction in the chamber. As one device operator described the process, the reaction would "give you a reading on a read-out meter on top of the detector which tells you something is out there."

The first prototype of the device, the Personnel Detector Manpack, included a small cloud chamber worn as a backpack, with a small vacuum intake to attach to the barrel of a rifle. However, the technology worked inconsistently, often detecting the operator's own sweat and signaling a false alarm. Even a wayward greasy fingerprint on the machine could lead the sniffer to malfunction. If an area had been the target of a recent artillery barrage, there was little hope of trustworthy readings.

In light of these issues, Army commanders looked to apply the expertise of the ASAP to troubleshoot the sniffer. The ASAP recruited John D. Baldeschwieler, a chemistry professor at Stanford University, to work on the project. Having been an Army reservist in graduate school, Baldeschwieler was the ideal candidate. "I had a scientific base," he later recalled, "but I also knew what it was like to be in the mud and to have equipment that must function under those conditions." Despite Baldeschwieler's work, members of the ad hoc group on Vietnam were growing exasperated by the vagaries of the people sniffer. One meeting in August 1967 included "hot and heavy" discussion, as members spoke out against continued investment in the device. An exceptionally critical voice equated continued funding of the project as "buying a technical pig in a poke." In the end, the ad hoc group unanimously approved a statement that recommended delaying sniffer operations until scientists had corrected various faults and ensured consistent results.

In late November 1967, Baldeschwieler and Goldman visited Vietnam on an ASAP technical mission. They assessed countermine activities and the possibility of using radar to locate extensive underground tunnel complexes maintained by the Viet Cong. They found that "people in the field are extremely clever in adapting equipment to new uses." For example, they found one Army major with a PhD in mechanical engineering who had used old bogie wheels to construct a device to clear minefields. Most importantly, Baldeschwieler observed the sniffer in action, and he came away surprised that, for all of its technical inconsistencies, the device seemed to be of some use on the ground. "In-country testimonials formerly given little credence have now convinced Baldeschwieler that the sniffer works," the ASAP minutes from the following January recorded, though registering that "the how and why is still open to question." It later transpired that the sniffer was more useful at finding smoke than people—the very activity for which the Navy had employed it in World War II. "The Vietcong and the NVA [North Vietnamese Army] tended . . . to use little hibachis and even electrical generators that produced particulates," Baldeschwieler later noted.

Units in Vietnam mounted the second iteration of the people sniffer in a helicopter that flew perpendicular to the wind and 50 feet above the jungle canopy. "If the lead helicopter detected something," Baldeschwieler recalled, "they would designate the spot and call in artillery or an air strike in the jungle." When troops later returned to the area, "they sometimes found they'd killed somebody." Time spent in the field demonstrated that there was still much work to do to deliver upon the ad hoc panel's original mission of facilitating better communication between soldiers in combat and the scientific community back home. But Baldeschwieler and Goldman returned from Vietnam with a "shopping list of requirements" and a renewed commitment to the idea of the ASAP as a liaison between the Army and civilian scientists for the benefit of young soldiers in the field. In November 1968, the ad hoc group folded its operations to allow the ASAP to engage more widely with the technical issues of the conflict and to respond to problems on a case-by-case basis in Vietnam.



The "people sniffer" personnel detector, mounted on a helicopter in Vietnam.
(Department of Defense)

As American involvement in Vietnam grew, so did ASAP interest in operational issues. Studies conducted during this period included assessments of mine detection and neutralization, as well as the possibility of using radar to penetrate dense foliage. The war stimulated work by the panel outside of its previous focus on the physical sciences. In June 1966, Willis Hawkins invited the ASAP chairman to organize an ad hoc group to study psychological operations in Vietnam. "Current and Cold War Army commitments on a worldwide basis," Hawkins stated, "require that recent experience in these operations be studied for effective application." In June 1967, the panel's ad hoc group on this issue published a report advising the Army not to restrict itself "solely to the military functions of PSYOP [psychological operations]." The group argued that the service should take account of the psychological, economic, political, and social aspects of war. It recommended developing a career path for officers trained to provide expert advice to commanders on the wide-ranging implications of military force.

Even as the ASAP sought to assist the Army's efforts in Vietnam, the conflict also influenced the way the panel structured itself. In October 1968, Russell O'Neal, the assistant secretary of the Army for research and development, asked the panel's chair to organize an ad hoc study on the panel's own organization and management. The group, which included Baldeschwieler and former Assistant Secretary Hawkins, by then serving as an ASAP member, concluded that the panel needed to find a better balance in its membership between scientists and engineers. "Members and consultants are sought not only for their excellence in scientific disciplines," they wrote, "but also for their experience and engineering 'know-how' in specific Army systems." They felt that the ASAP should continue to have specialists in chemistry and physics, but it should also encourage the participation of people with knowledge of ground vehicles, weapons and ammunition, and electronics. The panel needed experts who could readily apply knowledge to the field, especially in Vietnam.

In response, Secretary of the Army Stanley R. Resor directed changes to the ASAP in 1970. The reorganization created an executive committee within the panel whose principal purpose was to recommend new members. This new broader consultation for recruitment thus worked to diversify the ASAP's expertise and its ability to contribute to the Army's short- and long-term goals.

As the drawdown in forces in Vietnam began in the early 1970s, the Nixon administration began a policy of easing of tensions with the Soviet Union. This policy meant that the ASAP would enter the 1970s focused on new areas of analysis. For twenty years, the ASAP had helped the Army adjust to the scientific advances and technological changes in the darkest moments of the Cold War. Throughout the 1950s and into the 1960s, the ASAP had helped the Army take advantage of rapid developments in science and technology. Moving forward, the ASAP increasingly would be called upon to respond to social changes affecting the Army.

3

C

Chapter

THE ARMY SCIENCE BOARD AND THE ARMY RENAISSANCE

As the U.S. engagement in Southeast Asia wound down in the early 1970s, Army leaders looked ahead to the challenges facing the service. The war in Vietnam had both reflected and exacerbated social, economic, and cultural divisions within American society. During the 1970s and into the 1980s, the ASAP would play an important role in the service's post-Vietnam transformation, and the work of the ASAP broadened to include a wide range of organizational and personnel issues.

A critical issue for the ASAP in the early 1970s was the Army's transition from a draft-based force to an all-volunteer force. In grappling with these complex issues, the Army turned to the social sciences. In April 1971, the chair of the ASAP formed an ad hoc group to evaluate the Army's existing social science program. The subsequent report highlighted gaps in the research agenda and emphasized the need for the Army to improve its understanding of human behavior. The report also concluded that in combat zones, the Army needed a more nuanced understanding of the social and psychological effects of its military operations on combatants and on civilian bystanders. Knowledge of cultural differences could also facilitate better relationships with allied nations. At home, the report suggested that targeted research to anticipate human behavior could "help the Army to function more smoothly as an institution." It also highlighted interpersonal conflicts, youth culture, drug abuse, and race relations as areas in need of special attention.

The ASAP conducted studies addressing personnel issues, and in August 1972, the panel published a report, *The Modern Volunteer Army*. With antimilitary sentiment among young people at a high level, the Army found it difficult to attract a sufficient number of men and women to enlist. Army leaders faced a dilemma: to fill the ranks of the all-volunteer force, they needed large numbers of recruits, but they also sought to maintain high standards by attracting individuals with "intellectual prowess." In response, the report returned to the importance of social science, recommending the creation of new institutional structures to support a sustained social science research program that could routinely survey Army personnel. Army leaders could then create policy safe in the knowledge that they had the backing of a majority of soldiers. To cultivate public goodwill, the report also suggested that the Army publicize its vast contributions to civil society. As examples of the Army's notable achievements in supporting its soldiers and the public as a whole, the ASAP cited the fact that the Army operated daycare centers and had made great efforts to find a cure for equine encephalitis. In short, a robust effort to enhance the Army's brand could help to mitigate the challenges in recruitment.

In 1974, the ASAP conducted a study on predicting soldier success. Members of the ad hoc study group visited Fort Ord, California, and Fort Jackson, South Carolina, questioning drill sergeants and company and battalion commanders about how to attract the most satisfactory recruits and how to deter those with the potential to cause problems. The preliminary report gained the approval of Secretary of the Army Howard H. Callaway. He was especially interested in the group's observation that recruits enlisted without a full understanding of what it meant to join the Army. According to Callaway, Army leaders needed "to develop some imaginative ways to give the new enlistee a good picture of Army life prior to the time [they] actually begin formal training." The panel implored the Army to support emerging social science research methods as a way to more easily accomplish its goals at home and abroad, to make itself a more socially cohesive institution, and to better predict (and respond to) the prevailing attitudes of the American public.

Around the same time, driven by the combined political fallout of the war in Vietnam and the Watergate scandal, Congress began to enact a series of "good government" reforms designed to increase public trust in official institutions by making government more transparent. In 1974, legislators passed amendments to the Freedom of Information Act, which increased citizens' powers to view official documents. Although the good government initiatives did much to reform the federal bureaucracy in the 1970s, they also affected the operations of advisory boards such as the ASAP. By the early 1970s, some 3,000 boards and their 20,000 members were operating at a cost of $75 million per year to the taxpayer. In the wake of high-profile political scandals, many elected representatives looked at these quasifederal organizations with unease. Congress sought clearer regulations to guard against representatives of industry seeking to influence government policy unduly through advisory boards, and to reduce perceived wasteful spending.

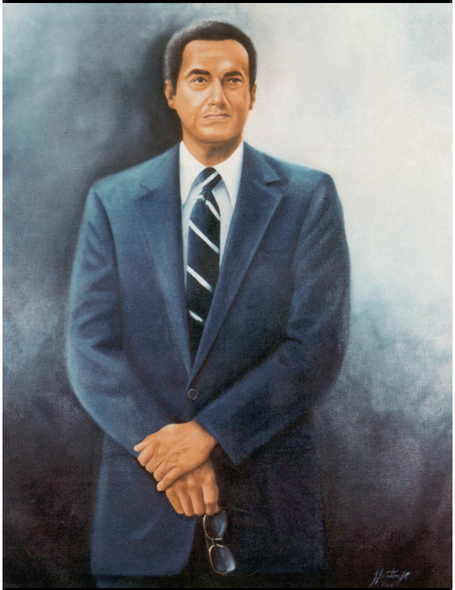
On 6 October 1972, Congress passed the Federal Advisory Committee Act. The act established a process by which members of the public could learn the number, purpose, membership, and activities of committees that offered advice to the president or to federal agencies. It required that membership of advisory boards be "fairly balanced in terms of the points of view represented and the functions to be performed." Boards, which previously had operated in relative secrecy, were now required to announce their meetings in the *Federal Register*. Boards would have to keep minutes, and their corresponding agencies would have to provide financial records of their activities. The law also established policy regarding financial conflict of interests among board members.

The effort to make civilian advisory boards more transparent and more relevant continued under President James E. "Jimmy" Carter Jr. Carter appointed Clifford L. Alexander Jr. as secretary of the Army, the first African American to hold the position. With a passionate interest in the social, cultural, and economic challenges in American society known as "human issues," Secretary Alexander oversaw the final transition of the Army into an all-volunteer force, which he keenly supported. He paid special interest to the issues of race and gender in the Army. He criticized the prevailing view on recruitment, which had surfaced in several ASAP reports in the early 1970s, that stressed the necessity of finding "high-quality" recruits. He argued that such a subjective category could serve as a way to exclude qualified recruits of color—many of whom saw the Army as a stable career path and means to social mobility.

Alexander brought his reform to the Army in other ways. In June 1977, he added acquisition to the responsibilities of the assistant secretary of the Army for research and development. The assistant secretary also assumed responsibility for the ASAP. Alexander had a new vision for the panel, one that started with its name. In November 1977, the organization became the Army Science Board and received its charter under the FACA. The board took up the activities of several related Army science bodies, including the Ballistic Missile Defense Research Scientific Advisory Committee, the Tank Automotive R&D Command Scientific Advisory Group, and the Scientific Advisory Group of the Missile Command. Retaining its ad hoc group structure, the membership of the ASB was set at a maximum of thirty permanent members and up to sixty associate members, formerly known as consultants. They would serve two-year terms. As with the ASAP, remuneration was not considered to be a driving factor for participation in the activities of the board. Though members

Secretary of the Army Clifford L. Alexander Jr.

Clifford L. Alexander Jr. served as secretary of the Army from 14 February 1977 to 20 January 1981. During his tenure, the Army Scientific Advisory Panel was redesignated the Army Science Board. Secretary Alexander's commitment to shaping a more inclusive Army led to the ASB conducting research in a wide range of social science issues. After his service to the Army, Alexander served on the boards of several national corporations.



Secretary of the Army Clifford L. Alexander Jr., by *Germain Green Glidden.*
(U.S. Army Art Collection)

could opt to receive per diem, reimbursement for travel expenses, and the daily salary of a GS–15 civil servant, Alexander hoped that board members would regard their service as "a patriotic privilege as well as a duty."

These organizational changes clarified the administrative structure of the ASB. An ASB secretariat would provide administrative support to meetings and membership, and provide "long-range direction to the ASB's participation in the Army's research, development, and acquisition program." The secretariat was to consist of four members: an executive director, assistant executive director, an executive secretary, and one staff assistant. In accordance with FACA requirements, the executive director would be the designated federal employee of the ASB. The ASB executive director would also serve on the executive review board, which determined "problem areas," and assessed requests for study and analysis.

In its new form, the ASB would be an open and approachable institution. "Problem areas for ad hoc committee consideration will originate from all parts of the Army," the *Army Research and Development News Magazine* reported in January 1978, "from laboratory commanders to commanders of major Army units in the field." Potential topics might include narrow technical problems or "broad concepts for new systems." Meeting these diverse requests would "encourage [ASB] members to suggest new and innovative solutions to Army problems." In line with the terms of the FACA, Army Regulation 15–8 published on 15 August 1979 defined the official process for requesting that the board organize a study.

With these long-term goals in mind, the ASB began to take shape. The initial order of business was to recruit new members. Secretary Alexander sought to increase the diversity of the Army, and the ASB was no exception. Joseph H. Yang, an immigrant from Taiwan, became the ASB executive director, and two women, Irene C. Peden and Rhoda Baruch, became members of the board. Peden would continue her involvement with the ASB for many years and in 1986 became the first woman to serve as ASB chair.

Joseph H. Yang

Joseph H. Yang came to the United States from Taiwan as a student in 1960. After receiving a PhD in electrical engineering from Johns Hopkins University in 1968, Yang worked in many civilian positions and within the U.S. government. During the Carter administration, Yang played a key role in preparing the ASB to meet the challenges of the late Cold War period.

Alexander sought to raise the ASB's profile within the Army, the DoD, and the wider federal government. If the board could recruit several members with impressive credentials and resumes, their combined prestige could work "to increase visibility and enhance understanding of the scope of ASB advisory services." It was around this time that Yang approached Neil Armstrong. The world-famous astronaut and test pilot had left the federal government to work as the director of the Institute of Engineering and Medicine at the University of Cincinnati. Yang asked Armstrong to join the reformed board, citing its creation as a "significant step [in] implement[ing] President Carter's pledge to the American people to streamline the Federal Government." Armstrong's expertise could go a long way toward delivering on this promise. Armstrong—ever the patriot—wrote that he "would do all that is reasonably possible to be a fully productive member of the Board." In March 1978, Secretary Alexander officially approved his nomination to the ASB, and Armstrong's name appears prominently on the first list of board members. By the following June, however, Armstrong had walked back on this earlier commitment and officially withdrew his nomination in October 1978, citing a further complication. "Although it was not my intention to accept compensation for board work," he wrote, "it was clear that board members are considered government employees and are bound by all the constraints inherent in that status." He found himself unable to commit to this arrangement.

The ASB nevertheless began the year auspiciously in its new form. On 2 March 1978, Secretary Alexander addressed the first meeting of the board at the Pentagon. He declared that Army leaders now had a duty to listen to what the ASB had to say. "The Army needs the best expertise available," he said, as well as "recommendations on what it should do and not do." The conception of the ASB as the Army's honest broker on R&D became a common refrain at its first meeting, mirroring the role of the ASAP. Echoing Alexander, Under Secretary of the Army Walter B. LaBerge announced that what the Army needed was "the ability to stand back and look at ourselves." The board provided that capacity. "We encourage you to look deeply at us, [and] not only at your area of interest," he told members. For Percy Pierre, the assistant secretary of the Army for research, development, and acquisitions (RDA), the ASB could serve as the Army's "alter ego." He encouraged members to pen "Dear Percy" letters to him, delivering hard truths on the elements of the Army that needed urgent attention.

Another major topic of discussion at the March 1978 ASB meeting was the Total Army concept. Whereas the Army had fought the war in Vietnam with only a token mobilization of the reserve components, the Total Army would better integrate the Army National Guard, the Army Reserve, and the civilian work force with the Regular Army. Vice Chief of Staff General Walter T. Kerwin Jr. addressed how the ASB could help deliver upon the goals of the Total Army. First, the "future development goal" was the board's natural domain, as members spent their time tackling the long-term challenges facing the Army, from organizational issues to weapons development. In a time of budget cutbacks, the ASB could help the Army to allocate its resources judiciously. In supporting the Total Army's "readiness goal," the board could help to facilitate closer integration by developing smarter communications technologies that outpaced advances in the field of electronic warfare. For Kerwin, board members could help improve training by "design[ing] equipment . . . sophisticated enough to meet the needs of today's battlefield, yet simple enough that the average soldier can learn to operate it with minimum strength." And lastly, the ASAP already had spent the past few years focusing on the Total Army's "human goal," working through issues like recruitment, retention, and morale, and this work provided a solid foundation for ASB studies.

The second meeting of the ASB in 1978 was a "key issues" conference, in which members prioritized the challenges facing the Army. Given Secretary Alexander's interest in issues of equality and social justice, it came as little surprise that one of the first ASB studies that came out of this conference was on human issues. Assistant Secretary Pierre appointed a Human Issues Transition Committee to decide whether the ASB "was a practical and desirable mechanism for reviewing and evaluating Army personnel research and developing human and sociological forecasting." In its investigation, the committee interviewed senior Army leaders, including Secretary Alexander. Many were interested in how the ASB could help the Army anticipate future social and cultural issues.

Like Alexander, interviewees were equally concerned with the issues of race and gender. The Army's chief public affairs officer, Maj. Gen. Robert B. Solomon, noted the changing face of the all-volunteer army. "Younger soldiers create a new set of problems," he noted, citing one specific example: "What provisions should be made for fifteen or sixteen year old wives left alone while their husbands are on maneuvers in the force in USAREUR [U.S. Army Europe]?" These comments prefaced the Army's growing concerns for the family, later the subject of an extensive ASB study in 1989. For her part, Jill S. Wine-Volner, the Army's first female general counsel, noted that traditional gender stereotypes affected women working in nontraditional roles. The Army had failed to consider, for instance, changes in equipment design to accommodate female soldiers.

Wine-Volner also highlighted policy challenges that the Army needed to confront. As more women joined the ranks, for example, how would the Army handle the issue of pregnancy? When asked to recommend potential members of the ASB who could speak to these issues with some authority, Wine-Volner suggested a law professor at Columbia University named Ruth Bader Ginsburg—an expert on gender discrimination and women's rights. Even though the board never managed to recruit the future Supreme Court justice, the fact that the Army considered seeking her views on the issue shows the extent to which Alexander's reforms had transformed the ASB.

In May 1979, the Human Issues Transitional Committee concluded that the ASB could play an important role in helping the Army respond to social and cultural challenges. In response to the report, the board's chair added several more social scientists to the ranks of the board. He also appointed three separate ad hoc groups to produce a combined report on human issues—one on personnel and manpower, one on policy research, and one on mapping and modeling strategies. In its final report, the three human issues ad hoc groups recommended that the service create a high-level personnel advisory council in Headquarters, Department of the Army (HQDA). They also provided a framework and guidelines to evaluate the Army's existing social scientific research program.

During the 1980s, ASB members continued the board's commitment to social science and to human issues. Army leaders and the ASB were aware of the changing definitions of the traditional family unit. This evolution posed new challenges for the organization, necessitating flexible policies and adaptable social services. Army Chief of Staff General John A. Wickham Jr., who served from 1983 to 1987, sought a practical method to track the Army's progress in this area. He appointed an advisory task force of ten experts in the fields of family and wellness policy. This task force subsequently became an ad hoc subgroup of the ASB, whose members met with Army leadership to share their insights on education, skills training, and community engagement. Between 1984 and 1986, the task force provided eighty-seven recommendations to improve the Army's family programs. These policy statements dealt with everything from physical education to spousal abuse and substance addiction.

In 1987, ASB members made trips to Army posts around the world to inspect families' living conditions and to get a sense of local needs. Barbara Pate Glacel—a human resources consultant—visited several Army installations in South Korea. Glacel's trip coincided with an official policy statement by General Louis C. Menetrey, commander of U.S. Forces Korea, which pledged to treat deployed families better. Official Army policy had long sought to discourage soldiers from bringing their spouses with them to Korea, and only a comparatively small number of "command-sponsored" families could use military housing and schools. Glacel noted that much like Army posts at home, "installations in Korea lack resources, volunteers, and facilities for offering a full range of family programs." The majority of non-command-sponsored spouses were Korean, many of whom continued to live locally with their own families. They received limited assistance from the Army, with no access to schools, healthcare, or other facilities on post. This arrangement raised difficulties, especially when the soldier's deployment ended and the spouse and children journeyed to the United States for the first time. "Many children speak no English," Glacel reported, "and are unprepared for American schools." Near Camp Pelham, Glacel also found twelve non-command-sponsored American wives. These women were married to enlisted soldiers and many had small children. They lived in stark conditions off post in one-room apartments with cold-water taps and no indoor toilets. For Glacel, these women were "akin to the pioneer women of America." They "instill[ed] the values of family and society into the Army community even at remote sites."

Glacel's report spurred interest in commissioning a wider ASB study. ASB chair Gilbert F. Decker asked her to head an ad hoc group on the Army family in April 1988. The terms of reference for the new group held that it was "appropriate for the ASB to ask whether the goal of the [Army Family] White Paper is being realized: that of increasing the bonding between the family unit and the Army community to create a sense of interdependence." Members would study the Army Family Action Plan, analyzing if it "continued to carry [forward] the philosophy of the White Paper." They also would interview

Army leaders, analyze demographic data in order to judge emerging trends, and visit various Army posts, including in Europe.

The group's report found some Army families living in difficult conditions, without adequate transportation or healthcare, just as Glacel reported seeing in Korea. The group recommended that unit leaders be educated about Army services so that they could better assist soldiers and their families. "Family and community quality of life programs provide the job conditions that, when not present, result in dissatisfaction among employees and soldiers," the report concluded.

After the study's publication, Lt. Gen. Allen K. Ono, the deputy chief of staff for personnel, wrote to Army Chief of Staff General Carl E. Vuono to laud its conclusion "that unit readiness and soldier retention are significantly enhanced by quality of life programs." The ASB report helped strengthen Ono's hand in securing adequate funding in the budget breakdown. The ad hoc group ultimately made thirty-two specific policy recommendations on how the Army could serve families, from spousal employment to better management training for new enlistees. By June 1990, the Army had implemented seventeen of these recommendations and the remaining fifteen were at varying stages of implementation.

Even as the ASB was establishing itself in new areas of research, the Army as a whole also was undergoing a period of technological change. In the context of the Cold War, Vietnam had been a distraction from the Soviet threat. For nearly a decade, innovation in the Army had focused on problems specific to Vietnam. In that space, the Soviet Union began to make gains in weapons development. After the war, the U.S. military endured budget cuts, much as it had after previous conflicts. Senior Army leaders prioritized investment in a modernization program that could deliver the next generation of weapon systems to match the Soviet threat. The most important procurement programs came to be known as the "Big Five:" the M1 Abrams tank, the Bradley fighting vehicle, the Apache helicopter, the Black Hawk helicopter, and the Patriot air defense system.

At the ASB's March 1978 meeting, development of the Big Five was one of the topics. Lt. Gen. Donald R. Keith, the deputy chief of staff for research, development, and acquisition, told the board that, although the Army had not yet fielded these systems, the relevant technology had advanced since they had been designed. "In the next five years," General Keith noted, "we must be thinking of modifications which could improve the effectiveness of these weapons." Keith's predictions proved correct. In 1980, the ASB formed an ad hoc group on vertical lift technology. In the terms of reference, Assistant Secretary Pierre asked members to consider which "areas should be pursued to preclude recurrence of technical problems as encountered in the Blackhawk and AAH [Advanced Attack Helicopter] programs." The group received fifty briefings, reviewed over a thousand pages of written material, and engaged in dialogue with the leaders of commercial rotorcraft companies. In its subsequent report, they noted that since the 1970s, the United States had been unable to maintain superiority in helicopter technology, citing technological developments in the Soviet Union, France, and Italy. The group recommended that the Army dramatically increase budgets for helicopter research.

The report also acknowledged that the Black Hawk and Apache helicopter programs were examples of the benefits of the Army maintaining close interagency partnerships, with much of the research carried out in coordination with NASA (National Aeronautics and Space Administration). "The effort to truly integrate the assets of these organizations has been highly successful," it concluded, "and should be furthered." In September 1980, NASA director Robert A. Frosch wrote to Assistant Secretary Pierre that he had reviewed the ASB study and found it to be a "valuable and timely critique of general interest to NASA." Frosch requested that members of the ad hoc group visit NASA headquarters to brief him personally on their research.

New security problems also came to the board's attention. In November 1979, a group of Iranians stormed the U.S. embassy in Tehran, taking dozens of American personnel hostage. The ensuing hostage crisis became a leading example of the unconventional security threats that the U.S. military faced abroad. At the assistant secretary's request, the ASB formed an ad hoc group to assess the Army's capability to respond to terrorism. The subsequent report, published in 1982, noted that the once "distant, foreign problem" of terrorism was quickly becoming more prevalent, from airline hijackings to targeted attacks on U.S. military installations abroad. The Iranian hostage crisis, and especially the failed rescue mission in 1980, had made the Army "[appear] impotent, capable of only inflicting nuclear carnage." The board concluded that the Cold War's bipolar confrontation had become "an ambiguous multi-actor game" in which the United States faced threats from multiple nation states and non-state actors. The report recommended a thorough systems analysis to determine the costs and benefits of the Army broadening its operations in counterterrorism.

Despite these unconventional perils, the Army's senior leaders focused on the Soviet threat during these years. As part of this effort, the service revamped its operations doctrine. In 1983, the ASB's chair organized an ad hoc group to evaluate the new AirLand Battle doctrine as a future warfighting concept. The group recommended that the Army's Training and Doctrine Command (TRADOC) conduct game analysis on AirLand Battle by April 1984 to assess its combat effectiveness. It also recommended that the service extend the target date for implementation of the doctrine in recognition of the limitations in Army modernization programs. As the report noted, this broader timeframe would help the Army better integrate commercial developments in the fields of computers and new materials into its weapon systems development, which would both improve capabilities and lower operating costs.

The ASB's analysis of doctrine was part of the decision of Army senior leaders to alter immediate funding priorities in the early 1980s. To overcome the numerical superiority of the Warsaw Pact nations, the Army determined that it needed to concentrate R&D efforts on technologies in which the United States already had an edge. They identified "Five Thrusts" for priority treatment. These included a sensor program called Very Intelligent

Surveillance and Target Acquisition, advanced battlefield communication networks, smart munitions, artificial intelligence, and biotechnology, including new vaccines and injury treatments. The deputy chief of staff for RDA, Lt. Gen. James H. Merryman, told the ASB that the Army desperately needed assistance with technology for "seeing deep, kill[ing] deep, and [providing] the requisite command, control, and communications needs."

AirLand Battle both directly and indirectly shaped the contours of many ASB studies in the 1980s, especially those that focused on modernization. For example, the ad hoc group on artificial intelligence and robotics noted in 1982 that artificial intelligence could contribute to the Army's advantage in the continuous combat envisioned by AirLand Battle. Artificial intelligence could also "introduce confusion into the enemy battle plan and disrupt its forces." Moreover, even though the state of technology in the 1980s did not allow for full autonomy, designs that incorporated robotic elements working in conjunction with a human operator could become more independent and capable through improvements in artificial intelligence products. In much the same way, the 1983 report *Acquiring Army Software* highlighted how weapon systems were becoming more reliant on software and computers to integrate systems hardware. The report prefaced a dawning realization about the importance of computing to the Army's activities, especially its ability to respond swiftly to crises.

Work related to the acquisition of new systems and advanced technology did lead indirectly to problems for the ASB. The presence of members from industry, who had expertise in understanding complex systems and development programs, raised congressional concerns that the board was not fulfilling its obligations to disclose conflicts of interest and provide objective assessments. In November 1983, the House of Representatives Committee on Government Operations released a report that revealed 25 percent of the ASB members of critical panels on new technology were employed by or had financial interests that could influence the panel recommendations. In addition, the report noted that uniformed military personnel had played a role in writing ASB reports, and in one case had served as a member on the panel.

Another challenge for the ASB was the desire of senior officials to utilize scientific expertise to refine heavily politicized programs, such as acquisition. In the summer of 1988, the board reviewed the quality and effectiveness of Army testing at the request of the assistant secretary of the Army for research and development. During the 1980s, the development of the Bradley fighting vehicle was the subject of numerous congressional hearings and negative news reports that alleged that Army weapons testing was flawed. After a series of interviews with testing personnel, policy reviews, and examinations of testing facilities, the ASB concluded that the Army needed to make improvements to ensure the objectivity of testing. A particularly critical finding was that problems had occurred largely because of "pressures to shortcut the process by deviating from stated Army T&E [Testing and Evaluation] policy." The use of ASB to conduct studies on Army processes and report on the effectiveness of ongoing programs was a major shift that would bring the ASB's work into closer contact with ongoing Army institutional functions.

The use of the ASB during the 1970s and 1980s was reflective of a larger overall evolution of the Army. During the period from the end of the Vietnam War to the waning of Cold War tensions in the late 1980s, the Army had made dramatic progress in efforts to develop a sound doctrine, field effective weapons, and better train personnel. The ASB had contributed greatly to this progress by providing insights and expertise that helped shape a professional, volunteer force capable of using highly advanced equipment. Moving into the post–Cold War environment, the ASB would need to continue to engage, coordinate, and support the transformation of the Army as the world entered the digital age.

4 C Chapter

THE END OF THE COLD WAR AND NEW SCIENCE MISSIONS

The end of the Cold War led to new missions for the Army and a reshaping of the ASB's research focus. A wide range of threats, from global terrorism to regional powers like Iraq, required a more diverse and flexible response. The board worked to help the Army become more flexible and deployable by utilizing new technology, while also helping to keep the service connected to changes in American society.

Two early examples of new trends in ASB areas of study are the 1988 study on water supplies in the western United States and a 1990 study on the impact of AIDS (acquired immunodeficiency syndrome) on an Army deployment. The 1988 study on water noted that environmental concerns needed to be assessed and integrated into Army policies, and particularly in the comparatively dry western United States, water resources needed to be protected and scientifically managed. The 1990 study on AIDS found that the Army "should fully evaluate the medical, physiological, psychological, performance, operational, and command issues which accompany the retention of HIV [human immunodeficiency virus]-infected soldiers in active and reserve units." Both environmental and medical issues would have been far removed from the original fields of study in the 1950s, but as the needs of the Army evolved, so too did the ASB.

In 1989, the Berlin Wall came down, and within two years, the Soviet Union had dissolved. The Cold War was at an end, but the Army soon found itself engaged in another conflict. In August 1990, Iraqi forces invaded Kuwait, seizing control of the small nation's key oil fields. By January 1991, the United States had assembled the largest international coalition since World War II, and the allies began a joint operation to expel the Iraqi invaders. In March 1991, Assistant Secretary of the Army for Research, Development, and Acquisitions Stephen K. Conver tasked the ASB to study logistical support and strategic deployment during the Gulf War. The liberation of Kuwait was a "logistician's war," the ad hoc group concluded, with the coordination of forward-deployed troops and pre-positioned stocks in an operation far from the continental United States. The Army had lived down any residual doubts about Vietnam. "The value of the all-volunteer Army," the group wrote, "was confirmed by the excellent performance of Army personnel in meeting that challenge." The conflict had also tested the Army's next generation of weapon systems and its new warfighting doctrine. The Big Five proved to be immeasurably important in ground operations, and Army commanders also efficiently executed joint operations, in line with the precepts of AirLand Battle.

At the same time, ASB members were involved in the study of another "war"—this one taking place on the home front. In January 1990, the board formed a group to analyze the potential usefulness of Army systems and technologies in waging the so-called War on Drugs. Army leaders wanted to know whether it would be feasible for law enforcement agencies to use the communication and information collections systems, surveillance sensors, and chemical and biological detectors in ways "other than their intended, 'conventional' roles." After the publication of the report, members of the group took the unconventional step of writing directly to Secretary of the Army Michael P. W. Stone in November 1990 to provide their opinions of the War on Drugs, beyond the study's official terms of reference. There was no coherent national strategy to the operation, they argued. Instead, agencies fought individual wars, "jealous of prerogatives, and thus [were] unable to interact with others to provide a synergistic effect to the total effort." In contrast to the well-funded and highly organized drug cartels, federal government efforts lacked funding and interagency coordination. The Army was a national resource, they told Stone, which should be used "in a variety of imaginative ways." There was no constitutional barrier to its involvement in counternarcotics efforts. "We fully understand the current pressures from the Middle East," they wrote, in light of the buildup of troops and materiel in the Persian Gulf, "but this war on drugs is at least as large, as important, and as chronic." The group members were prepared to see the Army commit troops to both crises—in Kuwait, to ensure "fair access of fuel and commodities" for the United States, and in the War on Drugs, to deny "access of those poisons that will otherwise destroy [the nation]."

Even as it produced reports on conventional and unconventional wars in the early 1990s, the ASB began a series of studies that dealt with the individual soldier, as the Army's greatest resource. These reports dovetailed with the focus on the Army family in the late 1980s. In 1991, the ASB convened an ad hoc study group on the concept of the "Soldier as a System." The group's members compared the RDA process for soldier materiel with other weapon systems in order to apply the fast-paced advances of technology and science to the soldier—or, in the words of the report, "to [move] the soldier of today to the enhanced capabilities of the future." In the end, the report recommended that Army leaders create specific roles within the R&D process to facilitate a Soldier Modernization Plan. Much like the Big Five, "soldiers need to be managed as a system," they concluded.

Working in the same vein, the Army began to consider how the aggressive application of emerging technological innovations in the 1990s could benefit the individual soldier. The primary driver of the technological revolution of the 1980s and 1990s was the microchip, whose ever-smaller size and ever-greater capacity made it possible to manage huge quantities of information and transfer data at the speed of light. For example, an ASB ad hoc group evaluated the ongoing adaptation of computer simulation technology to training and readiness requirements. Training costs placed such a heavy burden on the Army budgets, and the use of simulators was a cheap and innovative alternative. Army leaders instructed the group to study the "realism" of simulated exercises to the trainee. The subsequent study drew upon an earlier 1988 ASB report on close combat training and simulation. With the implementation of the Intermediate Range Nuclear Forces treaty and other arms-reductions efforts, the ASB concluded that the potential use of conventional forces was likely to increase. More than ever, soldiers needed the best preparation for combat. In the mid-1980s, the Defense Advanced Research Projects Agency had developed SIMNET, a wide area network for real-time virtual combat simulation. On a visit to Fort Knox, Kentucky, in March 1988, ASB members observed cavalry units training on SIMNET, which they later described as "an alternative to training in the field at Fort Bliss—an opportunity that fell victim to the budget ax."

Surveying SIMNET and the other advances in simulation technology, the 1991 report on simulation strategy implored the Army to invoke the idea of the "Electronic Battlefield"—by which it meant "a single, comprehensive simulation environment which can support combat development, system acquisition, test and evaluation, training, and mission planning and rehearsal." Simulation technology was a useful and cost-effective addition to the Army's training repertoire, but it was still too tentative and fragmentary. Instead, they implored Army leaders to adopt the Electronic Battlefield as a "constantly evolving system" with great benefits to training and readiness. By 1997, the secretary of defense had established a Defense Modeling and Simulation Office, and funding for simulations quickly reached $500 million a year.

Like simulation, the Army also sought to take advantage of the digital revolution of the late 1990s by embracing new developments in distance learning as an alternative training strategy. In March 1997, the ASB convened an ad hoc group to study how the Army's geographically dispersed units, spread over a thousand separate locations, could benefit from distance education facilitated by technology. The traditional training regime of residential education—in other words, bringing soldiers to the Army's Combat Training Centers—was, according to the assistant secretary of the Army, "a pervasive, continual process which consumes a huge amount of resources." Though an Army Distance Learning Plan was already in place, the ASB found that it "intellectually perpetuat[ed] the traditional teaching paradigm of an instructor presenting material to an assemblage of students at a prescribed time." Embracing the recent advances of the Internet, ASB members found that "training could be provided locally at a time convenient to the Soldier as well as his commander with TDY [temporary duty assignment] and per diem costs greatly reduced." For the 10 percent of soldiers stationed outside the continental United States, distance learning would be even more revolutionary. The report estimated that a robust program could save the Army $114 million a year and over 10,000 work hours. Although the study would play an important role in the evolution of training strategies, one member of the ad hoc group, Allen F. Grum, later recalled that "If we had done [it] five years later, I think people would have said, 'That's right . . . We need to do that.'" The Internet was just getting started, he added, and while distance learning eventually would catch on, it was an example of the ASB working too far ahead of the curve.

Aside from force digitization in the 1990s, Army commanders also were keen to ensure that the Army continued to attract highly educated recruits. With a growing economy increasing competition for young college graduates, the Army anticipated recruiting deficiencies in science and engineering by 2000. Army leaders believed that women and minorities, whose college acceptance rates continued to grow, could fill this gap. Commanders needed to adopt creative strategies that would steer promising scientists and engineers from these groups toward the Army. One of the ASB's signal studies of the 1990s was a report on improving Army support for science and technical fields at Historically Black Colleges and Universities/Minority Institutions (HBCU/MIs). In 1988, the Army awarded 5.3 percent of its contractual outlays to HBCU/MIs, exceeding the 5 percent federal target. The 1992 ASB report recommended that the Army bolster this investment, establishing several research centers to focus on a single emerging technology of key interest to the Army. A HBCU/MI would take the lead in directing the research at these centers and four or five others would act as feeder schools into the program, supplying faculty, researchers, and students. In the year after the ASB published its study, two new Army Centers of Excellence were opened in Information Sciences and Training Research, each headed by HBCU/MIs, and the Army worked to pour resources into other promising ventures with these institutions.

A challenging issue for the ASB in the 1990s was assessing the Army's structure and effectiveness while budgets were decreasing sharply. With the end of the Cold War, the "peace dividend"—significant cuts to defense spending after a major conflict—led to a reduction in the size the of the Army. The ASB initiated several studies to assess the impact of personnel reductions and budget cuts on the Army scientific community. One example of this new dynamic occurred in the spring of 1995, when an ASB study of Army analytical agencies concluded that the Center for Army Analysis (CAA) appeared "to be at or below critical analytical mass in certain functional areas," due to personnel reductions. As a result, the ASB study found that "the future of Army analyses may be in jeopardy due to the offloading of key infrastructure tasks such as: study and model documentation, verification and validation activities, mentoring and recruiting of junior analysts, and reduction in cross training of analysts to provide backup or surge capability." After reviewing the study, Walter W. Hollis, the deputy under secretary of the Army, wrote to Vice Chief of Staff General Ronald H. Griffith, reminding him that the previous vice chief had set staffing floors for several Army research organizations, such as CAA, and that personnel strength had been cut below these mandated levels. Though the ASB's involvement in difficult questions such as personnel strength levels presented a challenge to the board, its objective assessments of the Army's programs provided decision-makers with accurate information from which to make policy.

In 1999, Army Chief of Staff General Eric K. Shinseki stressed the need for the Army to quicken the pace of its transformation into a post–Cold War force. The ASB would be heavily engaged in this line of effort. As Shinseki stated in June 1999, “heavy forces must be more strategically deployable and more agile with a smaller logistical footprint, and light forces must be more lethal, survivable, and tactically mobile.” Army planners envisioned an “Objective Force” that would be able to field a combat-ready brigade anywhere in the world in four days and a division in five days. Technology would be a critical aspect of this effort, with computers and communications networks being integral to the Objective Force concept. This bold program would require the rapid introduction of new concepts and technology, and the ASB conducted multiple studies on the Objective Force during General Shinseki’s tenure. These studies were difficult for the ASB because rather than bringing scientific concepts to improve Army operations or promote the development of new technology, the ASB was being asked to provide more specific ways to meet a predetermined, fixed objective.

A good example of the impact that the Objective Force concept had on the ASB was the production of the study report *The Objective Force Soldier/Soldier Team*, released in November 2001. The terms of reference for the study were extremely detailed, and specified that the ASB must “characterize the level and nature of lethality, survivability, logistical and information systems for command, control, communications and computer improvements that must be achieved to yield a more effective Objective Force Soldier across the operational spectrum.” In addition, the ASB had to “evaluate connectivity/interface between Future Combat System variants and the Objective Force Soldier.” This guidance placed the ASB in the difficult position of projecting future developments across a broad range of technological, operational, and even logistical fields. Another complicating aspect of the study was the inclusion of multiple retired senior military officers on the study team, with two of the three chairs being retired general officers. The result of this atypical study was a series of recommendations that were largely in line with preexisting Army policies and the statements of senior Army leaders, rather than the innovative (and sometimes provocative) outside-the-box assessments that the ASB had produced in the 1970s and 1980s.

The Cold War had ended, but new concerns emerged that would require the ASB’s expertise. It helped the Army adapt to a quickly changing technological and geopolitical context. All the while, Army commanders continued to focus on soldiers—their education, training, and readiness—as the Army’s most important system. ASB efforts to help the Army adapt and improve after the Cold War would be severely tested early in the next century as new wars required its expert advice and assistance.

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Chapter

THE ARMY SCIENCE BOARD IN THE NEW MILLENNIUM

The turn of the twenty-first century brought new challenges to the ASB. The terrorist attacks of 11 September 2001 reordered Army priorities. By late 2003, the United States was embroiled in counterinsurgency campaigns in Afghanistan and Iraq. Just as the ASAP during the late 1960s addressed issues in Vietnam, the ASB mobilized to provide technical and scientific solutions to the battlefield situation in the Middle East. Among its tasks was an order to evaluate the development of strategies and technologies to counter the increasing use of improvised explosive devices (IEDs) by militant groups in Iraq. Later, in the 2010s, the ASB would work closely with many elements of the institutional Army, as doctrine and priorities shifted to address the challenge posed by near-peer competitors such as Russia and China.

An early demonstration of ASB's ability to assess the operational concerns of the Army during operations in Iraq was a study of intratheater logistics in U.S. Central Command in 2004. The assistant secretary of the Army for acquisition, logistics, and technology (AL&T), Army Materiel Command (AMC), and the deputy chief of staff, G–4, cosponsored the study. During operations in Iraq, problems with logistics distribution and asset visibility had burdened unit commanders. In addition, difficulties with water production had further hampered logistics operations by requiring the transport of bottled water over long distances. The study recommended revising the organizational structure of the joint command to include a Joint Logistics Commander. Another key recommendation was that Theater Distribution Center organizations were required in a joint environment to handle logistics during reception, staging, onward movement, and integration. Although logistics issues would remain a challenge during Army operations in Iraq, the detailed assessments and highly focused recommendations of the ASB provided critical information to Army policymakers.

Another example of the ASB's topical and operational study efforts began in February 2005, when Assistant Secretary of the Army Claude M. Bolton Jr. requested the board to conduct a study of IEDs and other asymmetric threats. By 2004, roadside bombs had caused significant casualties in Iraq. Bolton instructed the ASB to recommend strategies to predict, detect, prevent, and neutralize their use. Owing to the urgent nature of the request, the broad terms of reference instructed the ASB to examine historically similar situations, technical candidates to counter IEDs, and integration of possible solutions into the Army. One member of ad the hoc group, Steven E. Kornguth, professor of neuroscience at the University of Texas at Austin, recalled meeting with members of the Israeli and British intelligence communities who convinced him that "intel was an absolutely critical element of the defeat of the terrorists." Based on their own experiences, "technology had enormous limits." That said, the group found some potential technical solutions. In a progress report on the study, the group surveyed various technological breakthroughs in airborne and ground surveillance, including remotely operated aerial and ground vehicles that could detect IEDs. A two-part ASB study in 2009 examining the use of Predator drones later carried this research forward. Members also received strong recommendations for the acquisition of a "buffalo-like vehicle" [a specialized mine protected transport] from South Africa, as well as platforms with a V-shaped hull that would protect against ground blasts. In February 2006, after the publication of the ASB report on IEDs, the DoD formed the Joint Improvised Explosive Device Defeat Organization (JIEDDO). In three years, the budget for the counter-IED project expanded from $100 million to $3.6 billion—though some observers have questioned the overall effectiveness of the JIEDDO initiative.

The conflicts in Iraq and Afghanistan placed great stress on the Army's force structure, and the ASB played a role in assessing its effectiveness. The Army had been examining a modular force structure since the end of the Cold War, and

Site Visits

Members of the ASB frequently visit Army installations as part of the study process. Briefings and demonstrations of new technology and scientific advances made in Army laboratories and research centers can help ASB members accurately assess programs and policies. The numerous research and acquisition facilities at the Aberdeen Proving Ground in Maryland are a frequent destination for ASB members.

Engineers demonstrate their R&D initiatives in battery testing and power technologies at Aberdeen Proving Ground, Maryland.
(Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance and Reconnaissance Center)

the issue became especially salient owing to the demands of the wars in Iraq and Afghanistan for rotational brigade-sized forces. The Army transitioned from a division-based to a modular brigade-based force structure beginning in 2004. An ASB report in January 2007 found that this conversion suffered from a lack of focus on readiness and other measurements. Personnel shortfalls in modular units, particularly the necessity for additional personnel to support software, network management, and remotely operated systems, were also an area of concern. The report concluded that the Army needed to adjust modularity plans and programs to address these shortcomings.

A key development in many of the studies conducted in the 2000s was that board members made a concerted effort to understand Army operations and the ASB established closer contact with the operational Army to gain a better sense of the Army's challenges and key issues. For example, in March 2008, an ASB study team met with soldiers from the 1st Cavalry Division to gain insights from personnel recently returned from Iraq. Soldiers were optimistic that by sharing their lessons from combat, they could improve Army policies. As one officer noted, "The Army Science Board members are very well in tune with what's going on in the Army and their feedback and recommendations will prove invaluable for future operations." Visits to Army installations and units would also help ASB members, many of whom might not have served in the military, understand the culture of the Army.

Another challenge in adjusting the ASB study process to ongoing military operations was balancing the transparency required by the FACA and military security concerns. By the mid-2000s, the ASB had greatly restricted

Frank H. Akers Jr.

Frank H. Akers Jr. served as ASB chair from 2005 to 2011. During his tenure, the Army was heavily involved in operations in Iraq and Afghanistan, and the ASB worked on a wide range of issues related to combat operations. Akers is a retired brigadier general who served in Vietnam and later received a doctorate in history from Duke University. Prior to his work with the ASB, Akers was an associate lab director at the Oak Ridge National Laboratory.

access to many reports because of the sensitive information in the materials. News organizations and other nongovernmental organizations such as the Federation of American Scientists utilized the Freedom of Information Act to request documents, but the lengthy review period, in conjunction with the repeated failure of the ASB to comply with FACA requirements to announce meeting schedules, led to criticism. Limited distribution of reports owing to security concerns also diminished the influence of ASB studies. One congressional staffer in 2006 remarked that "I'm trying to remember right now any Army Science Board publication or product that comes to mind and I can't think of any"—which was a clear indication that the board needed to reform and adjust its procedures.

At the same time, the Army adapted to changes at home after the 2001 terrorist attack and the possibility of further terrorism in the continental United States. In 2006 and 2007, the ASB produced a two-phase study on homeland security and the Army's role in supporting civil authorities. The study group convened in the wake of Hurricane Katrina, which had highlighted the need for the Army to respond not just to terrorism but also to environmental emergencies. "The nation expects the Army to address the full spectrum of national emergencies," the subsequent report declared. "How well can the Army fulfill this mission?" The report advised the secretary of the Army to seek to amend the DoD's official directive on military assistance to civilians "to allow consideration of the Army's unique civil support requirements and the associated resource implications." The DoD ultimately updated the directive in 2010.

While the board considered the civil-military effects of future natural disasters like Hurricane Katrina, it would later weigh the implications of another pressing environmental issue: climate change. In 2013, the ASB produced a report on the effects that a warming climate would have on Army operations by 2030. After reviewing scientific data and secondary research, the group interviewed experts from NASA, the National Oceanic and Atmospheric Administration, and the Department of Energy. They concluded that the warming climate would destabilize fragile states, driving population displacement and increasing pressure on urban areas. Climate change would increase the frequency, scale, and complexity of future Army operations. The ASB study found that climate change would negatively affect Army operations because the worst effects of environmental stress likely would occur in regions where local infrastructure was already poor. If the Army became involved in a conflict or intervention, "this situation limits or slows cross-country movement," board members wrote. The panel suggested that the use of remotely operated vertical take-off and landing vehicles would be more efficient than ground convoys. Another suggestion to compensate for degraded infrastructure was to reduce unit consumption of supplies, for example by recycling or purifying water rather than supplying water, thereby reducing transport requirements. Climate change would also reshape more routine Army activities, including training regimes. In warmer weather, units and individual soldiers would need to be lighter, consuming less resources and producing less waste. The study concluded that climate change would increase the requirements for Army humanitarian support operations.

Starting in 2010, the ASB faced an unexpected challenge from declining Army budgets that put the ASB in jeopardy. In that year, Secretary of Defense Robert M. Gates began an "Efficiencies Review," which specifically examined DoD advisory groups. These groups had cost a total of $30 million in fiscal year 2010, of which the ASB budget was $3 million. The 2011 Budget Control Act then led to large budget cuts to the Army. In response, HQDA conducted a thorough examination of ASB operations while searching for ways to reduce expenditures. The board's membership shrank from eighty in 2010 to sixty in

2012. After an extensive review of ASB research and analysis, and an audit of the board's operating expenses (which were $2.5 million in fiscal year 2012), HQDA determined that the ASB was functioning efficiently.

Reduced Army budgets also affected the ASB's work. One of the board's chairs from this period, James A. Tegnelia, wrote, "the ASB has factored into its analyses the fiscal realities of ongoing budget constraints. The ASB didn't recommend innovative ideas without understanding and acknowledging the major tradeoffs required with existing programs." Expecting budgets for the coming decade to be constrained, Secretary of the Army John M. McHugh directed the board to examine the service's portfolio of science and technology projects. Its report, released in February 2013, looked at two factors: mission effectiveness and anticipated budget reductions. The study determined that the Army lacked an effective science and technology strategy and investment plan that would meet likely future challenges, and noted significant issues that slowed the acquisition of new technology and hindered the Army's ability to foster innovation.

The board suggested that AMC's science and technology organizations should divest tasks not related to critical technologies, and emphasize "high-risk research on game-changing technologies." A key recommendation was that the Army needed to improve the recruitment and retention of highly qualified science and engineering professionals. A specific initiative discussed was providing laboratory directors with "direct hire" authority to be more successful in pursuing in-demand science and engineering graduates.

Organization	Must Do In-House	Should Support	Should Leverage
AMRDEC – Aviation	Evaluation of critical components (structural, ballistic protection, IR suppressors, ASE equipment) and flight testing.	Rotorcraft drive (gears, tribology, multi-speed) and active rotor technologies.	Alternative fuels, batteries, and energy storage technology. ★
AMRDEC – Missiles	Development of overt, high-bandwidth millimeter-wave/terahertz navigation radar and communication/data links.	Advanced electronic and opto-electronic materials and device fabrication.	Information sciences research relevant to Army missile system needs. ★
ARDEC	Munition systems technologies, including energetics (propellants and explosives), warheads (KE, SC, EFP), and fuzing.	Novel advanced high-performance materials for warheads and gun systems. ★	Hypervelocity impact research and technology developments. ★
CERDEC	Model development and validation for characterization/testing of imaging sensors (EO/IR, countermine, etc.).	Power systems R&D: electro-chemical, power electronics, renewable energy devices. ★	Image and signal processing technology. ★
ECBC	Advanced concepts in chemical and biological sensing and signaling, novel threat agent synthesis and characterization.	Chemical and biochemical computational methods based on processes in nature.	R&D in the areas of nano-technology, microfluidics, aerosols, and metamaterials. ★
NSRDEC	Advanced fiber and textiles, including smart, responsive, or other multifunctional types, for extreme environments.	Power technology for the individual soldier and small units.	Nanomaterials, fiber-reinforced composites, flexible displays. ★
TARDEC	Ground vehicle systems design tools, analysis (M&S), and testing; concept development, component integration, testing.	Unmanned ground systems technology, robotics technology. ★	Fuel economy technology (e.g., hybrid drive), water purification ★

★ reflects change from current state

Proposed changes in the Army's Research, Development and Engineering Centers in the ASB report The Strategic Direction for Army Science and Technology, 2013
(Army Science Board)

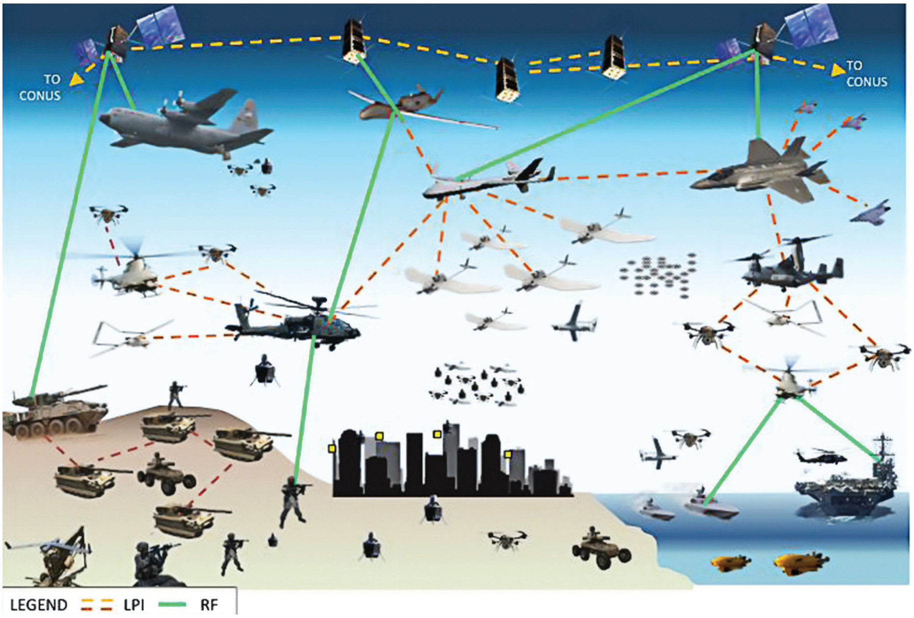
As part of a larger effort to refine and focus Army programs, in October 2013, Secretary McHugh transferred the responsibilities for the ASB from the Office of the Assistant Secretary of the Army (AL&T) to the Office of the Deputy Under Secretary of the Army. He expected that moving the board to the supervision of this office would allow for a more objective and professional analysis of Army programs.

Since the change, the role and scope of the ASB has continued to broaden, affecting numerous Army programs. Doctrine and strategic analysis became ever more important for the board as the Army shifted its focus from counterinsurgency to large-scale combat operations. In October 2016, the Army announced that a new doctrinal concept, Multi-Domain Battle (MDB), would be part of a larger effort to keep the service ahead of potential adversaries. Whereas AirLand Battle had allowed the Army to operate in two domains in the bipolar context of the Cold War, MDB also included space, sea, and cyber, as warfighting domains for the Army. The doctrine addressed the challenges of near-peer adversaries, like China and Russia, who have the capability to challenge U.S. military supremacy in one or more of these domains. In February 2017, acting Secretary of the Army Robert M. Speer instructed the ASB to form an ad hoc group on MDB to examine "how expanding and rebalancing the Army's focus on AirLand Battle . . . could significantly enhance tactical, operational, and strategic outcomes." The chair of the study group was Ronald M. Sega.

Ronald M. Sega

Ronald M. Sega is a retired major general in the Air Force, as well as a former Under Secretary of the Air Force. After receiving a PhD in electrical engineering from the University of Colorado, Boulder, Sega was involved in the U.S. space program, and flew on two Space Shuttle missions. Sega served on the ASB during the late 2010s and was the chair of a study on MDB.

The group spent five months meeting with Army organizations as well as agencies such as the Defense Advanced Research Projects Agency. The study's final report, released in January 2018, highlighted the development of emerging operational environments like the electromagnetic spectrum and cognitive battlefields, which had increased the uncertainty and ambiguity of warfare because of the greater complexity and the more rapid rate of technological change. The group recommended that the Army work with the joint community to formulate a DoD-wide strategy for MDB, including modeling, exercises, and experimentation. In its assessment of Army programs, the report criticized the caution in fielding these capabilities and the potential dangers of not moving more quickly, noting that "there appears to be resistance in several areas of the Army to the use of autonomous systems, but potential adversaries do not appear to share



The connections and integration of massively distributed "bots," from a 2014 Army Science Board report on Multi-Domain Battle.
(Army Science Board)

that reluctance." The report found that in the Army, "the assumed pace of technology insertion and availability is too conservative," and that changes were occurring much sooner than anticipated. In terms of technological possibilities, the study found "strong synergy among autonomy, artificial intelligence, and big data supporting MDB, which enables operational flexibility and increased options." Specifically, the study highlighted the possible benefits of a network of "Massively Distributed Bots," composed of remotely operated systems, modular networks, and decision-making tools shaped by autonomous or artificial intelligence components.

The board elaborated on many of its findings concerning MDB, with another report, sponsored by TRADOC, released in January 2018. Michael R. Macedonia, appointed to the ASB in 2015 and a West Point graduate with a PhD in computer science, chaired this Character of Future Warfare study group. The study group's task was to look ahead to the 2030–2050 timeframe and "identify solution strategies for capability development that the Army could initiate in the near-term," in order to gain a strategic advantage. One of its primary findings was that the Army's Centers of Excellence were doing good work and valuable research, but they needed to be better connected. Another finding was that manned-unmanned teaming would be vitally important and the service needed to prioritize investment in it across successive Program Objective Memorandums. The study emphasized that the Army would need to make "Big Bets" in key areas to maximize the utility of limited R&D dollars.

Evelyn M. Mullen

Evelyn M. Mullen is the associate director, threat identification and response at Los Alamos National Laboratory in New Mexico and contributed to many ASB efforts in the 2010s. After joining the ASB in 2014, she applied her expertise to numerous topics including battlefield uses of artificial intelligence, nuclear survivability, and modeling and simulation. She served as vice chair for the study *Internet of Things*. In 2021, she received the Civil Service Commendation Medal in recognition of her efforts.

Evelyn M. Mullen
(Los Alamos National Laboratory)

As part of its efforts to improve the service's responsiveness to technological changes, the board played a role in the creation of the Army Futures Command (AFC). Beginning in the early 2000s, the ASB had made recommendations for substantive changes in how the Army's R&D programs used science and technology to meet both current acquisition needs and prepare for future challenges. In the 2002 report *Human Robot Interface Issues*, it noted that "much formerly in-house Army R&D work has migrated to industry, with a consequent degeneration of government engineering muscle into bureaucratic gristle." The report found "pockets of solid technological capability in the Army system," but a lack of communication and interaction. In the 2006 report *Science and Technology for the Future Force*, the board recommended greater fusion of scientific, TRADOC, and acquisition personnel to reduce the impact of the Army's "stovepipe" organization where personnel worked exclusively within their chain of command, with little outside engagement. The report concluded that an office that could develop "cross-cutting" initiatives would help link programs and accelerate technological changes. In 2010, the ASB released a report that assessed the nine different groups or offices created to field new technology and address specific gaps in Army capabilities. The report concluded that these ad hoc organizations lacked the structure to be a coherent, institutionalized element of the Army that could address future capability gaps. In early 2014, the ASB produced a report, *Creating an Innovative Culture in the Army*, which found that many Army organizations relied on hierarchical cultures and resisted innovations developed outside their organization. In contrast, many successful business organizations worked to speed innovation by cultivating the ideas and talent of junior-level employees or adopting ideas from outside their organization. In 2013, the ASB released a report that suggested creating an organization that could promote and integrate prototyping efforts, accelerate technology insertion into key programs, and proactively demonstrate game-changing concepts.

The establishment of the AFC to modernize the Army by developing future force requirements, designing future force organizations, and delivering prototype materiel capabilities addressed these ASB concerns. The command's mission brings it into contact with a wide range of scientific fields, and a major element in its creation was the desire to create a workplace culture that was more open to lower-level employees and external organizations. ASB Chair Leonard W. Braverman participated in the formal review process for the AFC and the establishment of the AFC's cross-functional teams. The creation of AFC shifted the organizational alignment of the Army's research and testing organizations, and the U.S. Army Futures and Concepts Center realigned from TRADOC to the AFC. The Army redesignated the U.S. Army Research, Development, and Engineering Command as the U.S. Army Combat Capabilities Development Command and transferred it from AMC to AFC in February 2019. These changes sought to make the Army more effective in adapting to changing technology, and the ASB has worked closely with the AFC since it was established.

The late 2010s and early 2020s included significant changes to ASB operations and unexpected challenges. In August 2019, the ASB established the Chief of Engineers' Environmental Advisory Board Subcommittee as a permanent subcommittee. The Environmental Advisory Board had been

Leonard W. Braverman

Leonard W. Braverman served as ASB chair from 2017 through 2020. During his tenure, the ASB was heavily involved in the shift in Army strategy to near-peer competitors and the creation of the AFC. After receiving his PhD in electrical engineering from the University of California, Berkeley, Braverman worked for a number of electronics companies such as Universal Voltronics, Hipotronics, Maxwell Labs, and General Electric.

Army Science Board Chair Leonard W. Braverman (*center*) along with other members of the Army Science Board visit the Combat Capabilities Development Command, a subordinate unit of Army Futures Command. ***(U.S. Army)*** operating under the chief of engineers since 1970, examining environmental issues and coordinating environmental programs. The decision to realign the Environmental Advisory Board under the ASB would allow for better integration of Army environmental studies.

In 2021, Secretary of Defense Lloyd J. Austin III, shortly after taking office, ordered a "zero-based review" of all DoD advisory committees to align the focus of committees with strategic priorities and the National Defense Strategy. The secretary also directed the immediate suspension of all advisory committee operations until the review was completed. The review required each committee's sponsor to examine the business case for the committee and prepare a fact-based justification for continuation of the committee. On 2 September 2021, the DoD review board approved the ASB to resume operations. Later that year, Secretary of the Army Christine E. Wormuth reassigned the ASB from the Office of the Deputy Under Secretary of the Army to the Office of the Assistant Secretary of the Army (AL&T).

In the nearly twenty years after 9/11, the ASB played a significant role in key areas of Army policy, from the Iraq War to remotely operated vehicles to climate change. In accordance with the guidance of senior Army leaders, the ASB continued to facilitate technological, scientific, and doctrinal innovation.

Gisele Bennett

Giselle Bennett has chaired, cochaired, and contributed to numerous ASB studies including the Internet of Things (Chair) and the 2019 study Battlefield Uses of Artificial Intelligence (Co-Chair). She received her PhD in electrical engineering from the Georgia Institute of Technology and has expertise in optical imaging systems, supply chain technology, and decision support systems.

Giselle Bennett
(Army Science Board)

As the Army began to shift in the late 2010s back to focus on high-intensity conflict against a peer competitor, the ASB also shifted its focus, evolving to maintain relevance and utility in our ever-changing world.

CONCLUSION
"NEW FRONTIERS OF THE MIND"

The May 2020 charter of the ASB provides a mechanism by which scientific expertise can assist the Army into the future. It directed the board to provide independent advice and recommendations on matters relating to the Army's scientific, technical, manufacturing, acquisition, logistics, and business management functions; environmental and water resource management issues involving the Corps of Engineers; and other matters as determined by the secretary of the Army. As the U.S. Army has evolved, so has the focus of the ASB. As of 21 May 2020, the board had five permanent subcommittees to provide specialized assessments: Basic Science and Disruptive Technologies; Chief of Engineers' Environmental Advisory Board; Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance; Systems Engineering, Integration, and Sustainment; and Weapon Systems.

After nearly seventy years of evolution and adaptation, the ASB's organization and process has become efficient and deliberate. The board's annual study cycle corresponds with the fiscal year and runs from October

Marc A. Zissman, associate head of the Cyber Security and Information Services Division, Massachusetts Institute of Technology, speaks to a U.S. Army Cyber Command team.
(U.S. Army Cyber Command)

through September. In a typical year, it produces five studies, and these are completed when a quorum of current members vote to adopt the study findings and recommendations. The ASB also continues to provide the public with a better understanding of the Army and the future challenges faced in providing for the national defense. The board considers unclassified studies in sessions open to the public. A small support staff, working for the executive director, provides vital services such as travel coordination, security management, and information technology support.

The history of the ASAP and ASB sit at the heart of the Army's long relationship with civilian expertise—and with science itself. As the United States struggled to outpace the Soviet Union in technological advances in the 1950s, the ASAP helped to streamline the service's R&D program, making it easier for innovative ideas to progress from development to fruition. The establishment of the ASAP heralded the onset of the Army's visionary approach to R&D, finally delivering on President Franklin D. Roosevelt's 1944 call for the federal government to embrace the "new frontiers of the mind." The ASB later facilitated developments in fields as diverse as physics, chemistry, biology, environmental science, medicine, engineering, psychology, sociology, and management studies. It played a significant role in the evolution of Army doctrine and in the development of key weapon systems. Today, when private businesses conduct more R&D than the federal government, the ASB's role as a bridge between the larger scientific community and the Army has never been more important. Sixty-five years after the founding of the ASAP, the ASB maintains its essential position as the Army's senior scientific authority, spearheading innovation in technology and doctrine, all while maintaining a robust relationship with industry and academia. The exceptional quality of the people of the board, who have used their scientific expertise to assist the Army, remains the enduring foundation of the ASB.

George T. Singley III receives the Joseph V. Braddock Award from Secretary of the Army Mark T. Esper at the Army Science Board 2018 Fall Plenary.
(Secretary of the Army)

Appendix

Army Science Board Chairs

Jeffrey A. Isaacson	2021–
Leonard W. Braverman	2017–2020
James A. Tegnelia	2014–2017
George T. Singley III	2011–2014
Frank H. Akers Jr.	2005–2011
James A. Tegnelia	2004–2005
Joseph V. Braddock	2002–2004
Michael J. Bayer	1998–2002
Michael Frankel	1996–1998
Walter B. LaBerge	1992–1995
James Jacobs	1991–1992
Duane A. Adams	1990–1991
Dennis R. Horn	1989–1990
Gilbert F. Decker	1987–1989
Irene C. Peden	1986–1987
Wilson K. Talley	1983–1986
Richard A. Montgomery	1981–1983
J. Ernest Wilkins Jr.	1978–1981

Army Scientific Advisory Panel Chairs

Bruce A. Reese	1976–1977
Lawrence H. O'Neill	1971–1976
Harold M. Agnew	1966–1970
Finn J. Larsen	1965
Morrough P. O'Brien	1961–1964
Clifford C. Furnas	1960–1961
James W. McRae	1960
Richard S. Morse	1958–1959
Frederick L. Hoyde	1956–1957
James R. Killian Jr.	1951–1956

Abbreviations and Acronyms

AAH	Advanced Attack Helicopter
AFC	Army Futures Command
AIDS	acquired immunodeficiency syndrome
AL&T	acquisition, logistics, and technology
AMC	Army Materiel Command
ASAP	Army Scientific Advisory Panel
ASB	Army Science Board
CAA	Center for Army Analysis
DoD	Department of Defense
FACA	Federal Advisory Committee Act
HBCU/MI	Historically Black Colleges and Universities/Minority Institutions
HIV	human immunodeficiency virus
HQDA	Headquarters, Department of the Army
IED	improvised explosive device
JIEDDO	Joint Improvised Explosive Device Defeat Organization
MDB	Multi-Domain Battle
NASA	National Aeronautics and Space Administration
NDRC	National Defense Research Committee
NVA	North Vietnamese Army
OSRD	Office of Scientific Research and Development
PSYOP	psychological operations
R&D	research and development
RDA	research, development, and acquisitions
T&E	Testing and Evaluation
TDY	temporary duty assignment
TRADOC	U.S. Army Training and Doctrine Command
USAREUR	U.S. Army Europe

About the Authors

Joel M. Hebert is assistant professor of special collections and archives research and chief of special collections at the United States Air Force Academy. He previously worked as a historian at the Naval History and Heritage Command and at the U.S. Army Center of Military History. He holds a PhD in history from the University of North Carolina at Chapel Hill, where he trained in the field of British imperial history. His research interests cover the social, political, cultural, and institutional histories of the U.S. military.

Eric B. Setzekorn is a historian with the U.S. Army Center of Military History. After serving in the U.S. Army, he earned a PhD in history from George Washington University. He is the author of *The Rise and Fall of an Officer Corps: The Republic of China Military, 1942–1955* (University of Oklahoma Press, 2018). He has also written for the U.S. Army War College journal, *Parameters*, as well as Army University Press' *Military Review*.

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“The Army Science Board brings in a non-political perspective, based upon science and years of experiential learning.”

Leonard W. Braverman
Chair, Army Science Board, 2017–2020

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