# LESSONS FROM THE PAST

NEW MEXICO HERITAGE ON THE DEPARTMENT OF ARMY
WHITE SANDS MISSILE RANGE, NEW MEXICO
PREPARED BY HUMAN SYSTEMS RESEARCH, INC.


## Cold War Rocket Science at White Sands Proving Ground, New Mexico

**by William B. Boehm**

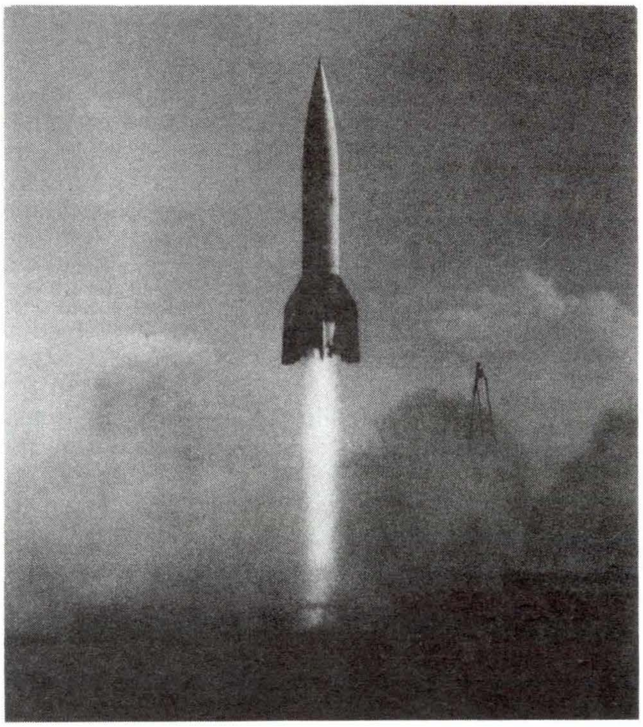
White Sands Missile Range assumed a position as the leading rocket and missile test facility in the United States during the early stages of the **Cold War** (1945-1965). The testing of projectiles such as the V-2 rocket allowed the United States, through scientific diligence, to (1) advance liquid-fuel-based rocket propulsion as a means of national defense through the use of missile systems, (2) design methods to test an entirely new type of weapon, and (3) develop a practical means of human space travel and landing astronauts on the moon, goals achieved by the end of the 1960s.

Participating in this set of readings and activities will provide upper-level middle school and high school students a more complete understanding of both the technical and the human aspects of the Cold War in the United States.

### ENVIRONMENTAL AND HISTORICAL SETTING

White Sands Missile Range, along with Fort Bliss, Texas, and large areas owned by the Bureau of Land Management, State of New Mexico, and the U.S. Forest Service, make up most of the Tularosa, Jornada del Muerto, and Hueco Basins of south-central New Mexico. These closed basins, so named because no streams carry water to rivers flowing to the ocean, lie at the extreme southern end of the Rocky Mountains, in a region of basin-and-range topography. Barren alkali flats alternate with dry lake beds, immense sand dunes, and patches of desert grassland across basin floors. The famous white sands, which are cool to the touch, but which reflect light on a sunny day, gave White Sands Proving Ground its name. These vast, white dune fields occupy the lowest part of the Tularosa Basin. The rugged Sacramento, Sierra Blanca, San Andres, and Organ Mountains border the three basins; isolated ranges rise abruptly from the desert floor; and deep arroyos have eaten into lower mountain slopes. Soils in the area are dry and erode easily. Desert shrubs, sparse grasses, tumbleweed, and cacti are the most common plants in the basins. This basin desertscrub biotic community grades into semiarid piñon-juniper woodland on the lower mountain slopes and onto subalpine conifer forests higher in the mountains.

After World War II ended in 1945, the fight to stop the spread of world Communism began through an unprecedented military build-up in the United States. First aimed at countering Soviet aggression that arose in eastern Europe, the nation fought an undeclared conflict on several fronts. The **Cold War,** as it was known, transformed American society economically, socially, and culturally in all its manifestations for the next 45 years. The White Sands Proving Ground, founded near the end of World War II and located in the Tularosa Basin in south-central New Mexico,



V-2 rocket during initial launch (ca. late 1940s) rapidly became a prominent military center for rocket and missile testing.

"Special Mission V-2," led by Colonel Holger Toffoy, became the unit that collected German rocket components and shipped them to the United States after our country's victory in Europe. The German wartime V-2 became an American instrument of scientific research. The testing and extension of the liquid-propelled V-2 rocket into a vital research vehicle at the Proving Ground in the late 1940s and early 1950s provided the framework for later rocket-booster systems. Though the rocket was developed for use in warfare, the wealth of knowledge gained through this test program ultimately allowed manned space travel to become a reality. V-2 research was continued by the work of German scientists who surrendered to the United States at war's end. Most of them were housed at Fort Bliss, Texas, south of the Proving Ground, yet many were billeted at White Sands during prolonged project assignments on the rocket. The scientists were commanded by Major James Hamill at Fort Bliss and to Colonel Harrold Turner at White Sands. The V-2's successes helped pave the way for the modernization of the U.S. Military. Military growth paralleled the technological advances of American society. To this day, the reach into space continues to fire the American imagination. Hence, today's White Sands Missile Range (as the Proving Ground has been known since 1958) can justly claim to be the "Birthplace of America's Missile and Space Activity."

American physicist Robert H. Goddard is considered by most as the foremost pioneer of modern rocketry through his early firings and observations. Still, his tests in the eastern New Mexico desert attracted little, if any, attention from government interests until World War II. With the end of World War II, however, American rocket and missile studies entered another phase. The rise of White Sands Proving Ground to its role as a leading Cold War institution makes a fascinating story, considering what few facilities existed here in 1945. Historical interest is currently being sparked by the recent anniversaries of many World War II landmarks, as well as post-War events, such as the formation of the North Atlantic Treaty Organization (NATO), the Marshall Plan, and the Truman Doctrine. These events continue to have repercussions in the post-Cold War era, which allows these early milestones to be scrutinized in a different light than during the Cold War. Furthermore, this allows students to appreciate the role of history in examining the impact of modern events and policy. This lesson on the early technical history of the former White Sands Proving Ground, focusing on the V-2 rocket program, is based on primary and secondary material from the early Cold War era. Materials for students' use include readings, diagrams of the rocket, and photographs of various rockets taken from the firing range and within the local cummunities so as to illustrate the cultural impact of the rockets' first firings.

## OBJECTIVES FOR STUDENTS

- Learn about the early German scientists who contributed to the success of the earliest V-2 tests and the circumstances under which they came to the United States.

- Learn about early rocketry at White Sands Proving Ground in the late 1940s and 1950s, which led to human space travel by the 1960s.

- Learn what effect rocket tests had on national consciousness and how they affected popular culture.

## TEACHING ACTIVITIES

### *Setting the Stage*

The U.S. Army, with the cooperation of the California Institute of Technology, initiated Project ORDCIT that fired the military's first rockets in the California and Texas deserts before the end of World War II. In 1945, after World War II, the U.S. Army embarked on a missile development program that, in and of itself, was a marked departure from the usual postwar activity of reducing troops and armaments. Emphasize that using the German scientists, who possessed the necessary technological know-how, resulted in more efficient development of rocket systems. The V-2 rocket owed its German name, *Vergeltungswaffe-2* ("Vengeance Weapon 2") to Nazi Propaganda Minister Joseph Goebbels, who dubbed the rocket thusly in an attempt to intimidate Allied forces. Parts for at least 100 rockets arrived at White Sands from Germany in the summer of 1945, shipped overland by rail in nearly 300 boxcars (Boehm 1997; Lang 1948:37). Though sections of nearly 2,000 projectiles were thought to be among this war booty, Nazi sabotage and the inaccessibility of German-made rocket parts ultimately limited recon-struction to less than 100 rockets, of which 67 were fired.

The first of the American V-2s was formally tested in March 1946. Most of the V-2s launched at the White Sands Proving Ground until 1952 were highly successful, although some of the flights failed (Ordway and Sharpe 1976:353; Quinn 1986:1). Overall, these tests were significant because they were the first definitive trials in atmospheric testing, airborne experiments, and rocket-booster launches. Subsequent tests proved that animals could withstand the effects of gravitational force, and that humans are equally capable of space travel. The V-2 was instrumental in the first foray into outer space, on February 24, 1949, when it powered the WAC Corporal missile to a then-record altitude of 244 miles as part of the multistage rocket program, "Project Bumper" (Eidenbach et al. 1996:33, 39; Kennedy 1983:65; Quinn 1986:12). Although minuscule alongside the later Saturn rockets that took humans to the moon, the V-2 was the starting point for all modern U.S. rocketry, especially in regard to space travel.

### *Locating the Site*

Have students find the location of White Sands Missile Range on a map of New Mexico (p. 13). Note the length and width of the Missile Range (approximately 40 miles wide by 100 miles long), the route of U.S. Highway 70 where it crosses the Range, and the locations of nearby communities. Point out how the lack of rail lines, shipping lanes, and large metropolitan areas in this part of New Mexico was influential in selecting this as the site for the White Sands Proving Ground in 1945 (as well as its World War II-era, Army Air Force predecessor, the Alamogordo Bombing Range). Considering the activities associated with testing the V-2, what other physical limitations (i.e., landforms, climatic conditions, etc.), would have been considered during the selection of a place from which to fire the V-2 rocket and conduct other weapons testing? Would there have been any better location in New Mexico for the proving ground? Why or why not? Students should examine the remaining three maps on page 13 for information that will help them answer these questions.

## DETERMINING THE FACTS

### *Reading 1. The Paperclippers Arrive*

Few people are aware of the role German scientists played in U.S. rocket-science history. Have your students read *The Paperclippers Arrive* (p. 7) and answer the following questions to guide them to an understanding of why we enlisted German scientists to work in the United States after Germany's surrender and how they contributed to weapons and space technology following the war.

1. Who was the lead scientist of the German contingent? What were some of his accomplishments?
2. What was Operation Overcast and why was its name changed?
3. Why was Operation Paperclip important?

### *Reading 2. Basic Rocketry: The Formative Years*

The history of rockets embodies hundreds of years. Have your students read *Basic Rocketry* (p. 8) and answer the following questions to help them understand how the manufacture and use of rockets has progressed during the twentieth century.

1. As a weapon of war, what advantage does a rocket have over a gun?
2. What ingredients were necessary for the V-2 to become airborne?
3. What instrument is used to measure cosmic-ray radiation in the atmosphere?
4. What part of the rocket is essential in controlling the projectile's course?
5. German V-2s carried explosive warheads; what did the U.S. military substitute on the launches of the V-2 at White Sands? What did the U.S. Army hope these parts would measure?
6. How did the military plan to have rockets reach beyond the ionosphere, into what we call "outer space," in 1947? What was the theory behind this launching method and how would it work?

### *Reading 3. Humble Beginnings: Early V-2 Testing at White Sands*

The novelty of rockets being fired into the New Mexico sky in the mid-1940s aroused awe in much the same way the first airplanes did earlier in the twentieth century. As a result of Operation Paperclip, the United States possessed a vast stockpile of German-developed rocket parts. Within several months, these were launched hundreds of miles into the sky and thereafter opened the frontier of space to all Americans. Have your students read *Humble Beginnings* (p. 10) and answer the following questions.

1. What was the main reason for the United States to develop missiles?
2. What happened to the Army rocket program after Japan's surrender to the United States in World War II?
3. Despite its early difficulties, why was the V-2 program significant to America after World War II?
4. What were the most important accomplishments of V-2 launches at White Sands Proving Ground in the late 1940s and early 1950s, according to the author?

### *Reading 4. The Scientists: Another Look*

Many U.S. citizens felt that the scientists who emigrated to the United States upon Germany's surrender during World War II were Nazi collaborators. Have your students read *The Scientists: Another Look* (p. 12) and answer the following questions. The final question is intended to be open-ended and can serve as a springboard to more in-depth discussion at the discretion of the teacher. The nature of the entire reading can lead the class to additional questions. It is included in order to present both sides of this potentially controversial issue.

1. What were some of the problems the German scientists faced upon their arrival in the United States?
2. In the opinion of the author, why did the German scientists have such an excellent understanding of a complex subject like rocketry?
3. Do you think that the United States needed the German rocket scientists? Why?

### *Visual Evidence. The Space-Age Photo Album*

Present the students with copies of *The Space-Age Photo Album* (pp. 14-15). One of the most enduring images of the Cold War is the presence of rockets as an everyday icon in American popular culture. Rockets showed up as props for playground equipment, as hobby kits, in signs for businesses having "Space Age" names, or as novelty attractions at other establishments. Schools (particularly those located near military and rocket-testing facilities) even adopted rockets or missiles as their school mascots (e.g., the Goddard Rockets in Roswell). Remember that during the Cold War, the military conducted thousands of missile and rocket tests, as fear of Soviet aggression in all corners of the world took hold. Ask your class why architects would adopt futuristic designs for otherwise ordinary buildings? Why would the nation develop rockets as it did, after it won World War II? Recalling some notable events of the time (the Sputnik launch, for example) may offer clues as to why this rocket image became so prevalent, particularly in the Fifties.

## PUTTING IT ALL TOGETHER

Students should discuss Readings 1 through 4 and decide whether or not the points presented in these excerpts have much in common with what is reported in school textbooks. Examine points that are not featured in the texts, such as cultural history and regional geography. Your class may enjoy participating in one or more of the following activities, which were developed to supplement the basic lesson and broaden students' understanding of a significant period in U.S. history. Students will be encouraged to use their imaginations in new ways, such as in designing a blueprint of a working rocket, and to develop their observation and research skills.

### *Activity 1. Rocket Science in Action: Using Blueprints, Diagrams, and Imagination*

Some of the earliest lectures on the V-2 rocket (Steinhoff and Riedel 1946) were presented in the winter of 1946, shortly after the arrival and assembly of the rocket parts from Europe. Drs. Ernst Steinhoff and Walter Riedel, two of von Braun's high-ranking assistants, used blueprints, diagrams, and photographs during these lectures to teach personnel the complex principles of rocketry, something not well understood by most Americans. These graphics are presented here because they provide even those without a working knowledge of physics and rocket science insight into the technological advancements introduced to the United States by this legion of scientists.

Present the students with copies of the A-4 rocket blueprint (A) and diagram (B) (p. 16). "A-4" was the original, scientific name given to the rocket that the German government renamed the "V-2" in a propoganda move (see *Setting the Stage*). Examine the blueprint from the lecture material on the V-2 rocket. This diagram illustrates the complex parts of the rocket; however, the rocket's operation is summarized simply (see labels), without the need for complex mathematical notations. To summarize this process, first, the alcohol and oxygen mixture burns to provide the power for the thrust unit to lift the rocket. The burner releases excess oxygen and alcohol, while the tail fin and rudders control the direction in which the rocket travels. In the top section of the rocket, the warhead section delivers the explosive matériel (in the German model; the White Sands V-2 carried atmospheric equipment to measure temperature and conduct experiments, etc.). Finally, the steering control effects the distance the rocket will travel and the maximum height that it can achieve.

Have the students work individually or in groups to prepare their own sets of "blueprints" for a rocket. Use the diagram labeled in German to provide plausible rocket proportions for this exercise. Students should provide rocket dimensions (height, length, and width); label primary parts; develop a name for the rocket; and identify any other relevant devices (e.g., a booster) used to help the rocket "accomplish its mission." When the students have completed this assignment, have each give a brief presentation on the rocket's purpose and why they think their design will work.

### *Activity 2. The V-2 Rocket: A Cultural Icon*

After examining the photographs in *The Space-Age Photo Album* (pp. 14-15), showing rockets and rocket images in everyday settings (see *Visual Evidence*), have students locate some other vestige of the Cold War (preferably, one that showcases a rocket) in their community or the local area that exists today. After all the students have found this likeness, have them identify it, describe its characteristics, and explain why it is a popular image that is representative of the early years of the Cold War era (1945-1965). If no rocket icons exist in your community, look for businesses or public establishments that contain names from the "Rocket Era" or retain characteristics of the early Cold War period (i.e., Civil Defense fallout shelters, drive-in restaurants [e.g., Sonic], movies, etc.).

### *Activity 3. Military Presence in the Southwest*

A map of New Mexico (p. 13), showing the locations of other military facilities (past and present) in the state is provided to help students get started on this activity. Have students form groups to conduct research on an installation of their choice. Each group should prepare a brief report on the installation that includes a description of its location, the branch of the service for which the installation operated (i.e., Army or Air Force), and a brief history of the installation during the Cold War era. Details should include information such as whether the installation is still operating and what sort of research and/or training activities take/took place at this facility. Have each group present its findings to the rest of the class.

Newspapers and libraries are excellent sources of information that can provide details on the above. In addition to White Sands Missile Range, the following are/were military installations in or near the state of New Mexico.

- Holloman AFB, NM (Alamogordo)
- Kirtland AFB, NM (Albuquerque)
- Cannon AFB, NM (Clovis)
- Walker AFB, NM (Roswell; now closed)
- Fort Wingate, NM (Gallup)
- Fort Bliss, TX (El Paso)

### *Activity 4. A Glimpse at the Paper: The Cold War Comes Home*

Students can investigate how the Age of Rocketry impacted their community during the early years of the Cold War in a number of ways. With a testing facility such as White Sands Missile Range nearby, firing events that transpired in southern New Mexico undoubtedly affected the local community. In later years, human space flights caught the attention of the media across the nation.

To gain some measure of the impact of the rocket and space programs on society, have students research an important event in the development of rocket travel. Use the readings for ideas, such as the significance of the Project Bumper launches, or suggest a more recent but related event, such as the 1969 moon landing. Students should determine the date of the particular event, then find a local newspaper (or prominent national or regional paper) in which their event is covered. Student reports on these events should include details on the firing, launch, etc., as well as comments about other national or local happenings reported in the paper, which place their events in a temporal and social context. When studying the social impact of particular historical occurrences, it is important to be aware of what else was going on at the time. Identifying cultural signposts, such as advertisements (i.e., grocery prices), popular dress styles, and other important events, can make things that happened "a long time ago" seem more interesting and not so distant after all.

## GLOSSARY

**Allies**: a leader or nation associated with other leaders or nations by treaty or other binding agreement. Our chief allies in fighting Japan and Germany during World War II were Great Britain and the Soviet Union; however, several smaller nations also fought on the side of the Allies. When referring to this group, the term "Allies" is considered a proper name.

**Arsenal:** a storage facility for weapons and ammunition.

**Booster**: the term applied to rockets attached to each other, with one rocket providing the propulsion or boost to lift a second rocket to a higher elevation.

**Cold war**: a period of hostility and sharp conflict in areas such as diplomacy and economics between nations, during which there is no actual warfare. The Cold War, as a proper name, is applied to that period in world history (1945-1989) during which the United States worked to stop the spread of Communism, in part through military buildup.

**Concentration camps**: work camps established by Nazi forces throughout Europe that served to alleviate labor shortages during the World War II, but which also became facilities where prisoners were executed or worked to death through starvation and harsh treatment.

**Freedom of Information Act**: a law passed in 1966 that allows American citizens access to certain government documents.

**Geiger counter**: a device used to measure radiation levels.

**Gyroscope**: a guidance instrument that aids in directing the path of a missile.

**Holocaust**: the mass execution of over 6 million Europeans of Jewish descent launched by German Chancellor Adolf Hitler.

**Ionosphere**: the highest layer of the earth's atmosphere (above the troposphere and stratosphere), beyond which lies outer space.

**Matériel:** equipment, apparatus, or supplies used by an organization.

**Meteorologist:** one who studies the atmosphere, weather, and weather forecasting.

**Mittelwerk**: the German factory where the Nazis forced prisoners-of-war and other laborers to assemble V-2 rockets.

**Nuremberg**: the city in Germany where a series of war-crimes trials were held during 1946 and 1947, in which several members of the German High Command were convicted of war crimes.

**Operation Overcast:** the original name given to the project that brought German scientists to the United States to develop weapons that would end the War in the Pacific. This name was dropped for security reasons, and the project was dubbed Project Paperclip because a single paperclip on personnel files identified the scientists who would enter the United States from Germany.

**Ordnance:** armaments, ammunition, and related equipment in a military force; a post-World War II department within the U.S. Army governing the development of rockets and missiles.

**Physicist**: a specialist in the study of properties, changes, and interactions of matter and energy.

**Project Bumper**: an early Army rocket project in which a V-2 missile was launched carrying a payloadcontaining a lighter WAC Corporal missile, which ignited after the V-2 reached maximum height and velocity. It was the first missile to break into outer space (on February 24, 1949), reaching an altitude of nearly 250 miles.

**Projectile**: any object that travels through the air; typically, rockets or missiles.

**Propulsive:** driving or pushing forward.

**Radiation**: the process by which energy, in the form of rays of heat, light, etc., is sent out through space from atoms and molecules as they undergo internal change.

**SS:** the Nazi Secret Police organization that monitored and worked to stop anti-Nazi activity.

**Sulfur (sulphur)**: a yellowish, nonmetallic element; an ingredient in gun powder and other solid propulsive mixtures.

**Vacuum**: a space devoid of matter.

## REFERENCES CITED


Boehm, William B.
1997 *From Barren Desert to Thriving Community: The Early Social History of White Sands Proving Ground, 1945-1954.* Human Systems Research Report No. 9428/9531.

Eidenbach, Peter L., Richard L. Wessel, Lisa M., Meyer and, Gail C. Wimberly
1996 *Star Throwers of the Tularosa: The Early Cold War Legacy of White Sands Missile Range.* Human Systems Research Report No. 9422.

Kennedy, Gregory P.
1983 *Vengeance Weapon 2: The V-2 Guided Missile.* Smithsonian Institution, Washington D.C.

Lang, David
1948 What's Up There? *The New Yorker.* 31 July: 37–46.

Ley, Willy
1947a Rockets I. *Federal Science Progress* 1(1): 40–43.
1947b Rockets II: The Frontier of Knowledge Goes Forward with Liquid-Fuel Rockets. *Federal Science Progress* 1(2):39–40.

*Missile Ranger*
1990 Various editions.

Ordway Frederick I., III, and Mitchell R. Sharpe
1982 *The Rocket Team: From the V-2 to the Saturn Moon Rocket.* MIT Press, Cambridge.

Quinn, Michael C.
1986 *White Sands Missile Range V-2 Rocket Facilities, 1945–1952.* Historic American Engineering Record NM-1B. HABS/HAER Division, National Park Service, Washington, D.C.

Steinhoff, Ernst, and Walter Riedel
1946 *8 Lectures on the V-2.* Unpublished ms. on file, Special Collections, Branson Library, New Mexico State University, Las Cruces.


## FURTHER READING


Bower, Tom
1987 *The Paperclip Conspiracy: The Battle for the Spoils and Secrets of Nazi Germany.* Michael Joseph, London. This work provides details on the experiences and research of von Braun's German scientists.

Lasby, Clarence G.
1971 *Project Paperclip: German Scientists and the Cold War.* Atheneum, New York. This was written without the benefit of several declassified sources, but it is, nevertheless, a solid work.

Ordway, Frederick I., III, and Mitchell R. Sharp
1982 *The Rocket Team: From the V-2 to the Saturn Moon Rocket.* MIT Press, Cambridge. The best overall account of the evolution of the V-2 rocket, the German scientists, and the early history of White Sands Proving Ground.

Lang, David
1948 White Sands. *The New Yorker.* 24 July:39–43. A good, general account for those interested in the early years at the White Sands facility and the initial V-2 firings, when paired with Lang's 31 July (*The New Yorker*) article (see *References Cited* above).


## VISITING THE SITE

The Cold War has ended with the fall of the Berlin Wall; however, White Sands Missile Range is still a viable facility where the military continues to conduct a multitude of research projects and missile firings. Today, the general public can take a glimpse at post history and the many Cold War-era missile programs at the White Sands Missile Range museum located just south of the Las Cruces gate. This facility is open to the public from 8:00 a.m. to 4:30 p.m., Monday through Friday. For information write or call

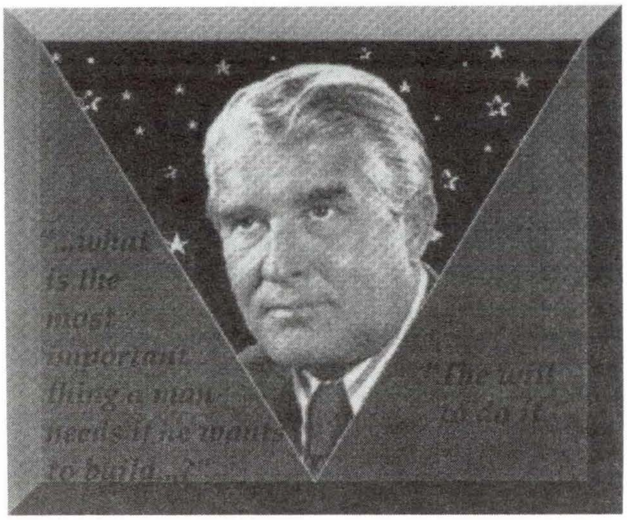
USA WSMR
STEWS-CA-PRF/CWF (Museum)
PO Box 400
White Sands Missile Range, NM 88002-5506
(505) 678-8824

For additional information about White Sands Missile Range, contact

U.S. Army Public Affairs Office
White Sands Missile Range
Building 122
White Sands Missile Range, NM 88002
(505) 678-1134

## READING 1. THE PAPERCLIPPERS ARRIVE

### *Part A. Wernher von Braun:* **Wunderkind** *Rocket Team Leader*




Wernher von Braun was born the son of Baron Magnus and Baroness Emmy (von Quistorp) von Braun [in 1912]. . . . [and] his decision to explore rocketry paved the way for him to excel in both mathematics and physics. Von Braun's will to appreciate math manifested after reading Hermann Oberth's *Rocket into Planetary Space,* and his determination to become a space pioneer/physicist unfolded after his mother gave him an astronomical telescope. . . . With the knowledge acquired from Oberth's book and the excitement about astronomy sparked from his mother's present, von Braun enthusiastically launched his desire to explore the outer limits of Earth. . . .

[By 1934, at the age of 22, von Braun] received his Ph.D in physics from the University of Berlin [and had been testing liquid-filled rocket engines for two years]. . . . Peenemunde [von Braun's last German experimental site], located on the Baltic coast, . . . [was situated to] allow the launching and monitoring of German rockets over ranges up to about 200 miles . . . and relieve the fear of harming lives. . . . During World War II, the base was bombed by allied nations. . . . [and near war's end] von Braun and his planning staff surrendered to the U.S. Army. . . .

Wernher von Braun [attained recognition as] one of the world's first and foremost rocket engineers and a leading authority on space travel. His will to expand man's knowledge through the exploration of space led to the development of the Explorer satellites, the Jupiter and Jupiter-C rockets, Pershing, the Redstone rocket, Saturn rockets, and Skylab, the world's first space station. Additionally, his determination . . . led to mankind setting foot on the moon.

### *Part B. The Paperclippers: Going to America*

On 19 July, 1945 **Operation Overcast** was officially established by a secret memorandum from the Joint Chiefs of Staff which read in part: Overcast—project of exploiting German civilian scientists, and its establishment under the Chief, Military Intelligence Service, on an island in Boston Harbor at a camp formerly known as Fort Standish (Fort Strong).

Operation Overcast was conceived as purely a short-term arrangement. Not all of the Germans were enthusiastic about going to the United States or even working with their former enemies in Europe. One [German] engineer pointed out . . . "We despise the French. We are mortally afraid of the Russians. We do not believe the British can afford us. So that leaves the Americans.". . .

[Dependents of the German scientists were housed] in Landshut [a camp located in Bavaria, run within the American zone of occupied Germany], which had become known locally as Camp Overcast. This dismayed the US military who considered Overcast a secret operation and on 16 March 1946 it was officially renamed Operation Paperclip (This latter title was taken from the fact that all the German scientists and engineers' personnel files had paperclips attached to them. . . .[Actually, only the files of those selected to come to this country were so marked]).

The first group of Germans arrived at White Sands Proving Ground in October [1945] and were billeted in Building H. (. . . it is true that these personnel living at White Sands were primarily technicians, . . . [but] von Braun and his theoretical team also lived there . . . and were even furnished Army buses for sojourns in Cloudcroft and Ruidoso on weekends when the [Proving Ground's] desert setting caused homesickness for mountain greenery). . . .

Operation Paperclip...resulted in planning that would extend the usefulness of a temporary installation in the New Mexico desert that had been named White Sands Proving Ground. The **Ordnance** Department, and the Army, could rightfully claim years later the credit for laying the foundation for this nation's first satellite and putting a man on the moon.

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Part A extracted from the NASA Liftoff Website, www.http://liftoff.msfc.nasa.gov.
Part B extracted from "Paperclipped Plans were Major Root of WSMR," by Tom Starkweather. In *Missile Ranger,* January 5, 1990 pp. 2-3.

## READING 2. BASIC ROCKETRY: THE FORMATIVE YEARS

### *Rockets in History—Early Models*

The earliest historical mention of a powder rocket dates back to the year 1256, in the . . . City of Cologne-on-the-Rhine [Germany].* That rocket was obviously a rare curiosity. [Beginning about A.D. 1400], rockets were employed in warfare as a means of setting fire to enemy fortifications. That was the purpose of the rockets the British were using four hundred years later when Francis Scott Key noted the "red glare" in the "Star-Spangled Banner."

For over five centuries rocket making [did] not fundamentally [change]. The raw material for the **propulsive** charge was ordinary black gunpowder—the mixture of saltpeter, pulverized charcoal, and **sulfur**—from which these rockets got the name "blackpowder rockets." However, even blackpowder of poor quality burned too fast for the rockets, so the rate of burning was slowed down by an additional amount of charcoal. . . . [Yet,] since the burning area provided by the cross-section of a tube of . . . blackpowder gave insufficient thrust to lift the rocket off the ground, a conical center was provided to increase the amount of gas released per unit time. This central open cone [was] called the "soul.". . .

Blackpowder rockets were dangerous and unpredictable, both in manufacture and in use. When compressed by a plunger pounded with a heavy mallet in the hands of a strong man, the powder heated up and frequently exploded. Much of the skill of the old-time fireworks makers consisted of knowing when to stop pounding. Moreover, compression made the blackpowder mixture very brittle. The powder developed invisible cracks that could not be detected, and when the flame reached these cracks the burning surface suddenly increased and the rocket exploded. . . .

About [1800,] an Englishman, Sir William Congreve, invented a safer way to manufacture rockets. The blackpowder mixture was wetted with alcohol to a thick crumbling paste. Because the alcohol absorbed some heat and, more important, because it replaced the air ordinarily trapped between powder particles, compression could be carried to a higher degree. . . . Rockets made by [Congreve's] "wet procedure" had to dry for many weeks before they were ready for service. Nevertheless, Congreve rockets were used extensively by the British and other armies. It was rockets of this type that set the Capitol at Washington afire in 1814. . . .

### *Newton's Third Law—The Case for Liquid Fuel Rockets*

The rocket is perhaps the most direct application of . . . Sir Isaac Newton's Third Law of Motion: for every action, there is an equal and opposite reaction. . . . The backward force of gases from the burning fuel is matched by a reaction of equal force which pushes the rocket forward. The push of the escaping gases against the atmosphere has nothing to do with accelerating the rocket. In fact, the absence of air resistance makes rockets travel best in a **vacuum**. . . .

A genuine rocket carries all necessary fuel ingredients, including oxygen, required in forming the propellant gas. . . . Unlike a gun, a rocket exerts no recoil on the launching device, which is one of its principal advantages. This permits it to be fired from a lightweight tube or trough which serves merely to guide it during the initial stages of flight. Hence, rockets may be fired from relatively fragile structures of vehicles which could not carry the weight of a gun and its heavy recoil mechanism.

### *Liquid-Fuel Rockets and the Early Development of the V-2*

Three hundred railway cars were required to carry the parts for what are probably the most spectacular instruments for scientific research in the United States. Brought over from Germany by the United States Army, these parts when assembled made 25 liquid-fuel, V-2 rockets, capable of reaching heights of over 100 miles and speeds of 3,500 miles per hour.

These 12-ton behemoths stand 46 feet, with a body diameter of 5.4 feet and a fin-to-fin diameter of nearly 12 feet. The rocket structure and power unit weighs 6,750 pounds, and carries at take-off almost 8 tons of fuel—alcohol and liquid oxygen. . . .

*Rocketry, at first a curiosity rather than a utilitarian idea, actually has been traced back to the Chinese.

Large liquid-fuel rockets have far lower accelerations; pressures are relatively low; they are long burning; and erratic flight may be corrected to some extent by **gyro[scope]**-controlled fins. The V-2 leaves the ground with an acceleration of 38 feet per second, only 19 percent greater than that of gravity. Near the end of burning a minute or so later, the acceleration has increased but only to about 8 g's [approximately 8 times the speed of sound, or miles per hour].

Long-burning rockets are particularly effective when moving straight up. Rocket physics show that the efficiency of a rocket as a motor increases with velocity, reaching a maximum at the point where the speed of the **projectile** equals the speed of the exhaust gases. . . . In the rarified upper atmosphere the air is so thin that resistance remains low even at very high velocities. Hence, by shooting the V-2 straight up, it quickly passes through the dense air of the lower atmosphere to reach the region of the most efficient fuel consumption.

These qualities add up to make the liquid-fuel rocket an ideal laboratory instrument for exploration of the upper atmosphere. The huge war head, which made the V-2 a bearer of destruction and terror, has been emptied of high explosive, and the delicate instruments of the **meteorologist** and the **physicist** have been substituted.

At White Sands Proving Ground in the deserts of [southern] New Mexico, United States Army **ordnance** experts have sent the V-2 up to 115 miles. From these flights Army technicians are learning much about the mechanics of rockets and rocket design. The V-2 was designed as a bomb carrier instead of a research instrument. Moreover, the Germans, hurried by military necessity, did not build the best possible rocket for its size. . . . [Nonetheless,] the V-2 . . . does reach an altitude of 100 miles, and it provides varied opportunity for study.

The accumulating mass of scientific data is of real value. Physicists are interested in cosmic ray **radiation** at these heights, so **Geiger counters** have been carried aloft. Ozone in the upper air filters out about half the wave lengths in radiation from the sun. For the first time we have been able to read the complete spectrum of the sun.

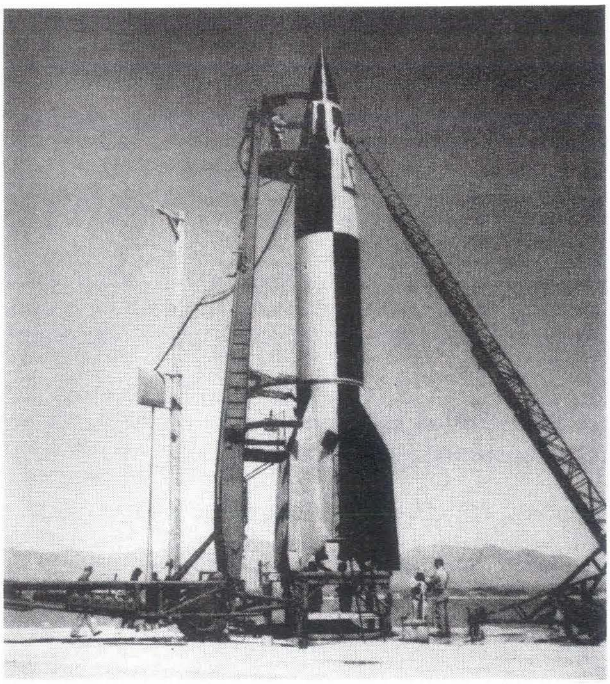
Aerodynamicists take continuous skin temperature readings at various spots over the rocket for studies of air friction and other high-speed flight problems. Weather men, communications experts and Army Air Force scientists are interested in the various layers of ionized particles that form in the rarified upper regions. It is impossible to study these layers from the ground, since only radio waves of high frequency can penetrate them. Those of lower frequencies bounce back as light is reflected by a mirror.

Our atmosphere is divided into three quite distinct layers or shells. The one nearest the ground is called the troposphere; . . . [the next highest, the stratosphere; and finally, the **ionosphere**. The distance from base of the troposphere to the outer limits of the ionosphere is approximately 200 miles].

Thus, some knowledge of the upper reaches is available. To the expert, however, it is the barest beginning, essentially just an indication that there is something to be explored. . . . Because of the success of the first flights, the V-2 program at White Sands has been extended to May 1948. At least 50 missiles will be fired in all, about half of which will be completely American built.

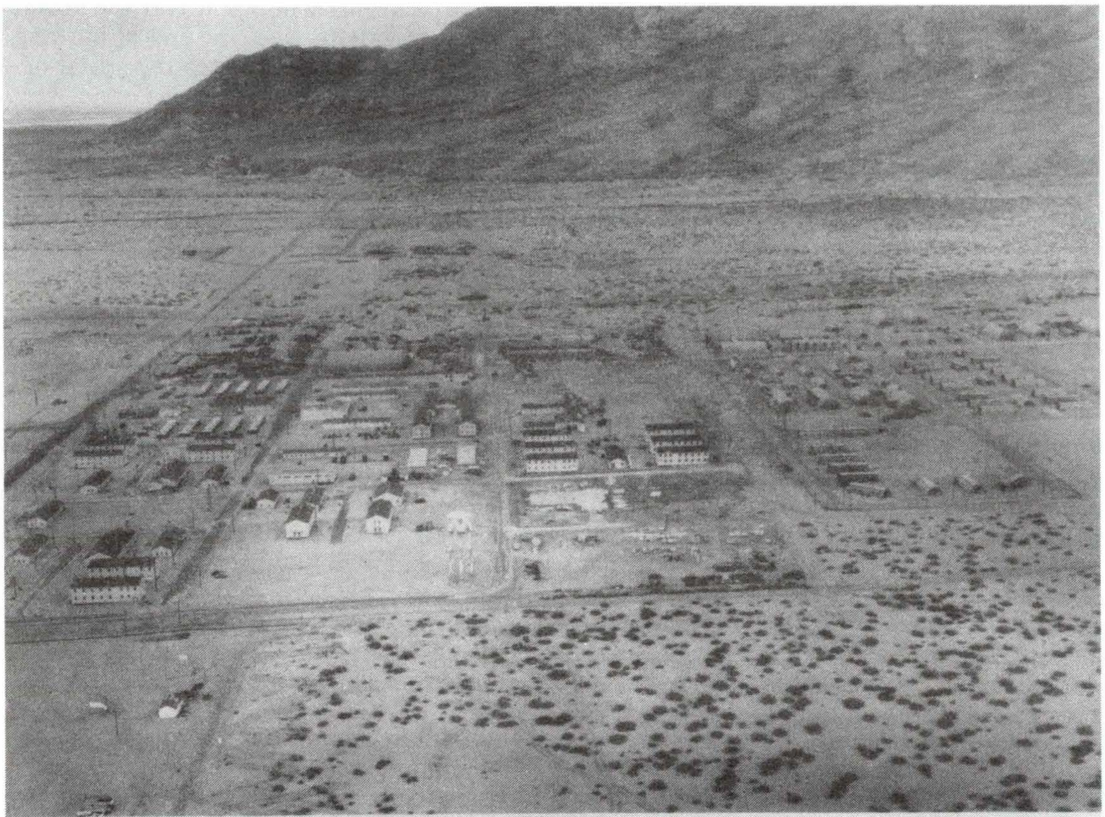
Meanwhile, research continues on bigger and better liquid-fuel rockets. . . . [and] tandem rockets are on the drawing boards. A rocket or jet-propelled **booster** will carry a second rocket for 10 miles or so to the rarified atmosphere. Then the second projectile will ignite and continue the trip, while the booster drops off.

The attack on the ionosphere has just begun. The rocketeer is out to prove the sky is not the limit.



Preparing V-2 rocket for launch (ca. 1940s)

This reading consists of excerpts from Rockets I and from Rockets II: The Frontier of Knowledge Goes Forward with Liquid-Fuel Rockets, articles written by Willy Ley and published in *Federal Science Progress in 1947.*



CANTONMENT AREA
WHITE SANDS, 1948

[Some time before the arrival of the Paperclippers,] the American Army had begun work on establishing a land range that would permit safe testing, launching, monitoring, and recovery of long range rockets. After reviewing a number of sites, the Army selected a large area around White Sands National Monument in New Mexico in late 1944. The site's isolation, topography, and dry, cloudless climate were nearly ideal. In February 1945, the Army ordered the consolidation of the existing military ranges, national parks, and private lands within the site's boundaries. By this time Germany's defeat was imminent, but few military planners realized that war with Japan would also end soon. Most were preparing for a lengthy and costly conflict that might be shortened by the use of rockets. The Corps of Engineers began construction at White Sands in late June 1945, and V-2 **matériel** arrived a month later. On a remote site of the proving ground an apparently unrelated test took place the same month: the July 16th explosion of the world's first atomic bomb at Trinity Site.

The concentrated impetus to develop rockets abruptly ended on August 14th with Japan's surrender. The American rocket program continued, perhaps neglected in the jubilation and disorder of sudden peace and demobilization. But within a year, the Army's large rocket program became one without a clear purpose. . . . [A 1947 Army] memorandum concluded that the only suitable use for large rockets was for the delivery of atomic weapons. But the . . . atomic bomb was massive, requiring a rocket eight to ten times larger than a V-2. With exclusive possession of the bomb and with existing aircraft able to deliver it, the Army saw no reason to embark on such an expensive rocketry program. The Soviet Union, faced with much the same choice, made the opposite decision and began developing massive rockets that would not only deliver atomic bombs but would eventually give it the capability to put the first man into earth orbit.

[B]y February 1946 the 124-man German rocket development team had been reunited. About 20 went on to White Sands [upon arrival] to assist in the assembly, testing, and launching of the captured V-2s, while the balance remained at Ft. Bliss, ostensibly to develop new rockets. But the Army's interest in rockets had already waned, and the German team's hopes of developing rockets for manned space exploration appeared frustrated. Over the next four years it assisted in the launch of about sixty V-2s, hardly more than would have been launched in one or two months at Peenemünde. Not until early 1950 when the German team was transferred to Redstone **Arsenal** in Huntsville, Alabama to begin the development of the Redstone rocket would their hopes be revived.

Yet the V-2 program was of seminal importance to the United States. Though dwarfed by Germany's wartime effort, it initiated America's rocket program and directly foretold its space program. At the most immediate level, it transferred the knowledge developed by years of German research to the U.S., providing America with its first direct experience in assembling, manufacturing, and launching large liquid fueled rockets.

During their years at White Sands and Ft. Bliss, the German engineers visited American manufacturers and lectured on the technical aspects of rockets. Virtually all remained in rocket engineering through the 1970s, most with the military or the National Aeronautics and Space Administration [NASA], with a few joining companies that manufactured equipment for the rocket program. And while the Germans regarded their time in New Mexico as one of forced inactivity, it was an important incubation period for ideas, particularly those dealing with staged rockets and the question of human survival in space.

Staged rockets had been postulated by theoreticians as the most feasible means of attaining high altitudes, earth orbit, and even escape velocity. In a staged rocket, two or more rockets are combined, one atop the other, and fired in sequence. With each firing the heavy mass of the previous stage's motor, tanks, and other equipment is shed, greatly reducing the overall energy needed to overcome earth's gravity. The efficiency of staging more than offsets the added weight of duplicating the rocket system in each stage.

In the late 1940s, however, the technical problems of ground launch were just being mastered. No one was sure that a second stage launch could be accomplished by remote control and with the precise timing required to realize the efficiencies of staging. The Army began to confront these technical problems in 1948 through a series of experiments known as "**Project Bumper**." In the Bumper experiments the payload section of a V-2 was fitted with the WAC Corporal, a smaller liquid fueled rocket. After the V-2 was launched and had attained maximum velocity, the Corporal was fired. Eight V-2s were modified for Project Bumper, three of which were unconditional successes, demonstrating that the technical problems of staged launches could be overcome. The Bumper flight of February 24, 1949 reached an altitude of 250 miles, nearly twice that attainable by a V-2 alone. Because the Army wanted to test the maximum range of the Bumper V-2, which far exceeded the length of White Sands, several were launched across the Atlantic from an isolated point in Florida known as Cape Canaveral. . . .

Other Army experiments investigated the question of whether life could survive the weightlessness and radiation of space. Initial experiments . . . rapidly advanced to sending animals—first a mouse, then a monkey—aloft. All the animals survived outer space apparently unharmed, although none survived reentry impact. But the experiments indicated that, properly protected, humans would not be harmed in space and thus could undertake its exploration.

By a combination of such experiments, the basic concepts of the U.S. space program were developed in the V-2 launches. While enormous technical problems of space travel remained, the task was more one of executing the mechanics of rocket flight than testing theories. The large Saturn rockets that would eventually boost the Apollo into moon orbit were direct descendants of the V-2. . . .

The V-2 program also demonstrated the value of research even when its benefits could not be anticipated. Even though the Army's interest had centered on gaining experience in handling large rockets, it found that the V-2 provided an unprecedented opportunity to explore the upper atmosphere. The first dozen or so launches did little more than provide handling experience, but later flights carried simple instruments for measuring the temperature of the upper atmosphere and determining radiation levels outside the atmosphere. In January 1947, the Army established the V-2 Upper Atmosphere Research Panel, composed of civilian scientists, to direct and select experiments to be carried in the V-2. The number and sophistication of scientific experiments accelerated rapidly. "Mapping" of the upper atmosphere began, with the documentation of its different layers, their gaseous composition, and their temperature, humidity, and wind characteristics. Detailed analysis of the sun was also undertaken, with special equipment sent above earth's atmosphere to take direct solar measurements. Such experiments enormously enriched scientific understanding of the earth and solar system.

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This reading is from *White Sands Missile Range V-2 Rocket Facilities, 1945-1952*, by Michael Quinn.

## READING 4. THE SCIENTISTS: ANOTHER LOOK

Were the German scientists that were brought to this country under Operation Paperclip members of the Nazi Party?. . . [R]ecent disclosures under the **Freedom of Information Act** indicate that practically all of them were party members. Some were also members of the dreaded **SS**. Supposedly, all had been cleared of war crimes. . . . [but] did not stand trial in **Nuremberg**. Several years ago this nation deported . . . [Alan Rudolph]—a scientist who had achieved a high position in the NASA structure and was instrumental in the Apollo and earlier programs—because evidence had surfaced . . . that he was aware of and had apparently condoned use of slave labor at **Mittelwerk** and other V-1/V-2 fabrication sites. [It is] difficult to believe that all of the Operation Paperclippers did not know about the use of forced labor from the concentration camps. . . . [and] that the German populace-at-large claimed to be unaware of the concentration camps, the crematoriums, and the "final solution.". . . [It would seem that] every German fought on the Eastern Front against the Communists. [How is it, then, that U.S.] troops did not just walk into Germany without firing a shot?

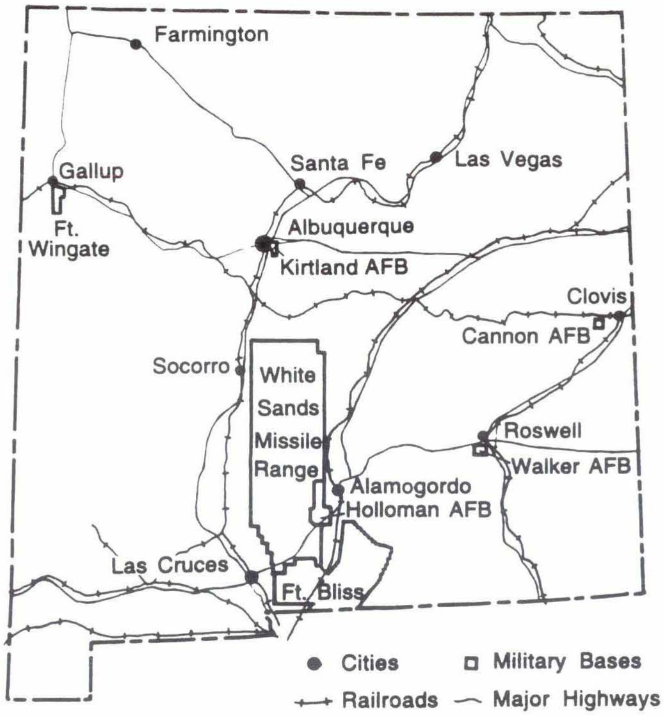
On the other hand, what is to be gained by freely making such admissions after the fact? What were those outside the SS power structure expected to do about such atrocities in a police state if they were aware of them? [One would] suspect very few [people] would be anxious to volunteer information to a victorious enemy that could land [them] in jail or . . . put a noose around [their] necks. And, if [the United States] were defending this land against an enemy invasion, we would [not] be overly concerned about where [our] weapons . . . came from or who made them and how. . . . [The] primary concern would be that the weapons kept coming as long as there was a chance of winning. [This is no excuse] for those responsible for what has become known as the **Holocaust**. [The] point is that it is easy to be judgmental and sanctimonious when your side wins and you're not personally involved. . . .

Did we as a nation really need these German scientists for our national security? . . . We did, if we intended to keep up with or stay ahead of our allies from the recent war. Russia, Great Britain, and France were all vying for their services. None of the allies seemed too concerned with the extent of the German scientists' involvement with slave labor or **concentration camp** medical experiments—everyone's interest was to take advantage of what they had learned. And they were . . . years ahead of this nation in . . . missile development. . . . This nation . . . kept [the Paperclippers] from the hands of other countries but now that we had them we did not seem to know what to do with them. In part . . . this was because [the government] did not fully trust them. And, in part, was because this country had no agreed-upon objectives for missile and space activity. So they sat around consulting on V-2 firings at White Sands, translating documents, submitting to the same interviews and interrogations, and feeling frustrated. . . . [However t]he creation of the Army Ordnance Missile Center in Huntsville, Alabama in 1950 and the mass transfer of the German scientists put the Paperclippers back to . . . productive work, designing new and better missiles. . . .

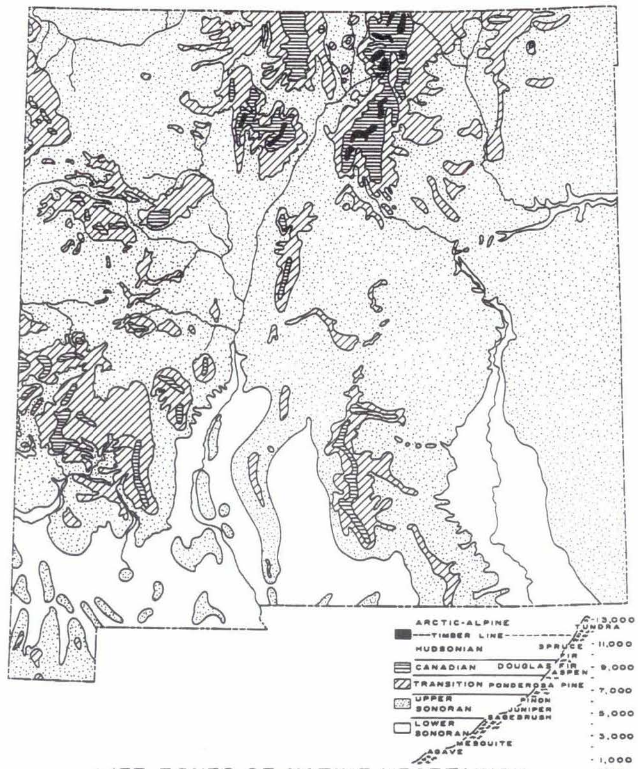
Were the Germans some type of supermen? . . . Not really. Their native culture gave them a highly disciplined approach to problems. Reporters who visited . . . Fort Bliss were impressed with how they respected authority and . . . wrote about it in the articles they dispatched. Technicians deferred to engineers, engineers to PhDs, PhDs to professors, professors to von Braun and all deferred to Major [James P.] Hamill. It seems . . . they possessed a certain . . . arrogance to assume their talents and experience would be in great demand at war's end. . . . [T]he possibility they would be tried as war criminals [did not seem to enter] their mind. . . . [Yet] in many respects they were ordinary men. . . .

Some of the German scientists, known as the Paperclippers (ca. 1946-1947)

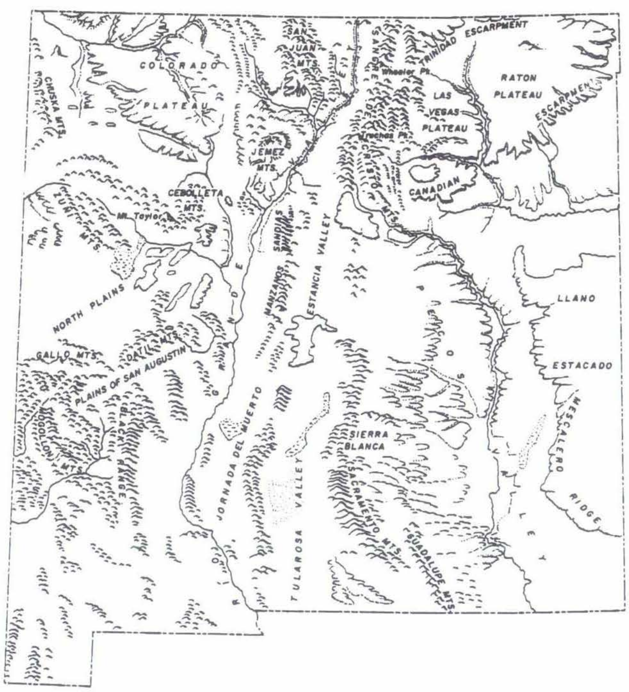
This reading taken from "Did 'Paperclip' Scientists Belong to the Nazi Party?" by Tom Starkweather. In *Missile Ranger*, February 16 1990, p. 18.



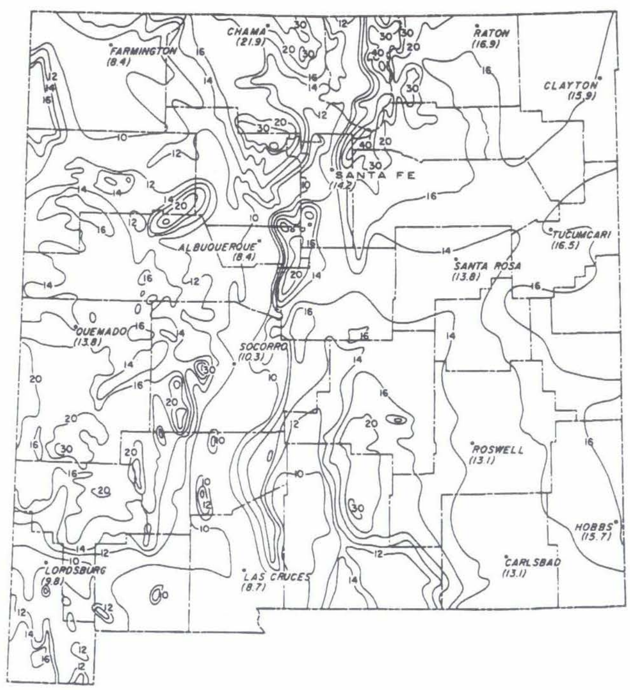

MILITARY INSTALLATIONS




LIFE ZONES OF NATIVE VEGETATION

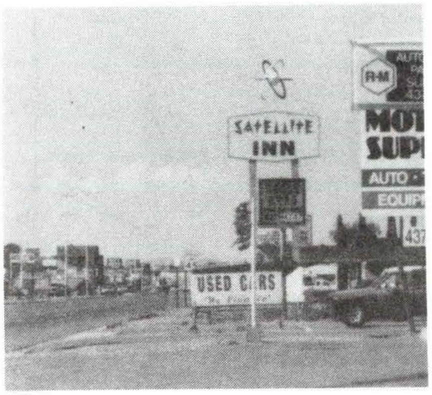



LANDFORMS

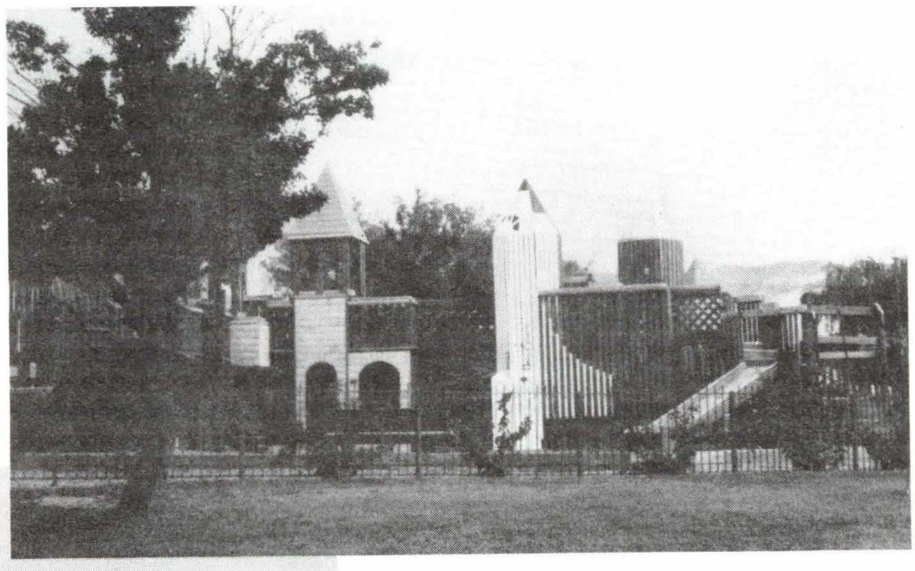



AVERAGE ANNUAL PRECIPITATION
(IN INCHES)

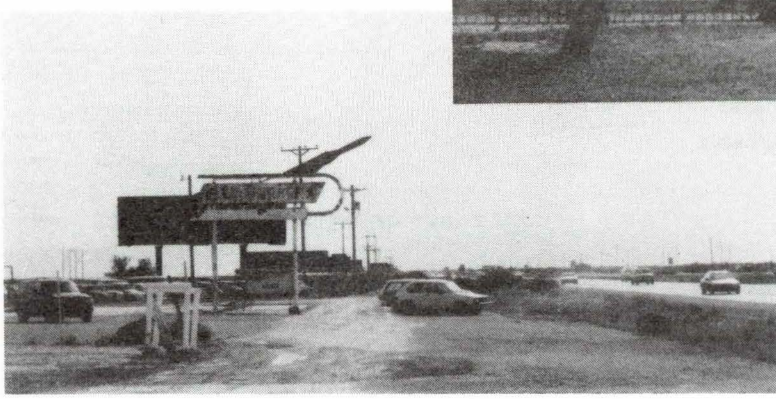
Landform, precipitation, and vegetation maps reprinted with permission from *Historical Atlas of New Mexico* by Warren A. Beck and Ynez D. Haase, University of Oklahoma Press, 1969.




Satellite Inn, Alamogordo.

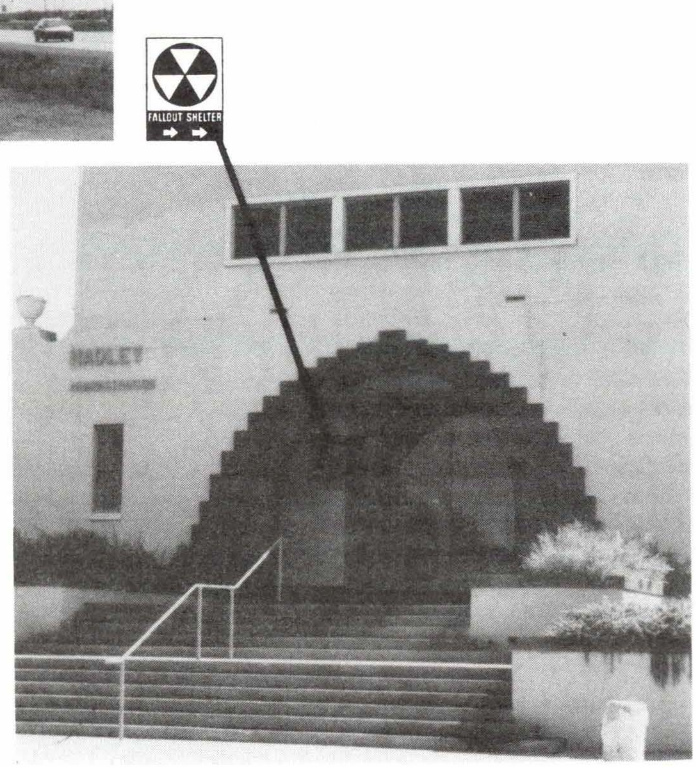


Space shuttle slide at Kid's Kingdom, Alamogordo.



Site of the former (ca. late 1950s) Rocket Gas Station, Alamogordo.


Sonic Drive-In restaurant, Las Cruces, indicative of drive-ins of the 1950s.



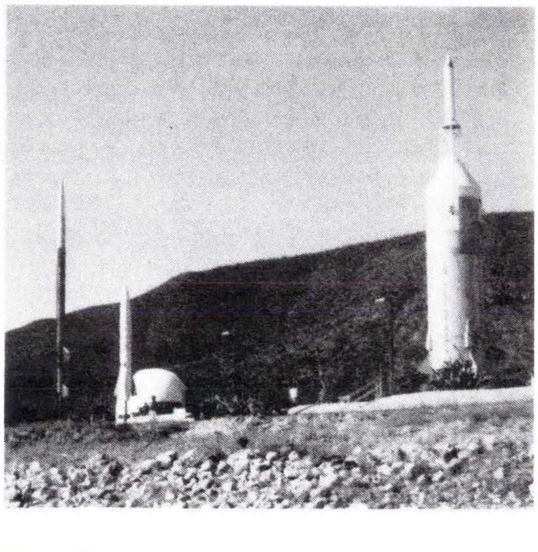

Civil Defense sign indicating presence of fallout shelter, Hadley Hall, NMSU.

V-2 used on float in Aggie homecoming parade, Las Cruces, 1952. Courtesy U.S. Army Public Affairs Office, White Sands Missile Range.

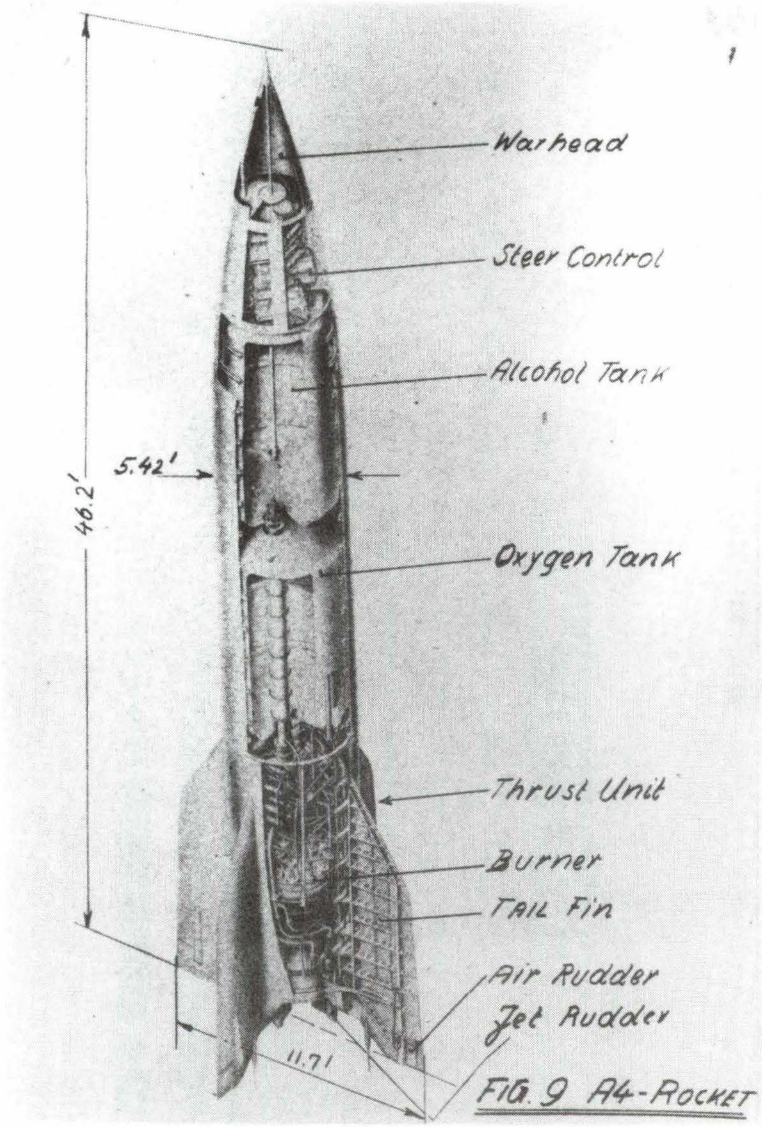

Rocket Inn, Alamogordo.


The Rocket Drive-In, Las Cruces, ca. mid-1950s.
Courtesy Rio Grande Historical Collections, NMSU Library.

"Little Joe" and other Army rockets, Alamogordo Space Center.



A-4/V-2 ROCKET BLUEPRINT

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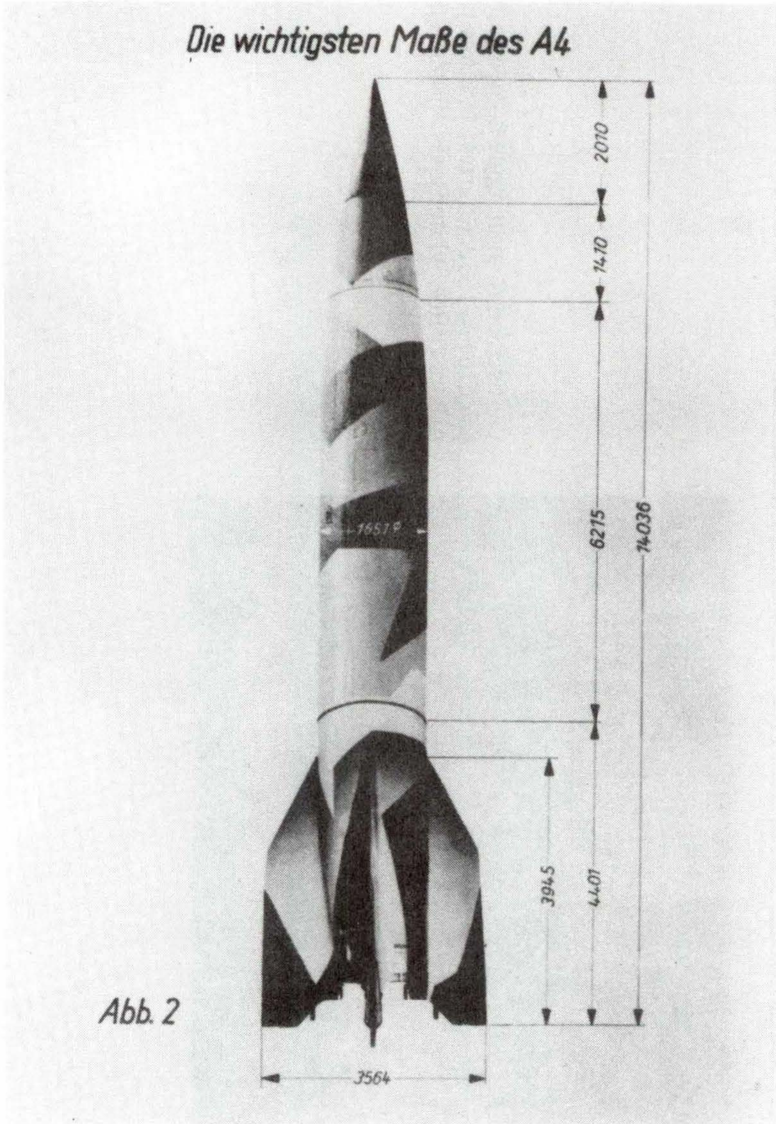
A-4/V-2 ROCKET DIAGRAM

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