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Chapter 2

Rocket Center Peenemünde: Personal Memories*

Konrad Dannenberg and Ernst Stuhlinger†

Rockets played a central role, even in the early phases of von Braun's life. As his mother remembered many years later, he and his friends were constantly on the move, building unmanned and manned rocket cars, and frequently terrifying neighbors with broken windows and ruined flower gardens. When Wernher was 13 years old, his mother gave him a telescope, a gift that was to set his course for his next 53 years. He became an avid amateur astronomer; looking at the Moon and Mars, he exclaimed in his youthful exuberance: "We should not only look there, we should go there!," and he decided to devote his life to the building of rockets that would open the gateway to our neighbors in space.

At 15, Wernher wrote his first essay about spaceflight, published in a German youth journal. Its title was "Journey to the Moon: Its Astronomical and Technical Aspects." He had just read the book by Hermann Oberth, *The Rocket to Planetary Space*, and he knew how to calculate the velocity a rocket had to reach to either enter into a satellite orbit around the Earth, or to escape into deep space. During the next five decades, von Braun was to publish about 500 essays, papers, and books about rockets and spaceflight.

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When he was 16 years old, von Braun joined the Verein für Raumschiffahrt in Berlin. At 18, he became an assistant to Professor Oberth, who experimented with rockets at the Physikalisch-Technische Reichsanstalt in Berlin—similar to the Bureau of Standards in America. At that time, the Verein für Raumschiffahrt tried, heroically, to develop rockets that could be controlled and guided. The success was very modest, simply because of a total lack of money, not only for instruments and test equipment, but even for the basic livelihood of the rocketeers.

Rolf Engel, one of the early friends of von Braun who is still active in rocket and space matters today, recalls a remark von Braun made to him late in 1931: "Look, Rolf, we want to push this thing. And we have no money. The only way we can get the money, the assistance, and all the means, is the Army."

When von Braun made this remark, he thought of the history of aviation. Before World War I, airplanes were rare, and of low performance and reliability. After the war, they were well on their way to one of the decisive elements of modern civilization, thanks to the military that had nurtured and driven their rapid development during the war years.

The German Reichswehr began, in 1929, to develop rockets in a program for military preparedness, an activity in which all autonomous nations have engaged throughout history. The Reichswehr's rocket program was in the hands of Captain (later Major General) Walter Dornberger.

During 1931 and 1932, Dornberger and other army officers became aware of von Braun's rocket work in Berlin. In the fall of 1932, the Reichswehr offered von Braun a contract to develop military rockets.

Von Braun's aim had always been our neighbors in space. From the beginning, he realized that the most important requirement would be powerful precision rockets, that would take off from Earth and transport heavy payloads into satellite orbits, and also further out into space. Convinced that only a military organization could breathe life into such a program, he accepted the army's offer. However, with this acceptance came also the burning question which lingered on von Braun's mind for the rest of his life: is it right for an engineer or a scientist to support a project that, in any way, could be used for military activities? Von Braun often pondered this grave dilemma, which almost every person with a creative mind must face, and for which nobody has found the right answer yet.

It should be noted that the German Reichswehr wanted to develop a weapon for defense, and a deterrent for any would be aggressor. In fact, the "deterrent power" of modern rockets, particularly when equipped with atomic warheads, has been proven by the fact that no World War III has broken out yet.

It should also be noted that von Braun built rockets under the Army's auspices for ten years, from 1932 until 1942, before Hitler decided to use von Braun's A-4 rocket as a weapon in his war of aggression.

From 1932 until 1936, von Braun and his team of about 80 persons succeeded in building and flight-testing several rocket types. Impressed by their work, the Reichswehr, together with the Luftwaffe, built a rocket development and test center at Peenemünde, a small fishing village on the Baltic Sea north of Berlin. Rocket work began there in 1937. The A-4, a 25-ton rocket with a 300 km range, had its first successful flight in October 1942. In the fall of 1944, it was named V-2 (retaliation weapon Nr. 2) by Dr. Goebbels.

Hitler first ignored, and then ridiculed the rocket project; it was kept alive by the Reichswehr, and also by Albert Speer, minister of Ammunition and War Production. Under their protection, von Braun's rocket team enjoyed a modest growth. Konrad Dannenberg was assigned (*dienstverpflichtet*) to Peenemünde in 1940.

Dannenberg had been a member of a small group of rocket enthusiasts in his hometown of Hannover during the late 1920s and early 1030s. This group had studied Hermann Oberth's books, and with this background decided to develop huge rockets for space travel, beginning with a mail rocket system, and with rocket thrust units for the take-off of soaring planes. One of Dannenberg's rocketeer friends, Albert Püllenberg, whom Dornberger had brought to Peenemünde, wrote to Dannenberg and indicated that a project was underway in Peenemünde that would definitely be of interest to him. Dannenberg visited the island and submitted an application. Although his company in Hannover worked on military contracts, his transfer to Peenemünde was approved. Having worked on fuel injectors for high-pressure Diesel engines at the Technical University in Hannover, he was well qualified to work on fuel injectors for high-pressure rocket engines, that still presented problems in Peenemünde at that time.

Dannenberg worked under Dr. Walter Thiel, a fuel injection and rocket engine specialist, who worked with von Braun under Dornberger. Being responsible for the propulsion system of the A-4, Thiel first laid out plans for a cluster of 18 rather small rocket motors, each developing 1.4 tonnes of thrust for a total thrust force of 25.2 tonnes. As an intermediate step, Thiel conceived a 4.2 tonne engine by clustering 3 injection units. Dannenberg was project engineer for this system, which became the basis for the rather complicated A-4 rocket motor. Simpler designs were tried, but they did not work. Wartime conditions finally stopped this work. In spite of forecast difficulties in production, it was decided to proceed with the existing design. Surprisingly, manufacturing problems were far less serious than anticipated.

When Dannenberg joined the Peenemünde project in 1940, the potential use of the A-4 as a weapon in World War II had not yet been considered by Hitler's government. The army, however, wanted to develop it as a deterrent. Since the missile used liquid propellants, it could be transported empty. In spite of its large size of 14 m in height, 1.65 m in diameter at the center section, and 3.65 m between fin tips, its empty weight was only 2,800 kg. The accurate propellant cutoff determined its exact range. Using a turbopump to feed the propellants was a major technological advance, which permitted low pressure and light weight for the huge propellant tanks. The turbine was driven by a hydrogen peroxide steam generator. On the same shaft with the turbine were two centrifugal pumps, turning at 6,000 rpm and pressurizing the propellants to levels 3 to 5 atm. above the combustion chamber pressure of about 15 atm. The A-4 motor generated a thrust of 25.4 tonnes; total weight of the A-4 at take-off was 13 tonnes.

In 1942, when the German armed forces were loosing ground quickly, Hitler turned to the Peenemünde rocket and ordered a rapid build-up of its workforce. Numerous engineers and scientists who had been drafted into the armed forces were transferred to the rocket project; one of them was Ernst Stuhlinger. He received his order to report to Peenemünde in the middle of the Ukrainian snow fields in April 1943. The existence of the rocket project, and the names of its leaders, were kept secret in Germany. Most people at that time did not know anything about the Peenemünde works, about rockets, and about Dornberger and von Braun.

Stuhlinger arrived in Peenemünde as an *Obergefreiter*—private first class—and remained so. "If you were made a civilian," he was told, "the relentless draft board would get a hold of you and send you right back to the Russian front." Trained as a physicist, he had worked in cosmic rays and nuclear physics in Berlin before being drafted; now, he joined a group that worked on the development and testing of accelerometers for the inertial guidance of the A-4 rocket. The group was headed by Dr. Walter Schwidetzky. The total workforce at Peenemünde was several thousand persons; a similar number of engineers, scientists, and technicians worked for Peenemünde at other places all over Germany.

The accelerometer laboratory was frequently visited by colleagues who brought or picked up instruments, or discussed measuring data. "One day," Stuhlinger remembered, "a young man came to our laboratory who was different from all other visitors. 'Good afternoon, Doctor,' he said to Walter. 'How do you do?' - While I barely noticed the many people who came and went through our laboratory, I was immediately struck with fascination when I saw and heard this man. Not only was he an impressive human being, tall, blond, and of strong

build; he talked and moved with greatest ease, but his eyes and face, in fact his entire body, expressed an utmost alertness, a total involvement in the thoughts he was trying to convey. And yet, he was in no way overbearing. His questions were precise and to the point, but they stimulated creative thought; they brought out the best capabilities in the person he asked. They were the questions of a partner and colleague, not of a boss.

As the young man asked Walter how the accelerometer tests had gone the day before, I noticed that he was fully familiar with the work we were doing in this laboratory. While he talked, he sat down on a wooden box in the corner, discarding the chair Walter had offered him. We ran through a whole gamut of vibration frequencies, but the instrument held up quite well, thanks to some recent modifications, Walter said. - 'Did you find any strong resonances?' - 'There were some, but obviously without any adverse effects.' -'Did you use sinusoidal vibrations only?' -'Yes, sir.' - 'I wonder,' the young man said, 'whether you could perhaps record on a magnetic wire recorder the real noise of a rocket engine during one of our next captive firing tests. Then, you could play this recorded noise through a power amplifier and feed it directly into the coil of your vibration table. That would give you a more realistic test than the pure sine waves. Would you think that this could be done?' - 'I imagine so,' Walter said, 'I'll try it immediately.' - 'Keep me posted, please,' was the brief reply, and he left as quickly as he had come in.

For a little while, I was under a strange spell, then I asked Walter who that man was. In an almost solemn voice, he said: "This was Dr. von Braun." - "How old is he?" I wondered. "Thirty-one." - "And he is the director of this huge establishment?" - "He has been its director from the beginning, for six years already. In fact," Walter added, "I doubt whether he has been anything else but the director, wherever he was!"

Schwidetzky used to talk quite nonchalantly with all the many people who came to see him in his laboratory, but he was a different man when he talked with von Braun. There was certainly no sign of obedience or submissiveness, nor a feeling of inferiority, in his attitude; it was rather a spontaneous desire to give his very best in a brief, but very spirited exchange of thought and knowledge.

For more than thirty years, both Dannenberg and Stuhlinger had the good fortune of being close to von Braun innumerable times, but the magic spell that radiated from his personality never came to an end. When he entered a room or joined a group of people, he was immediately the center of gravity, the invisible force that attracted attention and interest from everyone. When he talked, everybody listened (it must be said, though, that he sometimes started talking before the other person had ended his or her sentence!). It was always easy to spot him

in a large gathering of people. The crowd was always densest where he stood, laughing and talking, and obviously relishing the fact that so many were eager to see him and to hear him talk.

His true passion, however, was undoubtedly the technical debate with his co-workers. There, he would listen with fullest attention and great patience, absorbing every detail, correlating the new information with the countless bits stored in his quick-access memory, jumping in with a quick question or a stimulating remark, and at frequent intervals summing up the situation in characteristic von Braun fashion, with the most lucid words and cogent logic that would make sure that everybody around understood the problem in the way he believed it should be understood.

Von Braun always respected dissident opinions, but they had to start from the common baseline, and they had to proceed from there with uninterrupted logic, and without violating the laws of nature or the principles of sound engineering. In all such discussions, he followed a simple line of action: recognize a problem, analyze it, and solve it. When a man reported a failure of a test or a deadlock in a development, von Braun asked first: "What are you going to do about it?," and he left no doubt that a man responsible for a project was also responsible for the solution of all the problems he might encounter, but with the active help from his colleagues, and particularly from von Braun personally.

The rocket project was central to the lives of the Peenemünders. The sheer volume of problems that had to be solved extended to the limits of their imagination. Many of these problems called for technical and also scientific innovations for which no precedents existed. And, hard to believe today, there were no computers in existence to help in calculations and designs.

The rocket motor for the A-4, with turbopumps, steam generator, valves, and jacket cooling, slowly took shape under the ingenious leadership of Walter Thiel. There was no experience in supersonic aerodynamics for rockets. Rudolf Hermann, aerodynamicist from the Technical University in Aachen, built a supersonic wind tunnel at Peenemünde. There was the problem of controlling and guiding the motions of the rocket during flight. Sensors were developed that would measure every movement of the big machine; networks would transform their readouts into signals that would control the servo motors that moved the jet vanes. Gyroscopes were developed, with help from Siemens and Kreiselgerate in Berlin, to provide a stable reference system. Electronic simulators for the various interplays of forces and motions of the big rocket were invented and built; they were huge, full of glass body tubes, and continuously suffering from overheating, but they were forerunners of analog computers, and they were a decisive help in the development of the A-4 guidance system. The directorate

for guidance, control, communications, and instrumentation was brought to life by Gerhard Reisig; later, it was taken over by Ernst Steinhoff.

For most of the members of the Peenemünde work force, it was impossible to keep track of all these innumerable activities. However, many of them, including Dannenberg and Stuhlinger, attended meetings in which von Braun was present, and they still remember these meetings. Regardless of what the subject was—combustion instability, supersonic aerodynamics, control theory, accelerometers, ballistic trajectories, gyroscopes—von Braun was always fully knowledgeable of the basic subject, and of its status. He quickly grasped the problem; formulating it so that everybody understood it clearly. He was a peer to the experts with his questions, his thoughts, and his suggestions. All these meetings ended on a positive note: Solutions appeared possible, ways to solve the difficulties became obvious. Something could be done, and would be done, to assure continuing progress.

The Peenemünde rocket, with its propulsion, guidance, and telemeter systems, was developed 10 years before the first transistor appeared on the market, and 25 years before the age of high-speed computers began. By today's standards, those early systems appear antiquated. Modern guidance and control systems are far smaller, more accurate, and more reliable. However, those Peenemünde systems broke the ground for entirely new technologies, without which our modern space flight accomplishments would not have been possible.

Launching of an A-4 in Peenemünde was always very exciting, not only for those directly involved in launch procedures, but for almost everybody. Word of an imminent launching was spread by telephone. Some watched from roofs of high buildings; others walked over to the vicinity of the launch area, or just stood in the street to see the rocket rise over the tree tops at a distance of 3 or 4 kilometers.

Dannenberg was directly involved in A-4 test launchings from the beginning. Being in charge of the design and development of the combustion chamber, and later of the entire propulsion unit, including tank pressurization, he was greatly interested in flight results. During early testing, many failures and even explosions occurred. The first A-4 launch, on 13 June 1942, was a great disappointment. The rocket toppled over and exploded. The second test rocket took off successfully, on 16 August, and it penetrated the sound barrier, but then it veered from its course and broke up after 45 seconds of flight. That flight at least proved that a large rocket could be made to work, and that it could fly through the sound barrier. The third launching, on 3 October 1942, was a complete success. That date marks the real beginning of the space age.

Extensive testing of all components obviously paid off. The rocket had reached outer space, and it had used this new medium to travel from one point

on Earth to another, as Dornberger remarked. He, von Braun, and the entire team were delighted. The missile had obtained a range of 196 km and an altitude of 85 km during its flight of 300 seconds. Calculations showed that after removal of measuring and tracking equipment, a range of 300 km, as required by military specifications, would be possible.

Stuhlinger saw his first launch in April 1943, the third successful flight of an A-4. "Standing on the roof of Teststand P-7," Stuhlinger remembers, "I saw how liquid oxygen was filled into the rocket from a tank truck. Even while everything was still very quiet, I was deeply impressed by that sight: Here stood this beautiful machine, sleek and smooth on the outside, but filled with the most advanced technology of the time, and with a tremendous amount of energy waiting to be released. By all contemporary rocket standards, its size was fantastic. In a few minutes, the launch signal would be given; superheated steam would drive a turbine with 460 horsepower that would force 120 kilograms of alcohol and liquid oxygen into the combustion chamber. Twenty-five tons of rocket thrust would lift the rocket and, in a minute's time, accelerate it to 2,000 meters per second, faster than any other vehicle had flown before. - As these thoughts went through my mind, the wisp of vapor from the oxygen pressure release valve at the rocket's side disappeared, and the loudspeaker announced ...3...2...1...0...ignition...prestage...mainstage...lift-of f! Then I saw for the first time what in future years I would see many times, and millions of people around the globe would see at rocket launchings. A white cloud of steam and smoke broke out of the nozzle, a yellow beam of fire followed, and in a moment the rear of the rocket was engulfed in a most violent turbulence of fire and smoke. After half a second, the sound arrived with a tremendous bang, but it was a bang that continued with unbroken strength as a thunderous howling. Everything vibrated and shook. Actually, it was quite painful, but who would think of pain in such a moment?

Almost miraculously, the upper portion of the rocket, visible above the fire, remained completely immobile. At 'mainstage,' it began to rise very, very slowly, with unbelievable steadiness. After some time of vertical rise, the rocket slowly turned into an easterly direction, parallel to the coast line of the Baltic Sea. . . ."

Not every launching in Peenemünde was successful. A number of rockets failed during the first few seconds after lift-off. "None of these failures," von Braun used to say, "is really a loss. Each of them teaches us how to build the A-4 better. . . ." In fact, he personally led a most tireless investigation after each launch failure. Typically for him, no blame for a failure was ever pinned on a person. It was understood that everybody had been as careful in his work as he possibly could have been.

A memorable event occurred in the summer of 1943. Reichsführer SS Himmler, certainly the most powerful, most enigmatic, most vicious, and most dreaded man under Hitler at that time, announced his visit to Peenemünde, and his desire to see an A-4 test launching. For Dornberger and von Braun, this visit was a matter of great tension and concern, because they knew that Himmler wanted to force the A-4 project out of the Army's hands, and to put it under his own commend.

The A-4 took off without a flaw. However, after reaching an altitude of 20 or 30 meters, it began to turn slightly, then became erratic, turned over, and flew toward the airfield at Peenemünde West, a sister organization under the Air Force, where guided air-launched bombs, rocket planes, and also the buzz bomb (later to be called V-1) were developed. The explosion at impact destroyed several parked aircraft.

Von Braun later told his co-workers: "Himmler remarked with a sarcastic smile: 'This now removes any doubt on my part. I will go ahead and order the production of ground weapons.'"

Von Braun was too much of a realist not to be prepared for a possible failure. Less than one hour after the unsuccessful launch attempt, another A-4 stood on the launch table, filled with alcohol and liquid oxygen, checked out, and ready for launch. This time, it was a picture book launching. The rocket reached its predicted impact point in the Baltic Sea with an accuracy of one quarter of one percent.

Himmler's mind remained impenetrable. Von Braun, trying to make the best out of the situation, pointed out to Himmler that the potentialities of the A-4 were demonstrated by the second launch, while the first launch clearly showed how much development and testing work was still necessary, before production of the rocket as a missile could be started. Himmler remarked that he would talk to the Führer about it.

Himmler did indeed talk to the Führer about it, but it was not in the way von Braun had wished and hoped, but in the way he had feared.

Himmler's dark scheming to gain control over the A-4 program received unexpected help through a long-feared event: a bombing raid by the British Air Force.

During the night of 17 August 1943, waves of 600 bombers unloaded 1,500 tons of explosive and incendiary bombs on Peenemünde. Flak and night fighters shot down 47 bombers. While the technical damage to installations and test stands was surprisingly light, many of the housing units were destroyed, and 735 people lost their lives.

This bombing raid was a clear indication that the Allies knew about the project, so Hitler gave orders to put all the planned production facilities for the

A-4 into underground installations. He assigned the responsibility to carry out that order to Himmler, and he also made Himmler responsible for the mass production and military deployment of the A-4 as a weapon.

Details of the attempts of Himmler and his SS to subject Peenemünde to their control became known after the war, mostly through books written by Dornberger and Albert Speer. It is a confusing story, full of morbid ambition, intrigue, recklessness, ignorance, megalomania, and stupidity on one side, and enormous efforts to resist on the other. Himmler did acquire full control over mass production and military use of the A-4, but not over development and testing. Dornberger and von Braun demanded more time for testing and technical work, hoping that the war would be over before the A-4 could be used as a weapon. In order to enforce mass production, Hitler appointed a Missile Production Czar, Degenkolb, who had distinguished himself earlier by enforcing the monthly production of 2,000 'war locomotives,' a simplified version of an existing steam locomotive. Degenkolb put much pressure on the Peenemünde people by demanding blueprints for mass production while many features were still undefined. Dornberger described Degenkolb as "violent, menacing, vain, distrustful, and without regard for rule and order."

By 1943, Peenemünde had grown so large that the Army decided to reorganize it as a private company with the name Electro-Mechanische Werke (EW); other official names at that time were Heeres-Versuchsstelle/Versuchsanstalt Peenemünde (HVP), and Heimat Artillerie Park (HAP). This step, it was hoped, would also make it possible for Peenemünde to stay out of the claws of Himmler—a hope that was not to be fulfilled.

After Himmler had assumed responsibility to mass-produce the A-4 in an underground factory in 1943, he established production facilities in a former gypsum mine in the Harz mountains, later called Mittelwerk. Production of other weapon systems was also carried out there, among them the buzz bomb V-1, and parts of fighter planes and submarines. Himmler, who was in charge of all the concentration camps in Germany, proposed the use of inmates as workers in the Mittelwerk, against Speer's recommendations. New camps were built near the factory, among them camps Dora, Harzungen, and Ellrich, and inmates were transferred there from other camps, such as Buchenwald. As Speer later wrote, conditions in the camps, and also in the underground factory, were "barbarous" and "scandalous." Von Braun, who had to visit Mittelwerk occasionally to help solve technical problems, and one of his chief engineers, Arthur Rudolph, who was assigned to Mittelwerk as technical director of A-4 production, were horrified when they saw under what subhuman conditions the inmates had to work and to live. They tried to persuade the SS guards to treat the inmates more humanely, and to give them better living conditions in the camps, only to be

told to shut up or wear the same striped uniform as the inmates. A large number of the inmates died in the camps from diseases, from mistreatments, or simply from total exhaustion. - After the war, Rudolph stated repeatedly, under oath, that none of the inmates assigned to his department died at their place of work in the Mittelwerk.

In a staff study of 1947, the Air Materiel Command in Wright Field reported that, during the time of maximum activity late in 1944, about 32,000 persons, civilian and forced labor, worked at the Mittelwerk. After the initial build-up, the number of forced laborers was continuously reduced, and the number of professional civilian employees increased, because, as the report states, unskilled inmates were not able to perform work of the necessary professional quality. In October 1944, the report says, the labor force working for Rudolph in the A-4 production in the Mittelwerk comprised 7,500 persons, 4,000 civilian employees and 3,500 inmates.

Von Braun's and Rudolph's efforts to ease the plight of the Mittelwerk inmates led to some improvement in the harsh treatment they received from the SS, but, as von Braun remarked much later, "the vision of those luckless prisoners has haunted me ever since. The most depressing thought is the fact that I was absolutely without power to do anything substantial. Even if I had left the place and my work and gotten to jail, Himmler would have given orders to continue, but only under harsher and more stupid conditions. The inmates would undoubtedly have suffered even more."

As mass production of the still immature A-4 began, about 65,000 technical changes became necessary in order to make the missile ready for production. Many of these changes were caused by the extreme shortage of materials that were no longer available in wartime Germany. This was particularly true for nickel, chromium, silver, and copper, but also for the proper ingredients of steel and aluminum alloys. Many compromises had to be made, often requiring the redesign of components, even of seals and gaskets. In connection with such changes, Dannenberg had to make several trips to the Mittelwerk to deliver redesign drawings to the engineers, and to discuss specific problems resulting from the difficult supply situation.

After the SS had established its grip on the A-4 project, at least on production and military deployment, high-ranking officers often came to Peenemünde to see the facilities. Von Braun usually obliged with politeness and patience—what else could he have done? But sometimes, the arrogance of his visitors drove him to a bit of sarcasm. A high officer from Berlin once showed up in von Braun's office and saw his desk full of notes, reports, drawings, and other documents, neatly stacked and carefully arranged. "Dr. von Braun," the visitor said, "what a mess of papers you have on your desk! This is intolerable!

My general in Berlin never has more than one piece of paper on his desk at any time!" - "Yes, sir," von Braun replied, "I know. It is the paper in which his wife wrapped his morning sandwich for him."

Such replies did not create an amiable atmosphere between von Braun and the SS, in spite of the fact that Himmler, as one of the gimmicks with which he tried to lure von Braun away from the Army and into the SS, bestowed an honorary SS rank (*Untersturmführer*, equivalent to second lieutenant in the U.S. Army) upon him at the time when the A-4 had its first successes. Von Braun was greatly upset by this fake show of generosity. He and his closest associates came to the conclusion that declining this 'honor' would result in a fit of rage on the part of Himmler, with unpredictable consequences. So von Braun accepted the honorary rank, but he quickly stowed his SS uniform away in a closet. Himmler, continuing his attempt to win von Braun over to his side, promoted him further and made him *Sturmbannführer* (equivalent to major) on 28 June 1943. When all these shows of benevolence proved to be of no avail, Himmler put von Braun into a Gestapo jail in Stettin, in March 1944, under the accusation that von Braun had only spaceflight in his mind, and not the support of Germany's war effort. Von Braun spent his 32nd birthday in jail. Dornberger and Speer succeeded in persuading Hitler to release von Braun after two weeks—on probation.

Even before the air raid on Peenemünde in 1943, many of the laboratories and shops had been moved to a variety of places all over Germany. New laboratories and workshops were established in schoolrooms, warehouses and temporary buildings. Much traveling by rail became necessary, often under the most difficult circumstances because of the frequent air raids. The bombardment of railroad stations, bridges, and control centers caused delays of hours, even days. Communication by telephone functioned only sporadically. In spite of all these difficulties, work on the A-4 continued, and its reliability improved.

The abundance of technical and scientific problems that had to be solved was overwhelming. Von Braun participated in the discussions whenever he could; his ingenuity in getting to the bottom of a problem, and in finding solutions, always amazed his co-workers. Against the background of a dreadful war with all its miseries, there persisted a spirit of devotion to the joint project. Certainly, no chance was seen that the A-4 could influence the outcome of this war. However, the men and women working in Peenemünde knew that they stood at the threshold of a totally new technology, and that they were about to transform a dream into a real accomplishment which, if successful, would be a firm possession of mankind from here on out. There was the constant hope among the Peenemünders that the war would be over before their rocket could be used as a weapon of war. And there was another wisp of hope—that there

may be a time when they could work on a rocket that would not be used as a weapon, but only for the exploration of the high atmosphere, the Moon, and the planets.

The first of these hopes was not to be fulfilled. A-4 rockets were launched against cities in France, Belgium, and England, and the war continued to its bitter end. But the second hope, a remote dream in 1944, came true. When Russian troops proceeded toward Peenemünde early in 1945, the entire workforce was ordered to move to Bavaria. With SS support, the Peenemünders loaded three trains, about one thousand trucks, even river boats and other vehicles, and moved south. About 500 of the men and women were relocated in Oberammergau, Garmisch, and other places near the Austrian border. Dornberger, von Braun, and some of their co-workers stayed in Oberjoch. In May, when Allied troops approached the area, von Braun sent his younger brother Magnus out to make contact with the Americans who were greatly surprised to find so many rocket people there.

During the ensuing weeks, the British conducted "Operation Backfire," launching three A-4s from a site near Cuxhaven. They had captured not only a number of A-4s, handling and launching equipment, fuel and LOX transporters, and other components, but also a number of German soldiers who had served in missile firing units. They also brought a number of Peenemünde and Mittelwerk workers as consultants to the site, among them Dannenberg. The French initiated an active missile program soon after war's end, utilizing a number of former Peenemünders. Russian troops took over Peenemünde and the Mittelwerk; they transported hundreds of Peenemünde specialists to Russia and used them in their missile program.

About 130 of the Peenemünders were offered contracts to continue rocket work in the United States. Fourteen months after the last A-4 had been launched from Peenemünde into the Baltic Sea, A-4s began to be launched at White Sands in New Mexico. Between 1946 and 1952, about 70 A-4s made successful high altitude flights. Instead of warheads, they carried scientific instruments to investigate the high atmosphere, and the space beyond. Rocket work continued in the United States, and in many countries around the globe. After developing several rockets for military use and launching a number of satellites, von Braun's team—at that time a work force of 8,000 men and women, supported by almost 400,000 members of industrial firms—built the mighty Saturn rocket that launched twelve Apollo astronauts on their way to the Moon.

Fifteen years later, reminiscing about Peenemünde, von Braun wrote: "From those humble beginnings, rocket engineering has advanced to the threshold of space exploration. . . . Peenemünde has become a legend. . . it gave life to an idea that far transcended its immediate application as a weapon of war. . . ."