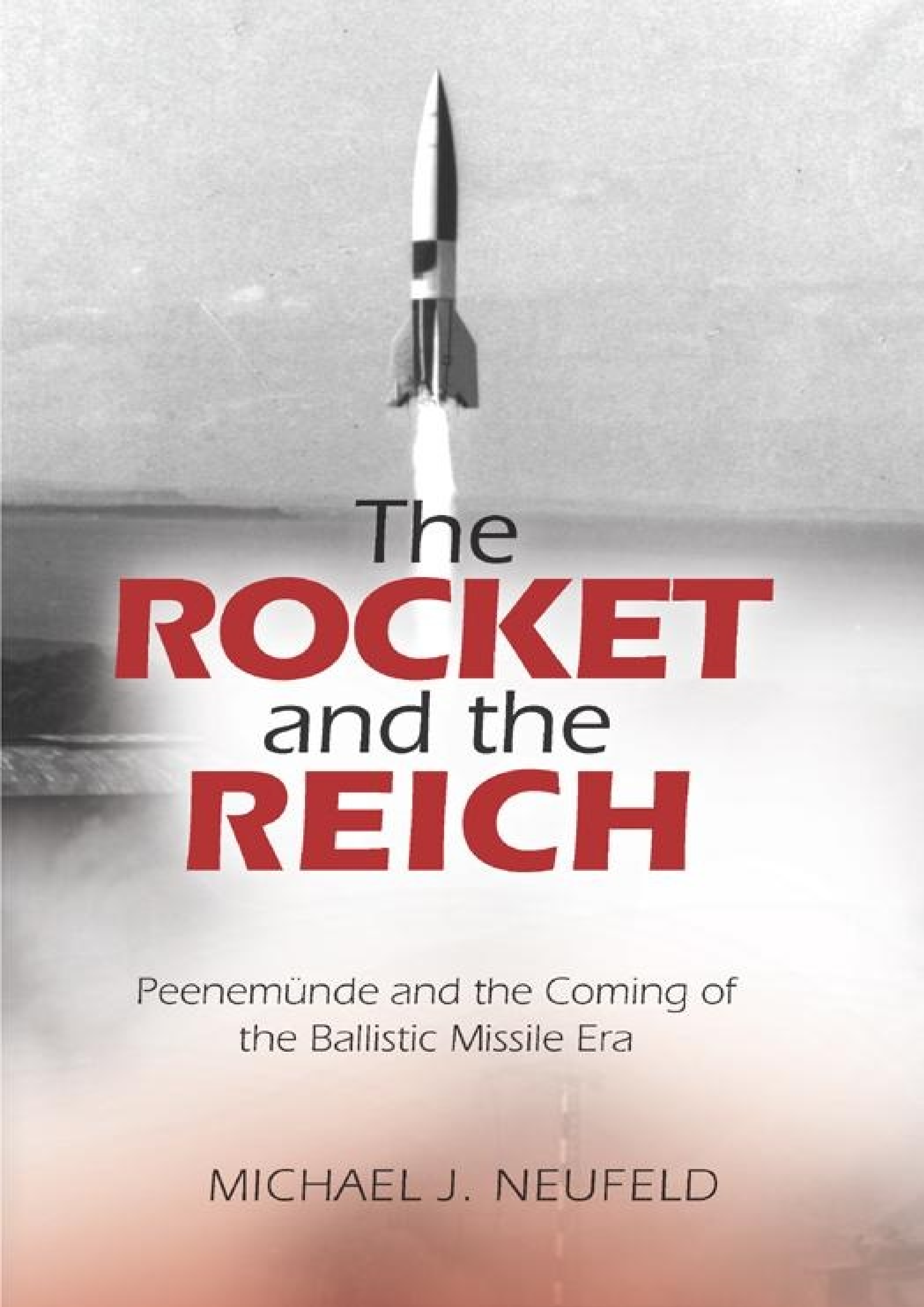
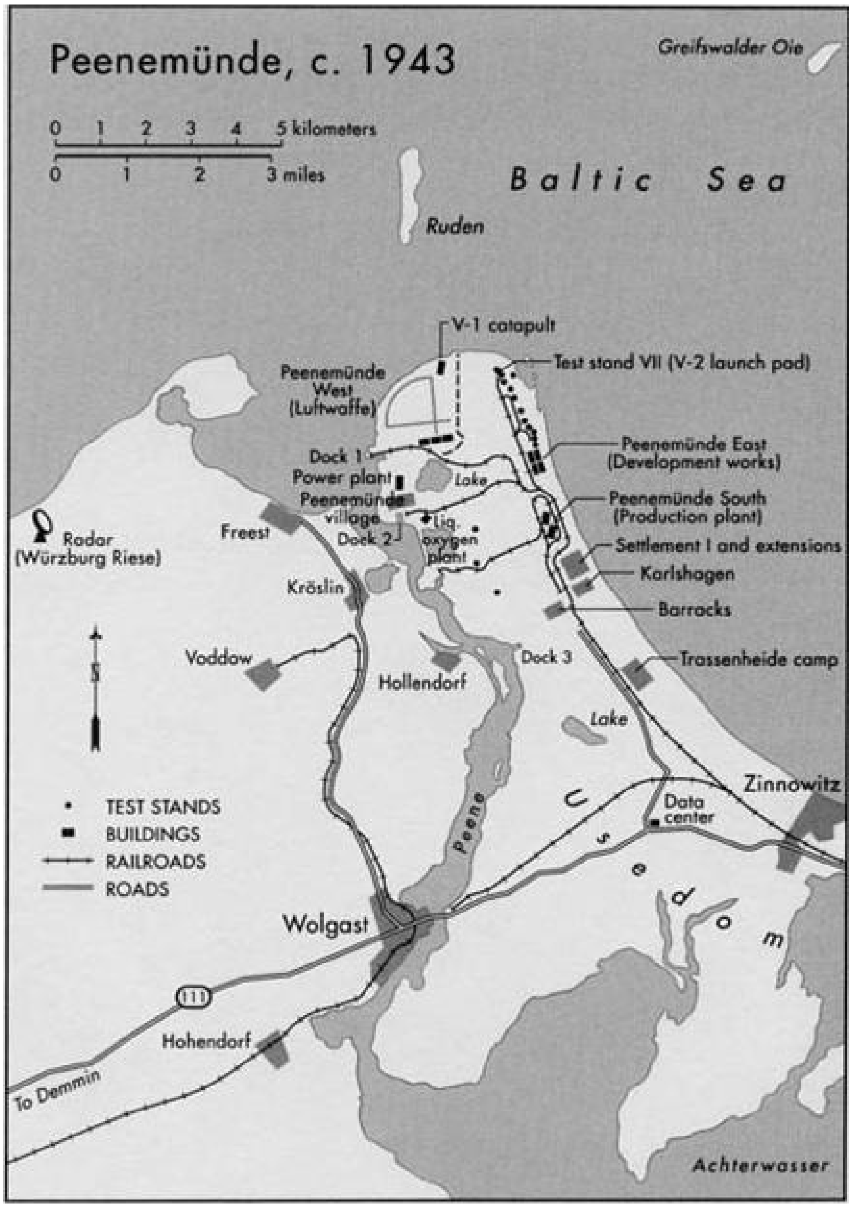


The ROCKET and the REICH

Peenemünde and the Coming of the Ballistic Missile Era

MICHAEL J. NEUFELD


Peenemünde, c. 1943
Greifswalder Oie
0 1 2 3 4 5 kilometers
0 1 2 3 miles
Baltic Sea
Ruden
V-1 catapult
Test stand VII (V-2 launch pad)
Peenemünde West (Luftwaffe)
Dock 1
Power plant
Peenemünde village
Dock 2
Lake
Liq. oxygen plant
Peenemünde East (Development works)
Peenemünde South (Production plant)
Settlement I and extensions
Karlshagen
Barracks
Radar (Würzburg Riese)
Freest
Kröslin
Voddow
Hollendorf
Dock 3
Trassenheide camp
Lake
Zinnowitz
Data center
Usedom
Peene
TEST STANDS
BUILDINGS
RAILROADS
ROADS
Wolgast
111
Hohendorf
To Demmin
Achterwasser

Michael J. Neufeld

The ROCKET and the REICH

Peenemünde and the Coming of the Ballistic Missile Era

Smithsonian Books
Washington, DC

First published in hardcover by The Free Press, a division of Simon & Schuster, Inc., 1995

Library of Congress Cataloging-in-Publication Data

Neufeld, Michael J.
The rocket and the reich : Peenemunde and the coming of the ballistic missile era. / Michael J. Neufeld
p. cm.
Includes bibliographical references.
eISBN: 978-1-58834466-3
1. Rockets (Ordnance)—Research—History—20th century. 2. Liquid propellant rockets—Research—History. 3. Ordnance—Manufacture—History—20th century. 4. Germany. Heer. Heeresversuchstelle Peenemunde—History. 5. Pennemunde (Germany)—Manufactures—History. I. Title.
UF535.G3N48 195
355.8'25195'094309044—dc20

94-30088

v3.1

To the tens of thousands of prisoners
who suffered, died—or survived—
Dora and the other concentration camps of the V2 program

May their sacrifice never be forgotten

Contents

Preface

I first became interested in the German rocket engineers as a small boy in Canada when my father discussed the space race. Did the Russians get the better Germans, or did the Americans fail to exploit their advantage when they got Wernher von Braun's group after the war? That was one of the questions bandied about in the media and around the dinner table at the time. In the aftermath of those early discussions—and televised launches—I lived and breathed spaceflight as a teenager in the 1960s. My ambition to become an aerospace engineer or an astronomer was not realized, however, so I followed other interests and became a historian specializing in modem Germany. Only after revising my dissertation in labor history did I turn back to my old avocation in search of a field that would sustain my enthusiasm. The history of science and technology in general, and the story of German rocketry in particular, seemed to offer an ideal combination of my new and old interests.

In mid-1988 I came to the National Air and Space Museum as a visiting fellow. I soon concluded that a new book on Peenemünde and the V-2 would be far from redundant, that indeed it was a necessity. Although the development of the first large ballistic missile was one of foundations of the nuclear arms and space races, the topic's history had not been well researched. The books on this subject, especially those in English, tended to cite the memoirs of participants uncritically, while giving a less-than-frank treatment of the Nazi records of prominent leaders like von Braun. With two exceptions, Heinz Dieter Hölsken's *Die V-Waffen (The V-Weapons)* and David living's *The Mare's Nest*, serious archival research was entirely neglected and even Irving's research was incomplete and unfootnoted.

In the mid-1980s a new genre began to appear: books by investigative journalists on the scandals of Project Paperclip, which brought German scientists and engineers to the United States after the war. Those works were largely engendered by the Rudolph affair. In 1984 the Justice Department forced Arthur Rudolph, the former project manager of NASA's Saturn V moon rocket, to leave the United States because of his involvement with concentration camp labor during V-2 production. While the resulting exposés uncovered much new information about the Nazi records of the German rocketeers, all too often they combined sensationalism with a simplistic view of life in the Third Reich.

The present work thus aims to provide a balanced and readable history of the German Army liquid-fuel rocket program based on archival research. The symbolic center of the book is the rise and fall of the Army rocket facility at Peenemünde as a major research and development institution. Because the stunning technological revolution effected at Peenemünde is so central to understanding the shape of the institution and the character of the program, I do not shy away from discussions of the technology. But, for the sake of readability, I eschew jargon or a more theoretical examination of the place of Peenemünde in the history of science, technology, and the military in the twentieth century. The epilogue will draw attention to some interesting aspects of Peenemünde's legacy which emerge from the rocket program's relationship with Nazism and its transfer to the United States and elsewhere. Readers looking for a more theoretical or historiographic examination of those topics are invited to consult my articles listed in the bibliography. Those who want more detail about the organizational history of the rocket program should turn to Appendix 2.

This book would not have been finished without the National Air and Space Museum (NASM) and the Smithsonian Institution. The project was supported in its first two years by a NASM Verville Fellowship and by a Smithsonian Institution Postdoctoral Fellowship. The National Science Foundation also made a large contribution through a Scholar's Award (DIR-8911103) from the Science and Technology Studies Program. During my fellowship period in the NASM Department of Space History, David DeVorkin, Allan Needell, Robert Smith, Martin Collins, John Mauer, Frank Winter, Ron Doel, Michael Dennis, Paul Ceruzzi, Cathy Lewis, Gregg Herken, Joe Tatarewicz, Mandy Young, Joanne Bailey, and Pat Fredericks provided me with a fruitful intellectual climate and helpful administrative support. Frank Winter in particular gave me the benefit of his extensive knowledge of the early rocket societies.

Since my move to the Aeronautics Department as a curator in 1990, its chairman, Tom Crouch, has not only given me much time to finish the book but also provided me with the fruits of his own deep thinking about Peenemünde and Wernher von Braun. I have learned much about the Luftwaffe from Tom Dietz, while Anita Mason and Collette Williams have given cheerful and helpful administrative assistance. I have also benefited from discussions with Von Hardesty, Dom Pisano, Peter Jakab, Jacob Vander Meulen, and Claudio Segrè. I would further like to thank the NASM branch of SI Libraries, especially its current and former branch chiefs, Martin Smith and Dave Spencer, for allowing me to borrow a microfilm machine, plus Mary Pavlovich for her help with interlibrary loans. I am also grateful to the Archives Division, above all to Paul Silberman for turning up the long-forgotten and mislabeled "FE" microfilm of Peenemünde documents.

Every chapter was carefully read by two close friends and colleagues from my days in Space History: David DeVorkin, curator of the history of astronomy, and Ron Doel, twice a visiting fellow in the Department. Their good advice has been incorporated everywhere in the book. Robert Smith also gave me valuable comments on early chapters. They can take no responsibility for my errors and misjudgments, however, nor do the opinions expressed in this book necessarily represent the views of the National Air and Space Museum or the Smithsonian Institution.

From outside the museum, I would especially like to thank Michael Hubenstorf of the Free University of Berlin, who provided me with comfortable accommodations, warm hospitality, and helpful research hints during my stays in that city. Richard Muller of the Air Command and Staff College, a former NASM fellow, sent me material about the Luftwaffe and gave me the benefit of his encyclopedic knowledge of German military history. Guillaume de Syon of Boston University, Richard Breitman of American University, Donald MacKenzie of the University of Edinburgh, and Wolfgang Rüdig of the University of Strathclyde have kindly supplied me with archival and secondary information relevant to the book, while Yves Béon and Roland Hautefeuille, both of Paris, generously gave me copies of their books. Joyce Seltzer of Harvard University Press, my former editor at The Free Press, made many helpful suggestions for improving the writing of this study. Sheila Weiss of Clarkson University encouraged me to take the plunge into the new field in the first place.

My debts to archives and libraries are considerable. I would like to thank Robert Wolfe, Harry Riley, Ed Reese, and other members of the National Archives staff; David Marwell and Frau Wolf of the Berlin Document Center; Philip Reed of the Imperial War Museum; James Hagler of the Space and Rocket Center; Rudolf Heinrich, former archivist of the Deutsches Museum; and Helmut Trischler, its current research director. I would also like to express my gratitude to the staffs of the Bundesarchiv Koblenz, the Bundesarchiv/Militärarchiv Freiburg, the Humboldt University Archive, the Redstone Scientific Information Center, the Kz-Gedenkstätte Mittelbau-Dora and the Peenemünder Informationszentrum. The *Journal of Military History* kindly allowed me to reprint material that first appeared in a different form in that publication.

For the kind granting of their time and permission to conduct oral history interviews, I would like to thank the former Peenemünders whom I visited in Huntsville and elsewhere, especially Gerhard Reisig, who was very helpful at an early stage of this project. I know that some of the things I have said in this book will anger them, but I have always tried to be faithful to the truth as I saw it. I do not think that there is such a thing as collective guilt; each case must be evaluated individually. The German rocket engineers were neither uniformly innocent nor uniformly guilty of Nazi enthusiasm or the abuse of slave labor. It is time that they stop being lumped together. I understand that the majority were merely doing their job in wartime in a totalitarian society over which they had no control, but neither is that a reason to exempt every last one from responsibility. On those questions, I am grateful to Eli Rosenbaum of the Office of Special Investigations, U.S. Justice Department, and to a freelance journalist, Linda Hunt, for supplying me with valuable information. Other interviews were kindly granted by Dr. Hermann Kurzweg, Rolf Engel, Dr. and Mrs. Hans Geipel, Mr. and Mrs. Manfred Schubert, and Mr. and Mrs. Gerhard Zanssen.

Finally, Karen Levenback gave me much love and support during the writing of this book, as well as the benefit of her professional expertise in editing and writing. Nearly every chapter is better written because of her insightful advice. Her encouragement during the long hours at the computer have been invaluable as well. I would also like to thank our cats, Newt, Birch, and Kepler, for the suggestions they made by jumping on my keyboard. It would not have been the same without them.

Prologue
Summer 1943

In early August 1943 Dieter Huzel, a newcomer to the secret German Army rocket center at Peenemünde, at last got his chance to see the A-4 missile. As a friend showed him into the launch checkout building for the vehicle that would later become famous as “Vengeance Weapon 2” or V-2, his eyes slowly adjusted from the glare of the summer sun. Finally,

> I saw them—four, fantastic shapes but a few feet away, strange and towering above us in the subdued light. I could only think that they must be out of some science fiction film—*Frau im Mond [The Woman in the Moon]* brought to earth.
>
> I just stood and stared, my mouth hanging open for an exclamation that never emerged. Then, slowly, I walked around them. They fitted the classic concept of the space ship—smooth, torpedo-shaped—giving no hint of the mechanisms within, and resting tip-toe on the points of four swept cruciform fins. By today’s standards the A-4 was a small missile, but these were 46 feet tall and by all odds bigger than anything I had ever dreamed of. They were painted a dull olive green, and this, said Hartmut, as well as their shape, had won them the nickname of cucumber. I laughed, and the spell was broken.[1]

It was indeed a remarkable sight. Despite the A-4’s Utopian origins in the spaceflight movement of the 1920s, the German Army had committed massive resources to build this exotic weapon, and had succeeded. But the missile was only the most spectacular product of this investment. What the money had purchased, first and foremost, was the Peenemünde Army Center, which had created this astonishing technological achievement.

Huzel had arrived just as the institution was reaching the apogee of its trajectory. Up to 12,000 people worked—or were forced to work—for the Army on the Baltic island of Usedom, where Peenemünde was located. Since his arrival, Huzel had passed through the new “works train” station, where the hordes of commuters reminded his friend “of the Berlin U and S stations at rush hour.” From the the modern electric train that coursed through the center, Huzel had viewed massive facilities, including a camp of mostly Russian and Polish forced laborers and the F-1 assembly building at the Pilot Production Plant (Peenemünde-South). That building, more than 250 meters (800 feet) long, held an assembly line that would produce three hundred A-4s a month in the fall. Unbeknownst to him, F-1 also contained a small concentration camp, where six hundred mostly Russian and French-speaking prisoners were held under SS guard as the first installment of the labor force.[2]

The newcomer’s journeys also took him to the older Development Works at Peenemünde-North (or -East, the original name used to distinguish it from the much smaller Luftwaffe facility at Peenemünde-West). At the Development Works Huzel found, scattered among the trees, a large campus of administrative buildings, laboratories, test stands, and workshops. About six thousand engineers and skilled hands worked in this facility alone as a result of concentrating “everything under one roof” instead of contracting out most work to companies. Here the first A-4s had been designed and built since the center opened in 1937.[3]

How had this remarkable institution come about? Why had the Third Reich invested hundreds of millions of marks in guided missile research and development? And why had the leaders of the Army rocket program incorporated into their project, willingly or unwillingly, one of the worst features of the Nazi regime for which they worked—concentration camp labor? To answer those questions, we must first turn to the late 1920s and early 1930s. During that period key officers in artillery development came to believe that liquid-fuel rocketry could be the basis for a potentially war-winning secret weapon: the ballistic missile. Supersonic projectiles like the A-4 would rain down on potential enemies, causing physical destruction and psychological shock. If the surprise was great enough, opposing leaders might well concede victory to the technologically superior German forces. But the Army’s interest in the technology had been awakened by quite another scenario, one popularized by a small but determined band of spaceflight enthusiasts. To those true believers, the liquid-fuel rocket would be the means for liberating the human race from the bonds of the earth.

Chapter 1
The Birth of the Missile

Berlin, October 1929. In the fashionable west end, near the Kurfürstendamm, the entire façade of the UFA Palace movie theater was “covered with a gigantic animated panel, showing the earth and the moon against a starry sky and a projectile-like moon rocket making round trips between them.”[1] Playing in the theater was the new science fiction movie *Frau in Mond (The Woman in the Moon)*, by Fritz Lang, the renowned director of *Metropolis*. The newspapers carried notices of the impending launch of a stratospheric rocket by Hermann Oberth, the film’s scientific adviser and the father of the Weimar spaceflight movement. That movement had arisen in response to Oberth’s writings about the feasibility of space travel, but it was also an expression of the Weimar Republic’s forward-looking and innovative culture. The upheavals of 1918—the loss of World War I, the abdication of the Kaiser, and the founding of a democratic republic—had created unprecedented freedom but had also exacerbated deep social and political tensions in German society. Those conditions fostered original art and original thinking.

Not far from the theater, in the quarters of the Army Ordnance Office, Lieutenant Colonel Karl Emil Becker (1879–1940) had begun to investigate the revival of the rocket as a weapon. Since the mid-nineteenth century, when rifled, breech-loading artillery guns had greatly improved accuracy and range, the black-powder rocket had fallen out of favor as a bombardment weapon. Military experts and lay people alike came to regard this traditional form of the rocket, which burned a gunpowder-like fuel in a metal or paper casing, as little better than a toy. In World War I rockets had been used only for signal or illuminating flares and other minor applications. In the interwar period, however, improved possibilities for the safe manufacture and storage of solid propellants, including new smokeless powders, made rocketry again more interesting to the military. Becker, who had a doctorate in engineering and headed Section 1 (ballistics and munitions) of Army Ordnance’s Testing Division, was especially interested in solid-fuel rockets as a means of launching poison gas against enemy troops on the battlefield.[2]

The fact that the Allied-imposed Versailles Treaty of 1919 omitted any mention of rocket development reinforced Becker’s interest in the technology. Like most of his fellow officers, he was an ultranationalist who yearned for the day when a new right-wing authoritarian regime could overthrow the treaty’s onerous limits on German military power. Until that day, however, Becker and his compatriots would use all available means to circumvent the treaty, which restricted the Reich to an Army of

100,000 lightly armed men, a tiny Navy, and no air force at all. Not only had the Army maintained hidden units to violate its size limit, it had conducted covert research into poison gas, aircraft, tanks, and other banned weapons at home and abroad, most notably in the Soviet Union. The investigation of legal technologies like the rocket was yet another way to prepare for rearmament, an increasing concern of the Weimar military in the relatively stable years of the late 1920s. But Becker's interest in rocketry as a means of illegal chemical warfare shows that finding a loophole in the treaty was not central to his decision to look into the technology. Of more significance was the Versailles ban on heavy artillery, an important class of weapons that was Becker's specialty. Provided that rockets could be made sufficiently powerful, they could replace not only short-range battlefield weapons but also long-range heavy guns.[3]

If Becker had military reasons for taking up rocketry, the Weimar spaceflight fad also undoubtedly had a crucial impact. The fad had begun with Hermann Oberth's seminal 1923 book, *Die Rakete zu den Planetenräumen (The Rocket into Interplanetary Space)*. Oberth (1894–1989), a member of the German minority of Transylvania, was an unwilling Rumanian citizen after the Hapsburg Empire's collapse in 1918. His slim volume had defended the radical concept of manned spaceflight and had made concrete suggestions for overcoming the technical difficulties involved. Most notably, Oberth's book showed that by mixing and burning a liquid fuel like alcohol with an oxidizer like liquid oxygen, one could dramatically improve performance over the traditional black powder rocket. At first the book attracted little notice, but in 1924 Oberth's cause was taken up by the irrepressible Max Valier, an Austrian writer and self-proclaimed astronomer residing in Munich.[4]

Valier's articles, books, and speeches did much to popularize the idea of spaceflight with the Weimar public. Although most of Oberth's ideas had been anticipated by, among others, Konstantin Tsiolkovsky in Russia and Robert Goddard in the United States, their insights were inaccessible to lay and specialist readers alike. Tsiolkovsky's publications went back as far as 1903 but were buried in obscure Russian periodicals. Goddard's "A Method of Reaching Extreme Altitudes" (1919–20) had avoided explicit references to liquid-fuel rocketry and manned spaceflight. Even so, his discussion of a staged powder rocket to hit the moon had unleashed a wave of sensationalism and ridicule in the newspapers that made the shy physicist even more secretive than before. His impact in Europe was largely confined to wild rumors in the popular press about his activities. The fact that he had launched the world's first liquid-fuel rocket in 1926 remained virtually unknown for a decade afterward.[5]

Oberth's intellectual boldness and Valier's knack for publicity, in contrast, made the spaceflight idea more visible and respectable in Germany than almost anywhere else. In 1927 Valier participated in the formation of the Society for Space Travel, often known by its German abbreviation, VfR. Until 1930 the VfR was headquartered in Breslau (now Wroclaw, Poland), because its first president was Johannes Winkler, a church administrator and frustrated engineer there. Winkler's new journal, *Die Rakete* (The Rocket), became the organ of the society. But it was Valier's alliance with Fritz von Opel, heir to the car manufacturing fortune, that finally put rocketry on the front pages. In order to generate publicity, Opel and Valier used commercial black-powder rockets to power spectacular race car demonstrations in April and May 1928. Those experiments unleashed a wave of publicity in the media, and other stunts followed with rail cars, gliders, bicycles, and even a Valier rocket ice sled. Their visibility also strengthened Fritz Lang's resolve to make the moon flight movie he had been thinking about since *Metropolis*.[6]

Although some skepticism and ridicule had accompanied all that activity, especially speculations on the subject of spaceflight, the 1928–29 popular fad showed that, with the possible exception of Soviet Russia, Germany responded more enthusiastically to the potential of the rocket than any other country. Nationalism no doubt played a key part here. Germans tended to seize on almost any sign of their technological superiority or their rapid recovery from the humiliations of the war and Versailles. Despite bitter political and ideological divisions in the country, technological progress was desired by almost everyone, and the rocket fad provided escapist entertainment for the new mass culture of the 1920s.[7]

Thus, when Becker began to investigate the rocket in 1929, he did so against a background of media publicity and highly visible demonstrations of powder rockets in action. His curiosity may also have been piqued by discussions, mostly on the margins of the spaceflight movement, of the possibility of a large ballistic missile based on liquid fuels. Oberth, for one, had discussed the possibility of launching poison-gas attacks on enemy cities with intercontinental rockets in the enlarged 1929 version of his book, *Wege zur Raumschiffahrt* (Ways to Spaceflight), apparently because he had received so many queries from the public about the idea. He considered it impractical for the next decade or two, however, because of the difficulty of accurately guiding the missile to its target.[8]

At the end of 1929 Becker asked for and received permission from the Reich Defense Minister for a small solid-fuel rocket program. Testing of commercial black-powder units began shortly thereafter. Assisting the fifty-year-old Becker were a small number of junior officers with engineering training. His second in command in the ballistics and munitions section bore the impressive aristocratic moniker d'Aubigny von Engelbrunner Ritter [Knight] von Horstig. Captain von Horstig (b. 1893) also had an engineering doctorate and shared his superior's World War I experience in the artillery. Three slightly younger veterans would soon emerge as the central figures in the administration of the early program: Erich Schneider, Walter Dornberger, and Leo Zanssen.[9]

All three were products of a "study officer" program that Becker had been instrumental in founding. Appalled by the antitechnological attitudes of the old Imperial officer corps and dismayed over personal experiences with poorly organized procurement in wartime heavy artillery development, Becker successfully pushed engineering training for selected individuals in the Army. He was aided in that endeavor by the new Army leadership and by his mentor, Professor Carl Cranz, author of a famous ballistics textbook, which Becker helped to revise in the 1920s. Cranz's Prussian Army artillery laboratory had been converted into an institute of applied physics at the Technical University of Berlin after the war, in order to prevent its dissolution under the Versailles Treaty. Not only did Becker receive his doctorate from Cranz's institute, but it also became the center of a regular "diploma engineer" program (equivalent to a master's degree) for study officers. Schneider graduated from the University in 1928, Dornberger in 1931, and Zanssen in 1933, all as mechanical engineers with special expertise in artillery ballistics.[10]

Of the three, Dornberger (1895–1980) would become the most important. The son of a pharmacist from the southwest German city of Giessen and a veteran of heavy artillery units on the Western Front, Dornberger would become a masterful salesman, administrator, and political infighter for the rocket program. A spaceflight enthusiast, he read Oberth's Wege around the time of its appearance in 1929. He began work in Becker's section in 1930, purportedly with the assignment of looking into liquid-fuel rocketry, but until 1936 his main area of concentration was small battlefield solid-fuel rockets. Zanssen, another middle-class officer from western Germany and a close friend from the University, was Dornberger's alter ego and served under him through much of the history of the program.[11]

THE RISE OF AMATEUR ROCKETRY

At the same time as Army Ordnance began its small-scale investigations in 1929–30, liquid-fuel rocket development began in earnest among the spaceflight fanatics in the VfR and outside of it. It had been apparent for some time that a move from theory to practice was necessary. As early as 1924 Oberth and Valier had been looking for a funding source, such as a millionaire or a corporation, to make that possible. Valier's search eventually led him to his short-lived alliance with Opel and to the idea of using commercially available black-powder rockets to put on a series of stunts with cars and other vehicles. That publicity-seeking approach, which did nothing to advance rocket engine development in the short run, proved to be the last straw for the already strained relationship between the querulous and suspicious Oberth and the technically untutored Valier. Like almost everyone else in the spaceflight movement, however, the two looked to the same models: the heroic independent inventors of the late nineteenth and early twentieth centuries, like Edison, Diesel, and Ford. They expected some far-sighted, wealthy investor to finance their rocket development and did not foresee that such an enormously expensive technology could only be created by a government-financed military-industrial complex. Motivated by a burning vision of travel to the moon and the planets, the spaceflight pioneers also grossly underestimated the complexity and difficulty of the technology.[12]

Some of the early pioneers did receive limited corporate support. Johannes Winkler was the first to begin more serious work, with preliminary experiments in Breslau in 1928–29 and further work at the Junkers Aircraft Company in Dessau in 1929–31. The head of the company, Hugo Junkers, a well-known airplane designer, hoped that rocket engines could be used to assist the takeoff of heavy airplanes and could serve as a propulsion system for high-speed aircraft. Winkler made preliminary experiments using various propellants, such as ethane and nitrogen monoxide, but settled on methane and liquid oxygen as his main fuels. Liquid oxygen was the ideal oxidizer, but that entailed all the difficulties of handling a fluid that boils at a temperature of –183°C (–297°F), and one which had a distressing tendency to set off explosions if it came into contact with grease and organic materials. Winkler nonetheless succeeded in making the first verifiable launch in Europe of a liquid-propellant rocket in March 1931, immediately after quitting Junkers and obtaining private money. Winkler's rocket engine generated only 7 kg (14 lb) of thrust. (Thrust is the force on the rocket created by the gases exiting the engine nozzle, as per Newton's third law of motion: Every action produces an equal and opposite reaction.)[13]

Valier, meanwhile, had secured the support of a manufacturer of liquid-oxygen equipment, Paul Heylandt. One of Heylandt's firms, the Industrial Gas Utilization Company in south Berlin, became the site of Valier's attempts to develop a rocket car using liquid fuels beginning in late 1929. Assisted by one of Heylandt's engineers, Walter Riedel (1902–68), later chief of the design bureau at Peenemünde, Valier designed an engine using kerosene and liquid oxygen. Its performance was unstable because of problems with the injection and atomization of the fuel, one of the most critical difficulties experienced by all the early experimenters. Arthur Rudolph (b. 1906), another young engineer at Heylandt and a future branch chief at Peenemünde, witnessed the accident that killed Valier on Saturday evening, May 17, 1930. As the three were making engine runs on a primitive test stand, the motor suddenly exploded in a hail of metal. Riedel caught the staggering Valier and then ran for help. Rudolph, who was knocked flat by the explosion, finally reached Valier, but a piece of shrapnel had punctured the Austrian's aorta. Within a minute Valier was dead, the first victim of a dangerous trade. There was a minor public uproar, and a bill was introduced in the Reichstag to ban rocket experiments, but it did not pass. Heylandt decided to discontinue his involvement, but Rudolph would not quit so easily.[14]

The most important rocket group of the early 1930s—*Raketenflugplatz* (Rocketport) *Berlin*—arose, however, as a byproduct of Hermann Oberth's involvement with the film *Frau im Mond*. Oberth came to Berlin from Rumania in late 1928 to work as scientific adviser for the movie, which promised to be a historic breakthrough for the spaceflight movement. Fritz Lang was the most famous and powerful German film director of his era. Once in Berlin, Oberth asked Lang to help him obtain money for rocket development. Lang persuaded the UFA film conglomerate to bankroll the launching of a stratospheric sounding rocket during the film's premiere. But Oberth, an impractical physics teacher from a small town in Transylvania, had no engineering experience. He advertised for assistants, and a World War I fighter pilot with dubious engineering credentials showed up. Rudolf Nebel was more of a salesman and a con artist than an engineer. It is appropriate that his last name can be translated as "fog." Oberth found a second assistant in a freelance aviation and space writer, Alexander Sherchevsky, "a Russian emigrant … who lived," Oberth wrote a few years later, "completely in filth. And fairly literally at that. I had the impression that, if one threw him against the wall, he would stick there." On another occasion Oberth described him as "the second laziest man I ever met."[15]

The three set out to build the rocket, but the project turned into a fiasco. Scherchevsky was useless and had to be let go, Oberth was injured in an explosion, and the film company issued exaggerated and misleading press releases about the rocket's performance. After suffering a nervous breakdown, Oberth left for Rumania even before the movie's star-studded premiere on October 15. He had lost most of his money in the venture, because the film company refused to reimburse him. The ill-fated project was left in the hands of Rudolf Nebel, who delayed the announced launch until November and then canceled it altogether. About the same time—the end of 1929—Winkler had to stop publication of *The Rocket* because the journal's finances had been poorly managed. That cut off much of the membership of the VfR from contact with the society, with the result that the number of members dropped significantly. The Berlin leadership regrouped and decided to form a liquid-fuel rocket group, starting with the leftover materials from the Oberth rocket. Because Nebel had been empowered as Oberth's representative and was energetic and unscrupulous, he came to dominate this effort.[16]

Nebel began making the rounds of government ministries, scientific institutions, and corporations to look for funds to continue Oberth's work. In the first months of 1930 he may even have talked himself into the offices of Albert Einstein and Reich Interior Minister Carl Severing. Severing allegedly promised support, but soon thereafter the coalition cabinet he was in collapsed under the economic strain of the Great Depression, ushering in an era of weak right-wing governments dependent on the decree powers of Reich President Paul von Hindenburg, the retired Field Marshal. Nebel's campaign nevertheless produced one success. After he met Becker, Army Ordnance gave him a fairly large sum of money; Nebel's memoirs say 5,000 marks (about $1,200). The money was supposed to be at the disposal of Oberth for the launch of his rocket on the Baltic coast. Through Severing or Becker, Nebel was referred to the Reich Institution of Chemical Technology, which performed some of the same functions as the U.S. Bureau of Standards. Its director agreed to provide workshop space and a certification of Oberth's rocket engine, which would be useful in further fundraising.[17]

Nebel wired Oberth to join him in Berlin, which Oberth eventually did. After some work they finally succeeded in constructing a small 7-kg-thrust gasoline-liquid-oxygen engine. A famous picture taken on the day of the official test, July 23, 1930, shows Oberth and Nebel with the institute director and a number of helpers. Among them were two whose future roles at Peenemünde would be crucial: Klaus Riedel (1903–44) and Wernher von Braun (1912–77). Riedel (no relation to his namesake at Heylandt), a heavy-set young engineer and spaceflight enthusiast, would be Nebel's primary designer in the rocket group. Von Braun, in a suit with knee breeches, looks both his age and his status: eighteen years old and wealthy. He came from venerable Prussian Junker stock and possessed the title of *Freiherr* (baron), although he did not consistently use it. His father had been a high-ranking civil servant in Imperial Germany, but was forced out in 1920 for not distancing himself sufficiently from a far-right coup attempt against the new Weimar Republic. The elder von Braun became a banker with close connections to President Hindenburg and the old reactionary elites. His son's enthusiasm for engineering and advanced technology was mysterious to him. Wernher had become a teenage spaceflight fanatic after encountering Oberth's works in 1926. By 1930 he was preparing to go to engineering school at the Technical University of Berlin, an unusual career choice for an aristocrat.[18]

After the test Oberth once again returned to Rumania, but Nebel founded the famous Raketenflugplatz Berlin. Nebel and Riedel had already begun working on what they called the *Mirak*, for "minimum rocket," a small rocket based on a modified Oberth engine. In his search for an appropriate testing ground, Nebel found an abandoned ammunition dump in Reinickendorf, a nondescript working-class district near the northern edge of Berlin. A number of massive concrete storage bunkers surrounded by earthen blast walls were situated in the midst of a hilly and wooded area. The only access road was poor, and the lowlands were swampy. Nebel was able to obtain permission from the city and the Reich Defense Ministry to use the land, and he, Riedel, and others opened the Raketenflugplatz on September 27, 1930.[19]

Unbeknownst to anyone in the group except Nebel, the ballistics and munitions section had played a key role in securing him a lease for three years on the facility. Becker's section may even have suggested the location. In short order, however, Becker became disgusted with Nebel. In a May 1931 memorandum to Ordnance's aviation section, he denounced Nebel's dishonesty; his lack of the "necessary practicality, quietude, and secrecy"; and his tendency to write "sensationalistic articles in newspapers and magazines" merely for the purpose of raising money. The issue of secrecy was doubtlessly crucial, but there was also a culture clash between Nebel's blatant self-promotion and the mentality of the officer corps. Ordnance had thus cut off all contact with him before the spring of 1931.[20]

Nebel's *modus operandi* was later described by von Braun:

> One day, Nebel took me out on one of his "acquisition trips." We visited a director of the large Siemens corporation. Nebel told him eloquently about his plans—the liquid [-fuel] rocket motor, the stratosphere, lightning voyages across the ocean, the moon. The man was half amused, half impressed. The result was a trunk full of welding wires. With the wires we proceeded to a welding shop in town. Nebel told the shop superintendant that we had plenty of aluminum welding to do, but suffered from lack of a skilled man. Soon a deal was worked out, according to which Nebel would supply the shop with welding wires, while they would weld our tanks and rocket motors—all on a cash-free basis.[21]

Nebel made it a point never to pay for anything. Shell Oil provided free gasoline, Siemens free meals. He acquired skilled labor by giving unemployed craftsmen free housing in the bunkers in return for work on the rockets; many of them became true believers. Dimitri Marianoff, Einstein's "stepson-in-law" and a visitor at Raketenflugplatz, said: "The impression you took away with you was the frenzied devotion of Nebel's men to their work.… Not one of these men was married, none of them smoked or drank. They belonged exclusively to a world dominated by one single wholehearted idea." But they were not so single-minded that they could not celebrate. Von Braun reports that successes were often followed by drinking parties at a "downtown nightclub." If so, he must have been footing much of the bill, since most of the others were receiving only miserly sums from unemployment insurance.[22]

With Klaus Riedel primarily responsible for design and Rudolph Nebel concentrating on raising funds and materials, the Raketenflugplatz worked toward a flying version of the Mirak. After its launching in May 1931 it was rechristened the *Repulsor*, for the space vehicles in a popular German science-fiction novel. Throughout the rest of 1931 and into 1932, Nebel's group launched various versions dozens of times, including many demonstrations for which spectators were charged admission. The Raketenflugplatz also publicly demonstrated the burning of larger rocket motors with thrusts of up to about 50 kg (110 lb).[23]

The Raketenflugplatz's many different engine and vehicle configurations embodied certain common principles. Liquid oxygen was the oxidizer, and the fuel was easily obtainable gasoline. In line with Oberth's original suggestions, however, alcohol was later substituted, because that made it possible to add water, lowering the combustion temperature. Cooling the engine was a difficult problem; burnthroughs of nozzle walls, leading to explosions or erratic performance were common. The group first tried surrounding the engine with the liquid oxygen tank for cooling, then putting a jacket of water around the combustion chamber, and finally circulating watered alcohol through the cooling jacket before injection. The technique of using fuel circulation through the engine and nozzle walls, foreseen by Oberth and other pioneers, is called “regenerative cooling” and is a central feature of almost all large rocket engines.

All the early engines fed the fuels into the combustion chamber under pressure. The Raketenflugplatz at first used the liquid oxygen’s own evaporation to build pressure in that tank and employed a carbon dioxide cartridge in the gasoline tank, but in the end it adopted a better solution: Compressed nitrogen expelled the propellants in both tanks.

The most distinctive feature of the vehicles produced by the Berlin group, and by most other groups at the time, was the “nose drive” configuration. In contrast to the stereotypical image of the rocket-with engine and tail fins at the rear—these rockets had the engine at the top and the tanks trailing behind. According to Willy Ley, a VfR member and freelance science writer who came to the United States in 1935 to escape Hitler’s regime, the Raketenflugplatz had begun by consciously imitating the classic black-powder rocket. The first “One-Stick Repulsor” had its gasoline tank in a long tube attached to the side of the engine head. For centuries a stick had been used to give powder rockets a crude stability, but the aerodynamic principles had not been understood at the time, and even if the amateur experimenters did understand them, they had lacked the resources and systematic approach to exploit that knowledge. The bizarre-looking vehicles that resulted from the “nose drive” showed that the Raketenflugplatz never mastered stability and control in flight. But that was less important than getting a vehicle off the ground without endangering the onlookers too much. The endless problems with propulsion—burnthroughs, leaks, explosions, and valves and lines frozen by liquid oxygen—were much more pressing.[24]

ARMY ORDNANCE AND THE BALLISTIC MISSILE

As the enthusiastic amateur groups stumbled forward into the new territory of liquid-fuel rocketry without a map, but with the goal of spaceflight on the distant horizon, Becker and his subordinates began to chart a path toward their own objective: the ballistic missile. Long-range artillery had approached its limits with the Paris Gun, a special 21-centimeter (8.25-inch) howitzer used by the Germans to shell the French capital from 130 kilometers (80 miles) away in the spring of 1918. Becker had worked as an assistant on that spectacular project. After lobbing only 320 shells, however, each with 10 kilograms (22 pounds) of high explosives, the gun wore out its main and reserve barrels and had made little impact on French morale. By replacing conventional gunnery with liquid-fuel rocket engines, one could eliminate not only barrels and their massive supporting equipment but also all limits on range and payload. Moreover, Becker believed, the surprise deployment of stunning new weapons could have a dramatic effect on the enemy’s psychology. A rain of fairly accurate long-distance projectiles might even cause the collapse of enemy morale. That idea had failed with the Paris Gun, but the sudden deployment of a much larger projectile based on a revolutionary technology could be effective. To produce the necessary shock and surprise, it would be imperative to develop the ballistic missile in absolute secrecy, even though it was not outlawed by Versailles. Secrecy would have the added benefit of concealing the missile’s potential from the other powers.[25]

Such were the concepts that stood behind Army Ordnance's growing commitment to liquid-fuel rocketry from 1930 to 1932. Becker's group nevertheless moved only haltingly toward an investment in the infant and unproven technology. After the abortive attempt to support Oberth and Nebel in 1930, the ballistics and munitions section did little with liquid fuels for nearly a year. The cash-strapped Ordnance rocket project, itself only a small part of artillery development under Becker, focused instead on the feasibility of unguided, solid-fuel battlefield weapons with poison gas or high-explosive warheads. The first sign of renewed interest in the more advanced technology came on October 16, 1931, when Becker wrote to the Heylandt company requesting a confidential meeting between Captain von Horstig and Paul Heylandt. Becker expressed interest in the company's "liquid-fuel blow-pipe." His awkward use of the term "blow-pipe," instead of "rocket" or "motor," shows that he was unfamiliar with the technology.[26]

Becker's inquiry was sparked by a new rocket car that the Heylandt company had finished and tested in April–May 1931. After the death of Valier, Arthur Rudolph had continued to experiment with the engine to determine why its combustion was so unstable. He did so against the express orders of Heylandt and almost lost his job as a result. Sometime in late 1930 or early 1931, Paul Heylandt started a new rocket-car project. He was still fascinated with advanced technology and was interested in recouping his investment of more than twenty thousand marks in Valier's experiments. Most of the work on the car was done by Riedel and his superior, Alfons Pietsch, and Rudolph helped produce a much improved, regeneratively cooled engine with about 160 kg of thrust. Heylandt returned from a trip to the United States in time for the public trials, but the impact of the Depression plus the fading of enthusiasm for rocket stunts made the new car a financial and public relations flop. Pietsch lost his job shortly thereafter in one of the company's many layoffs. The car was shown again during the summer months, but with no better result—at least until Becker inquired about its engine.[27]

A number of things may have sparked Ordnance's renewed attention to liquid-fuel rocketry, beyond a general interest in the futuristic ballistic missile concept, which most military officers of that era would have regarded as Utopian or impossible. During the spring and summer of 1931, the activities of the Raketenflugplatz, the Heylandt group, and Johannes Winkler had made the technology more visible and viable. Army Ordnance may also have been influenced by the political climate. During the proceeding year the country had begun to slide into chaos. The mass unemployment of the Great Depression, combined with the Weimar Republic's already weak popular support, had led to political polarization and street fighting. On the far left, the Communists gained much ground, but their gains were eclipsed by the extreme right-wing National Socialists (Nazis), who leaped from marginality to major party status in the national elections of 1930. The weak Weimar cabinet of Chancellor Heinrich Brüning also became increasingly conservative and authoritarian. In this poisonous environment, nationalist interest in new weapons technologies and rearmament grew. The military possibilities of rocketry were mentioned more often in the press, among others by Nebel, who tried jingoistic appeals for funds. Nebel was a supporter of the ultraconservative German National People's Party and a member of its massive veterans' organization, the Stahlhelm (Steel Helmet), but he was not opposed