Rebecca Ullrich
History of Science Society Meeting
November 8, 1996
Atlanta, Georgia

BUILDING ON AND SPINNING OFF: SANDIA NATIONAL LABS' CREATION OF SENSORS FOR VIETNAM*

CONF-961112--1

Introduction

Today I'd like to talk about one piece of research I've been doing on Sandia National Laboratories' development of new technologies for use in the Vietnam War - specifically the seismic sensors deployed to detect troop and vehicle movement - first along the Ho Chi Minh Trail and later in perimeter defense for American military encampments in South Vietnam. Although the sensor story is a small one, I think it is interesting because it dovetails nicely with our understanding of the war in Vietnam and its frustrations; of the creation of new technologies for war and American enthusiasm for that technology; and of a technological military and the organizational research and development structure created to support it.

Within the defense establishment, the sensors were proposed within the context of a larger concept - that of a barrier to prevent the infiltration of troops and supplies from North Vietnam to the South.

All of the discussion of the best way to fight in Vietnam is couched in the perception that this was a different kind of war than America was used to fighting. The emphasis was on countering the problems posed by guerrilla/revolutionary warfare and eventually by the apparent constraints of being involved in a military action, not an

* This work was supported by the United States Department of Energy under Contract DE-AC04-94AL85000.

outright war. The American response was to find the right **technology** to do the job - to control the war by applying a technological tincture to its wounds and to make the war familiar and fightable on American terms. And, when doubts were raised about the effectiveness of applying existing technologies (namely, the bombing of North Vietnam and Laos), the doubters turned to new technologies. The sensors that were developed for use in Vietnam were a direct product of this sort of thinking - on the part of the engineers at Sandia who created the sensors, the civilian scientific advisors who recommended them, and, ultimately, the soldiers in the field who had to use them.

Vietnam

One of the problems reflected in the military discussions of the war is the puzzle of infiltration - how much movement was there from North to South Vietnam, what was its significance, and how could it be stopped? There was a strong belief on the part of the American command that infiltration from the North had to be stopped to stop the insurgency (the revolutionary effort) in the South. The two were almost synonymous with one another in the American reasoning. Under President Kennedy's administration, the focus had been on efforts to counter insurgency in South Vietnam through pacification programs and the Counter-Insurgency Program. Ultimately, decisions to bomb in North Vietnam and Laos were justified as necessary to stop the movement of troops and supplies southward (trying to hit supply stations in the North and bombing part of the trails in Laos). The attitude was that if support from the North were curtailed, a stable government would prevail in the South. Little distinction was made between the North

Vietnamese Army and the Viet Cong,[1] and, as a result, counterinsurgency and counter-infiltration are collapsed into the same thing.

So, 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 crossing the Demilitarized Zone and/or moving down the system of north-south trails, particularly the system known as the Ho Chi Minh Trail.

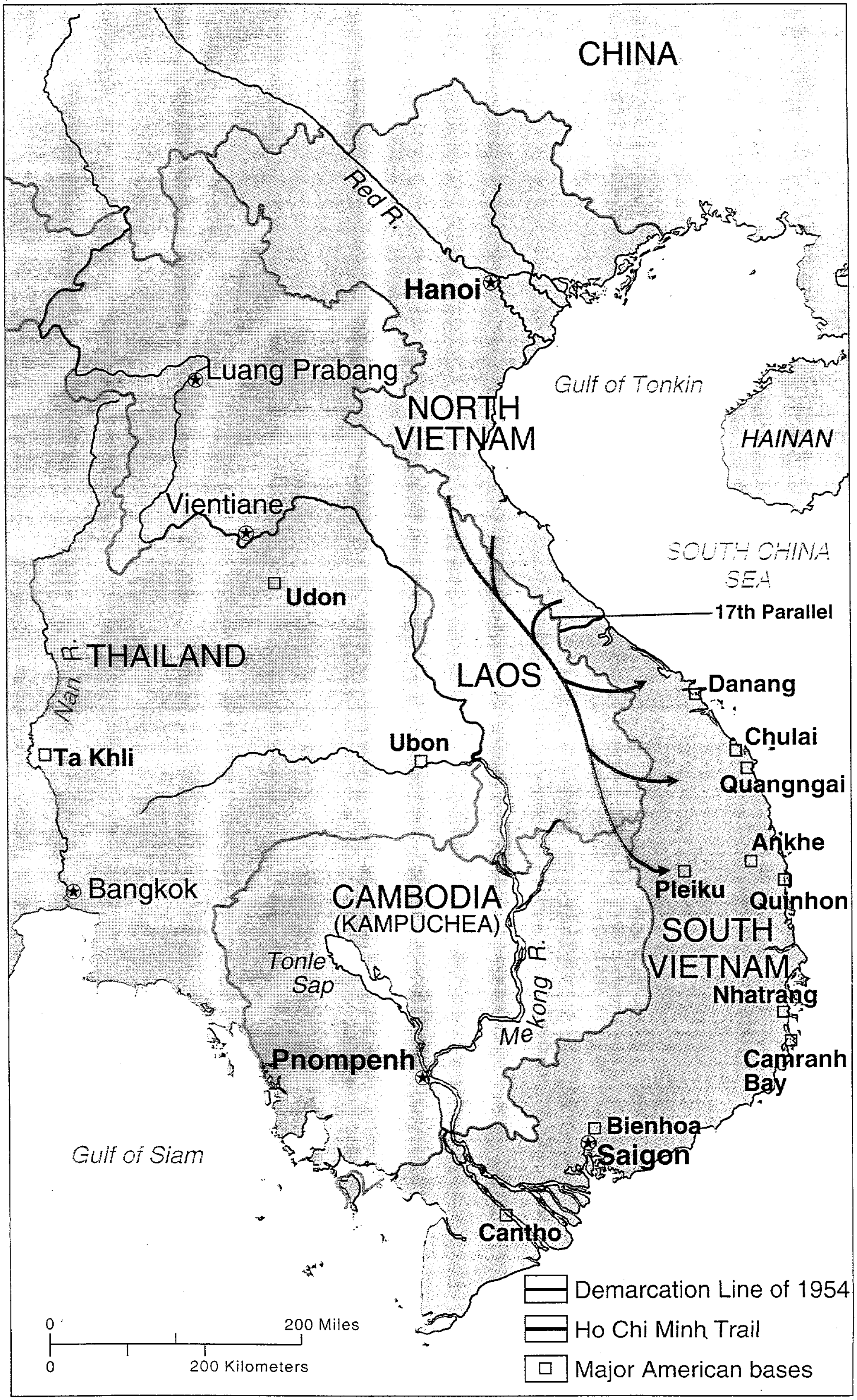
VIEWGRAPH OF MAP OF VIETNAM [Point out DMZ, some crossing there - also Ho Chi Minh Trail - not nearly so tidy as it looks here - enters Vietnam at several points; it also extends further south. Estimates of the number of infiltrators increased in 1965 and again in 1966-67.[2]

Re: Ho Chi Minh Trail "what began as a network of small trails was at war's end an enormous all-weather highway system, looping and backtracking to provide alternative routes to bombed-out sections for 9,600 miles."[3]

Problem is the flexibility of the enemy - can't just put up a roadblock - they'll go around - there's no single chokepoint.]

By 1966, some civilians within the Pentagon expressed doubts about the effectiveness of using bombing to stop the movement of troops and supplies southward. The idea of building a barrier to cut off the movement once it was underway (rather than trying to destroy the supplies before they began to move), was floated at the Pentagon,

[1] Marilyn B. Young, *The Vietnam Wars 1945-1990* (New York: HarperPerennial, 1991), p. 187.
[2] Marilyn B. Young, *The Vietnam Wars 1945-1990* (New York: HarperPerennial, 1991), p. 142.
[3] Marilyn B. Young, *The Vietnam Wars 1945-1990* (New York: HarperPerennial, 1991), p. 187.



CHINA
Red R.
Hanoi
Luang Prabang
Gulf of Tonkin
NORTH VIETNAM
HAINAN
Vientiane
SOUTH CHINA SEA
Udon
17th Parallel
THAILAND
Nan R.
LAOS
Danang
Chulai
Ubon
Ta Khli
Quangngai
Ankhe
Bangkok
Pleiku
Quinhon
CAMBODIA (KAMPUCHEA)
SOUTH VIETNAM
Tonle Sap
Mekong R.
Nhatrang
Pnompenh
Camranh Bay
Bienhoa
Gulf of Siam
Saigon
Cantho
Demarcation Line of 1954
Ho Chi Minh Trail
Major American bases
0
200 Miles
0
200 Kilometers

eventually reaching Secretary of Defense Robert McNamara. The proposal was to use a combination of fences, mines, listening devices, and personnel to physically block the entrances to South Vietnam. McNamara like the idea and sounded out the Joint Chiefs of Staff on it. They, and the officers in command of American forces in Vietnam, were less than enthusiastic. To accept the barrier idea would mean agreeing that the existing bombing effort was not effective, and they believed it was (or at least could be). It also might mean diverting resources from existing programs. Of course, it's not that they don't like the idea of new technologies - it is, rather, a disagreement over whose technology is going to be funded.

JASON

In the spring of 1966, a group of scientific advisors to the Pentagon, known as the Jasons, were asked 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. They had deliberately chosen to look at Vietnam and basically volunteered their assistance to McNamara. One of the concepts he asked them to look at was the barrier. The report they issued at the end of the summer of 1966 focused on the and criticized the bombing as ineffective.[4]

To cut off the traffic in these areas they proposed constructing a physical barrier across the southern edge of the Demilitarized Zone, extending into Laos. It was

[4] S. Deitchman, et. al., "Air-Supported Anti-Infiltration Barrier," Institute for Defense Analysis, Jason Division, Study S-255, August 1966.

conceived as an air-supported barrier - air-supported in that the monitoring and anti-personnel technologies (mines) 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 McNamara approved the idea of putting in a barrier system, it became known as 'McNamara's Wall' or 'McNamara's Barrier' (there was a lot of discussion in the press). 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.

The Defense proposal was reviewed by the Joint Chiefs of Staff and they were, again, not completely behind it. The argument was again made that implementing the barrier would require the redirection of resources currently used in other crucial efforts. They argued instead that increasing resources to current efforts would be just as effective, and would not cost as much.[5] McNamara authorized the program anyway.

When the Department of Defense went looking for existing technology out of which to construct their barrier, they found several programs in the works. Anti-personnel mines and bombs were available in some abundance by this point in the war (although never in the numbers envisioned in the Jason report). And, as for the listening devices - the acoustic sensors envisioned by the Jason Group - exploratory programs were

[5] See *The Pentagon Papers*. For most of this discussion, I have relied on volume 4 of the Senator Gravel Edition of *The Pentagon Papers: The Defense Department History of United States Decisionmaking on Vietnam* (Boston: Beacon Press, 1975).

underway within several institutions. For example, the Navy was working on an acoustic sensor - called Acoubuoy - designed to hang in the jungle canopy and transmit sound back to its caretakers. The Army was investigating the possibility of a hand-emplaced, hard-wired listening device. And, in Albuquerque, a small group within the Information Systems program at Sandia Laboratories was working on a wireless seismic sensor (not acoustic). Because one of their devices was eventually widely deployed and because I think the mechanics of their involvement in the sensor program are interesting, I am going to focus on the Sandia program.

State of the Art

Sandia is a nuclear weapons laboratory. Responsible for turning the nuclear physics package designed by Los Alamos and Lawrence Livermore into workable weapons, 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 had developed an array of nuclear blast measurement technology. That technological capability was expanded beyond the immediate realm of weapon design to projects aimed at developing technologies to detect nuclear detonations. One of those projects was the Unmanned Seismic Observatory - a program to design stations that could detect underground nuclear bursts, to be scattered around the world, most notably in countries with known nuclear programs. 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.

In 1965, Sandia got involved in research on the possibility of creating seismic sensors to be deployed in Vietnam. The project lasted until 1971. It relied on the abilities Sandia had developed in its nuclear weapons work, as well as its existing relationships with both the military and the integrated contractor complex. Sandia's work on the sensors 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. The interweaving of the individuals and institutions involved in defense work is tight. For example, the head of the Defense group working on the sensors, Lt. General Alfred Dodd Starbird, had been the head of the Atomic Energy Commission's Division of Military Application, working closely with Sandia and the rest of the AEC 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 group.

In November of 1964, ARPA director Dr. R.L. Sproull visited Sandia to check on the progress of the 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 research and development for Vietnam. Patterson responded in January of 1965 with a letter in which he proposed some assistance from Sandia with the problems of Vietnam. "You mentioned while you were here that you were interested in studies of limited war situations, or scenarios as some are prone to call them. I would like to explore some ideas with your people who are responsible for these investigations. It is possible that some of the [seismic observatory] concepts might be applicable."[6]

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 roads nearby. Patterson thought this nuisance might be used to good advantage in developing a technology for use in Vietnam. Like the scientists making up the Jason group, Patterson was very interested in helping out the war effort, in volunteering his (and his teams') abilities for the war.

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.[7] An ARPA order authorizing a "program of analytical and experimental research in seismic detection related to counterinsurgency applications" was issued in July of 1965.[8]

The Technology

The sensors Sandia developed relied heavily on existing technologies brought together in the lab (the technology the developed reflects the technology they knew). The

[6] H.H. Patterson of Sandia to Dr. R.L. Sproull, Director of ARPA, January 26, 1965. Copy in Jerry Wallace's report on COIN in the COIN Collection, Sandia Corporate Archives.
[7] 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.
[8] ARPA Order No. 754, copy in COIN Collection, SNL Archives.

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 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.

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 a seismic detector, 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.

There was some debate as to whether the radio signal from the seismic intrusion detector could penetrate the thick jungle canopy prevalent in some areas of Vietnam. Tests were done in jungle conditions in Panama, 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, on the grounds that the thickest jungle canopy is rarely encountered. [Although not as complex as the missile systems Donald Mackenzie wrote about, the sensors reflect the same issues about determining when the technology is good enough.[9] We can talk about that during the discussion if you would like.]

By April of 1966, experimental prototypes of the seismic detector were available and they were put through field trials in Thailand. Both ARPA and the military observers were pleased with the results. Apparently, the sensors were seen as having a great potential in perimeter defense and on patrols.

Then, 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 seismic detector was a hand-emplaced device, but the barrier system proposed by the Jason report envisioned air-delivered sensors. In response, Patterson's group at Sandia came up with an Air-Deliverable Seismic Intrusion Device.

Viewgraph of Tom McConnell with ADSID [McConnell first Sandian to do a tour with Starbird's group]

The air-delivered seismic sensor had the same detection range as the original seismic intrusion detector - about 100 feet for people walking [depending on the terrain] 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.

---

[9] Donald A. Mackenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge: MIT Press, 1990).

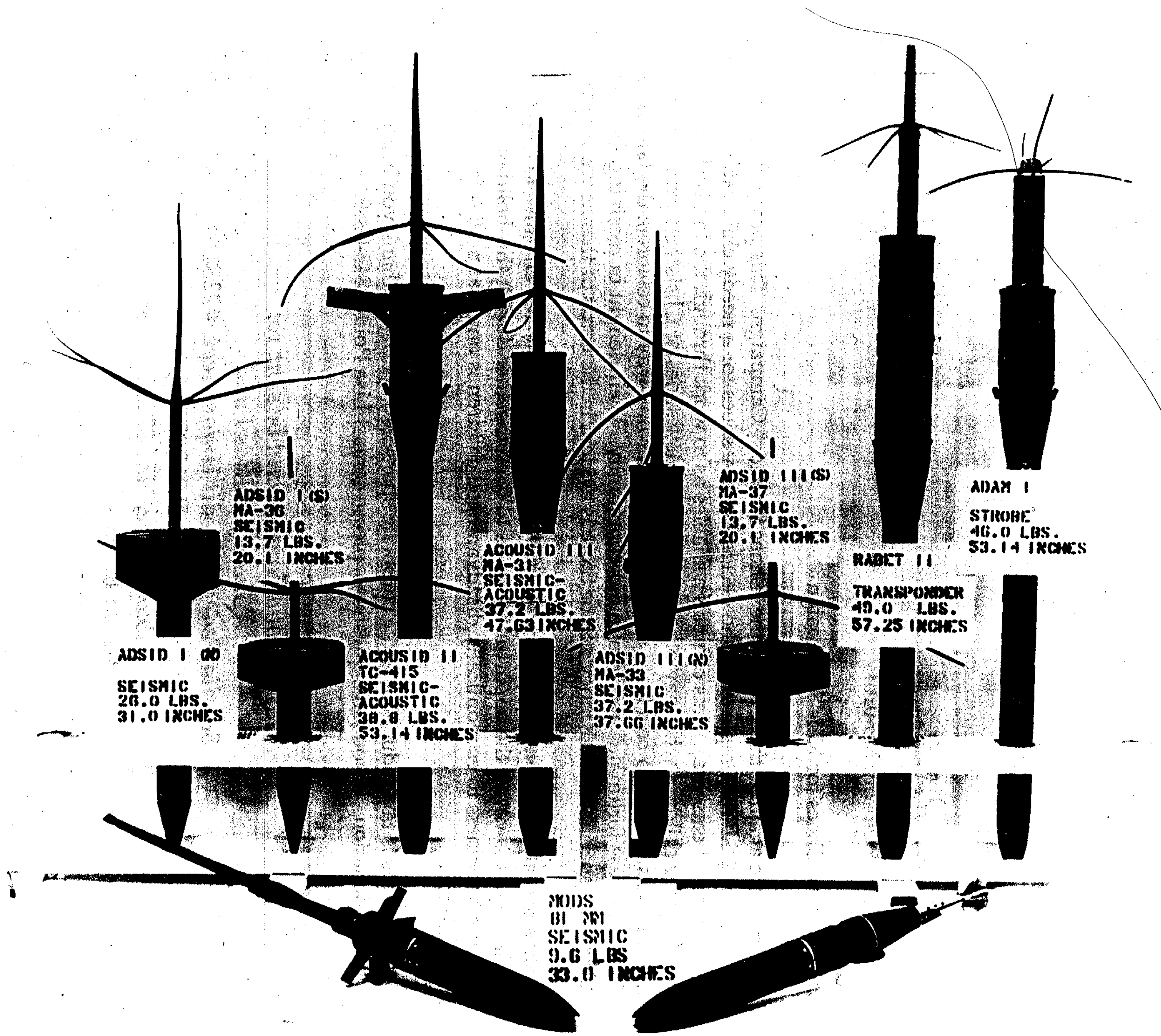
The air-deliverable requirement for the sensor brought Sandia's aerodynamics group into the loop. At the time, Sandia was pursuing research in a relatively new field known as terradynamics - an area pioneered by Sandia as it grew directly out of studies of nuclear weapons [from the attempt to make earth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

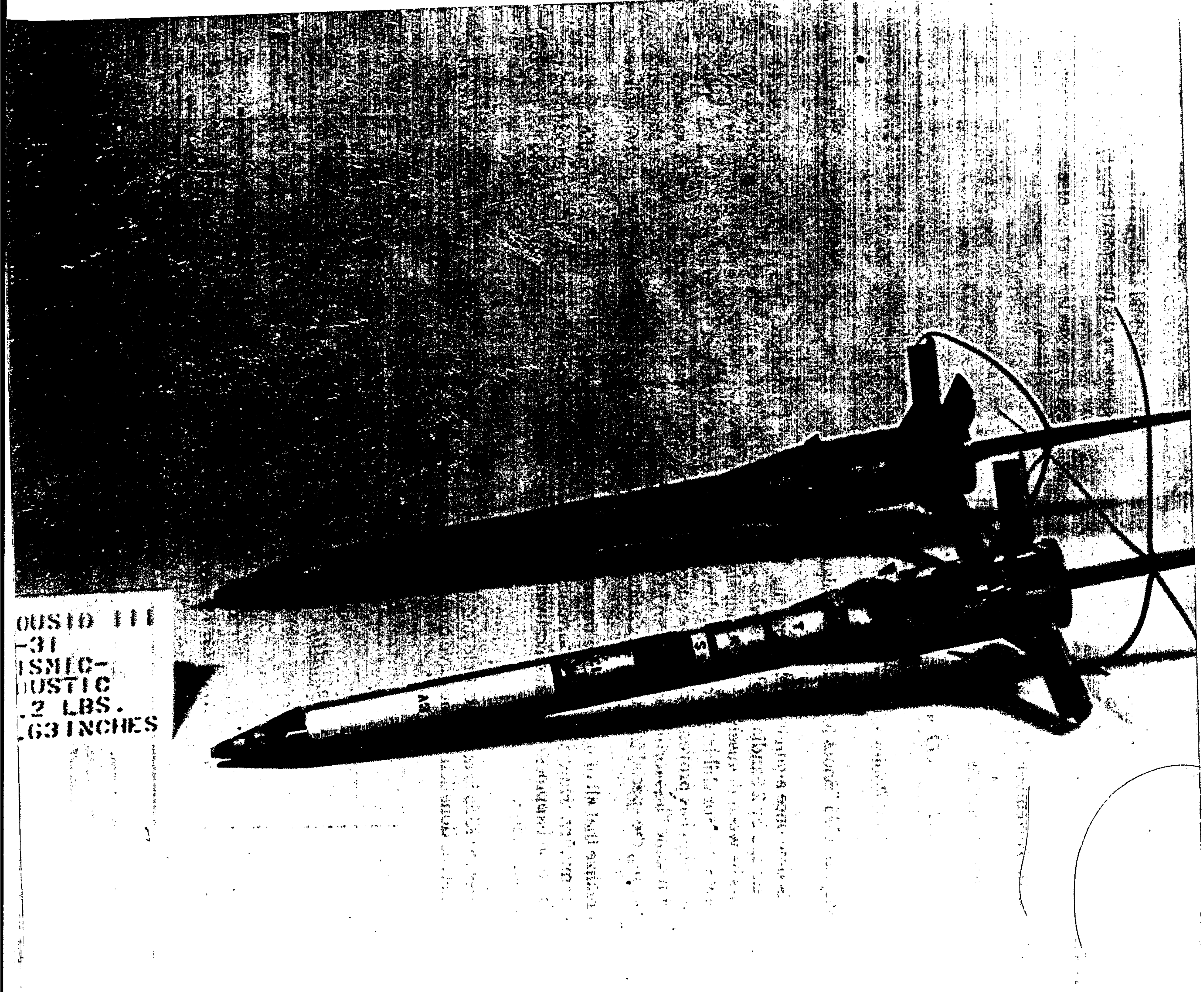
Viewgraph of Sensor Family (point out first Air-Deliverable Seismic Intrusion Device, then later incarnations - including ACOUSID, adding an acoustic capability - the Jasons had envisioned acoustic sensors, Sandia stuck with seismic detection but did add an acoustic capability. Indicate suitability for different delivery systems - e.g. terrabrakes - **Viewgraph of ACOUSID with Terrabrakes Displayed**.)

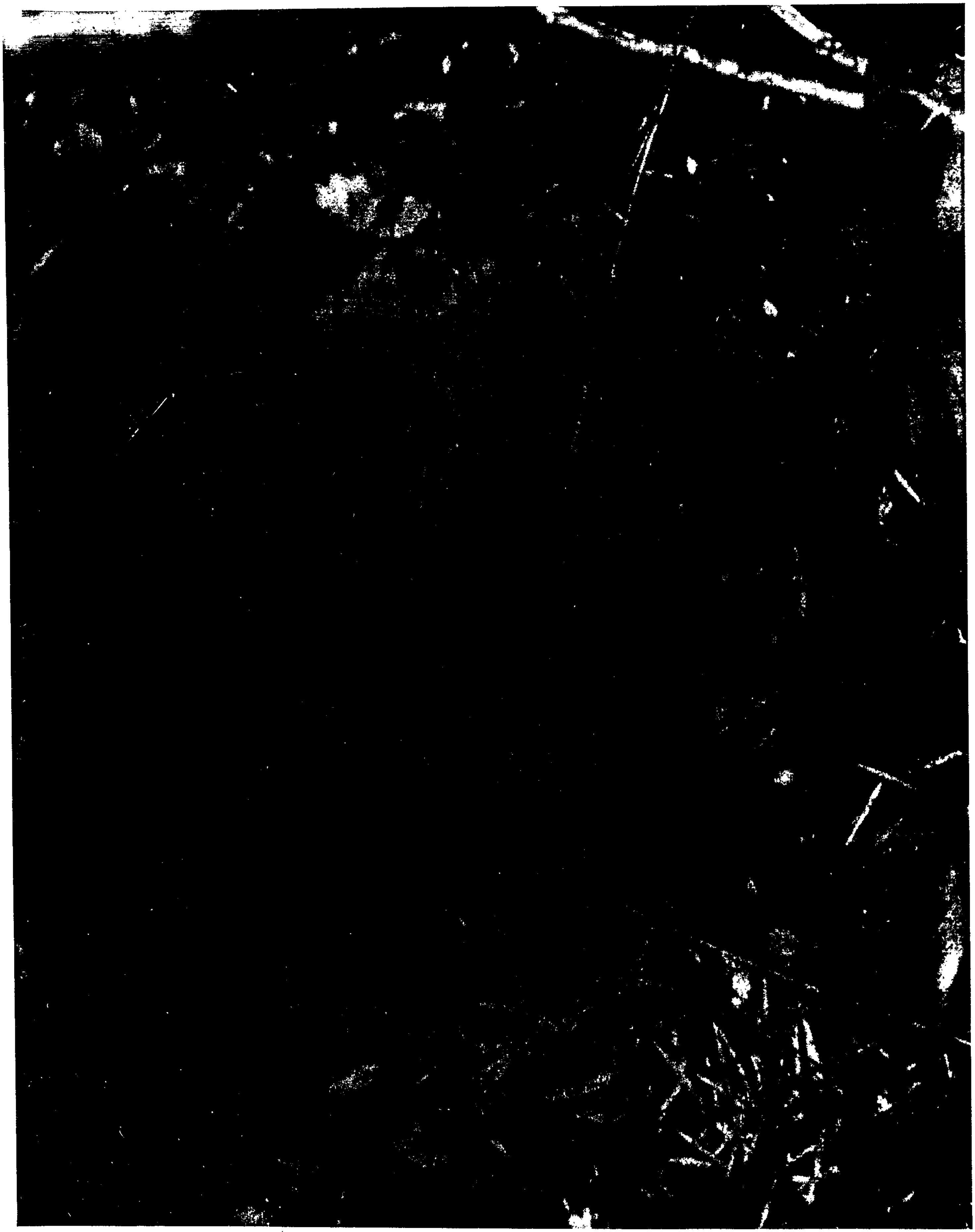
Viewgraph of Sensor in the Ground (note camouflage)

For the air-dropped sensor, procurement efforts began in January 1967 and deployment began in October that same year. A strong attempt was made to focus on off-the-shelf capabilities - to turn to suppliers who were making components similar to those designed for the sensors. The emphasis was on producing the devices quickly - on getting them into the field.

Deployment of the sensors in the fall of 1967 did not mean they stopped evolving, of course. The barrier system, as conceived by the Jasons, was never fully deployed. A


ADSID I
SEISMIC
26.0 LBS.
31.0 INCHES
ADSID I (S)
MA-36
SEISMIC
13.7 LBS.
20.1 INCHES
ACOUSID II
TC-415
SEISMIC-
ACOUSTIC
38.8 LBS.
53.14 INCHES
ACOUSID III
MA-31
SEISMIC-
ACOUSTIC
37.2 LBS.
47.63 INCHES
ADSID III (N)
MA-33
SEISMIC
37.2 LBS.
37.66 INCHES
ADSID III (S)
MA-37
SEISMIC
13.7 LBS.
20.1 INCHES
RABET II
TRANSPONDER
49.0 LBS.
57.25 INCHES
ADAM I
STROBE
46.0 LBS.
53.14 INCHES
MODS
SEISMIC
9.6 LBS
33.0 INCHES


OUSID III
-31
ISMIC-
OUSTIC
.2 LBS.
.63 INCHES



complete barrier was never built across the Demilitarized Zone - largely because of military concerns over the manpower that would require and the static nature of such a fence - the same concerns Westmoreland had had all along. But sensors **were** sown along trails. They were used in other ways, as well. In particular, sensors scheduled to be dropped in an anti-infiltration effort late in January of 1968 were instead dropped around the perimeter of the Marine encampment at Khe Sanh as buildup for the Tet Offensive was detected in the area. During the months of the siege of Khe Sanh in the first half of 1968 [beginning January 21, 1968], the devices were considered useful in fending off North Vietnamese Army troops. It is very difficult to know exactly what, if any, difference the sensors made, but several Marines, as well as Westmoreland, credited them with a significant role.

From this point on, 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 successfully pushed the sensor efforts away from the barrier notion and more toward perimeter defense, where he had wanted them to go all along. In a sense, Khe Sanh was a turning point for the sensors - for their acceptance into America's technological arsenal as a technology suited for this particular type of war.

Conclusion

And so, having enthusiastically rejected the plan to construct an anti-infiltration barrier, in the end the military nevertheless fully embraced the technology required for the plan. Bureaucrats and military officers, willing to see the possibility of salvation in the flicker of a seismic wave, adopted the sensors and incorporated them into the war effort. The sensors were produced quickly and they worked. If they did not win the war, members of the services, when testifying before Congress in 1971, nevertheless credited them with saving American lives. It is interesting to note, however, that assessments of the sensors' usefulness make little mention of their use as anti-infiltration devices. Movement down the Ho Chi Minh Trail was never stopped. Rather, they were touted, by the military, for their use in perimeter and patrol defense, and for detection of movement along trails. And the speed of sensor creation is always emphasized in descriptions of their adoption - as though deployment is a sign of effectiveness in and of itself. Effectiveness is, of course, very difficult to measure and therefore remains fuzzy in accounts of sensor development and deployment. For example, a 1969 *Journal of Defense Research* summary article on sensor readout and display techniques pointed out that "Knowledge of how the system in operation is doing is difficult to obtain," and went on to point out that target verification was difficult at best.[10]

The satisfaction with the sensors reflects, I think, the general perception of the stalemate in Vietnam, of the frustration with lack of American success in stopping the infiltration and insurgency, and the general perception of the need for new technologies to suit a new kind of war and to advance the one at hand. Jack Robertson, in an article in the *Electronic News* of May 12, 1969, clearly articulated this technological enthusiasm. After detailing, with some accuracy, the operation of the seismic sensors, he offered the

[10] Lt. Col. Charles H. Stevens, "Sensor Display and Readout Techniques for Tactical Applications," *Journal of Defense Research*, 1B:3 (Fall 1969):292.

assessment that "The 'electronic intrusion wall' has been one of the few smashing successes for the military in learning how to fight new limited wars."[11]

The Sandians who worked on the sensors came at the project with a strong faith in technological solutions[12] - 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.[13] The members of the Jason group had been equally enthusiastic about offering their services to the Vietnam effort. Indeed, there has not been a shortage of volunteers to the military research and development effort in the postwar period.

Sandia's participation 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 the engineers' quip, "Invention is the mother of necessity."[14])

The technologies developed for Vietnam have yet to be fully explored for what they might tell us about the way technological enthusiasm and generously funded research institutions have worked together to shape America's military outlook in the postwar period. They will, I hope, receive more attention by historians, especially as the current

---

[11] Jack Robertson, "'McNamara Wall' Wins a Vote," *Electronic News* (May 12, 1969):np.
[12] See Thomas Hughes, *American Genesis*, on faith in technology in the postwar world.
[13] In conversation with the author. See also COIN Collection in the Sandia Archives.
[14] Dick Claassen oral history interview, SNL Archives.

federal declassification effort continues. These studies should tell us a great deal about science/engineering/military relationships and the way weapons and other materiel were developed in the postwar period.