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## Chapter 26

# What the Russians Learned From German V-2 Technology*

**James Harford**†

For years Soviet space leaders put down the contribution that captured Germans and their V-2 technology made to the Soviet ballistic missile and space programs. "Not significant," they would say, "we got mostly the technicians. The Americans got von Braun and his top team. We sent our Germans back after a few years."

That explanation is no longer the Party line. In fact, it is now acknowledged that German rocket technology was bedrock to the USSR, just as it was to the US. One of the Russian rocket pioneers who tells the story candidly is Boris Chertok, still active as a consultant to Space Corporation Energia, the successor organization to the Korolev design bureau. Chertok was sent to Germany in 1945, along with a small number of Soviet rocket specialists, to gather V-2 technology, documentation and specialists.

But that wasn't the first Soviet foray into German rocketry. In an interview in *Izvestia* in 1992[1] Chertok recalled a clandestine visit in 1944, almost a year before the war ended, instigated by none other than the British Prime Minister:

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A personal and strictly secret message from Winston Churchill to Marshall Josef Stalin on July 13, 1944, in essence, marked the beginning of a broad interest by the USSR in German rocket technology.
Churchill reported that evidently the Germans had at their disposal a new rocket weapon which introduced a serious threat for London, and asked permission for English specialists to go into Poland for investigation of the test range which was located in the region of Soviet attack forces. Stalin answered that he understood the anxiety of the Prime Minister and promised to take the matter under personal control. Personal control for Stalin in that time meant a categorical command to carry out instructions at any price. To Poland immediately went a group of specialists from NII-1.

The Russians had already known about the German V-1, the jet-powered buzz bomb, and judged it to be "by no means powerful enough for massive German bombardment." But the V-2 was a different weapon. The expert team, with the help of Poles living near the test range in Debica, collected fuel tank fragments, a combustion chamber and parts of a missile frame, and shipped them back to Russia. For some days only "high authorities" were able to examine the hardware. But eventually, says Chertok, "sense took over and engineers were also allowed in. So I come into this hall. Several hours before me our engine man, Alexei Mikhailovich Isayev—one of the future stars of our rocket technology—was let in. I see the lower part of his body and his legs sticking out of the rocket engine nozzle, while his head is somewhere inside ... I approach Bolkhovitinov (NII-1 deputy for science)...
'What is this?'
'This is what cannot be,' he replies ... Understand, one of our most talented aircraft designers simply did not believe that in wartime conditions it would be possible to develop such a huge and powerful rocket engine. We had at the time liquid engines for our experimental rocket planes with thrusts of hundreds of kilograms. One and one half tons was the limit of our dreams. Yet here we quickly calculated, based on the nozzle dimensions, that the engine thrust was at least 20 tons."

The Russians then deduced that the rocket could lift vertically some 12-14 tons. "We were shocked," said Chertok, to note that the rocket used neither nitric acid nor kerosene, the Russians' customary fuels, but rather alcohol and liquid oxygen. In fact the V-2 engine had undergone a quite remarkable development under the supervision of Walter Thiel, between 1936 and 1941.[2] Thiel scaled up a 1.5 ton engine to 25 tons, while reducing engine size very substantially, by solving difficult problems of fuel injection and burn-through of the walls of the combustion chamber.[3]

The V-2 had a gross weight of 12.52 tons, confirming the Russian estimate. It could carry a one metric ton payload 200 kilometers. It was 14.3 meters long and had a diameter of 1.65 meters. It was the first missile to incorporate a turbopump, powered by an 80% hydrogen peroxide steam generator, and the

first to use a guidance system with a three-axis platform for stabilization, although the latter was developed too late for incorporation in the production V-2.[4] Honoring Churchill's request, the British were invited to Poland, and came "with their own spy, who had a map of all points of missile impact and of launch sites."[5]

Only a few weeks later, on September 8, 1944, the first attacks on Paris and London were launched from mobile V-2 installations in Belgium. Eventually, 3,225 V-2's were fired successfully, mostly from Holland and Germany. Estimates are that 12,685 people were killed and 33,700 homes and buildings destroyed by the weapon.[6]

Those numbers notwithstanding, it was a fantasy to believe, as Hitler apparently did, that the weapon might be decisive in the war. The fact is that the total explosive power of all of the V-2's fired was less than that of one RAF bomber raid. Nonetheless, the V-2 was a remarkable technological achievement, especially when one realizes that the 3,225 firings were made over a period of only 2-1/2 years from the time of the first experimental launch on June 13, 1942. Even more important to history, updated V-2 designs formed the basis of the first ballistic missiles and space launchers of not only the US and the Soviet Union but eventually of France, Britain and China. It is not very well known, for example, that some 80 Germans came to France in 1946 to help design the Viking engine used on the Ariane launch vehicle.[7] Ariane became a very successful launch vehicle, carrying, by the 1990s, more than 50% of the world's commercial communications satellites into orbit. In 1947 German V-2 experts came to Westcott in England, eventually helping the British to design the Black Knight missile, later abandoned in an economy move. In the 1950s, when the Russians and Chinese were collaborating intensively, a cadre of Chinese engineers were taught rocket design based on V-2's in Moscow.

But far and away the countries to benefit most from the V-2 technology were the USA and USSR. The Americans did, indeed, get the cream of the V-2 crop. Wernher von Braun kept most of his best engineers together, escaping the Russians by fleeing Peenemünde, which was in the Red Army zone, and giving himself and his team up to the Americans near Reutte, Austria, in May 1945. Eventually, 127 of the von Braun Germans came to the US. After a period at Fort Bliss in Texas they settled in Huntsville, Alabama, forming the technical strength of the Army Ballistic Missile Agency. There they escalated the V-2 technology into the design of the Army's Redstone missile and its first intermediate range ballistic missile, the Jupiter.

Then came the dramatic assignment of taking over the challenge of a US response to the October 4, 1957 launch of the Soviet Sputnik, a date recognized as the start of the Space Age. Two months later, on December 6, the Naval Research Laboratory's Vanguard—which was to have been the first US satellite—lost thrust on the pad at Cape Canaveral two seconds after ignition. The vehicle collapsed and exploded ingloriously before the world's television cam-

eras. The von Braun group, heretofore barred from going into action, got the green light and, in a matter or weeks, on January 31, 1958, readied and launched into orbit Explorer I on a rocket adapted from Redstone. That feat was surpassed in the next decade when von Braun's group joined NASA and backboned the development of the Saturn V rocket which carried twelve Apollo astronauts on six landings on the Moon in 1969-72, demolishing the Russian competitive effort. The Soviet Moon launcher, named the N-1, failed four times in secrecy-shrouded tests, and was eventually cancelled by Leonid Brezhnev, who lied that Russia had never been in a race to the Moon in the first place.

Soviet exploitation of the V-2 technology was at least equal in resourcefulness to that of America's, and even more Machiavellian. The 1944 foray of the Russian rocket experts into Poland was followed by a much more concerted effort beginning in April, 1945, to round up V-2 hardware, launch facilities, blueprints, and as many engineers and technicians as could be found. Since all of the launch and production facilities were in the Soviet zone, which became East Germany, the potential haul was huge. While most of the von Braun team was gone, and the Americans had already spirited off to the USA the blueprints, assembly jigs and fixtures, and as many of the intact V-2's as they were able to grab, there was still plenty of materiel, albeit in pieces, to salvage.

Chertok, a big hulk of a man—bald, craggy-faced, still full of conviction although in his early 80's—recounted the story decades later at the dining room table of Korolev's daughter, Natasha, after a Sunday night supper of zakuski.[8]

"I arrived in Germany," he said, sipping modestly from a tiny vodka glass, "on April 23, 1945. Isayev, the engine designer, and I ran the Institut Rabe (Raketenbau und Entwicklung—rocket manufacturing and development) in Bleicherode, near Nordhausen. Although unofficial, 'We never got Moscow's permission for this,' it was the first Russian-German venture after the war." Chertok, who had been promoted from soldier to Major in the Red Army, declared himself chief of Rabe, and began to recruit specialists. He and Isayev, ironically, were advised to take over the house in which von Braun had lived.

"(We were) dirty and dusty," he told his *Izvestia* interviewer, "we looked for a place to rest ... (We) discovered four toilets and three great bathrooms. A bedroom was on the second floor. Isayev threw aside a snow white feather blanket and plopped on the bed. There was a mirror in the ceiling. Alexei Mikhailovich smoked a Belomor (cigarette). 'You know, it is not bad at all, this Fascistic beast's pit.'"

"Eventually," said Chertok, "the institute comprised about 1,000 people, half of them Russian, the other half German workers, plus about 50-60 Peenemünde veterans, including mostly technicians and a few senior technical people—among them Helmut Grottrup. There were also Kurt Magnus, a gyro specialist, and a fellow named Hoch,[9] and there were some ballistics specialists from Krupp and Siemens. Our main job was to restore all of the V-2 documentation that von Braun had taken to the US."

Work at Rabe was started in a three-story building which had been an electric power station. The lure for the German engineers was more the accessibility of rations than money. The American occupation zone was only a few miles away, and the Americans weren't watching the border carefully, so the Russians started an enticement campaign, offering good jobs and lavish rations to those who would come over. "Both the Russians and the Americans were conducting intelligence operations," said Chertok. "We were trying to understand what the Americans were up to. They had 'Operation Paperclip' underway (the code name for the US operation which gathered up the von Braun team as well as the V-2 documentation and hardware). We had agents in the US zone to grab von Braun but he was guarded too well. Grottrup came to us for ideological reasons, but with a great deal of propaganda on our part.[10] I promised the German scientists that they could go back if they didn't like it. Professor Schuler did go back eventually, in January 1947. He was a Navy navigation expert and he didn't want to work for either the US or USSR."[11]

Although they may not have been vigilant about border crossings, US intelligence specialists were conscientiously watching these operations, as evidenced by a secret report which was eventually published by the Central Intelligence Agency some 15 years later, in 1960. The report[12] accurately identified Grottrup, who had been a valuable deputy for guidance and control to Ernst Steinhoff at Peenemünde (Steinhoff joined the von Braun team in the US), as the man designated by the Russians to lead a group which eventually numbered some 5,000 Germans. Their assignment, using the words of the CIA report, was to "recreate the design data, test equipment, drawings, manufacturing jigs and tools, ground support equipment, and operating instructions, for the A-4 (A-4 was the Peenemünde group's designation of the V-2. A-4 was renamed V-2, V for Vergeltung—meaning retaliation—by the Nazi Propaganda Ministry).[13] Further, the report goes on, they were to set up an assembly line to build A-4's from surviving components, test the engines, build two complete railroad trains for transporting the support equipment and staff for launches, instruct "one Soviet and one German launching and testing crew" and develop "proposals for further improvement of the A-4."

The Russians were awed by the underground Mittelwerk plant near Nordhausen to which manufacture of the V-2's had been moved after Allied planes had bombed the plant in Peenemünde. Built into the Kohnstein mountain it had two 3.5 kilometer galleries which opened on terrain level to the outside. Railroad tracks permitted an entire train to enter the plant. Production capacity was designed for 30-35 missiles per day.

"You won't find a plant on either American or on our territory, that would produce as many surface-to-surface missiles today," said Chertok. The fact that the plant had employed thousands of slave laborers brought in from the concentration camps under SS General Hans Kammler, many of whom died under the cruel working conditions imposed on them, might have accounted for the high

production rate. It could also have been the reason that the Russians didn't like the idea of working in the "gloomy underground" plant. They decided, instead, to use a nearby V-2 repair facility called Klein Bodungen to assemble and complete the missiles.

Grottrup had earlier turned down an American offer to join the von Braun group because he wanted to stay in Germany. That proved to be ironic because a year later he, along with thousands of other engineers, scientists and technicians would be shipped, literally, by trains, freight cars and trucks, with their families to the Soviet Union.

But before that would happen he would direct the blueprinting and dismantling of Mittelwerk, as well as the original missile development center at Peenemünde, and the engine development facilities and test stands in the Frankenwald mountains at Lehesten. The latter were in excellent condition, and under the direction of Valentin Glushko, who later became the USSR's premier rocket engine designer, the first firing of a V-2 engine took place on September 6, 1945. Eventually the Lehesten facilities were shipped in toto to the USSR.

For his work Grottrup was treated generously. He, his wife and two children were given the home near Bleicherode of a rich merchant who had been summarily ejected. He was paid a good salary and provided with excellent food rations.

Eventually Institute Rabe was reinforced with Soviet specialists from the Army and from industry. In the fall of 1945 such future missile luminaries as V. I. Kuznetsov, Vassily Mishin, N. A. Pilyugin and M. S. Ryazansky appeared, having been given military ranks and uniforms. They were confronted with some stiff challenges, including the lack of technical documentation, which had been gathered up by the Americans. Reconstructing it was very difficult. Mishin went all the way to Prague for some of the archives. Some valuable pieces of hardware were discovered, such as an especially crucial gyro-stabilized platform,[14] which had been under development for application to a two-stage missile.

"We solved puzzles every day," said Chertok, first understanding a device's functioning, then reconstructing the documentation. Pilyugin would usually disassemble a device "down to the last screw" personally, then direct the Germans to make detailed drawings. Then he would build the device from the drawings.

Russian exploitation of V-2 technology took place in many places throughout their zone of Germany. Besides the locations mentioned above there were a missile controls plant in Berlin; a design office in Sommerda, near Erfurt; an engine assembly plant called Montania near Nordhausen; and an electrical equipment factory in Sonderhausen. The last must have been especially appreciated because the Russians were not well versed in modern electrical technology. As one veteran Soviet electrical expert, Nikolai Sheremetyevsky, was later to

say, "All the electrical equipment that was later mounted on Korolev's rockets we initially took from the Germans and then improved."[15]

Korolev himself did not arrive in Germany until September 9, 1945, still technically a prisoner, fresh from the sharaga in Kazan. Belatedly recognizing his value to the USSR, the Red Army had made him a Colonel and sent him off to join the experts assessing the V-2. He apparently wasted no time getting his perks.

"My first meeting with Korolev," said Chertok, "was in his lavishly decorated study, which had been the home of a German electrical contractor (in Bleicherode). I had been given notice that he would be arriving and I was told by Colonel Tyulin to be polite to him and show him everything. Korolev drove up by himself in an Opel. He asked me why I, a Soviet official, had such a pretty German secretary. I said she could type and do stenography and speak both German and Russian. We were allowed to hire Germans, even if they had been Nazis, but we couldn't hire Russian prisoners of war—a paradox. Korolev looked very healthy, even though he had only recently been in prison. He had a prominent forehead, lively black eyes. He looked directly at you as though x-raying you. His uniform looked good on him. He was full of energy. It was a brief meeting. I explained the work of the institute to him but he turned down a tour. He said he was in a hurry to go back to Berlin and asked me for some gasoline, saying, 'I'm sure I'll see you later.'"[16]

Soon the brass from Moscow appeared, attaching great importance to the work. V. M Ryabikov, Deputy Minister of Armaments, arrived, and then the Minister, himself, Colonel-General Dimitri Ustinov. The latter would be a particularly influential figure in the development of the Soviet missile and space technology capability from the 1950s to the 1970s.

The decision was made to create a more formidable organization, the Nordhausen Institute, which would incorporate Rabe as the guidance system component. Chertok continued as head of the latter, with Pilyugin his chief engineer, but reported henceforth to the overall Institute Director, General Lev Mikhailovich Gaidukov. Gaidukov's deputy and chief engineer: Sergei Korolev.

The job of reconstructing all of the documentation was assigned to a joint Soviet-German design bureau in Sommerda. In command at first was V. S. Budnik, who was succeeded later by Mishin.

Glushko, already in charge of engine testing at Lehesten, got the task of reconstructing engine production technology at Montania. An institute for studying air defense missiles was created in Berlin under V. P. Barmin. Reconstruction of ground equipment was assigned to Barmin's deputy, Viktor Adamovich Rudnitsky.

Korolev, says Chertok, "was a wonderful organizer ... able to unify people around himself... He inspired us with the idea that this work was not just a reconstruction of German technology but the source of a major new direction."

Still, he was "outwardly reserved and uncommunicative," wrote Tyulin in a 1989 article.[17] "Once I asked him: Sergei Pavlovich, what do you think about all this? He did not answer at once... Much later I realized that the black period of repressions, prison, Kolyma, Magadan had made him cautious and he avoided opinions on acute matters as if he feared that everything might be repeated again."

He was especially rueful that the groundwork that he and his GIRD colleagues had done in the 1930s, work probably equal in significance to that of the youthful von Braun and his colleagues during the same period in Germany, had been aborted by the imprisonment of Glushko, Kleimanov, Langemak, and himself.

"We had accomplished much good groundwork back in the late 1930's," he told Tyulin. "We returned to this subject often. Korolev would present his views and pay due respect to 'von Braun's team' and the 'German breadth' but even then he believed that the design solution of the A-4 (V-2), the most sophisticated rocket of that time, could not be used for future developments." Aware that the Americans had made the biggest V-2 coup, the Russians must have been especially delighted when they were invited in October 1945 to a series of V-2 demonstration launches organized by the British near Cuxhaven on the North Sea just west of the mouth of the Elbe River.[18]

Authorization for the firings, known as Operation Backfire, had been planned by the British Air Defense Division as early as May 1 (VE day was May 8), when it was realized that Nordhausen, where the V-2 was manufactured, would soon be in the Russian zone. Over the next few months, some 25 V-2 specialists were transferred to Cuxhaven from the Peenemünde group at Garmisch Partenkirchen, although eventually 1,000 German nationals, including 274 prisoners of war, and 2,500 British military personnel were involved in the operation. Search parties scoured Germany, France, Belgium and Holland to find the weapons and their launch apparatus. They turned up enough materiel to fill 200 trucks and 400 freight cars, although much of it was in such bad shape that they could only assemble eight complete V-2's.

There were three demonstration launchings, on October 3, 4 and 15, with the Russians present only for the third. Most of the British and American witnesses were military officers, with no special expertise in rocketry. Exceptions among the Americans were Theodore von Kármán, founder of the Jet Propulsion Laboratory at the California Institute of Technology, William H. Pickering, who would become JPL Director himself in 1954, Lieutenant Commander Grayson Merrill, and Howard S. Seifert. Pickering, who eventually led the team that developed the payload for Explorer I and went on to send scientific spacecraft to the Moon and every planet except Pluto, doesn't recall that there were any Russians present for the one firing that he witnessed, but perhaps they kept a low profile.[19] Tyulin reports that the Russian representatives included, besides himself, General, A. I. Sokolov, and two first rate rocket engineers from NII-1, Yuri

Pobedonostsev and Glushko, and also Korolev. Another report, however,[20] says that Korolev had arrived unannounced from Nordhausen with a colleague and was kept stewing and fuming outside the fenced area.

Pictures taken at the time show a handsome, ramrod straight, if somewhat short and hefty Sergei Pavlovich. Only 39 years old, bull-necked, stern of face, he could have been portrayed by a young Rod Steiger in a movie. For a time he had his wife and daughter with him. "My mother and I joined him in Germany in May 1946 and stayed there until August," Natasha Koroleva told me. "I had a lot of fun with him in Germany. We visited a lot of interesting places. We even took an automobile tour around the country in an opel."[21]

Korolev's interaction with the Germans was substantive, and dealt mainly with technical questions. Magnus, in a very interesting book, describes his first meeting with Korolev, a meeting which revealed, even at the time, a deep interest in space flight:

> In our discussions during that evening, Korolev's interest focused mainly on ascent trajectories of rockets, characterized by the complicated interplay between propulsion and guidance, which finally determines the range of a rocket. 'And if we increase the range more and more,' he remarked, 'then we will finally be able to build artificial satellites which continue to orbit the Earth.'
>
> Such a statement, although absolutely correct on the basis of the well-known laws of planetary motion, appeared to us as a utopian project whose technical realization would be a matter of the far distant future. However, Korolev, unimpressed by our restraint and hesitation, continued enthusiastically 'And if we increased the cutoff velocity further by about 40 per cent, then we could visit the Moon. Let's all work together to achieve this.'[22]

Anticipating the day when the Soviets would move back to Russia, the idea developed, says Chertok, to build a special laboratory train that could be used to measure, test, and prove out missile elements. Thus, specialists could carry out their work "in any deserted place in the Soviet Union" under tolerable living conditions. Tyulin gives a different version of why the trains were built. Korolev, he says, wanted to conduct test launches of the V-2 in Germany, just as the British did in Cuxhaven.

"Many of our comrades supported the idea. By that time we had everything required for a test launch ... L. A. Voskresensky (later to become Korolev's deputy for testing) was appointed chief of the flight test group. We queried Moscow. We were refused on the grounds that it was advisable to conduct this kind of work in the Union. It cannot be said that we were disheartened by such a decision; to a certain extent we expected it and so the task arose immediately of building a special train that would consist of everything from cars with missiles and ground equipment, laboratories for testing gyroscopes and radio gear, and shops housing general service rooms."

A German railway firm built the train, then a second one, under contract to the Soviet industry. They were such a success, and so readily built by the Germans, that the military wanted one too, and they proved to be very valuable back in the ravaged Soviet Union.

The Russians were remarkably prescient in their use of the German know-how. They assigned one officer to the job of supervising the V-2 specialists in the compilation not only of detailed memoirs on their Peenemünde experiences but also on future projects that they had hoped to develop.

Astoundingly, a "Russian version of the book was later destroyed by our censorship. However, what we learned shook our imagination," said Chertok. "Many modern ideas were developed during the war years in Germany. One of the most audacious was the A-9/A-10 two stage missile, intended, prospectively, for bombardment of America." The first stage A-10 was to have been a more powerful version of the A-4. The second stage A-9, which was winged, would have ignited at 200 km altitude. Launch was envisioned from the coast of Portugal. Radio signals from the missile would be sent back to a control center which would reconcile its position to a map. At the right time the controller would signal the missile to descend to the target. The concept, remarks Chertok, except for modern guidance techniques, is not greatly different from the terrain-following cruise missiles used during the Gulf War.

Chertok's speculation shows that he is one more victim of a misunderstanding about A-9/A-10, according to Ernst Stuhlinger, a veteran of Peenemünde who later made very significant contributions to the US space effort as a member of the von Braun team. "The designation of the A-9/A-10 rocket as a missile intended for the bombardment of America is a horrendous misstatement perpetrated by those who try to prove that von Braun was a war criminal... Adolf Thiel, who happened to write his Ph.D. thesis on this project, explained that this two-stage rocket was studied in connection with the problem of bringing a spacecraft back from a satellite orbit, using a long glide path through the atmosphere. The total distance the A-9/A-10 combination would be able to cover came out as about 3,000 km. 'This is just about the distance from Portugal to America!' somebody said—and the fairy tale of the 'America rocket' was born." In any case, the concept was actually far beyond Peenemünde's technological grasp; the guidance requirements were too extreme, the aerodynamics were unknown, and the materials did not exist to prevent the upper stage from burning up during reentry into the atmosphere.[23] Nonetheless, the concept must have been intriguing for the Soviets when they began to develop plans for their own ICBM.

There were other very exotic ideas catalogued by the Germans. One even called for a manned version of the A-9/A-10. Another was to develop atomic reactors for rocket propulsion.[24] Still another was to reflect sunlight to Earth with an orbiting mirror. The latter is a concept still being fancied by advanced thinkers to supply energy to Earth. The Russians, in fact, tested a miniature

version of the concept by deploying a 21 m solar mirror from their Mir space station in 1993 to show that solar energy could gradually accelerate a "solar sail" to interstellar velocities.

Another concept from the V-2 Germans which presaged actual developments by not only the USSR but the US, Britain, France and modern Germany was the launch of spacecraft from airplanes. There was even rumor of a "kamikaze" plan. Some 25 volunteers, according to Chertok, were to have been recruited to be launched in specially modified V-1 plane-missiles from long-range bombers. Targets were even designated: the industrial complexes at Kuibyshev, Cheliabinsk, Magnitogorsk and other cities.

This rumor, says Stuhlinger, might have been sparked by a quite different idea, for a "one-way fighter plane, loaded with an explosive charge. The pilot would maneuver his plane into a collision course with an enemy bomber, and shortly before impact would push his ejection button, causing his entire cockpit to be jettisoned and parachuted to Earth. This project was not seriously pursued, as far as I know."[25]

By the Fall of 1946, the Germans under Grottrup had done what their Soviet captors had directed them to do. So what happened next must have been a big shock. Perhaps as many as 5,000 skilled Germans—not only the Grottrup group of rocket specialists, but also other engineers, scientists and technicians experienced in weapons systems, submarines and aircraft—were literally kidnapped and shipped, with their families, by trains, freight cars and trucks, to workplaces outside of Moscow. None of them were given a choice in the matter. On the contrary, the transport of the people was as sudden and peremptory as during the Stalin purges, even if their destination was much more salubrious. They were, in fact, treated quite deferentially.

A first hand account of the mass movement, which took place on October 26, 1946, was given in a television program, aired in the USA[26] in 1993, by Magnus and Grottrup's widow, Irmgaard.[27] From the TV transcript:

> *Magnus (through interpreter):* General Gaidukov was present and listened to all the proceedings. Then he said, with a large gesture, 'Well, you've been very industrious, I'd like to invite you to a dinner tonight.' A huge table had been set up in a big hall there. The whole thing was lit in a festive manner, and we were offered a meal, the like of which we, at the time—remember, it was autumn 1946, and there was nothing to eat in Germany—it was a meal the likes of which we'd never seen before. Fruit in absolute abundance, which was unheard of at the time, and, of course, vodka, vodka, vodka, nothing else to drink. When the party was over, shortly before midnight, each of us individually was taken home in a car by Soviet officers. And three hours later, they got us out of our beds.
>
> *Mrs. Grottrup (through interpreter):* ... I went to sleep, and around 3:00 AM I was wakened by the telephone. Someone, I can't remember who said, 'The Russians are at the front door. We're going to be taken away,' and I thought it was a joke.... We went off if in a terrible rush that night—it all seemed chaotic to us—but the train left with all of us aboard.

Magnus tried, on the night of the dinner, to have Korolev intercede for him. "'I refuse to join this transport, and I urgently request you to help me,' I said, ... (and) told him that I intended to marry soon; however, it would take some weeks before the necessary documents could be brought together. 'You can marry without any problem in the Soviet Union!' said Korolev. In response to my categorical 'No,' he asked that we—please—come along now, because the present action could not be stopped (but) he promised that we could return to Bleicherode in a few weeks."

"But do you really believe that we can travel back to Bleicherode? After what we have experienced today? I doubt it."

"I give you my word of honor as a Soviet officer."

"Alas! This was the end of the conversation. It would not be advisable to look for new arguments if the other side brought up such an emotional and dignified matter as a word of honor..."[28]

Chertok says that a special directive had been issued to treat the Germans gently during the mass movement, and allow them to take "any woman" they wished, "even if she is not a wife," and any possession they wanted. Mrs. Grottrup tested the latter directive to an extreme. The Russians had given the Grottrups use of a farm, and having been warned of famine in Russia, she said she would not move without the cows and their hay.

"What to do?" says Chertok, "Load it."

Sergei Kryukov, later one of Korolyov's key deputies in the development of ballistic missiles, recounted his personal experience as one of the Russians assigned to escort the Germans back to Moscow.[29] "We had one passenger car with 5-6 German families plus several cars containing their personal effects. One of the Germans, who had no family with him, abandoned the train somewhere in Germany or Poland, leaving his belongings. This caused a problem with officials, resulting in a delay, and then we lost three days because the Poles stole our locomotive and we had to get a new one."

Despite their forced transport, the Germans were given first class treatment on their arrival. The top people got much more commodious living quarters in the Moscow environs, two or three times the salaries, and much better food than their Soviet counterparts, who were still suffering wartime privations. It was embarrassing at times, says Mrs. Grottrup, to be faring so well while the Russian neighbors were so obviously on hard times. Not so well provided for were the German underlings, although they too were adequately fed and housed, first in modest wood-framed houses in various villages near Podlipki, about a 40-minute drive northeast of Moscow, along the Moscow-Yaroslavl highway.

Most of the rocket specialists reported to the newly created NII-88, which was the transformed NII-1, in Podlipki. The establishment of NII-88, by decree of the Party and the Council of Ministers, was a clear indication of the escalation in importance of missile development in the postwar USSR.

NII-88 was named the Central Scientific Research Institute of Machine Building in 1967 ("... so to speak, in order to bewilder the enemy").[30] It is today one of Russia's principal space research centers. An offspring of NII-88, created in 1956, was the Korolev design bureau, which underwent a series of name changes through the years. Known first as SKB-1 (Special Design Bureau), then OKB-1 (Opi'tni'i, or Experimental Design Bureau), then TsKBEM (Central Design Bureau of Experimental Machine Building), then NPO Energia, the company is currently known as RKK, Energia (Raketno-Kosmicheskaya Korporatsia "Energia" imeni S. P. Koroleva). It is the largest space enterprise in Russia. Podlipki, although the name is still used by some old-timers, is now the sizable city of Kaliningrad. In the middle of the town stands an imposing, larger than life statue of a formidable, stern looking Sergei Korolev. The community's entire livelihood—support services, school system, municipal transport, banks—revolves around the rocket factory. A super-secret institute for decades, the enterprise had some 35,000 employees throughout the former Soviet Union at its peak of operation in the 1980s. Its central facility in Kaliningrad, where Korolev had his office, and where his current successor, Yuri Semenov still has, is visited regularly by American, European and Japanese space engineers and government officials collaborating on the multi-billion dollar international space station scheduled to be built starting in 1997.

It is ironic that the NII-88 plant had been built by a German firm, Rhein-Metall Borsig, as a machinery factory, in 1926. But beginning in 1946 its business was missiles.

Virtually all of the technical leaders appointed during this period to head the Soviet missile and rocket effort had become acquainted with each other in Germany. Commander of NII-88, which reported to the Ministry of Armaments, was General Lev Gonor. Chief engineer was Yuri Pobedonostsev, who had been at Nordhausen. His deputy was Chertok. Chief designer of the OKB 456 rocket engine plant in Khimki, also near Moscow, was Glushko, reporting to the Ministry of the Aviation Industry. Chief designer of NII-885, reporting to the Ministry of the Communications Industry, and responsible for guidance systems, was Ryazansky, with Pilyugin his deputy.

Korolev was made chief designer of NII-88's SKB-1, responsible for long range ballistic missiles. It is mind boggling that such a dispersal of responsibility among facilities, and even worse among Ministries, could produce a working system. But it did work, and it was largely because of Korolev. Each of the principals had become used to accepting the authority of Korolev from the days in Germany when an unofficial council of chief designers came into being, with Sergei Pavlovich its chairman. As Chertok put it, "they perfectly well understood that without it (Korolev's authority), and with departmental compartmentalization, with dispersal among different ministries, we could not succeed in anything."

This highly competent group of engineer-managers not only functioned but achieved remarkable results in what could have been a paralytic government structure by following their own pragmatic rules under inspired leadership. It may be one more reason why the Soviets owe a debt to the V-2 Germans since the working relationship was originally built in Deutschland.

Those V-2 Germans not assigned to NII-88 went to work for either Glushko or Ryazansky. Some 150 Germans worked at NII-88, reported Chertok, including 13 professors, 32 doctor-engineers, 95 diploma-engineers and 21 engineer-practitioners. Only 17 of these men had actually worked at Peenemünde, said one of this group some years later. With their families they numbered nearly 500 when they were moved to the island of Gorodomliya, where they operated a kind of workshop as a branch of NII-88. Chertok says that, although it was surrounded by barbed wire and guarded by women gunners—the Germans, who were used to being guarded by the Gestapo, joked about that—it was actually a luxurious place. They received "quite tolerable feeding ... and on weekends were periodically transported to Moscow, to theater, museums."[31]

They were organized into work sectors, each supervised by a Russian and a German leader. In general, the propulsion, controls and construction sections were at NII-88 itself, while the ballistics, aerodynamics, design, physics, chemistry, shops, and static test sections were at what was called Branch 1 at Gorodomliya. In the beginning there was much moving back and forth but after May of 1948 all of the Germans were at Branch 1.

Their first jobs were to help install the A-4 assembly line brought from Nordhausen, in a large building at NII-88, and to restore 30 German A-4's. Some 15 of the latter were completely assembled, and the other 15 were in the form of major components.

The exploitation of the Germans, skills and experience was very carefully organized to minimize contact with Soviet peers. Magnus recalls the strategy used by the Russians:

> Most of the Soviet engineers who were to take care of us did not yet have any professional experience. Some of them were still students ... undergoing practical training ... only much later did we realize what tricky means the Soviets applied so that we would not learn what they were really doing: the Russian top experts, organized in work teams like we, worked in the same factory, but carefully separated from us ... there was a group of experts parallel to ours, but anonymous to us! Its members were first class specialists, they followed and controlled our work, but remained invisible to us... There were indications that Korolev was the chief of that phantom group. He, who had talked with us almost daily and very openly in Bleicherode, contacted us only rarely in the Podlipki works. And when he did come, he was always very curt, asked very precise questions, and then disappeared again quickly.[32]

In June of 1947 the Germans were asked to design a new long range ballistic missile, which was given the designation G-1. Grottrup headed the project and the Russians were asked to give them support. "However," says Chertok, "starting in 1948" there was an "active search for Russian authors of all inventions, discoveries and the newest scientific theories." This put the kibosh on any German-originated development. Korolev, himself, was not enamored personally of the idea of supporting the German ideas. As Tyulin put it, "He, one of the first pioneers of rocket technology in our country, had to drink a full cup of humiliation as a prisoner and to learn, after his release in 1944, that some of his own ideas had already been realized, and that German rocket men had gone farther than his most ambitious plans." It was galling to him to have been made chief designer and then asked to test, not his own concepts but the R-1, which was to be an exact replica of the V-2.

It was already recognized that the V-2 was obsolete but it was also recognized that mastering its production, learning how to launch it, and then instructing the military in its operation, were of vital importance. In fact, Stalin himself, according to Tyulin, was the one who insisted that a thorough understanding and construction of the V-2 was needed before going on to indigenous rockets. Korolev, said Tyulin, "was convinced that a group of our leading designers was capable of creating a more reliable rocket ... with longer range. Stalin listened to those words from Korolev in a private briefing. His response: 'First we must complete work on the R-1.'"

A description of the first of the A-4 test launches was given on the TV show by Magnus and Mrs. Grottrup.

"In the summer of 1947," said Magnus, "six or eight colleagues from our group suddenly disappeared. We weren't told where they'd been taken. We were very worried that they'd been abducted again, but it soon transpired that they'd been taken to this rocket testing site."

The site: Kapustin Yar, in the Astrakhan area of southern Russia, which became the main test area for ballistic missiles over the next decade, until Tyuratam, known better today as Baikonur, took over in the late 1950s. There, the first Soviet A-4, rebuilt under the tutelage of the Germans, was fired successfully. Mrs. Grottrup was told that, "After that launch, they were so happy and enthusiastic. They jumped-up and down like little children. High ranking ministers or not, they were just like little children. Then they grabbed their vodka bottles and got drunk."

Chertok gives the date of that first test launch as October 18, 1947. His account says that in September the contingent had arrived at what he calls the State Central Range at Kapustin Yar. "Officers were somehow accommodated in a small town. Soldiers lived in tents and dugouts." Tyulin describes the place as a "Bare, lifeless steppe with dry sagebrush gray from dust, camel's thorn, and sparse little islands of spurge. There was essentially no water. The hot wind chased the swirling dust and balls of tumbleweed."

The test stand, says Chertok, was "very close to our special train. An airfield, where planes landed on a ground strip, was also in the vicinity." Assembly and test was in a wooden barracks. "It was cold and the wind blew through it."

"At last, the missile was rolled out to the firing stand. However, we couldn't ignite the engine for a long time. The igniters ... kept failing ... one or another relay switch failed every time." These failures were "hotly debated at sessions of the State Commission" chaired by Marshal of Artillery N. D. Yakovlev. On the Commission were "not only such high chiefs as D. P. Ustinov but the deputy of Beria, Serov, as well ... a 'Damocles sword' of reprisal hung above everybody."

"The first launch was performed on 18 October 1947, at 10:47 AM, the second on 20 October. Early in the powered flight a strong deviation of the missile to the left was recorded. Reports of the expected impact did not come, and on site observers commented, not without humor: 'It went towards Saratov.'"

"Serov ticked off to us: 'Can you imagine what will happen if the missile landed in Saratov? I won't even tell you, you can guess yourself, what will happen to all of you.' But we understood that Saratov was more than 270 kilometers away from where the missile was launched (the range of the A-4), and therefore we were not nervous."

It was learned later that the deviation was 180 kilometers. Ustinov decided that the Germans should be consulted.

"Before that, Dr. Magnus, a specialist in the area of gyroscopes, and Dr. Hoch, knowledgeable in the area of electronic controls and guidance, had sat on the range without a particular job. Ustinov said to them: 'this is your missile, your devices,' and they were ordered to figure out what had gone wrong. They adjourned to the lab on the train, began analyzing the guidance data, and soon determined the cause of the deviation." (Tyulin's account says it was gyroscope error caused by vibration). Changes were made and the effect was immediate. The deviation on the next launch was small. Ustinov directed that all German specialists and their assistants were to get "huge" bonuses—15 thousand rubles each, and a "canister of alcohol... We amicably celebrated a successful launch."[33]

Quite a different version of the unsuccessful and successful launches is described in the book by Magnus. After the failure, says Magnus, "Ustinov ... looking at us with a stern face ... said: 'The day after tomorrow, the next rocket will be launched. Can ... each of you guarantee that the launching will he successful as planned?' What could we answer? We had been asked the same question again and again during these past few days."

Grottrup replied that the preparations were careful and there was no reason to expect failure. But Ustinov pressed relentlessly and there were "questions, blame, explanations, and justifications ... for some time." Korolev kept the discussion "within bearable limits by translations, interpretations, explanations...

We could not help being drawn into a jungle of technical details." Eventually Ustinov said, "You know that the next test launchings are very important. Do your job as you are expected, then you can count on an award."

"Grottrup, quick-witted as always ... replied ...Sir, the best award would be your decision to allow the German specialists to return to their home country."[34]

The next launch was, indeed, successful, and, as Magnus describes it, there was "Relief, even jubilation everywhere. Korolev is beaming with joy, he thanks us with a handshake." Later, however, Korolev asked the Germans to stay on for a talk. "There was something in the air; we sensed that immediately. As soon as we were alone, Korolev began with a serious, even worried expression on his face which did not fit at all with his victorious smile of a few minutes ago: 'The Minister ordered me to investigate whether the failure of the first two test launchings could have been caused by sabotage of the German specialists. It makes me very suspicious,' he said, because the error could be corrected in such a very short time."

"We thought that we had not heard correctly. That was a blow below the belt which showed us quickly that we lived in a land of institutionalized distrust.... 'How could we have committed sabotage, since we did not participate in the preparation of the tests at all?' I asked." Korolev persisted by asking if such failures had occurred in Peenemünde. Of course, said Grottrup, and they were always analyzed carefully. Korolev asked for a report, including guidelines for component tests in the future, and said that he personally did not suspect malicious intent. He was apparently under orders to carry out the grilling.[35]

Eleven of the German-built, Russian refurbished, V-2's were launched, and five of them reached their targets, the same percentage of effectiveness as the Germans had during the war. Five of the 11 had been assembled at Nordhausen, six at NII-88. "Both proved equally unreliable," was Chertok's comment.

After this the Russians set to the job of building their own missiles, a task "unbelievably difficult for our country... We had to develop a lot of technologies from scratch. Furthermore, where to get the materials ... absolutely new materials ... never produced by our industry before." There were "only" 35 research institutes and design bureaus and 16 principal plants involved in the R-1 program.

Back to Kapustin Yar went the Russians in the special train in the fall of 1948, this time with twelve NII-88 built R-1's. Nine were launched and seven reached their targets, a better score than the "trophy" missiles, but still not very reliable. Here Chertok directs a barb at contemporary manufacturing practices: "just try now, in our great shops," he says, "with wonderful equipment, to produce a new missile in a year. Give the personnel good rations and bonuses and you still won't be able to do it. Yet we did it. We made a first series, a second, a third. In 1951 the R-1 was commissioned for service. In parallel, work pro-

ceeded on other missiles and in ten years we followed the path from the R-1 to the R-7—the first ICBM—it is still performing for cosmonautics."

Backing that statement up, versions of the R-7, which was built as the first Soviet ICBM—although it was soon replaced as the USSR's operational ICBM by a missile developed by Mikhail Yangel—became the work horse launch vehicle for the Soviet space program. R-7 descendents, including the Vostok, Voskhod, Molniya and Soyuz not only placed Sputnik and Yuri Gagarin in orbit, but launched more than 1,500 spacecraft up through 1994.

The path to the R-7, however, had first to go through the R-2, R-3 and R-5. It began with the R-2 development starting in June 1947, paralleling Grottrup's work on G-1, which had the same design objectives—600 kilometer range, more than twice that of the V-2/R-1, and with a capability of warhead separation, propelling only that payload rather than the entire vehicle to its target. It is not clear, says Chertok, whether it was Korolev or Grottrup who first thought of warhead separation.[36]

In September, 1947, Grottrup submitted the G-1 design to the NII-88 science and technical council, proudly pointing to the fact that G-1 was not only capable of 600 kilometer range, but was no larger than the V-2 and promised ten times the accuracy. Furthermore, he said, it should provide a basis for development of much longer-range missiles. Korolev's similar R-2 project, he recommended, should be carried on in parallel, "absolutely independent of each other up to pilot production and test launch."

How to respond to that recommendation was the quandary of one Sergei Ivanovich Vetoshkin, Ustinov's principal assistant for rocket technology in the Ministry of Armaments. "... he asked me directly," says Chertok, "Boris Yevsevevich, you started all this activity in Germany ... and know what they are capable of better than I. Now they design a new rocket. The main question ... for which Dmitri Fedorovich has tortured me, is what to with this project? The Germans can't build it on the island with their own capabilities."

"The question wasn't simple," Chertok goes on. "There couldn't even be talk of Korolev working under Grottrup. What about Grottrup under Korolev? That's also unrealistic because Korolev would immediately declare that 'We'll do it ourselves.'"

The Soviets couldn't afford two parallel design bureaus, each with its network of subcontractors. Chertok's recommendation was to use the Germans' ideas and experience as resourcefully as possible but to gradually send them home. He went to see Grottrup in Gorodomliya in the winter of 1948. Grottrup made a "long speech" to the effect that they had not been able to implement any of the experiments fundamental to the G-1 design. They had not been permitted to carry out aerodynamic studies, use the engine test stands. How can we prove, he complained, that it is possible to drive a turbine with gases bled directly from the combustion chamber? Calculations won't provide the answer. Experiments

are necessary. Radio communications must be tested using aircraft and test ranges. He asked what the future of the Germans was.

"I don't have the right to kill his hope," Chertok thought, and advised Grottrup to continue his work. The G-1 project was upgraded and by the end of December, the draft design showed substantial improvements in prospective performance, including a range of 810 km, rather than 600 km. But there simply was not enough capability at NII-88 to keep the project going in parallel with Korolev's and so in 1950 the Ministry of Armaments cancelled further works on long range missiles in the German collective. For some months the Germans worked on "secondary tasks."

Magnus describes some of these jobs in his book: "a barometric altitude meter for airplanes ... chemists studied novel rocket propellant combinations... Electricians and electronic experts worked on a quartz clock (which) achieved an accuracy that approached that of the best mechanical clocks known at that time... One task that had particular importance for the island was the design of a 'hermaphroditic' vehicle, a crossbreeding of car, boat, and sled ... to guarantee contact between island and mainland at times when ice formation excluded traffic by boat but when ice cover was (not) thick enough to support a car or sled." Magnus himself worked on such devices as a "position gyroscope (a positional reference system) with a special double rotor ... to improve the ... accuracy of existing instruments with non-symmetrical rotor profile."[37]

The 1960 CIA report, which is so detailed that it must have been compiled by a particularly competent spy or even by one of the Germans working at Gorodomliya, says that most of the work performed up to December 1949 was on designs aimed at improving the A-4, but some "presented new and radical concepts."

There were three categories of design projects—the preliminary, or Vor-Projekt; the sketch, or Skizzen Projekt; and the technical, or Technisches Projekt. The Vor-Projekt was just a 10-20 page concept. The Skizzen Projekt was a detailed design including not only the chief project engineer's concept but comments and proposals by engineers responsible for major components. It could consist of 15-20 reports numbering 100-500 pages and drawings. Most advanced was the Technisches Projekt which offered new designs complete with all calculations, and parts drawn in enough detail to permit production drawings.

Some eight design proposals emerged. One was the R-10, which, based on the data in the CIA report, seems to be the G-1, whose ill-fated end was described by Chertok earlier. It would have achieved its increased performance over the R-1 by increasing the engine combustion chamber pressure; by eliminating the hydrogen peroxide gas generator system and bleeding combustion gases directly into a turbine which would power the fuel and oxidizer pumps (this was the concept referred to earlier, causing Grottrup to complain that they weren't allowed to do the experiments which would have enabled it to develop); and by reducing the vehicle's weight through the use of integral fuel tanks.

The German version of R-11 never got beyond the sketch stage. It would have increased the R-1's range by increasing the length of the vehicle by two feet, enabling it to carry more fuel. It also called for a redesigned engine that would have upped the thrust to 35 tons. The Russians did build an R-11 as their first tactical missile, however, with an engine designed by Isayev, using nitric acid and a "carbon hydrogen fuel." Its range was 270 km and the first launch was on April 18, 1953.[38]

The R-12 would have had three engines, two of them to be jettisoned after initial boost, as with the US Atlas ICBM, to increase range to as much as 2,500 kilometers. This project was ended between the Vor-Projekt and Skizzen stages.

The R-13 would have had a 1,000-kilometer range, using a single engine of 120 tons thrust. An alternative design would have had a cluster of four 35-ton engines. This project never reached the Skizzen stage.

Minister Ustinov, in the spring of 1949, says the CIA report, asked the Germans to produce a design for a ballistic missile which could carry a three ton warhead 2,500 kilometers. They came up with the R-14 and R-15. The R-14 would have been a cone-shaped vehicle, about 25 meters long, 3.7 meters maximum diameter, calling for engine thrust of 100 tons. "Range control," says Magnus, "would have been by fuel cutoff using either inertial or radio control. Guidance would have been by special gyros and by radio-beam."[39] It was carried through most of the final, or Technisches Projekt, stage. The R-15 was a two-stage concept. The first stage, an improved R-1, would boost the second stage onto a horizontal flight path at an altitude of about 140-200 kilometers. The second stage was a cruise missile powered by a winged ramjet, 12 meters long, with a five-meter wingspan. This concept reached only the Skizzen stage.

Both the R-14 and R-15 concepts were submitted to the NII-88 Scientific Technical Council. But unlike the case of the R-10/G-1 Grottrup was not given a chance to participate in the council deliberations, although numerous requests were made for more details. In fact, in 1952 two items which seemed to be related to the R-15 were actually ordered from the Germans.

In the summer of 1949, while they were working on the R-14, one of the senior NII-88 administrators, General Spiridonov, asked the designers to consider possible ways to counter a ballistic missile attack with an anti-missile. The Germans said they were too busy on the R-14. "Your work on the rocket R-14, with the exception of some details, will now be terminated. From now on you will work on a new project," the Germans were told by Ustinov himself, according to Magnus:

> Our surprise could not have been greater. Ustinov went on to explain that an anti-rocket rocket should now be developed. Its purpose should be to encounter and destroy approaching rockets at such high altitudes that their explosive charges would not do any damage on the ground. At first we thought that we had misunderstood what he had said ... Grottrup was the first to grasp the situation ... he remained admirably cool and, quite factually, asked the precise question: 'Are there Soviet instruments that allow us

to locate approaching rockets precisely and at an early time? And how much time do we have between having located the oncoming rocket and its destruction?'

Embarrassed silence. The Soviets looked at each other in surprise and whispered to each other. There was no translation. Finally, they said: 'Details will be clarified' after work on the project has been started.'[40]

A few of the Germans at Gorodomliya were put to work gathering data on the two surface to air missiles being developed during the war—the Schmetterling (Butterfly) and the Wasserfall (Waterfall). Neither of these missiles had been used operationally, not having matured sufficiently, but some work was done on their development while the Russians were in Berlin in 1946.

Schmetterling (HS-117) was a mid-winged monoplane about four meters long, with a 2 meter wingspan. It carried a 25-kilogram explosive charge about 15 miles against targets below 10 kilometers altitude. The Russians tested the control system of one of the two Schmetterling working models which had been reconstructed under Russian direction in Berlin. One of these had actually been launched from an aircraft to test the control system. In Russia the work continued and at one point the control system was tested in one of the wind tunnels at TsAGI (Central Institute for AeroHydrodynamics). TsAGI is still today one of the premier aerodynamic testing centers in the world, with such an enormous range of low speed to hypersonic range wind tunnels that US aerospace firms are contracting to carry out research there. In the spring of 1948 one of the German specialists was asked to prepare a test program for examining 20 of the Schmetterling missiles.

Wasserfall was an eight-meter long surface to air ballistic missile with a one-meter diameter body stabilized by four stub wings. Steering was by four vane assemblies in the rear. It weighed 3.5 tons and could carry about 90 kilograms of explosive to 20 kilometers altitude. Thrust was from an engine using nitric acid as an oxidizer and aniline as a fuel. A small group at NII-88 worked on reconstituting the missile but the effort was low key. It seemed that the Russian interest in both Schmetterling and Wasserfall was primarily in understanding the weapons technically rather than in producing them.

Much higher interest was manifested by the Russians in the R-113, a more advanced surface to air missile which would incorporate some of the Wasserfall features. A group at Gorodomliya was asked in September 1950 to do a design study of the R-113, using a Wasserfall power plant modified to give higher performance. Slant range was to be about 50 kilometers and the missile was to be effective in the range of 5 to 30 kilometers. The Germans worked six months on the proposal and handed it in in April 1951.[41]

During the German study, speculates the CIA report, the Russians, themselves, gave indications that they were doing surface to air missile development. The "... most definite indicator was the Soviet preference for the extensive use of wood and metal construction in the missile design. When the Germans raised

questions about the difficulty of bonding the two together, the Soviets provided excellent glues and practical solutions. The timing of the requirement, which came towards the end of the Germans' exploitation, and the interest of numerous Soviet visitors to the island, who were not part of the NII-88 staff, tend to support the conclusion that the Soviets wanted solutions to problems their own designers had encountered."

One of the interesting conclusions of the CIA report was that perhaps the Germans' "most valuable contribution" to the Soviets overall was in the field of instrumentation and test equipment. Most of the German work in the USSR, both in rebuilding German missiles and in researching new designs, was "the repair, refurbishment, and calibration of scientific and technical equipment without which the missile research and development program could not have proceeded. In certain cases the Germans created new pieces of test equipment, such as a flight simulator which would simulate the flight conditions of various Missile designs by means of electrical circuits and save many hours of practical testing."

Another statement in the report signals a policy which has served the Russians in a major way throughout the development of their space program, namely, the introduction of recent graduates of universities, and even those who were still students, into practical on-the-job engineering tasks. "... when the Germans were removed from their work on classified material," says the report, "the Russians assigned different groups of young, inexperienced engineers to Branch 1 on Gorodomliya Island so that they might learn from the German personnel." Throughout the 1950s and 1960s it was Korolev's consistent policy to integrate the university education of young engineers from such schools as Moscow State University (MGU), Moscow Aviation Institute (MAI), Bauman Moscow Higher Technical School (MVTU), Moscow Physical Technical Institute (MPTI), Moscow Engineering and Physical Institute (MIPI), and Leningrad Mechanical Institute with stints at NII-88 and later OKB-1, the Korolev design bureau.

This practice, with some notable exceptions, is not characteristic of the US aerospace industry. Generally, American undergraduates studying aerospace engineering have no exposure to the industry until they are hired by one of the companies. There are summer internships at NASA, and at most companies. But the Soviets follow a practice of systematically bringing students into the design bureaus as a regular part of their education. This probably accounts for the practicality of the Russian engineers' training, in contrast to the largely theoretical training of American aerospace engineers.

It was in October 1950, says Chertok, that all of the Germans' classified work was cancelled, although the Wasserfall modification described above must have been an exception. According to Gyorgi Vetrov, a veteran of the Korolyov Bureau who visited Gorodomliya in those days, "they did essentially nothing, playing tennis, planting flowers and waiting for repatriation."

Magnus says that, "We read, did some personal work, or simply loafed around. Well, one cannot just loaf around for months. Therefore, we began, mostly in groups of two or three, to beef up our professional knowledge. For example, one of these groups worked through a test book of theoretical physics, chapter by chapter, discussed the content and deepened everyone's understanding by solving the problems... For me, several months were filled with translation of a newly published monograph about the theory of dynamic stability."[42]

Back to Germany went the whole team, in three stages. The first group departed on January 20, 1952, the second on June 10 and 13, 1952. Finally, on November 20, 1953, the last group, including Grottrup and family, returned to the Fatherland, by then East Germany.[43]

## Reference Notes

[1]Konovalov, Boris, *Izvestia*, Numbers 54, 55, 56, 57, 58, Mar. 4-9, 1992 (Russian).

[2]Neufeld, Michael J., *The Guided Missile and the Third Reich: Peenemünde and the Forging of a Technological Revolution, in Science, Technology and National Socialism*, Cambridge University Press, New York, 1993.

[3]Thiel did most of his work on the engine at Kummersdorf. Later, at Peenemünde, von Braun made a major contribution to the V-2 engine development with his idea of incorporating 18 injector nozzles rather than a single injector plate. "Towards the end of the war the single plate solution worked well, but it was too late to introduce it because the SS had the production already running and did not want a major change like this. The statement that von Braun tried to claim some of Thiel's achievements as his own is absolutely false." Letter to the author from Ernst Stuhlinger, June 9, 1995.

[4]Schulze, Heinrich. A., *Technical Data on the Development of the A-4 V-2*, F&D 876-1126, a private report prepared for Wernher von Braun at NASA Marshall Space Flight Center, Huntsville, AL, Feb., 1965, and Stuhlinger, Ernst, letter to the author, June 9, 1995.

[5]*ibid.*, Konovalov.

[6]Ordway, Frederick I., III, and Sharpe, Mitchell R., *The Rocket Team*, pp. 251-252, Thomas Y. Crowell, New York, 1979.

[7]Rothmund, C., "The History of the Viking Engine," IAA Paper 2.2-93-675, in *History of Rocketry and Astronautics*, P. Jung, ed., *AAS History Series*, Vol. 22, pp. 297-319, 1998 (paper presented at the 44th International Astronautical Congress, Graz, Austria, October, 1993).

[8]Chertok interview with author, Dec. 4, 1991.

[9]Magnus and Hoch were from the University of Gottingen. Magnus has written an absorbing book on his experience with the Russians: *Raketensklaven* (In German), Deutschen Verlags-Anstalt, Stuttgart, 1993.

[10]"Grottrup's decision for the Russians was scarcely for ideological reasons. He refused the American offer because he did not wish to be separated from his family." Letter from Kurt Magnus to author, Feb. 21, 1995.

[11]*Ibid.*, Magnus letter. "Schuler visited Bleicherode in the summer of 1946 for only 2 or 3 days on invitation. He never intended to join the Bleicherode team."

[12]Scientific Intelligence Research Aid #74, Central Intelligence Agency, Washington, DC, *Scientific Research Institute and Experimental Factory 88 for Guided Missile Development, Moskva/Kaliningrad*, p. 2, Mar. 4, 1960.

[13]Huzel, Dieter K., *Peenemünde to Canaveral*, p. 81, Prentice-Hall, Englewood Cliffs, NJ, 1961.

[14]*Ibid.*, Magnus letter. This platform, "developed by Kreisel GmbH, Berlin, was not used in the V-2."

[15]Chertok interview in *Nezavasimaya Gazeta*, (Russian) Aug. 19, 1993, as translated in JPRS-USP-93-005, Oct. 5, 1993, p. 30, Washington, DC.

[16]*Ibid.*, Chertok interview with author. Dec. 4, 1991.

[17]Tyulin, Gyorgi Alexandrovich, *Krasnaya Zvyezda* (Russian), Apr. 1, 1989, pp. 3-4. Tyulin was named by General Gaidukov to head the so-called Soviet Technical Commission, which became known as the "Tyulin facility," on Bismarckstrasse in the Oberschoeneweide area. It included Chertok and a number of other engineers and designers.

[18]*Ibid.*, Ordway and Sharpe, Chapt. 15, pp. 294-309.

[19]Pickering telephone interview with author, Dec. 2, 1993.

[20]*Ibid.*, Ordway and Sharpe, p. 306.

[21]Natasha Koroleva interview with author, Dec. 9, 1991.

[22]*Ibid.*, *Raketensklaven*, pp. 29-36.

[23]Neufeld, Michael J., *The Rocket and the Reich*, Free Press, New York, 1995, p. 138.

[24]*Ibid.*, p. 156.

[25]*Ibid.*, letter to author from Stuhlinger.

[26]Nova television show #2004, "Nazis and the Russian Bomb," WGBH. Cambridge, MA, aired on Feb. 2, 1993.

[27]Mrs. Grottrup has also written of her Russian experience in *Rocket Wife*, Andre Deutch, London, 1969.

[28]*Ibid.*, *Raketensklaven*, pp. 44-45.

[29]Chertok interview with author, Sept. 8, 1993.

[30]Zak, Anatoli, *Nezavasimaya Gazeta*, Apr. 13, 1993, p. 6, translated into English in JPRS-USP-003, Jun. 28, 1993, p. 35.

[31]*Ibid.*, Magnus letter to author, Feb. 21, 1995. "I suppose that no one of our group will agree with this strange opinion of Mr. Chertok. He has a flourishing fantasy—also in his report in *Izvestia*. 'Periodically' means really perhaps 10 times for small groups (4 to 8 people) in 7 years! Most of us could enjoy this never at all."

[32]*Ibid.*, *Raketensklaven*, pp. 107-8.

[33]*Ibid.*, Chertok interview with author.

[34]*Ibid.*, *Raketensklaven*, pp. 130-31.

[35]*Ibid.*, pp. 133-34.

[36]*Ibid.*, Magnus letter. "As far as I know, this concept has already been discussed in Peenemünde."

[37]*Ibid.*, *Raketensklaven*, pp. 223-4.

[38]*From First Satellite to Energia-Buran and Mir*, RKK Energia, 1994, p. 7.

[39]*Ibid.*, Magnus letter.

[40]*Ibid.*, *Raketensklaven*, pp. 220-22.

[41]*Ibid.*, Magnus letter. "I do not remember that any of the Gorodomliya Germans have been working on such a project as R-113."

[42]Ibid., *Raketensklaven*, pp. 313-14.

[43]*Ibid.*, Magnus letter.