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ENGINEERING MANHATTAN STYLE: SANDIA LABORATORIES AS AN EXAMPLE OF POSTWAR ENGINEERING*

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Introduction:

A great deal has been written about the history of science in America since World War II. Much of that work has explored the government's research and development establishment, focusing on the scientific community immediately after the war. It is generally argued that the apparent triumphs of the huge and expensive wartime research and development projects gave rise to a belief that scientific resources should be nurtured and kept on hand - ready to provide service in an emergency. The Cold War drive for more and better weapons further fed this belief, leading to a massive system of national laboratories, military laboratories, and defense industries. The science of this complex is built on extensive financial support, the central strategy of which is that by steadily, and occasionally even lavishly funding large research programs, you will have a constant stream of scientific ideas that can be applied to national security purposes. What is true of science, is also true, in slightly modified form, of postwar engineering. The story I want to tell you today is, I think, an example of the way Cold War engineering r&d for national security worked.

My example comes from the work of Sandia Laboratories. Sandia National Laboratories is one of the U.S. Department of Energy's national laboratories. It is managed by Sandia Corporation, a wholly-owned subsidiary of Lockheed Martin.

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DISCLAIMER

Sandia's primary mission has been, since its separation from Los Alamos in 1949, the ordnance engineering of nuclear weapons - that is, Sandia took the nuclear physics package developed by Los Alamos or Lawrence Livermore Laboratories and turned it into a weapon. That was almost exclusively the sort of work the Lab did for the first few decades of its existence. Over time, the work done in support of that basic mission has evolved into a variety of projects, some of which do not, at first glance, seem especially nuclear weapon-related.

Sandia grew directly out of the Manhattan Project. It started as a single division of Los Alamos that was moved to Albuquerque, New Mexico at the war's end. With the responsibility for procurement, stockpile maintenance, and improving the Fat Man design, it grew quickly until, in 1949, it was split off as an independent operation. AT&T was persuaded to take on the management contract, turning the operation over to its manufacturing arm, Western Electric.

Sandia's weapon design work included providing support for nuclear testing, as well as extensive field testing of non-nuclear components. This meant that, by the early 1960s, the Lab's capabilities included an array of nuclear blast measurement technology. That technological capability was expanded beyond the immediate realm of weapons design to two projects aimed at developing technologies to detect nuclear detonations. The first was designing components for satellites (known as VELA). The second project, and the one of interest to us today, was the Unmanned Seismic Observatory (USO) - a program to design stations that could detect underground nuclear burts. This work was done in support of the Limited Test Ban Treaty of 1963 and was sponsored by the

Advanced Research Projects Agency (ARPA) of the Defense Department. [ARPA will come up again - since this is a government story there are a lot of agencies involved and a lot of acronyms as a result. In general, I've tried to streamline this, to leave out some of the alphabet soup.]

Vietnam:

In 1965, Sandia got involved in research on the possibility of creating seismic sensors to be deployed in Vietnam. The project, known as COIN (for COunter-INsurgency) lasted until 1971. It relied on capabilities Sandia had developed in its nuclear weapons work, as well as its existing relationships with both the military and the integrated contractor complex to get the work done - and done quickly. Sandia's work on COIN demonstrates the institutional familiarity with work across the spectrum of defense-related efforts, and the resulting ability to find experts quickly and draw them into an effort that is characteristic of postwar R&D. Further, it demonstrates the strong faith in technological solutions for military problems. And it underlines some of the tensions apparent between government-supported research and private industry that has become a familiar theme of postwar science and engineering.

By the mid-1960s, the perception was widespread that support for the communist effort within South Vietnam was coming directly (and almost exclusively) from North Vietnam. Concern focused on personnel and materiel coming into South Vietnam from the North - crossing the Demilitarized Zone and moving down the system of north-south trails, particularly the system known as the Ho Chi Minh Trail.

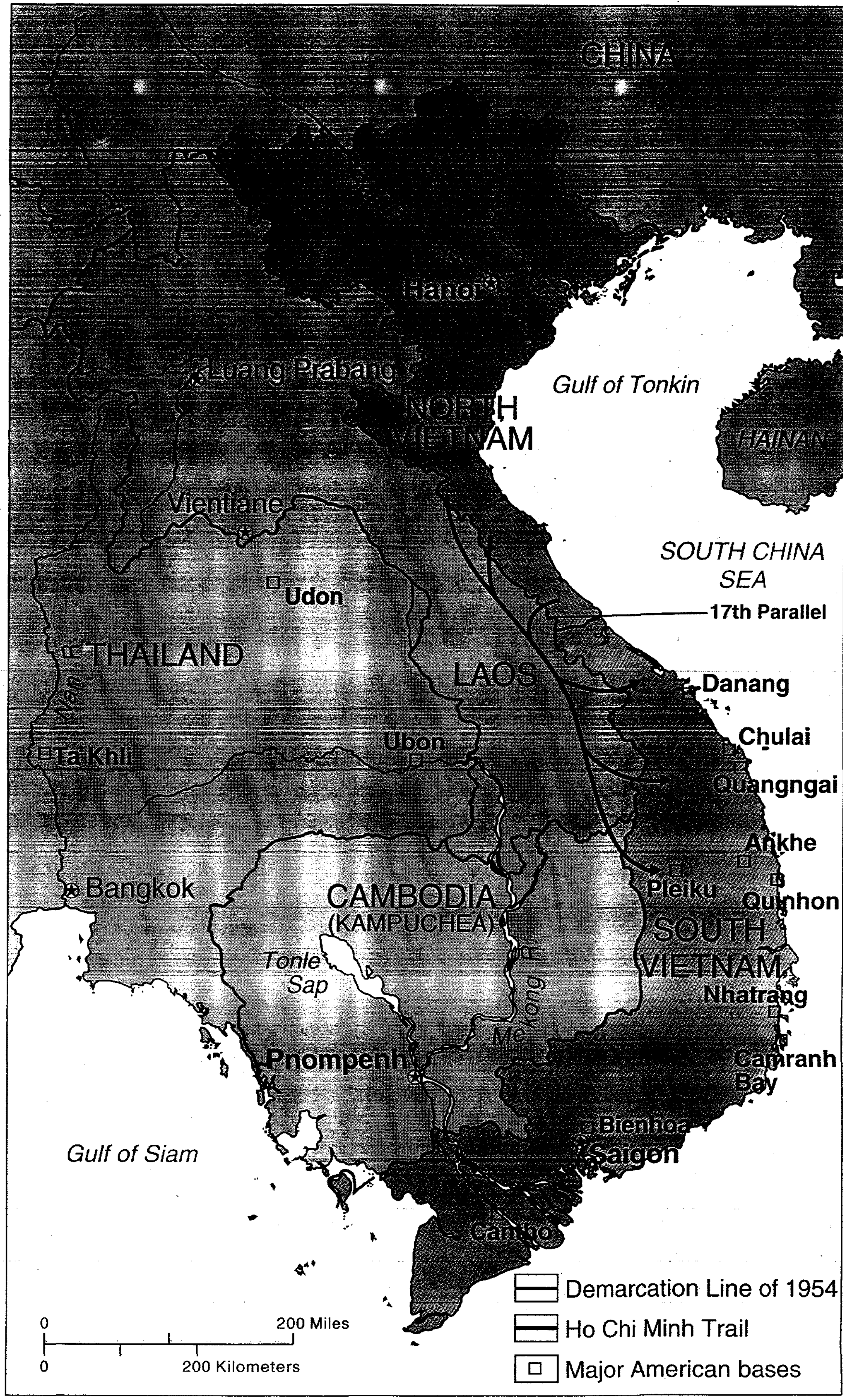
VIEWGRAPH OF MAP OF VIETNAM [Point out DMZ, some crossing there - also Ho Chi Minh Trail - not nearly so tidy as it looks here; it also extends further south. Problem is the flexibility of the enemy - can't just put up a roadblock - they'll go around.]

The Americans were having no success in slowing down, let alone stopping, that movement. The goal of the COIN project was to create devices that could aid in the detection of enemy forces. COIN was the general problem of ARPA.

<u>State of the Art</u>:

In November of 1964, ARPA director Dr. R.L. Sproull visited Sandia and checked on the progress of the Unmanned Seismic Observatory. He mentioned to H.H. "Pat" Patterson, a manager of the project, that much of ARPA's concern at the time focused on R&D for Vietnam. Patterson responded in January of 1965 with a letter suggesting that Sproull might find some of the Unmanned Seismic Observatory concepts useful. In particular, the Sandia group working on the technology for the seismic observatory had been frustrated by the fact that their prototype in the hills behind Sandia's facilities kept picking up seismic signals from workers' footsteps and from the traffic passing on the freeway below. Patterson thought this nuisance might be used to good advantage in developing a technology for use in Vietnam.

Patterson studied existing and developing technologies on seismic signals and then, in June of 1965, flew to Southeast Asia to get a firsthand look at Vietnam and to discussion COIN possibilities with the ARPA representative in Bangkok. This trip took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LAOS
Danang
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Mekong R.
Nhatrang
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Camranh Bay
Bienhoa
Saigon
Gulf of Siam
Cantho
Demarcation Line of 1954
Ho Chi Minh Trail
Major American bases
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200 Miles
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200 Kilometers

advantage of another Sandia program. Patterson went with a Sandia flight that was going to Australia to track an eclipse. [This was the Readiness Program - explain if anyone asks.]

After further discussion with one of ARPA's scientists, it seemed that Patterson's ideas might prove useful. ARPA agreed to pay for two Sandia staff members to explore the possibility of applying seismic measurement techniques developed for the Unmanned Seismic Observatory to Vietnam.[1] An ARPA order authorizing a "program of analytical and experimental research in seismic detection related to counterinsurgency applications" was issued July 16, 1965.[2]

The Technology

The sensors Sandia developed relied heavily on existing technologies brought together through the labs' existing capabilities. The initial goal of the program was to come up with some hand-implanted sensors able to detect a truck moving along the Ho Chi Minh Trail. The sensors were to be put in along the trail, and as a convoy passed it would set off the individual sensors in turn - indicating both the size and the speed of the group. The Seismic Intrusion Detector (SID) that resulted was a sturdy geophone with a radio link and data storage capabilities. It had to be put in place by a person, but once implanted would operate for about 45 days. The sensor sent its signals to a receiver at a ground location or on a plane flying overhead.

[1] Letter from R.L. Sproull to Glenn T. Seaborg, AEC, dated 30 April 1965, copy in COIN Collection, SNL Archives. Also letter from Glenn T. Seaborg to S.P. Schwartz, Sandia President, dated May 17, 1965, copy in COIN Collection, SNL Archives.
[2] ARPA Order No. 754, copy in COIN Collection, SNL Archives.

The geophone technology was modeled on those used by the oil industry in seismic exploration for petroleum. A geophone is made up of a magnetic circuit hooked to a small cylindrical case and a coil suspended by a low-frequency spring within the magnetic field. The case is stuck in the ground with, in the case of SID, a spike. When the surface shakes with seismic waves, the magnet moves but the coil stays still. The resulting effect is of a magnetic field moving past a conductor. The voltage generated is amplified and then recorded in a nearby data recording box.

If the SID were to be deployed in Vietnam, it needed to operate in a wide variety of terrain. Sandia conducted a series of studies to determine the seismic characteristics of human footsteps and human activities in different types of terrain. The goal was to come up with an idea of the different signals generated by, say, people walking through mud as opposed to dry, sandy soil, as well as the different signals generated by trucks on different soils in different climates. Studies were also done to compare different orientations of the components, as well as the seismic-wave propagation velocities in each type of terrain [to help determine the distance of the subject from the sensor].

There was also some debate as to whether the radio signal from the SID could penetrate the thick jungle canopy prevalent in some areas of Vietnam. Tests were done in jungle conditions in Panama [PotLid test area], to make sure the radio signal would make it through the thickest of jungle canopies. It did, about 90% of the time and that was deemed satisfactory.

Sandia was able to conduct tests frequently and quickly largely (according to Patterson) because of the labs' good relationship with the Air Force at Kirtland Base (where Sandia's New Mexico facilities are located). "The ready accessibility of military and chartered aircraft permitted execution of the tightly-scheduled aerial testing programs needed to meet pressing delivery deadlines."[3]

By April of 1966, experimental prototypes of SID were available and they were put through field trials in Thailand. Both ARPA and the military observers were pleased with the results.

JASONS

While Sandia was working on the SID prototype, there was another effort underway that, in the end, changed the direction of the sensor research, expanding both its purpose and its capabilities.

In the spring of 1966, a group of scientific advisors to the Pentagon, known as the Jasons, decided to take on the subject of counterinsurgency efforts for Vietnam in their annual summer study. The Jasons were a sort of annual 'think tank' made up of scientists - primarily academics - who met to discuss the application of recent science and technology to national security issues. The report they issued at the end of the summer of 1966, "Air-Supported Anti-Infiltration Barrier," focused on the infiltration from North to South Vietnam, across the DMZ and along the Ho Chi Minh Trail.

To cut off the traffic in these areas they proposed constructing a physical barrier across the southern edge of the DMZ, extending into Laos. It was conceived as an air-supported barrier - air-supported in that the monitoring and interdiction technologies

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[3] Jerry Wallace, "COIN Technology at Sandia Laboratories," draft in COIN Collection, SNL Archives, p. 26.

would be dropped from planes, the sensors would be monitored by planes, and bombing sorties would be sent in response to information from the sensors. The idea was to put the system into place within a year based on existing or nearly ready technologies.

Once Secretary of Defense Robert McNamara approved the idea of putting in a barrier system, it became known as 'McNamara's Wall' or 'McNamara's Barrier,' and sometimes as 'McNamara's Line.' The barrier system involved a variety of technologies other than the sensors, including mines, small noisemakers to trigger the sensors, as well as patrol, photo reconnaissance, and strike aircraft. Sensors were only one node in the barrier system and in counterinsurgency efforts in general.

In order to circumvent possible slowdowns in R&D on the barrier due to bureaucratic red tape and interservice rivalries, the Defense Communications Planning Group was formed in September of 1966 within the Department of Defense to create and deploy the technologies for the barrier system. This Group was to report directly to the Secretary of Defense and be able to cut through various interests in getting the work done.

Lt. General Alfred D. Starbird was appointed to head the Group. Starbird had previously been the head of the Atomic Energy Commission's Division of Military Application, working closely with Sandia and the rest of the national laboratories to coordinate lab and military capabilities.

Sandia was, in fact, very well-connected in the Defense Department's efforts to develop barrier technologies. In addition to Starbird, a former Sandian [Don Cotter] was heading up the Defense Research & Engineering efforts related to Vietnam. And

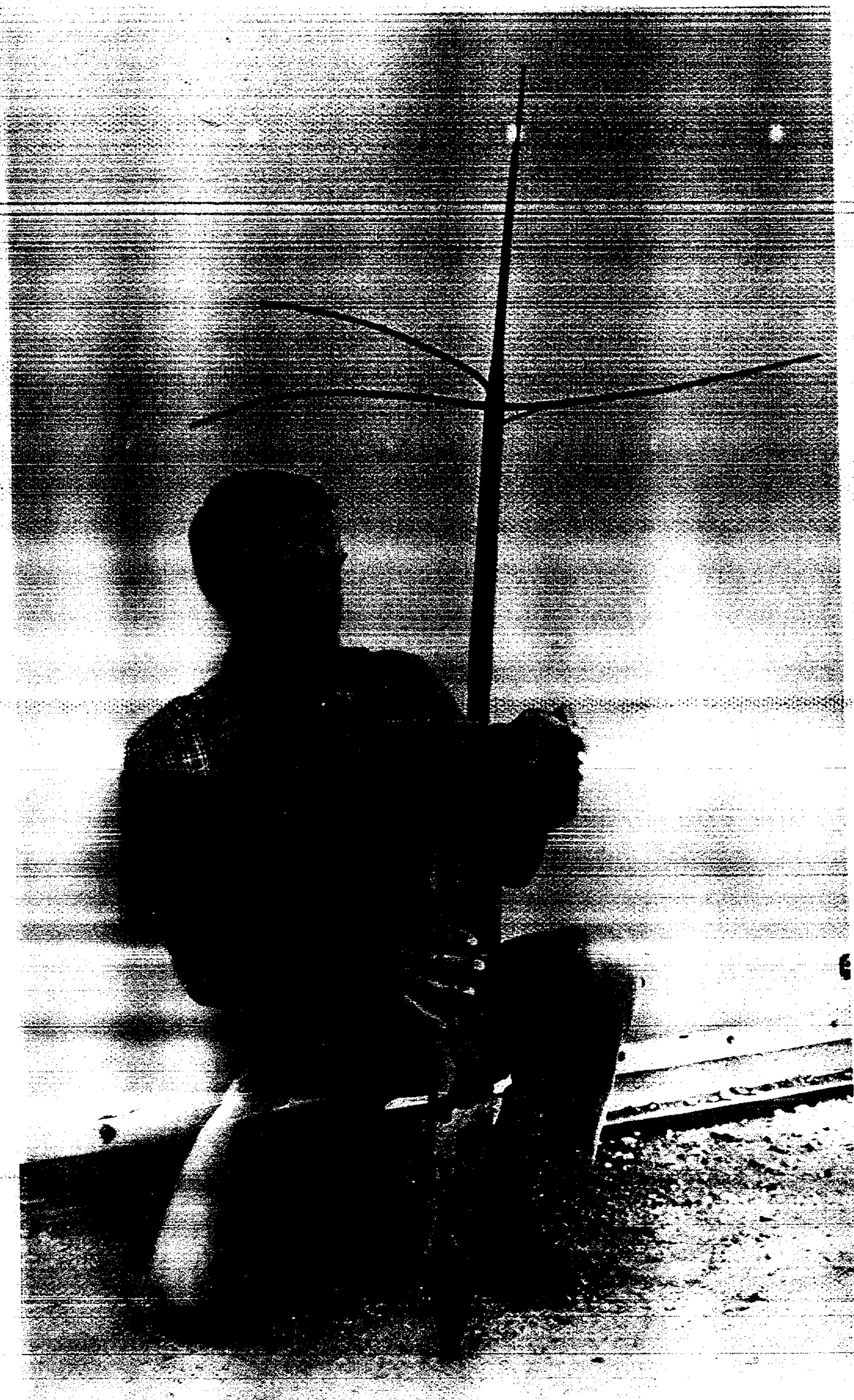
Sandians from the sensor program took turns serving as technical advisors to Starbird's new Group. This kind of institutional interconnectedness between the programs is, it seems to me, precisely the Manhattan Project outlook - knowing who does what and whom you can call on. Decide who would be best and get them.

Sandia shifted the emphasis in its sensor research as a result of the creation of Starbird's group and the pursuit of technologies for the barrier concept. The SID was a hand-emplaced device, but the barrier system proposed by the Jasons envisioned air-delivered sensors. In response, Patterson's group at Sandia came up with the ADSID (an Air-Deliverable Seismic Intrusion Device).

Viewgraph of Tom McConnell with ADSID [McConnell first Sandian to do a tour with the Defense Communications Planning Group]

ADSID had the same detection range as the SID - about 100 feet for people walking and 1,000 for vehicles. It was 31 inches long, 3 inches in diameter, and weighed about 25 pounds. Its fins had a span of 10 inches, and included 'terrabrakes' to prevent it from burying itself too far into the ground - the antenna needed to stay above the surface. The battery life of the device was about 45 days.

The air-deliverable requirement for the sensor brought Sandia's aerodynamics group into the loop. At the time, Sandia was pursuing research in a relatively new field known as terradynamics - this is an area pioneered by Sandia as it grew directly out of studies of nuclear weapons [the attempt to make earth penetrating nuclear weapons].



Terradynamics is just the study of dynamic earth penetration - how bodies pass through soil.

Viewgraph of Sensor Family (point out first ADSID, then later incarnations - including ACOUSID, adding an acoustic capability - the Jasons had envisioned acoustic sensors, Sandia stuck with seismic detection but did add an acoustic capability. Indicate suitability for different delivery systems.)

Viewgraph of Sensor in the ground (note camouflage)

Once the prototypes were available and tested, Sandia was expected to oversee the production of the devices. Sandia was not itself a production facility, but had a great deal of experience in procurement and in overseeing production. It had long-term relationships with a variety of defense suppliers and contractors, and sensor production took advantage of these existing capabilities.[4]

I don't want to dwell on the production aspects of the sensor story here, but I wanted to just mention the procurement situation, because it is the existing relationship that Sandia had with its suppliers and contractors that allowed for the speed of the deployment. For ADSID, procurement efforts began in January 1967 and deployment began in October of that same year. A strong attempt was made to focus on off-the-shelf

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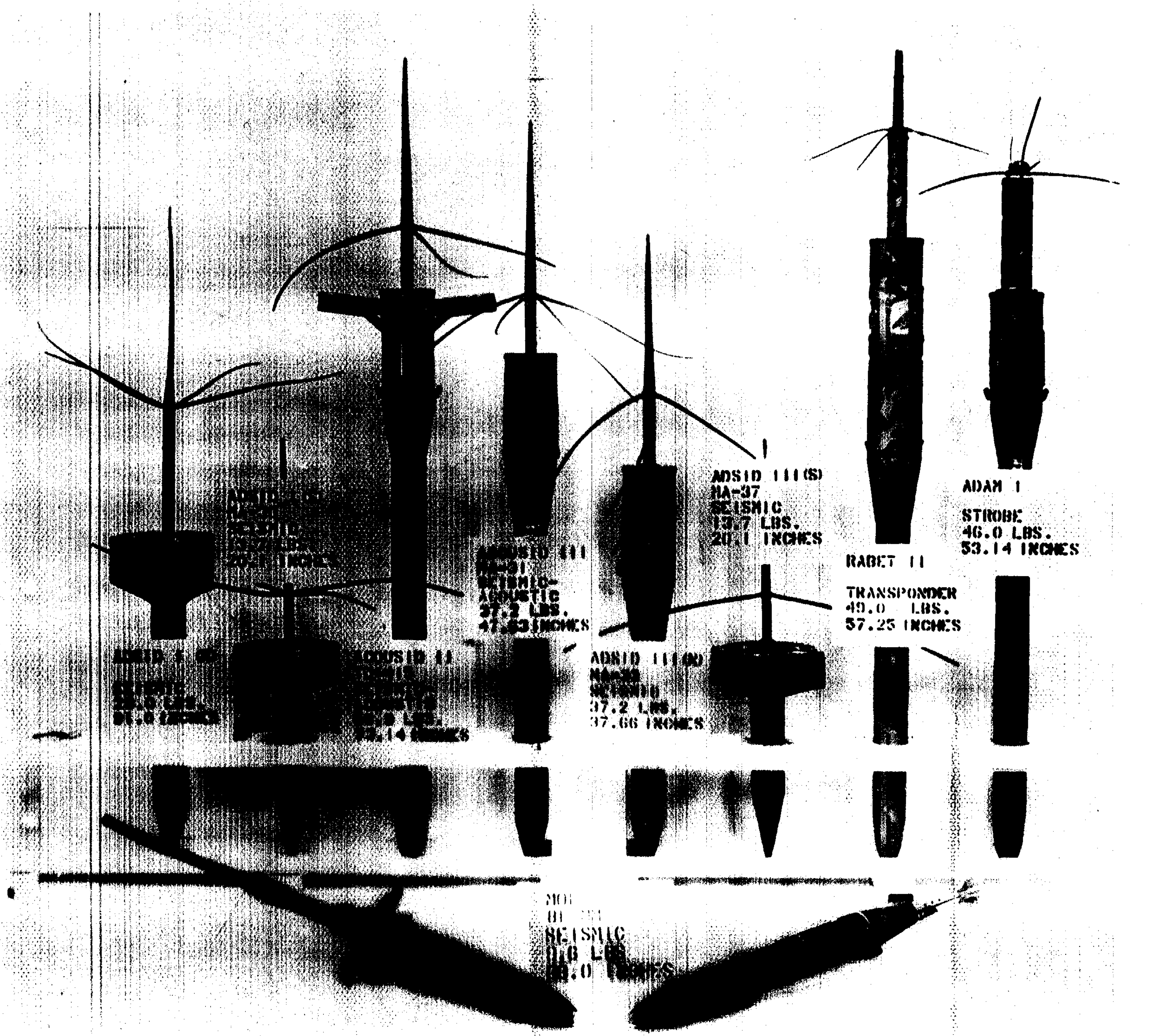
[4] Jerry Wallace, "COIN Technology at Sandia Laboratories," draft in COIN Collection, SNL Archives, p. 10.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ADAM I
STROBE
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RABET II
TRANSPONDER
49.0 LBS.
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ADSID 111
SEISMIC-
ACOUSTIC
37.2 LBS.
ADSID 111(M)
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capabilities - to turn to suppliers who were making components similar to those designed for the sensors. [emphasize engineering outlook here]

Once the sensors were deployed in the fall of 1967, both researchers and the military began to see results, with an ensuing evolution in uses for the devices. The barrier system, as conceived by the Jasons, was not fully deployed. A complete barrier was never built across the DMZ - largely because of military concerns over the manpower that would require and the static nature of such a fence. But sensors were sown along trails. They were used in other ways, as well. In particular, sensors were dropped around the perimeter of the Marine encampment at Khe Sanh and, during the months of the siege of Khe Sanh in the first half of 1968, were considered useful in fending off North Vietnamese troops. It is very difficult to know exactly what, if any, difference the sensors made, but several Marines, as well as Commanding General William Westmoreland, credited them with a significant role.

Westmoreland was enamored of the notion of the electronic battlefield and much of the response from the U.S. military in Vietnam was that more sensors should be used - and used in base perimeter and patrol defense. Westmoreland pushed the COIN efforts away from the barrier notion and more toward perimeter defense.

Wrap Up

Although ADSID was the real workhorse in the sensor world, Sandia continued its research into other types of sensors, as well as improvements to the monitoring systems that picked up signals from the sensors. There were personal sensors to be carried in the field, as well friendly patrol locators (devices attached to individuals sending out signals to indicate their presence).

There were other attempts around 1970 to spin the sensor work off into other, non-military areas. The US Border Patrol expressed some interest and testing was done along the U.S.-Mexico border. The Coast Guard also entertained the idea of using sensors in its ice penetration studies (1970- ice penetration tests in Alaska's Bering Strait).

In the long term, however, COIN was the root of later weapons-related work. Sensors really have become an area of expertise for Sandia - the lab has done a great deal of R&D for the services, and has also put a lot of effort put into technologies for monitoring special nuclear materials. Sandia has provided technical advisors to nuclear weapons reduction and test treaty negotiations and been heavily involved in developing devices for treaty monitoring and verification.

Conclusion

Bureaucratically and militarily the sensors are generally judged to have been a success. They were produced quickly and they worked. If they did not win the war, the services, when testifying before Congress, nevertheless credited them with saving American lives.

In all, Sandia oversaw the production of some 36,000 air-delivered sensors as well as a smaller number of hand-emplaced sensors during the course of the COIN program.

$30 million was spent through the lab on development while another $90 million went to production in industry.[5]

Sandia was not the only entity involved in the development of sensors for use in Vietnam, of course. There were both competing and complementary systems fielded by other parts of the defense industry - for example, RCA, Honeywell, Texas Instruments, and IBM were all active in sensor research.[6] Tensions sometimes arose over the perception that Sandia, a government laboratory, was competing with private industry. This tension seems inherent to the system of national laboratories working next to the private contractors that has existed in America since shortly after World War II. It is certainly a tension that continues today.

Sandia's participation, quick response, and style of approach to the problem of creating seismic sensors for use in Vietnam are direct reflections of the story we already know about postwar science. The national labs in general have their roots in the idea of having science at the ready. They have grown out of the belief that if you pay for ongoing research and create a stable institution for your ongoing research needs, then when you come to a problem you'll have ready-made problem solvers. And even more than that, you'll have people ready to help before you even know there is a problem. (Or, as one of Sandia's retirees puts it: "Invention is the mother of necessity."[7])

This story differs in some ways from the standard story of postwar science because Sandia is predominantly an engineering laboratory and it had not, by the mid-

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[5] Org. 1 Day Files - Jan-July 1986, SNL Archives.
[6] See Cannon, *The Superwarriors*, p. 298; the 1969 issue of the *Journal of Defense Research* devoted to articles on the Defense Communications Planning Group and seismic sensors for Vietnam; and the COIN collection in the SNL Archives.
[7] Dick Claassen oral history interview, SNL Archives.

1960s moved very far from its primary mission. As engineers, the Sandians who worked on the sensors came at the project with a strong faith in technological solutions[8] - indeed, Pat Patterson has said that he very much wanted to make a contribution to the war effort and that he saw an opportunity to do so in his work on sensors.[9]

As an established laboratory, Sandia was able to use its familiarity with the defense establishment and the integrated contractor complex to good advantage in creating the sensors. Because Patterson and his group were familiar with the labs' own resources as well as with the capabilities of its suppliers, they were able to move very quickly.

The technologies developed for Vietnam will, I hope, receive more attention by historians as the current declassification effort continues. I don't mean just studies of Sandia's work, of course, but of the technologies in general. These studies should shed more light on science/engineering/military relationships and the way weapons and other materiel were developed in the postwar period. They will also allow us a clearer understanding of the development of engineering in the second half of the twentieth century.

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[8] See Thomas Hughes, *American Genesis*, on faith in technology in the postwar world.
[9] In conversation with the author, DATE. See also COIN collection in the SNL Archives.