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The German Rocket Jet and the Nuclear Programs of World War II

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Abstract

German military technology in World War II was among the best of the major warring powers and in many cases it was the groundwork for postwar innovations that permanently changed global warfare. Three of the most important projects undertaken, which were not only German initiatives and therefore perhaps among the most valuable programs for both the major Axis and Allied nations, include the rocket, jet, and nuclear programs. In Germany, each of these technologies was given different levels of attention and met with varying degrees of success in their development and application. By the end of the war, both rockets and jets had been used in combat, but nuclear weapons, despite the work of some of the best nuclear scientists in the world, never came to fruition. For each program, the level of success depended on several different factors, such as how the war was going, the effect of Allied air raids, and Germany's industrial capacities. The course of the war in particular decided the extent of investment in each project. It influenced those within research and industry with regard to lobbying for more development support and also those in the Nazi military and leadership, who heeded such calls as it became more and more difficult for the German military to win using conventional weapons and tactics.

But Germany lost the war, which meant that none of these technological developments achieved the desired goal. Not only that, but they also represent a ton of time, resources, and manpower that were wasted instead of more practically applied to other military deficiencies, such as the Air Force's lack of long-range bombers. With all of this in mind, it begs the

question: why were revolutionary technology projects given such high levels of priority and attention? Moreover, how rational was it of those involved in the decision-making process in German technological research and development to invest in these technologies? The clear, present-day answer is that it was very irrational, given the many factors that inhibited the success of the programs. However, the pressure of a possible, looming defeat in a World War might explain why this modern conclusion would not have been as easy to reach during the war as it is now.

Introduction

If one reads a text on investment strategy today, the standard piece of advice given is to regularly review asset allocation in order to make sure the risk of investment is not disproportionate to one's capabilities. In Nazi Germany during World War II, the circumstances of the war made such risk-benefit analyses almost non-existent. Throughout the war, several big projects to develop exotic weapons were provided the highest level of priority for a weapons production program regardless of Germany's actual ability to carry out these tasks. Rockets and jets were two of the most well-known programs, and the rocket development project was actually Germany's biggest weapons program in the entire war. In the pre-war period both of these technologies were constantly researched and experimented with, and they had the virtue of peacetime to prevent damage to the efforts being made to produce results. But during the war these technologies suffered from serious deficiencies that came about as a result of Germany fighting a war that looked more and more like it would end in defeat for Germany every day. Manpower dwindled because of a need for men at the front to hold off the advancing Allied armies, thereby ruining the supply of skilled laborers in Germany. Resources were cut off with each territory the Allies reclaimed, thus reducing the quantity and quality of materials needed for such special weapons programs. And Allied air raids continuously pummeled German factories and research sites, forcing these projects to be conducted in conditions that were not conducive to mass-production. Before the war began, the Nazi leadership, specifically as a result of Hitler's

policies, based decisions on weapons development funding on an analysis of likely return on investment to support its war aims. During the war, however, Hitler and his associates clung to these pre-war exotic projects despite the worsening condition of the war, which meant that other, more practical weapons suffered from a lack of investment. The reliance placed upon rockets and jets reflected a sense of desperation among German war leaders and at the same time a complete lack of consideration for what was, realistically speaking, in the best interest of Germany's war effort at the time.

Throughout this thesis, three different exotic weapons projects will be examined: rockets, jets, and nuclear weapons. Each one will not only support the idea that they were invested in based on an analysis of return on investment, but also determine how rational that original analysis was and how rational it was to continue investment as the war progressed. For each example, a pre-war history of the technology will be discussed, because in order to properly assess the decisions made during the war to increase or decrease investment it is important to understand how far along the technology was at the time the war began. Chapter I will discuss rockets, for this was the most extensive, and perhaps most famous, futuristic weapons project that Germany undertook. Chapter II will explore aviation as a whole in Germany before and during the war in order to provide comparison points for understanding why jets were considered a project worthy of investment. Chapter III will look at the nuclear weapons program, specifically because it was the only one of the three that Germany ended up not investing in on as large of a scale as the first two. Finally, Chapter IV will compare the conditions during the war that did or did not justify investment in these programs, and will thereby provide a final

analysis of the rationality of the decisions to support exotic weapons. In the end, this thesis will prove that it made sense to invest in exotic weapons programs before the war began, but that it was ignorance of the reality of the war that made continued and increased support for such programs during the war a bad decision as far as Germany's hopes of winning World War II were concerned.

Chapter I: The German Rocket Program

Rocket Technology in the Interwar Period

Long before Wernher von Braun's first great creation, the infamous V-2 rocket and the first intercontinental ballistic missile, crashed down in an explosion of death and destruction in London in Autumn of 1944, the development of rocket technology had been a main focus for many German scientists. In the Weimar Republic, during the interwar period, the prospect of building rockets, which were at the time aimed towards flight into outer space, was an exciting one, especially given that Germany did not have much to be proud of after the humiliation of World War I.[1] Rocket technology was not entirely new, and it was not solely created by the Germans, but it was in Germany that the biggest push was made to turn the dreams of space flight into reality. In June of 1927, the *Verein für Raumschiffahrt* (VfR), or the Society for Space Travel, was formed,[2] and it was this organization that eventually achieved some early effective rocket launches.[3] Efforts were even made to attract public interest in rockets, with famous German director Fritz Lang releasing the film *Frau im Mond*, which was based on a 1928 book about a mission to the Moon, in 1929.[4]

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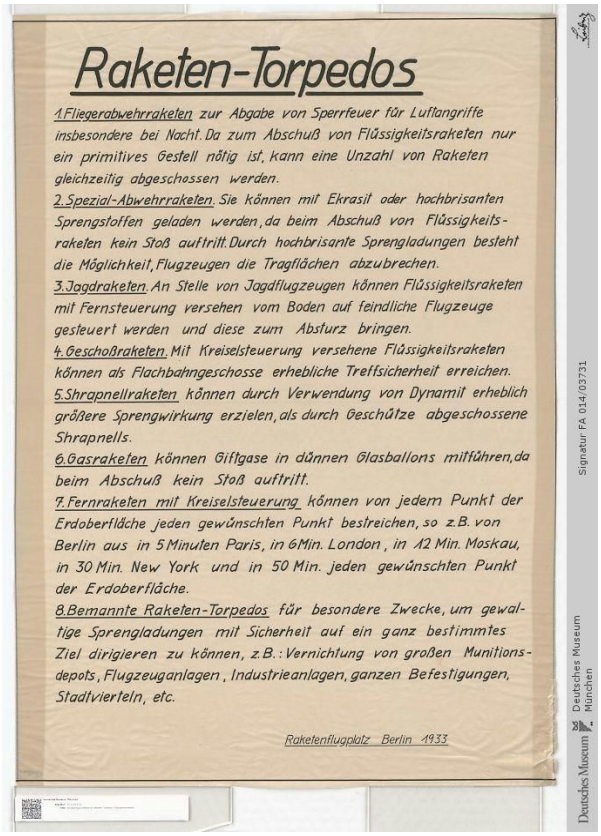
[1] Michael J. Neufeld, "The guided missile and the Third Reich," in *Science, Technology, and National Socialism*, eds. Monika Renneberg and Mark Walker (Cambridge University Press, 1994), 53.
[2] "Highlights in German Rocket Development from 1927-1945" http://history.msfc.nasa.gov/german/highlights.html (accessed November 16, 2015).
[3] Neufeld, "The guided missile and the Third Reich," 53.
[4] Neufeld, "The guided missile and the Third Reich," 53.

During the first World War, Germany had been a leader in developing new military technology that revolutionized warfare and helped define how the wars of the 20th century were fought. After the war, some Germans continued to attempt to put their country on top when it came to technological innovation. Despite the difficulties faced by early rocket scientists, such as Hermann Oberth and Wernher von Braun, in successfully testing their inventions,[5] the idea of rockets as possible weapons attracted interest from the German military.[6] In July of 1932, von Braun, as part of the VfR, demonstrated the Mirak II rocket to the German Army, and the following month the Army formally announced its work on a rocket development program.[7] In 1933, Rudolf Nebel, a controversial yet important figure in the early German rocket programs, had drawn up recommendations of possible uses for rockets, shown below in the copy of a document from the archives of the Deutsches Museum in Munich.[8]

[5] Neufeld, "The guided missile and the Third Reich," 56.
[6] Neufeld, "The guided missile and the Third Reich," 56.
[7] "Highlights in German Rocket Development from 1927-1945".
[8] "Einsatzmöglichkeiten für Raketen-Torpedos (Flüssigkeitsraketen)" http://www.digipeer.de/index.php?id=316862868.



Raketen-Torpedos

1.Fliegerabwehrraketen zur Abgabe von Sperrfeuer für Luftangriffe insbesondere bei Nacht. Da zum Abschuß von Flüssigkeitsraketen nur ein primitives Gestell nötig ist, kann eine Unzahl von Raketen gleichzeitig abgeschossen werden.
2.Spezial-Abwehrraketen. Sie können mit Ekrasit oder hochbrisanten Sprengstoffen geladen werden, da beim Abschuß von Flüssigkeits-raketen kein Stoß auftritt. Durch hochbrisante Sprengladungen besteht die Möglichkeit, Flugzeugen die Tragflächen abzubrechen.
3.Jagdraketen. An Stelle von Jagdflugzeugen können Flüssigkeitsraketen mit Fernsteuerung versehen vom Boden auf feindliche Flugzeuge gesteuert werden und diese zum Absturz bringen.
4.Geschoßraketen. Mit Kreiselsteuerung versehene Flüssigkeitsraketen können als Flachbahngeschosse erhebliche Treffsicherheit erreichen.
5.Shrapnellraketen können durch Verwendung von Dynamit erheblich größere Sprengwirkung erzielen, als durch Geschütze abgeschossene Shrapnells.
6.Gasraketen können Giftgase in dünnen Glasballons mitführen, da beim Abschuß kein Stoß auftritt.
7.Fernraketen mit Kreiselsteuerung können von jedem Punkt der Erdoberfläche jeden gewünschten Punkt bestreichen, so z.B. von Berlin aus in 5 Minuten Paris, in 6 Min. London, in 12 Min. Moskau, in 30 Min. New York und in 50 Min. jeden gewünschten Punkt der Erdoberfläche.
8.Bemannte Raketen-Torpedos für besondere Zwecke, um gewal-tige Sprengladungen mit Sicherheit auf ein ganz bestimmtes Ziel dirigieren zu können, z.B.: Vernichtung von großen Munitions-depots, Flugzeuganlagen, Industrieanlagen, ganzen Befestigungen, Stadtvierteln, etc.

Raketenflugplatz Berlin 1933

Deutsches Museum München
Signatur FA 014/03731
Deutsches Museum

The implementations listed in the document, which include defense against aircraft, attack rockets of various sorts including gas and shrapnel rockets, and even manned rocket-torpedoes, were all designed to appeal to potential military investors. Even before the Nazi Party gained much traction in Germany, technological developments and increase in production throughout German industry were already being geared towards military applications.[9] Despite the severe restrictions imposed on Germany's military capacities by the Allies at the end of World War I, there was always a sense of "nationalism [and] a widespread belief in technological progress"[10] among Germans, and this did not cease to exist during the Weimar Era. However, the ideas put

[9] Neufeld, "The guided missile and the Third Reich," 56.
[10] Michael J. Neufeld, "Weimar Culture and Futuristic Technology: The Rocketry and Spaceflight Fad in Germany 1923-1933," *Technology and Culture* 31 (1990), 725-752.

forth by people like Nebel proved to come the wrong time in German history. The Great Depression had shifted popular focus from technology to a topic far more important to the average German: survival. Nationalism was now no longer seen through the scope of pride through industrial and technological success. Instead, it centered more around fury over Germany's desperate state and the feeling that this, too, was a result of the winning powers of WWI's mistreatment and exploitation of the German nation and its people. Nationalism for many average Germans became bred from anger rather than pride. Soon enough, with the help of the Nazi Party, rockets almost entirely ceased to be a part of German society. In 1933, not long after the Depression hit, the Nazis took power, and "public experimentation with and discussion of rocketry were largely eliminated."[11] Not only could Germans not afford to pay attention to this "fad"[12], but the German Army had for a while desired to eliminate all public competition in the race to produce effective rockets, and now that the Nazis were in power it had the government's support in doing so.

Rockets Under the Nazis

While rockets were initially not a priority under the Nazis, there were Nazi military officials who were involved in rocket development even before the *Machtergreifung*, or seizure of power. As was discussed earlier, the German Army had formally announced its rocket development work in 1932. In 1929, though, General Karl Emil Becker, who was head of the *Heereswaffenamt* (HWA), or the Army Weapons Department, ballistics testing unit, expressed

[11] Neufeld, "Weimar Culture and Futuristic Technology," 725.
[12] Neufeld, "Weimar Culture and Futuristic Technology," 729.

his interest in rocket technology and his belief that it would ultimately lead to a "devastating new secret weapon: the long-range, ballistic missile."[13] It was he who received permission from the *Reichswehrministerium*, or Reich Ministry of Defense, to research rockets under an Army program. The most notable figure of the Army's involvement in rocket technology was, however, Captain Walter Dornberger, a subordinate of General Becker's.[14] An artillery officer who had served in the First World War, Dornberger had been placed in charge of HWA rocket studies[15] and was one of the main proponents of using rockets as weapons. In 1930 he had already begun looking at ways to use rockets, which were still being constructed with solid fuel rather than liquid and therefore had a shorter range, as a sort of short-range artillery;[16] by 1932, once the liquid rockets that members of the VfR had been developing showed far greater range potential,[17,18] he was recruiting VfR members to work for the HWA[19], specifically under the Army Ordnance group. After the Nazis took power, he was the man responsible for catapulting Germany's rocket technology into a massive military undertaking and turning it into the program that eventually produced the *Vergeltungswaffe*, or Vengeance Weapon, and thereby truly kickstart the rocket era. It is important to understand the way in which Dornberger achieved this, because it shows the degree to which the Nazis became invested in rockets, and it helps address

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[13] Michael J. Neufeld, *The Rocket and the Reich: Peenemünde and the Coming of Ballistic Missile Era* (New York: The Free Press, 1995), 82.
[14] Clayton K.S. Chun, *Thunder Over the Horizon: From V-2 Rockets to Ballistic Missiles* (Praeger Security International, 2006), 42; Neufeld, "The guided missile and the Third Reich," 56.
[15] "Highlights in German Rocket Development from 1927-1945".
[16] Chun, *Thunder Over the Horizon*, 42.
[17] "Der Raketenflug über 1000 km - technische Parameter" http://www.digipeer.de/index.php?id=330351697.
[18] "Reichweiten und Flugzeiten von Raketentorpedos (Flüssigkeitsraketen)" http://www.digipeer.de/index.php?id=371752204.
[19] Chun, *Thunder Over the Horizon*, 42.

the aspect of priority, as far as German decisions regarding which projects to invest in are concerned. Dornberger's most important tactic was to link the rocket program with the *Luftwaffe*, the German Air Force, which was vastly powerful and resource-rich and had its own interest in rocket technology for use in aircraft.[20] The *Luftwaffe* was run by Hermann Goering, who was of course extremely close to Hitler, and this granted a degree of legitimacy to the military rocket program and made it easier to push it as a project worthy of investment. By declaring, after various other missiles had already been tested but were unsuccessful, like the A3 in 1936, that the next creation could be a long-range weapon, Dornberger was able to accelerate the development. In 1936 he secured the support of General Werner von Fritsch, the then Commander-in-Chief of the Army, after several rocket engine demonstrations designed to present their potential as new, exotic weapons,[21] and achieved ultimate success in his endeavors with the construction of the research site at Peenemünde in 1937. The Peenemünde research site, which was built by the *Luftwaffe* and at which the V-2 rocket was eventually created, was the result of *Luftwaffe* money and resources and Dornberger's promise of the A4, the V-model rocket that became the V-2. Finally, on 3 October 1942, the first fully successful V-2 test was carried out, with the rocket flying 118 miles from the launch site at Peenemünde.[22] Over the course of 5 years, from 1932 to 1937, Dornberger had managed to recruit Wernher von Braun for the Army and to use him and his promising rocket technology to turn rocket research and production into a joint Army and Air Force program that backed by many top military officials.

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[20] Neufeld, "The guided missile and the Third Reich," 58.
[21] Chun, *Thunder Over the Horizon*, 43.
[22] "Highlights in German Rocket Development from 1927-1945".

Five years later, there were nearly 6,000 employees in the development section of Peenemünde alone,[23] and one more year after that, in 1943, Hitler declared the V-2 program to have the highest military priority.[24] The transition from a fantastical idea to a core value of the overall Nazi wartime strategy, military superiority through advanced technology, was complete.

Mittelbau-Dora

An aspect to rocket development under the Nazis that made it unique was that it incorporated the use of a concentration camp entirely for the purpose of building rockets. Mittelbau-Dora concentration camp, located in Nordhausen, in the center of Germany, was a forced labor subcamp of Buchenwald concentration camp. After the heavy bombardment of the Peenemünde site, the rocket program required a safer place to continue its work, and Mittelbau was chosen as the new location for its pre-existing tunnel system that dated back to the mid-1930s.[25] The establishment of this camp and the Mittelwerk (which was the name of the new factory) facilities that comprised the above-and-underground production of the V-1 and V-2 rockets contains several important intricacies. First, of course, is the use of slave labor. When Mittelbau was set up in summer of 1943, the German war industry was suffering from severe labor shortages as a result of the worsening situation in the war; many more men had been sent to the front to halt the Allied advances in North Africa, Italy, and on the Eastern Front. As a result, Arthur Rudolph, who was the Chief Production Engineer at Peenemünde's V-2 assembly site,

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[23] Walter R. Dornberger, *The German V-2*, *Technology and Culture* 4 (Johns Hopkins University Press, 1963), 393-409; Neufeld, "The guided missile and the Third Reich," 58.
[24] "Highlights in German Rocket Development from 1927-1945".
[25] P. Grigorieff, "The Mittelwerk/Mittelbau/Camp Dora Mittelbau GmbH - Mittelbau KZ". V2 Rocket.com http://www.v2rocket.com/start/chapters/mittel.html (accessed January 18, 2016).

recommended the use of forced labor to cope with the lack of German workers.[26] At this point, the German Army was desperate to field rockets in battle, and so Dornberger's team was in a rush to get rockets out of the prototype phase and into production. However, the required goal of 1,000 rockets a month[27] was highly unlikely to be met without sufficient manpower. As such, a few thousand prisoners were delivered to Peenemünde to work on the rocket program there. When the switch was made to Mittelbau, SS Brigadier General Hans Kammler, the newly appointed chief of the Mittelbau complex, requested prisoners from nearby Buchenwald, and the SS delivered the first contingents on August 28, 1943.[28] These prisoners were no longer held at Buchenwald, and the new camp set up at the Mittelbau factory to contain them was called Dora. While forced labor was used in some other industrial projects like regular aircraft development beginning already in 1939,[29] the rocket program was the first exotic weapon initiative to be undertaken with the help of this method. It thus relied on prisoners to help build an invention that had not yet been perfected, which meant that chance of failure was not exactly lessened, given that the rocket scientists themselves still had not figured everything out. This makes the use of forced labor unique in the sense that the Army was settling for quantity, not quality.

By comparison, this was not the sort of strategy the military had in mind when using forced labor at other work camps like Sachsenhausen, north of Berlin, where Heinkel planes were built. In this example, it was at the time already clear how to build planes, and despite

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[26] Grigorieff, *The Mittelwerk/Mittelbau/Camp Dora Mittelbau GmbH - Mittelbau KZ*.
[27] Adam Tooze, *The Wages of Destruction: The Making and Breaking of the Nazi Economy* (Penguin, 2008).
[28] Grigorieff, *The Mittelwerk/Mittelbau/Camp Dora Mittelbau GmbH - Mittelbau KZ*.
[29] Yves Béon, *Planet Dora: A Memoir of the Holocaust and the Birth of the Space Age*, (Westview, 1997), 18.

inevitable sabotage attempts, the outcome was still that the Air Force had working planes it could use (and repair, if something was wrong with them) to achieve its objectives. But the rockets were different. The prisoners were instructed as to how to assemble them, but the results were not good: the first three rockets delivered all suffered from "serious production defects," and even after production numbers hit the hundreds per month, there were still difficulties with product quality, which resulted in "disastrous misfires both on the launching pads and in mid-air."[30] Leaving aside the issue of the technology not yet being fully understood, the first V-2's also contained more basic deficiencies, like "bad welds, soldering problems, and faulty parts."[31] As a result, the laborers did not really have to sabotage anything, although there were certainly attempts at that.[32] They just built broken weapons that would only in the wildest dreams of the German military actually have an impact on the war.

A second intricacy of the creation of Dora-Mittelbau was the role the SS played in the rocket program. The SS always spied on other governmental and military groups and sought to control or monitor many aspects to the Nazi state, so it was not unusual that it attempted to dig its way into the rocket program. From the beginning of the program, the SS was trying to involve itself in minute ways.[33] Wernher von Braun, for example, was a Major in the SS, having joined as a Lieutenant in 1940 but having already attended the SS riding school in 1933. According to an account he gave to the US Department of War in 1947, he had no alternative but to join if he wanted to avoid any hostilities between the SS and the Army over the rocket program.[34] With

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[30] Tooze, *The Wages of Destruction*.
[31] Grigorieff, *The Mittelwerk/Mittelbau/Camp Dora Mittelbau GmbH - Mittelbau KZ*.
[32] Grigorieff, *The Mittelwerk/Mittelbau/Camp Dora Mittelbau GmbH - Mittelbau KZ*; Béon, *Planet Dora*, 132.
[33] Michael J. Neufeld, *Von Braun: Dreamer of Space, Engineer of War* (Vintage Books, 2008), 121.
[34] Neufeld, *Von Braun*, 120.

the establishment of Mittelbau-Dora, however, the SS received a very good opportunity to play power politics with the Army over the rocket program. As was discussed earlier, the forced laborers at the Mittelwerk were initially inmates from Buchenwald concentration camp, which meant that they had been provided to the rocket program by the SS, as the SS ran the concentration camps. And as was also noted, the new chief of the Mittelbau project was an SS General, Brigadier General Kammler. It was not coincidence that an SS General was now in charge, nor was it a coincidence that it was General Kammler. On August 18, 1943, *Reichsführer* of the SS Heinrich Himmler met with Hitler and then overtook command of V-2 rocket production from Albert Speer[35] before appointing Kammler as head at Mittelbau. Kammler was the right choice in Himmler's eyes for running a new camp because he was previously in charge of organizing the extermination camps, and of building the gas chambers at Auschwitz, Majdanek, and Belzec.[36] Now the SS had not only a "'finger in the pie'"[37] but actual authority at Mittelbau. It provided the workers for the rocket scientists, which meant that it controlled and organized the program's production capabilities as far as manpower was concerned. Furthermore, Mittelbau-Dora became larger and larger as the months passed on, which required that the increasing number of inmates be organized and contained, just like at the other camps. According to Yves Béon, a survivor of the Mittelbau-Dora work camp, "between the arrival of prisoners in September 1943 and the arrival of the American army in April 1945, the slave-labor workforce of about 12,000-15,000 men at Dora was replenished at least three or

[35] Grigorieff, *The Mittelwerk/Mittelbau/Camp Dora Mittelbau GmbH - Mittelbau KZ*.
[36] Grigorieff, *The Mittelwerk/Mittelbau/Camp Dora Mittelbau GmbH - Mittelbau KZ*.
[37] Neufeld, *Von Braun*, 121.

four times due to the horrific death rate among the prisoners."[38] With such a large workforce, and with so many new inmates coming in to fill the spots of those murdered before them, the camp had to be expanded and administered efficiently. Not only was the SS the default organization to manage such a task, it was the only real option because Himmler was in charge and would not have wanted or allowed anything else. Had there not been the quantity of labor available to the rocket team that uniquely the SS had to offer, there would not have been anywhere near the number of rockets that were eventually built (which was already not even close to the expected tally). In fact, the SS's direct involvement in the project, which spawned as a result of the establishment of Mittelbau-Dora, opened up organizational and managerial reservoirs that enabled the rocket program to operate to a degree of effectiveness impressive for the conditions under which it had to work. The creation of the massive tunnels and underground factories at Mittelbau was thanks to "concrete, steel, and the wrecked lives of countless prisoners"[39] all provided by the SS. Through the way in which the SS wove itself into various levels of the rocket program leadership and production, the SS forced the Army, specifically Dornberger and his team, to cooperate, and it made the program entirely dependent upon its willingness and ability to supply labor. Mittelbau-Dora personified slave labor as a means of achieving the end goal of a miracle weapon.

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[38] Béon, *Planet Dora*, 19.
[39] Michael Thad Allen, *The Business of Genocide: The SS, Slave Labor, and the Concentration Camps* (The University of North Carolina Press, 2005), 212.

The Rationality of Investing In Rockets

The question has to be asked: why did the German leadership choose to focus many of its efforts on exotic weapons like rockets rather than address the simpler issues that faced it at the time? The general answer is, as has been previously mentioned, that the Nazis believed that quality, not quantity, of weapons technology was the best strategy to pursue in deciding the war in Germany's favor. However, in looking at the rationality of the decision to invest in the rocket program, there are a few important factors to take into account.

First, there were certainly pressing issues that Germany never did address, such as the lack of effective long-range bombers, and these are points of comparison in examining the rationality of the decision to put so much work into an exotic weapons project instead of one geared towards a fundamental strategic need. This particular example is an important one because Germany's aviation technology was very good anyway, so the concept of quality could have been combined with quantity. It appears therefore that this was an oversight, a result of poor judgment on the part of military officials. The Soviet war industry had been relocated to the Ural Mountains upon Operation Barbarossa's commencement in June of 1941, and it forever remained out of range of German airfields in the Soviet Union. This was, of course, because the German assault was eventually completely stopped, but another explanation for the lack of development of a long-range bomber to cope with that challenge is that the German leadership clearly assumed that the military would soon continue moving forward, thereby removing the need for such planes. In addition, while pre-war or early-war circumstances, such as the invasion of Poland, did not necessitate heavy bombers because the enemies Germany was fighting were

no match for their military strength and *Blitzkrieg* strategy to begin with, this is not an excuse for a lack of adaptation. The wartime context, namely that the objective of reaching Moscow before the Winter of 1941 really set in had not at all been achieved, should have provided the Germans with the sense that something should perhaps be done about the problem just in case the tide did begin to turn against them in the end after all.

The second aspect also deals with the notion of misallocation of resources, but more so with regard to the fact that despite the eventual success in building the long-range weapon whose creation had been the sole objective of Peenemünde and all of Germany's investment in rocket technology, it was too little, too late. This is not necessarily a comment that can only be made with the privilege of hindsight, rather one that can be made by judging Germany's position in the war at the time of the first successful V-2 test and the eventual implementation of the rocket as a weapon. It makes sense that pre-war exotic weapons projects were not as high on the priority list for Hitler, because, as was mentioned earlier, Germany's first several enemies were all still using technology and strategy from the First World War, or, like Czechoslovakia, not using any strategy at all other than immediately signing annexation or surrender documents. However, if the fact that the V-2 was not considered a top priority until July of 1943,[40] even once exotic weapons did begin to play a role it was at the wrong time.

The first year of consistent Allied air raids on German factories was 1943, and in August the British conducted a bombing mission on Peenemünde itself,[41] forcing the whole program underground. This caused the development process to become far more rushed than it already

[40] "Highlights in German Rocket Development from 1927-1945".
[41] "Highlights in German Rocket Development from 1927-1945".

was, the thinking being that if the Germans were to have a chance at fighting back at the new wave of Allied airpower they had to move quickly on the rockets. Furthermore, the V-1's and V-2's were not even launched at enemy targets until September of 1944, three months after the Allies had completed their invasion of Normandy and at a point when Germany was in nearly full retreat on all fronts. As a result, the HWA spent years working on rockets that did not receive production approval in time to change the course of the war. However, despite this obviously frustrating conduct of the project, the blame for this really rests on Hitler, because it was he who denied mass production requests until the Soviets had won at Stalingrad and the Western Allies had expelled the Germans from most of North Africa.[42] Furthermore, Hitler had taken command of the Army in December of 1941, ending the succession of artillery officers who had commanded it for the previous 8 years of the Third Reich and thereby assuming responsibility for all of its projects.[43]

Finally, leaving aside the tide of war as far as combat is concerned, by 1943 there was a problem with Germany's emphasis on rocket production and the way in which priority was assigned to various military projects. To begin with, Germany's system of prioritization was practically non-existent. Every branch of the military considered the war an opportunity to run its own individual weapons programs and to make itself the best branch.[44] For example, even though Dornberger wanted to access the resources of the *Luftwaffe* and thereby fashion some cooperation between the Army and the *Luftwaffe*, in 1936 Air Force General Wolfram von

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[42] Neufeld, *The Rocket and the Reich*, 169.
[43] Neufeld, *The Rocket and the Reich*, 53.
[44] Michael J. Neufeld, "Hitler, the V-2, and the Battle for Priority," *The Journal of Military History* 57 (1993), 511-538.

Richthofen offered Army rocket scientists (like von Braun) 5 million Reichsmark for a *Luftwaffe* rocket project, and the Army had to outbid them at 6 million to end the conflict.[45] There was also very poor communication between those in charge of military industrial production, such as Fritz Todt and General Georg Thomas, and those actually conducting the war, such as Hermann Goering (who was directly connected to industry through his Four Year Plan but was also the Commander-in-Chief of the *Luftwaffe*).[46] Furthermore, while high priority was first assigned to the rocket program in 1943, as was mentioned earlier, the order for mass production of the V-2 rocket was given by Hitler in December of 1942, just under two months before the total collapse and surrender of the Sixth Army at Stalingrad.[47] To give the order to start mass producing a product that is not yet considered to be at the highest priority (which was the only level of priority that warranted full investment and mass production at this point in the war) does not really make sense. It demonstrates a degree of irrationality, perhaps even desperation, that should not have been playing a role in this sort of project. It was irrational because the rocket program was not at high priority status, which meant that it was not yet receiving the funds and effort that high priority status guaranteed. At the same time, it was expected that the rocket program could commence mass production, which it obviously could not realistically do if it did not have the resources it required. The decision was a desperate one because it came at a time when the German plan of action, which was to outdo its enemies with the supposedly superior

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[45] T. Dungan, "Early Days of Enthusiasts - The Road to Peenemünde". V2 Rocket.com http://www.v2rocket.com/start/chapters/peene/peenemuende.html. (accessed December 23, 2015).
[46] Hans Kehrl, *Krisenmanager im Dritten Reich: 6 Jahre Frieden, 6 Jahre Krieg: Erinnerungen* (Düsseldorf: Droste, 1973).
[47] Benjamin King and Timothy J. Kutta, *Impact: The History of Germany's V-weapons in World War II* (Rockville Centre, NY: Sarpedon, 1998).

technology it already possessed, was being proven not only ineffective but in fact detrimental to the German war cause. At this point, Hitler had to turn to an exotic weapon because he could no longer rely on the conventional warfare that had guaranteed the German military so much success in the first few years of the war.

Not only was there a problem with the logic of such a strategy, but there was also the issue of how feasible implementing it was. The reality of the state of the rocket program was clearly either underestimated or not accepted, and this was another problem with the decisions made in the last months of 1942 and the first months of 1943. The effect of the confusion and hesitance on the rocket program was serious: the problems it faced ran much deeper than just that it had not had the assistance it needed. Firstly, Dr. Walter Thiel, another of the leading scientists in Dornberger's rocket program and a close associate of von Braun's, declared in August of 1943 that not only did the deficiencies of the A4 rocket preclude it from mass-production, but that the engineers working on it did not even know yet how to turn it into something more than a prototype.[48] As such, "under accelerated delivery schedules of 1943," the only rocket engine ready for production was a "monstrosity and a plumber's nightmare."[49] In addition, as was discussed earlier, the Allied air raids on German factories became commonplace in this year. This meant that Dornberger, Army Ordnance, and the HWA now tried to operate an underfunded project on an accelerated time schedule in the face of continuous bombing missions aimed specifically at destroying the entire Peenemünde facility, at which this already complicated

[48] Encylopedia Astronautica, "Thiel, Walter" http://www.astronautix.com/astros/thialter.htm#chrono (accessed 23 December 2015).
[49] Claus Reuter, "The V-2 and the Russian and American Rocket Program" (German Canadian Museum of Applied History, 2000), 26.

struggle was taking place. In a further blow to the rocket development efforts, on August 17, 1943, Dr. Walter Thiel was killed in a bombing raid carried out by the British. Thiel was a brilliant scientist responsible for major performance improvements to the A4 engine after his transfer to Dornberger's group in 1936,[50] and his was a significant loss to the team at Peenemünde.

As far as actual production results are concerned, it appears that those officers and leaders requesting, or rather demanding, rockets for battle use were completely ignorant of the fact that given the state of the program there was no way they would get what they wanted. It is unlikely that these people were under the impression that the rocket project faced no real difficulties and was only slow in providing results because it was not yet expected to do so. Instead, they were uninformed and just did not want to hear excuses and only cared about the fact that rockets were a supposed to be capable of "devastating" the enemy.[51] An example of this involves *Generaloberst* (Colonel General) Friedrich Fromm, the Chief of the Office of Army Armament and the Replacement Army (which was set up as a result of Operation Barbarossa stalling at the end of 1941). On October 19, 1943, after Mittelbau GmbH was set up as part of Mittelbau-Dora concentration camp in September, Fromm ordered 12,000 V-2 rockets to be built, at a rate of 900 per month.[52] By the end of the war, Minister of Armaments and War Production Albert Speer's figures counted 5,951.[53] It cannot be that Fromm was so naïve that he figured that his order for 12,000 rockets would go through. It is that he either must not have

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[50] Neufeld, *The Rocket and the Reich*, 56.
[51] Neufeld, *The Rocket and the Reich*, 82.
[52] Reuter, *The V-2 and the Russian and American Rocket Program*, 104; http://www.v2rocket.com/start/chapters/mit004.jpg Original contract for production of 12,000 rockets.**
[53] Reuter, *The V-2 and the Russian and American Rocket Program*, 187.

been aware (most likely by choice) that there was only one type of engine ready for use and that it was only at the prototype stage, or that he did not care and wanted the scientists to figure some solution out despite that. Clearly, as soon as the war began to fall apart for Germany, the rocket program's chances of developing into something that would change the outcome of the war, or even the situation for Germany on the Eastern Front (since that was the most pressing issue at the time that it was assigned high priority) were doomed. Poor communication mixed with the hasty manner in which the rocket program was pushed along could not possibly, and in the end never did, allow for consistently coordinated planning and prioritization between the German leadership and industry managers, and was one reason for the failure of the rocket program to really play a vital role in the war.

The German rocket program was, on the whole, a brilliant idea that paved the way to space flight after the war ended in 1945. However, as far as whether or not it was actually wise of the HWA, of Hitler, and of all those who relented to Dornberger's insistence on their support, most notably to put so much effort into this program is concerned, it can be concluded that it absolutely was a serious misallocation of valuable military resources that could have, had they been used elsewhere, had the desired effect of turning the war, or keeping it, in Germany's favor. The rockets Germany had succeeded in building were, as has been discussed, long-range weapons, and there was never any emphasis placed on smaller, short distance rockets. It makes sense that the short distance rockets were not part of the Army Ordnance development plans because, as was discussed earlier, the Germans were not fighting enemies where rockets could have played a pivotal role for Germany, and therefore the more exotic, larger rocket could be the

main focus. As a result, however, the German product was not as battlefield applicable when the time finally came for this new technology to do what Hitler and all of the Generals who had agreed to fund and support the rocket program were so adamant it do: play a decisive role in combat. By comparison, the Soviet Union had been able to create smaller rockets, the famous Katyusha launchers, that were much easier to mass produce.[54] From the start, or in 1936, when Walter Dornberger promised the A-4 ballistic missile, what was eventually called the *Wunderwaffe*, or Wonder Weapon, by Hitler, the German rocket program was under pressure to create a viable weapon in an unrealistic period of time.

The overall issue is that while it made sense on the one hand for the Germans to build something revolutionary that no one could compete with, it only made sense while Germany was winning the war, which is to say at a time when Germany did not need new weapons. In this sense, it was rational for Germany to invest so heavily in such a project. Once Germany began losing, though, building something revolutionary for the sake of competition or achievement was no longer the objective. Instead, it was to produce a decisive weapon that would turn the tide back in Germany's favor. However, because the tables turned before that revolutionary weapon could be finished, it meant that everything regarding the project had to be changed to fit with the new circumstances. The development schedule had to be sped up, the shortage of manpower had to be compensated for by bringing in foreign workers and prisoners from concentration camps like Dora-Mittelbau, the products that were available were not the best, and in the end the German Army did not even effectively use what it had worked on for so long. This is when all

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[54] Ulrich Albrecht, Andreas Heinemann-Grüder, and Arend Wellmann, *Die Spezialisten: Deutsche Naturwissenschaftler und Techniker in der Sowjetunion nach 1945* (Berlin: Dietz Verlag, 1992), 86.

rationality disappears, and the focus can be placed on German failure. In this sense, the term "German" can be used when referring to the failure because it covers such a broad spectrum of players upon whom this failure can rest. Hitler was at the top of this chain, but it ran all the way down through Albert Speer and his Ministry of Armaments and War, through the *Heereswaffenamt* and the many Generals who assessed the various weapons programs, through the commanders who ordered more rockets than could possibly be produced, through those who backed Dornberger at the beginning, and even to Dornberger himself. It is true that the goal of building the ballistic missile as a weapon was achieved, but that was all. The purpose of achieving this goal was never even in sight, and if the situation is looked at in that way, it must be thought that the *Heereswaffenamt* should have realized this and turned their attention to easier and more practical applications that could have actually influenced the war.

Chapter II: Aviation in Nazi Germany

World War I

In July of 1917, Manfred von Richthofen, the World War I pilot known as the Red Baron and the most successful ace of the war, took to the skies in the Fokker Dr. I triplane for the first time. The Dr. I was the exotic result of the *Luftstreitskräfte*, or Air Force's, attempts to achieve air superiority in the war over the trenches of the Western Front, and it was the plane with which the Red Baron famously became associated. In July of 1944, the German Air Force, this time known as the *Luftwaffe*, also found itself struggling to regain air superiority against the Allies, and it, too, turned to an exotic weapon to save Germany. The result was the Messerschmitt Me-262, the world's first operational jet aircraft. As in the case of the First World War, however, it was too little, too late.

World War I was an industrial and technological competition as much as it was an actual war, and among its defining features was the newest dimension to warfare: aerial combat. As a result, it offered the world's leading industrial powers, and those rapidly advancing through industrialization, like the Soviet Union, an opportunity to explore the new technology of airplanes. In Germany in particular, interest in aviation was not limited to industry, but existed in the highest ranks of the German military leadership, starting all the way at the top with General Helmuth von Moltke, the Chief of the German General Staff.[55] The use of an internal

[55] Walter J. Boyne, *The Influence of Air Power Upon History* (Casemate Publishers, 2004), 50.

combustion engine for an airplane was introduced only a few years before the war began, and it was immediately pounced upon by military industry. Although the *Luftstreitskräfte* were not officially established until 1916, initiatives led by military men like Quartermaster General Erich Ludendorff and Captain (later General) Hermann von der Lieth-Thomsen, who served under Ludendorff as Chief of Field Aviation[56] and later as the Chief of Staff of the *Luftstreitskräfte*, helped cultivate the aviation industry's military applications. The Wright Brothers themselves had set up a company in Germany and by the time the war broke out there were almost a dozen different German aircraft manufacturers,[57] several of which became the brains behind such famous planes as the Dr. I and the Albatross D. VII.

However, despite Germany industry's initial eagerness in the effort to play a part in aviation in World War I (which may in part be explained by the fact that everyone saw the war as an impending and inevitable event), by the time the von Schlieffen plan fully failed and the trenches stretched hundreds of miles, the industry had been crippled by the Allied blockade and Germany's limited access to natural resources.[58] To make matters worse, German aerodromes, factories, and fighter aircraft airfields themselves were targeted by the Western Allies through the innovative technique of strategic bombing.[59] Under this sort of pressure, German industry had no chance of matching Allied production figures. To give a sense of this capability gap, France, for example, began the war with 138 front-line aircraft, and finished it with 4,500.

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[56] Boyne, *The Influence of Air Power Upon History*, 51.
[57] Boyne, *The Influence of Air Power Upon History*, 51.
[58] Boyne, *The Influence of Air Power Upon History*, 51.
[59] Robert F. Grattan, *The Origins of Air War: Development of Military Air Strategy in World War I* (I.B. Tauris, 2009), 53.

Germany began with 232 and finished with 2,390.[60] Not only did Germany end its war with more than 2,000 fewer combat planes than France, but it also lost over 20,000 of the 48,537 aircraft it had built in total throughout the entire war.[61] Given that Germany was not able to out-manufacture the Allies, the military had to try to out-perform its adversaries, and the *Luftstreitskräfte* played a key role in attempting to restore control over the tide of the war to Germany. The fighter aircraft were built to be more agile and more nimble than the Allied equivalents, as the Fokker Dr. I demonstrated, and Germany boasted some of the most successful aces of the war, most notably the Red Baron. Not only that, but newer fighter planes that were able to outfly their opponents were used in an early form of *Blitzkrieg* during the last major offensive in 1918.

For all the success the Air Force perceived in its fight against the increasingly powerful Allies, however, it ended up just not quite being enough. The problem was just that: the Allies were increasingly powerful, and the best pilots and the best planes, the latter of which Germany did not fully possess, were not going to change that. In the capacity of attacking Allied defenses as part of the 1918 offensive, the *Luftstreitskräfte* still suffered from high casualty rates, with one-seventh of the pilot force lost every month; the Army, which was conducting this ground offensive, did not even really benefit from the Air Force efforts: it lost one million men.[62] Finally, when the Treaty of Versailles was signed in 1919, the *Luftstreitskräfte* was dissolved and Germany was prohibited from future production of military aircraft. Aviation, while a new and

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[60] The Aerodrome, "The Aircraft of World War I" http://www.theaerodrome.com/aircraft/statistics.php (accessed 28 January, 2016).
[61] The Aerodrome, "The Aircraft of World War I".
[62] Grattan, *The Origins of Air War*, 55.

exciting technology, did not play a decisive role in determining the outcome of the war. Perhaps it required further experimentation in strategic applications and perhaps the technology needed to continue to be improved upon, but at this point airplanes were not what won or lost wars, they were just a new way of fighting.

Aviation Between the Wars

After World War I, the industrial aspect to aviation faced an uncertain fate. The German aviation industry had developed during the war into an economic sector of great importance,[63] but because there was no longer a military need (by mandate of the Treaty of Versailles, of course) for airplanes this sector virtually collapsed. However, aviation technology could naturally be used for civilian purposes as well, and it was precisely this application that the industry was determined to adopt in order to save itself. The new government ushered in by the revolution that occurred in November of 1918 was a pacifist one, and thus supported the idea of a civilian use for flight and was against the idea of violating the Treaty of Versailles and attempting to restore the now under strength military's air wing. Under the leadership of August Euler, an aviation industrialist whom the new government trusted because of his outspoken disapproval of the militarization of aviation before the war, the new society of aviation was to include the elements of the government, civilian air groups, the science and technology world,

[63] Helmuth Trischler, *Luft- und Raumfahrtforschung in Deutschland: 1900-1970; Politische Geschichte einer Wissenschaft* (Campus Verlag, 1992), 109.

and Germany's industry in creating a civilian air industry that could compete with those belonging to the major players on the international stage.[64]

In the Weimar Republic, civilian air industry was a booming success. The industry was recording revenues of 100 million Reichsmark per year,[65] and the 1920s were a decade of realizing the potential of aviation for commercial purposes. After Charles Lindbergh completed his Transatlantic flight from New York to Paris in May of 1927, it was clear that aviation was taking on a technologically revolutionary importance akin to that of the steam engine one century prior.[66] By the end of the decade, the *Wissenschaftliche Gesellschaft für Luft(- und Raum)fahrt* (WGL), or the Scientific Society for Air and Space Travel, which was established in 1914 and was one of Germany's premier aviation research groups, had over 800 members and even included names such as Hugo Junkers, the founder of the major aircraft manufacturer Junkers AG, and Claude Dornier, the founder of another important German aircraft company, Dornier Flugzeugwerke.

The time came, however, when the German people viewed the success of American and other industrialized nations' aviation efforts, such as Lindbergh's flight, as an indication that Germany was behind in the competition to be at the forefront of aviation innovation. Not only was the general public under this impression, but it was within the most important circles of German aviation organizations that concern over this was expressed.[67] It appeared that the

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[64] Trischler, *Luft- und Raumfahrtforschung in Deutschland*, 110-112.
[65] Trischler, *Luft- und Raumfahrtforschung in Deutschland*, 142.
[66] Trischler, *Luft- und Raumfahrtforschung in Deutschland*, 142.
[67] Letter from Ludwig Prandtl to Reichsminister Guérard, "Opinion of the German Aviation Research Council on the situation of aviation research at the end of the 20s," 18 March 1929, in Helmut Trischler, *Dokumente zur Geschichte der Luft- und Raumfahrtforschung in Deutschland 1900-1970*

government was at fault for this slowdown. A memorandum from the head of the *Deutsche Forschungsrat für Luftfahrt* (DFL), or German Aviation Research Council, Ludwig Prandtl, to the *Reichsverkehrsminister*, the Reich Minister of Transportation, Theodor von Guérard, indicated the opinion of the Council:

> Unfortunately it is not at all clear to those in the politically responsible circles of Germany that the great efforts abroad, through the construction of new, big test facilities, and the allocation of substantial funds for purely research and development purposes, give rise to the danger that German aviation research will fall very far behind in competition with that occurring abroad.[68]

Not only were the politicians to whom Prandtl was referring responsible, but so were the ever declining economic conditions. Prandtl noted in this same letter:

> The Göttingen Laboratory for Aerodynamics, for example, which in the immediate postwar period was considered across the world as a leader, can no longer maintain the competition against foreign countries in certain very important spheres. The German Laboratory for Aviation, which with its facilities was exemplary before the war, is also suffering seriously from scarcity of certain modern facilities and testing means.[69]

[68] Letter from Ludwig Prandtl to Reichsminister Guérard, 18 March 1929
[69] Letter from Ludwig Prandtl to Reichsminister Guérard, 18 March 1929

The end of the 1920s marked the beginning of a shift in the use of aircraft technology in Germany, something which was spurred on by the Great Depression. This unprecedented economic crisis helped remind Germans of the humiliation the Treaty of Versailles caused, and it is safe to say that the nationalist fervor brewing in Germany throughout the 20s certainly received a boost from the disastrous effects of the economic collapse. The eventual result of the anger and desperation over Germany's disparate situation was, of course, the seizure of power by Adolf Hitler and the Nazi Party in 1933. As regards flight, it was the Nazis' aim to seize the potential that aviation research had shown and been unable to cultivate in the interwar period and to put Germany back at the forefront of this technology. Aviation was thus no longer a civilian hobby and a peaceful source of revenue for industry and the economy, it was now a major component to the remilitarization of Germany.

The Establishment of the Luftwaffe and the Revitalization of Aviation Industry

The Nazis' rearming of Germany included the establishment of an Air Force, which became known as the *Luftwaffe*. The *Luftstreitskräfte* were dissolved under the terms of the Treaty of Versailles, and during the Weimar era there had not been a lot of opportunity to train military pilots. Under the 1922 Treaty of Rapallo with the USSR, the *Reichswehr*, which constituted Germany's military (*Reichswehr* translates to "Reich Defense") in the Weimar era, set up a pilot training facility in Lipetsk, approximately 220 miles southeast of Moscow.[70] However, in the entire eight year existence of the Lipetsk facility, which was shut down by Hitler

[70] John F. O'Connell, *The Effectiveness of Airpower in the 20th Century: Part One (1914-1939)* (iUniverse, 2007), 52.

after his rise to power in 1933, only 100 fighter pilots had been successfully trained,[71] which would have been considered a negligible number as far as German ambitions were concerned. On the other hand, aircraft industry made leaps and bounds under the Nazis because of Hitler's disregard for the terms of the Treaty of Versailles that specifically limited things like German industrial capacity and rearmament.

As was mentioned earlier, the civilian aviation industry had initially been very successful in Weimar Germany, but both the victorious powers of World War I and the Weimar government played a role in limiting the degree of this success. Clauses included in the Treaty of Versailles and in post-war documents severely limited what Germany could build, and the government was not inclined to disobey them. Not only did the Treaty of Versailles initially prohibit aircraft manufacturing of any sort,[72] but in 1922, once that prohibition expired, the Allies laid out further limitations that met 1916-era capabilities.[73] Furthermore, the Weimar government sought to be involved in aircraft industry in an advisory and oversight sense, and this was part of what made it difficult to produce many superior or more advanced airplanes.[74] The government did not offer enough resources to the various aviation research organizations (not that it was in a position to provide many funds anyway), leaving little in the way of opportunity for modern German aviation research, let alone production. In the eyes of those attempting to lead Germany into a new era of aviation, such as the DFL, this was a seriously important issue that failed to be

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[71] O'Connell, *The Effectiveness of Airpower*, 54.
[72] Firstworldwar.com, "Treaty of Versailles: Articles 159-213" http://www.firstworldwar.com/source/versailles159-213.htm
[73] O'Connell, *The Effectiveness of Airpower*, 55.
[74] Trischler, *Luft- und Raumfahrtforschung in Deutschland*, 117.

addressed.[75] In the terrible economic conditions of the Great Depression, Germany aviation industry was seriously underperforming: in 1933, it increased its production from 1932 by only 59%, and all of the models produced that year were the same as the ones from the year before.[76]

Hitler's first year in power, however, was all about centralizing or nationalizing industry and preparing the conditions within Germany that would enable massive military-industrial production.[77] As aviation was a big focus of the Nazi military reconstruction, it was in 1933 that the *Reichsluftfahrtministerium* (RLM), or Reich Aviation Ministry, was established with Hermann Göring at the helm as Minister of Aviation. After the Army aviation wing was transferred to the RLM in May of 1933, the *Luftwaffe* was established because aviation was considered by many in the German military to be very important in modern and future warfare and therefore worthy of its own branch.[78]

If there was to be an Air Force, however, there had to be the industry to build it. Within the first year of Hitler's rule, the aviation industry had been revived; new companies were established, old ones were increased in size, and by the end of 1933 "two million workers were employed on airfield and factory construction."[79] In 1934, after France, which was among the countries Hitler informed that year about the creation of the new Air Force, broke off discussions when Hitler presented the details of the size of the *Luftwaffe*, the plan to drastically increase

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[75] Letter from Ludwig Prandtl to Reichsminister Guérard, 18 March 1929
[76] Ferenc A. Vajda and Peter Dancey, *German Aircraft Industry and Production, 1933-1945* (McFarland, 1998), 12.
[77] Deutsche Geschichte in Dokumenten und Bildern, "Geheimrede Hitlers vor den Truppenkommandanten (10. Februar 1938)," http://germanhistorydocs.ghi-dc.org/pdf/deu/German53.pdf.
[78] Vajda and Dancey, *German Aircraft Industry and Production*, 12; O'Connell, *The Effectiveness of Airpower*, 57.
[79] Vajda and Dancey, *German Aircraft Industry and Production*, 12.

military aircraft production was fully put into action. Outrageous as it was for Germany to declare its intention to rearm itself, which was highly supported by the German public,[80] the plan, drafted by Secretary of State for Aviation *Generalmajor* (Major General) Erhard Milch, specified that there were to be 4,000 new airplanes by October 1, 1935.[81]

The Rationality of Investing in Jet Aircraft

Strategy and the Rationality of Investing in Jets

Despite the research on and the development of jet engines and aircraft that occurred before and during the war, the first jet plane, the Messerschmitt Me-262, did not fly in combat until July of 1944.[82] By that time the Allies commanded air superiority, they were continuously bombing German factories, and they were producing more planes overall than the Germans did, and when the war ended 10 months later, somewhere between only 1,200 and 1,500 Me-262's had been built.[83] Even if the war had lasted another two or three months, the production numbers were simply far too few to compete with Allied industrial and tactical capabilities, even if the Allies did not have jets. If the jets were built in relatively small numbers and had no impact on the war, then was it really worth all of the time, money, and resources that were poured into this effort? From a postwar point of view it is clear that the jet program was a waste of the *Luftwaffe's* efforts and that the jet proved to be nothing more (during the war, at least) than an impressive technological feat. However, in order to understand why it was a waste of time it is

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[80] Vajda and Dancey, *German Aircraft Industry and Production*, 11.
[81] Vajda and Dancey, *German Aircraft Industry and Production*, 12.
[82] World War II Database, "Me 262 Schwalbe" http://ww2db.com/aircraft_spec.php?aircraft_model_id=17.
[83] Sterling Michael Pavelec, "The German Jet Program 1939-1945" (Master's Thesis, University of Calgary, 1999); Alan J. Levine, *The Strategic Bombing of Germany, 1940-1945* (Greenwood, 1992), 185.

necessary to take into account the actual time period in which the decision-makers were operating, and in doing so to examine several important components to this conclusion: first, why the *Luftwaffe* was so invested in the jet program; second, the strategic thinking that drove investment in jets; and third, why the jet program failed, thereby answering whether or not it made sense for the Germans to invest in it.

Before the war, the German military was free to explore the increasingly advancing field of battlefield technology as Germany was experiencing economic improvement under the new Nazi regime and there was at this point no war going on that demanded that attention be paid to certain sectors rather than others. On the contrary, the military was preparing for war,[84] which meant that its goal was to find the best tools with which to win the war quickly and effectively. At the same time, however, it was filled with another purpose: to redeem Germany as an innovative arena.

As was discussed earlier, despite Germany's initial success in commercial aviation after World War I, the aviation industry was still seriously limited by Allied restrictions, and the struggling economy made it difficult to put the research that was done to the test. Now, however, the *Luftwaffe* was to be a key component to Germany's future battle strategies,[85] most famously *Blitzkrieg*, and as such it required planes and technology that would be superior to any enemies'. The result of *Luftwaffe's* work was famous planes like the Messerschmitt Bf-109, the Focke-Wulf 190, and the Junkers Ju-87, the plane that carried out the dreaded Stuka attacks. In

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[84] Deutsche Geschichte in Dokumenten und Bildern, "Hitlers vertrauliche Aufzeichnungen über Autarkie (August 1936)," http://germanhistorydocs.ghi-dc.org/pdf/deu/German61.pdf.
[85] O'Connell, *The Effectiveness of Airpower*, 57; Vajda and Dancey, *German Aircraft Industry and Production*, 12.

the early phases of the war, none of Germany's adversaries could match the quality of such aircraft or skill of the German pilots who flew them. But this was an anticipated fact on the part of German war planners, and that is why programs on more revolutionary technology, like the jet one, received attention. Such projects were initially aimed at demonstrating German innovation's prowess and cementing its glory. It was not until later that they took on a new role, one of devastating Germany's enemies in a way that would reverse the course of the war; in other words, a last gasp to save Germany from defeat.

The second part of explaining the rationality of investing in the jet program is how jets were implemented during the war. This aspect revolves the strategic role of aviation that German leaders took into consideration when examining various technologies. The state of the war at any given time determined the necessity of a technology, and as long as the war was going in Germany's favor, there was no need to speed up production or build any special weapons. By contrast, when the tide began to turn, strategy might logically have shifted to seeking out new ways of defeating the enemy, because the current methods and weapons available were not proving successful. Men like Erhard Milch, who as Secretary of State for Aviation had given support to the Heinkel and Messerschmitt companies in their experimental jet projects, Hermann Göring, who as head of the RLM passed down orders that controlled and changed the focus of production, or even Hitler himself, upon whom the ultimate decisions regarding the worthiness of a certain project or rested, all viewed jet development in the context of necessity.[86] This way

[86] Pavelec, "The German Jet Program 1939-1945," 9-10.

of looking at things (in either the positive or negative phases of the war) made sense from a political or strategic standpoint.

However, seeing everything in the scope of the time period is exactly what led to a big disconnect between two separate sectors of German military aviation: bombers and fighter aircraft, and jets. As was mentioned earlier, the whole reason an Air Force was created was because aviation was seen as an extremely important feature of modern warfare. Of course, with new technology comes new strategy, and this led to several important tactical proposals both before and during the war. In 1933, Robert Knauss, who was a close friend of Erhard Milch, proposed the creation of a 400-strong bomber fleet that would be used to wipe out the industries of who he perceived to be Germany's most threatening adversaries at the time, which included Poland, Czechoslovakia, and most notably France.[87] However, despite agreeing with Knauss's belief in the need for a bomber force, Colonel Walter Wever, the chief of the *Luftkommandoamt*, or Air Command Office, of the RLM, felt that the real enemy was the Soviet Union. This difference in opinion is actually huge, because the quality of the opponents mentioned was drastically different and the strategic approach against them could therefore be very different. The Soviet Union was in the midst of an industrial boom, churning out 160 bombers in 1933 and almost twice that the next year,[88] whereas Poland, for example, still had biplanes from World War I as the main aircraft of its Air Force. Moreover, Wever held this belief because it was what Hitler declared in *Mein Kampf*; he therefore desired 10,000 aircraft of all sorts to be produced.[89]

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[87] O'Connell, *The Effectiveness of Airpower*, 57; Vajda and Dancey, *German Aircraft Industry and Production*, 12.
[88] Vajda and Dancey, *German Aircraft Industry and Production*, 12.
[89] Vajda and Dancey, *German Aircraft Industry and Production*, 12.

For the German aviation industry, it was an opportunity for various aircraft companies to seize upon the need for bombers and win the contract to produce them. Colonel Wilhelm Wimmer, a former WWI pilot who agreed with Wever's view, became head of the RLM's *Technisches Amt*, or Technical Office, in 1933 and placed orders with Dornier and Junkers for long-range bombers.[90] He and Wever then approved of the proposed Dornier Do-17 and Junkers Ju-89 designs. Despite how clear it was to some strategists in the *Luftwaffe* that bombers were crucial to winning whichever war would soon come, in the end it turned out that these aircraft played a serious role in the calamitous downfall of the *Luftwaffe*. The strategy that those who supported the production of bombers had in mind did not line up with the reality of the situation. As described above, Wever and Wimmer believed the true enemy to be the USSR, and because the Soviet Union's main industrial plants were in the Ural Mountains, which were 2,500 kilometers away from Germany, it was absolutely essential to have aircraft that could fly such distances and destroy the factories. The problem was that they, despite being chiefs of two of the research and development branches of the RLM, were clearly not as well-informed about Hitler's plans for war as they thought. They did not expect the war to start until 1942 at the earliest,[91] which meant that there would be plenty of time for the Do-19 and the Ju-89 to be developed and perfected. Of course, the war started in 1939, and the Soviet Union, Wever and Wimmer's main concern, was invaded in 1941.

Although this demonstrates a serious disconnect between the highest level of German leadership and those who were there to make Hitler's plans possible, it is also understandable

[90] Vajda and Dancey, *German Aircraft Industry and Production*, 12.
[91] Vajda and Dancey, *German Aircraft Industry and Production*, 12.

because Hitler was not necessarily going to share his plan with a couple of Colonels. The serious disconnect that this does demonstrate, however, is between Göring (the head of the RLM) and his subordinates Wever, Wimmer, and even Erhard Milch, who was tasked with actually organizing the production of everything. In April of 1936, Wimmer, along with Adolf Baeumker, an advisory minister in the *Reichswehrministerium*, or Reich Ministry of Defense, presented to Göring the proposal for an academy for aviation research;[92] one month earlier, Generalingenieur, or Engineer General, Roluf Lucht of the RLM wrote to the most important members of the economic group of aviation industry that there needed to be greater cooperation between research and industry and as much emphasis placed on research as possible before the impending war.[93] While research leaders were busy offering ideas for how to improve German research capabilities, Göring did not provide them with an understanding of the true timeline that might have caused them to make do with what was available to them at the time and accelerate production. Had this happened, perhaps the Do-17 and Ju-89 would have been ready to bomb the Urals in 1941.

In 1933, jet engines were not being built. The technology was being researched, but at this point jets were not (and obviously could not be) considered the crux of the *Luftwaffe*'s aviation tactics. But if the discrepancies in bomber strategies had existed beginning in the early 1930s, well before the war began, why would the *Luftwaffe*, once the war started, maintain its

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[92]Presentation by Baeumker and Wimmer to Göring on the establishment of an academy for aviation research, "Notes on Presentation to Reich Minister of Aviation Göring," 7 April 1936, in Helmut Trischler, *Dokumente zur Geschichte der Luft- und Raumfahrtforschung in Deutschland 1900-1970*.

[93] Letter from Roluf Lucht to the economic group of the aviation industry, "Cooperation between Research and Industry," 19 March 1936, in Helmut Trischler *Dokumente zur Geschichte der Luft- und Raumfahrtforschung in Deutschland 1900-1970*.

focus on accelerating jet development instead of solve the problems facing the long-range bombers? To a certain extent, this can be blamed on the fact that most German commanders assumed the war would be a very quick one and that the bombers would not be needed; after all, Operation Barbarossa aimed to take over Moscow, which would have meant the capitulation of the Soviet Union and therefore removed the need for long-range bombers that could reach the Urals. This would thus have allowed jets to be more of a leisurely experiment than a wartime requirement. However, another answer is that by 1941, the circumstances of the war pretty much made the investment in the jet program a necessity. Inconsistencies in Germany's war plan, often created by Hitler's tinkering and whimsical desires, virtually required the continued development of a jet *Wunderwaffe* just in case things went wrong.

A good example of one of these strategic inconsistencies is the objective of aviation industry's in what it was producing before the war. As was mentioned earlier, the *Luftwaffe's* goal was to build aircraft superior to those of its enemies in order to make the aerial component to the battle plan as successful and effective as possible. It is true that improved industrial capacities had allowed aircraft to become mass-produced as early as 1934,[94] but that only made sense given that the industry had simply grown and that many previously unemployed workers were now being used in aviation. However, in 1940, the policy changed: Hitler issued an order that all projects that would not produce operational aircraft within 6-12 months were to be terminated.[95] In 1941, in another *Führerprotokoll*, or *Führer* decree, he reduced the time to 6

[94] Vajda and Dancey, *German Aircraft Industry and Production*, 12.
[95] Pavelec, "The German Jet Program 1939-1945," 9.

months.[96] This was because he now wanted the focus of the aviation industry to be on producing as many aircraft as possible, regardless of quality. Experimentation on jets, which still had a long way to go, was therefore banned. However, Erhard Milch, along with other researchers, must have understood that there was a possibility that the war might drag on, because in the same year he ignored Hitler and issued an order that encouraged Heinkel and Messerschmitt's jet projects.[97] Experimentation therefore continued, and that is why Messerschmitt was able to present a prototype Me-262 to Hitler in 1943.

Strategic coordination with regard to which projects deserved certain attention was therefore disastrous and involved subordinates of Göring and Hitler disobeying the two leaders. Not only did the bomber strategy that men like Knauss, Wever, and Wimmer had emphasized before the war fall apart in the face of a lack of bombers once Operation Barbarossa began, but important leaders in the *Luftwaffe* ended up disagreeing with the strategy as well and saw the jets, once their existence became known, as being completely misused. General Adolf Galland, one of the most famous German aces of the war, considered Hitler's insistence on the Me-262 being a bomber instead of a fighter to be a waste of an opportunity to fight back against the increasingly dominating Allied air forces.[98] He repeatedly advised Hitler, beginning in 1942, that he should focus on "building a massive jet-fighter force"[99] and believed that many more Me-262's could have been produced if they were designated for fighter design rather than

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[96] Pavelec, "The German Jet Program 1939-1945," 10.
[97] Pavelec, "The German Jet Program 1939-1945," 10.
[98] Adolf Galland, "Interview With World War II *Luftwaffe* General and Ace Pilot Adolf Galland," interview by Colin D. Heaton. *World War II*, January 1997 (accessed 18 February 2016) http://www.historynet.com/interview-with-world-war-ii-luftwaffe-general-and-ace-pilot-adolf-galland.htm.
[99] Adolf Galland, "Interview With World War II *Luftwaffe* General and Ace Pilot Adolf Galland"

bomber. In the end, although projects on jets did receive more investment and were given priority of raw materials and resources under Milch's 1941 order, the result was, of course, that the first one was not sent into combat until 1944. Theoretically, it did make sense for the *Luftwaffe* to keep up its jet program; at least there was a jet plane that Hitler believed could be a bomber. Realistically, however, the strategic mess that was Germany's aerial warfare plan meant that it was also a waste of time and valuable resources that could have been used elsewhere.

The final important aspect to address is why the jet program failed to produce the aviation *Wunderwaffe* Hitler had hoped for. Despite the logic of the previously discussed approach of acting based upon the circumstances of the current situation, there was a massive problem with this. While leaders like Hitler and Göring considered jets in the context of the war, they did not view jets in the context of capability. Capability does not refer in this case to the skill of German pilots or the number available to actually fly the planes. It is true that at the end of the war there were very few pilots left, let alone skilled ones, but the jet program did not suffer from this shortage. Instead, the pilots who were selected to fly the Me-262 once it became available for combat use were among the best fighter and bomber pilots Germany had.[100] This did leave the other air force units undermanned and with inexperienced pilots, and it is worthy of note because it clearly indicates that Hitler, who had eventually taken virtually all strategic decisions upon himself because he did not trust his Generals, believed the jet would be the thing to at least reclaim air superiority, if not also save the whole war effort. Capability instead means

[100] Pavelec, "The German Jet Program 1939-1945," 64.

Germany's actual industrial ability to manufacture jet planes. There were two main reasons why the jet program failed: first, that Germany lacked the resources to mass produce jet aircraft, and that as a result of the lack of resources the jets themselves were far too primitive to be relied upon to change the outcome of the war, as Hitler hoped they would; and second, that the Allies obliterated German industry and commanded such superior production output that they rendered the jets as obsolete as Germany's conventional aircraft.

In December of 1936, Albert Betz of the German Aerodynamic Laboratory wrote to Göring to outline the need for great investment to be made in *Luftwaffe* research institutes and in the acquisition of raw materials that could sustain the mass production of aircraft throughout the war, whenever it finally came. He stressed that it was important for the *Luftwaffe* to not lag behind its enemies by developing during the war rather than before it, like what had happened in World War I.[101] Betz's concerns were not unfounded: even in 1938, just one year before the war began, Germany "was almost completely deficient in 20 out of 26 strategic materials," such as bauxite and copper.[102] It was crucial for Germany to access and obtain as many of these resources as possible before the war, and this was a success: certain resources, in particular fuel, were imported from the Soviet Union during the period of non-aggression before 1941.

But again, that was before the war and for the first two years of it, when things were going well. Once Germany began losing, many crucial raw materials became inaccessible, both

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[101] Letter from Albert Betz to Reich Minister of Aviation Hermann Göring, "Planning of aviation research in case of war," 12 December 1936, in Helmut Trischler, *Dokumente zur Geschichte der Luft- und Raumfahrtforschung in Deutschland 1900-1970.*

[102] I.C.B. Dear and M.R.D. Foot, eds., *The Oxford Companion to World War II: raw materials* (Oxford University Press: 2014), accessed 18 February 2016 http://www.oxfordreference.com/view/10.1093/acref/9780198604464.001.0001/acref-9780198604464.

as a result of the Allied blockade and the fact that many of Germany's enemies (or countries it had occupied and then lost) were the main producers of such materials. This meant that Germany's industrial programs as a whole had to rely on what had been stockpiled rather than what could consistently be brought into the country. In particular, this was disastrous for jet production, because resources such as nickel, chrome, titanium, and molybdenum (not to mention aluminum, for the airframe), which were crucial to jet engines were not produced in Germany.[103] In addition, even though over 1,000 Me-262's were indeed built before the war ended, they suffered from serious design issues that had mostly to do with their engines. The engine was of course the core of the airplane, and without it the mass production of quality engines there could be no mass production of the plane itself. Not only did the lack of raw materials influence the ability to produce large quantities of jets, and it also affected the quality of the engines. The Me-262 engine, built by Junkers, had a lifespan of about 10 hours,[104] which was abysmal, and this was a result of the lack of necessary materials for which Germany had no substitute. As a result, scarce resources became even more unavailable as the war progressed, meaning that the jet program was essentially doomed from the moment that it became clear that Germany would lose the war. Despite all of this, however, the order was still given out to mass produce the Me-262. Germany's industrial state rendered this task impossible, yet Hitler and Göring did not care. False promises to Hitler from Göring[105] meant that Göring himself was

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[103] Dear and Foot, eds., *The Oxford Companion to World War II*; Pavelec, "The German Jet Program 1939-1945," 59.
[104] Pavelec, "The German Jet Program 1939-1945," 54.
[105] Günther Rall, "Aviation History: Interview With World War II *Luftwaffe* Ace Günther Rall," interview by Colin Heaton. *World War II*, September 1996 http://www.historynet.com/aviation-history-interview-with-world-war-ii-luftwaffe-ace-gunther-rall.htm (accessed 12 February 2016).

unwilling to see the reality of the situation, and that those in charge of the jet project, and *Luftwaffe* development programs all across the board, were forced to produce ends without a means.

The other significant blow to the jet program was that the Allies continuously bombed German industrial locations, often focusing specifically on jet manufacturing plants, and that the Allies could outdo Germany's production ability on a massive scale. As was noted earlier, the Allies blockaded Germany and thereby cut off its access to key raw materials. Even if the blockade had not existed, the United Kingdom and the United States themselves were also the main producers of such materials,[106] and because Germany was fighting them, there was no way they would be able to import anything from them. With regard to bombing raids, the major British and American air raids began in 1943, and no time was wasted in targeting the sources of Germany's exotic weapons. On 17 August, 1943, the US 8th Air Force hit the Messerschmitt plant in Regensburg, and much of the aircraft manufacturing equipment was destroyed; in 1945, when the Germans truly could not afford to lose anymore facilities, the US 491st Bombardment Group struck the Neuburg jet plant on 19 March and destroyed it.[107] On the Neuburg mission, which involved a target of high priority for the Germans, not a single American plane was lost;[108] with its country's industry crippled, there was no way the *Luftwaffe* would be able to field enough airplanes to threaten the Allies' domination of the skies. Not only were the Allies able to maintain air superiority, but they prevented the Germans from even being able to challenge them.

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[106] Dear and Foot, eds., *The Oxford Companion to World War II*.
[107] Pavelec, "The German Jet Program 1939-1945," 20; 491st.org, "491st Mission List - June 1944 to April 1945" http://www.491st.org/missions.html (accessed 18 February 2016).
[108] 491st.org, "491st Mission List - June 1944 to April 1945"

A lack of materials, a crippled industry, and an overpowering enemy were the reasons why once the jet program was thrown into full swing and its results were sent into battle it failed to alter the outcome of the war. However, it should have been Göring and Hitler's understanding that Germany was at a significant industrial disadvantage and that as a result, the jet was not to be relied upon as a *Wunderwaffe* that would turn the tide of the war in Germany's favor. In the case of the jet aircraft, the poor leadership of Göring and Hitler contributed to the failure of the program to not only change the outcome of the war, but even have an effect on the situation into which its products were thrust. They judged the need for various types of aircraft was based on how the war was going on the battlefield, and they wrongly judged the actual ability to make those kinds of planes based on the same criteria.

Germany's success with aviation in World War II was an astounding feat for a country that was, until a few years before the war began, deep in a depression and under the shackles of the Treaty of Versailles. Despite the difficulties it faced and its obvious status as a follower in the world of aviation, German aviation industry was able in a very short amount of time to make itself one of the best in the world. Even though factories in Germany in 1945 were being hit harder than ever by Allied air raids, German aircraft manufacturers were still churning out several thousand fighter planes a month, which was more than at any point in the war prior.[109] Its legacy is also undeniable: the Messerschmitt Bf-109 and Focke-Wulf Fw-190 were two of the most well-known aircraft of the war, and the *Luftwaffe*'s pilots were among the very best not only in the war but in aerial combat history. The top three aces of the war were all German and

[109] Pavelec, "The German Jet Program 1939-1945," 65.

they combined for a total of 927 victories, and all three survived the war; furthermore, approximately 2,500 German pilots achieved ace status during the war.[110] However, the prowess of the fighter pilots and the impressive industrial output of fighter aircraft only mattered while the war was going Germany's way. By 1942, victory began to slip out of Germany's grasp; the *Luftwaffe* started to experience serious fuel shortages at the Battle of Stalingrad, so no matter how good the German pilots were, they were no use if they could not actually fly their planes. The eventual destruction of the German Sixth Army at Stalingrad, the opening of a second front with the Allied invasion of Sicily, and the defeat in the Battle of Kursk in 1943 all but ensured that the war would end with an Allied victory.

It is clear that only a miracle could have saved Germany, but it is also clear that jets were not that miracle. As was explained, the poor strategic implementation of the jets that were built, the lack of raw materials, and the extreme superiority of Allied industry all made a reliable *Luftwaffe* jet wing wishful thinking. Jets were, as a result, a serious misuse of resources, manpower, and valuable time that Germany could not afford to waste. But at the same time, one has to consider the thinking at the time of those involved in making the decision to produce a jet plane. Aircraft manufacturers promised whatever the *Luftwaffe* or Hitler wanted because they were motivated by a desire to receive the government contract for a product. This is exemplified by Willy Messerschmitt's plans for the Me-262 to be a bomber because that was Hitler's wish. Everyone in the development program and the *Luftwaffe*, such as Adolf Galland, knew it was

[110] War History Online, "The Top 10 German Luftwaffe Aces of WWII" https://www.warhistoryonline.com/war-articles/top-10-luftwaffe-aces-of-wwii.html (accessed 26 February 2016).

best suited to be a fighter. But in order to ensure the acquisition of the materials necessary to bring his blueprints to life, Messerschmitt tailored it to what Hitler wanted rather than what tacticians like Galland felt was needed. From the points of view of firms like Messerschmitt, Heinkel, and Arado then, it was always a good idea to invest in jets. The German military and the Nazi leadership itself faced a serious dilemma: in 1943, Germany was clearly losing the war, so the options available were either to surrender or keep fighting. From the strategic, military (and perhaps less-ideologically-charged) perspective, continuing the fight meant avoiding Germany's complete destruction and coming to some sort of reasonable agreement with the Allies. From the leadership perspective, however, Hitler and his closest associates in Göring, Himmler, Speer, Goebbels, and so forth did not consider surrender an option and viewed the continuation of the fight as simply a delay of the final victory. In their eyes, therefore, if jets were what would help stop that delay then they were what Germany needed. However, while Hitler and his entourage were definitely desperate for the weapons that would outdo their enemies, even in 1943 they still believed that Germany would win the war. This is perhaps why they were convinced that a *Wunderwaffe* would actually work, and what motivated Hitler to approve and support the Me-262 and other jet programs.

As though history had planned it, the special airplane of the *Luftwaffe* in World War II was sent into combat in the second-to-last year of the war, just like the special airplane of the *Luftstreitskräfte* was deployed for the first time in the second-to-last year of World War I. In WWII, the *Luftwaffe* hoped the jet engines of the Me-262 would destroy the Allied bomber fleets and restore German air superiority over Western Europe. In World War I, the *Luftstreitskräfte*

figured the Fokker Dr. I would out-maneuver and out-fly its Allied counterparts and allow the German Army to break the stalemate on the ground. In both cases, the two Air Forces were relying on innovative technology at the wrong time.

Chapter III: Nuclear Weapons in Nazi Germany

The Development of the Nuclear Weapon

Nuclear fission was discovered in December of 1938 by German chemist Otto Hahn, who in 1944 received the Nobel Prize for this work, and Austrian physicist Lise Meitner, who was Jewish and fled Germany just before the discovery was confirmed and did not share the Nobel Prize with Hahn. Fission was a huge discovery, as it is the basis for the chain reaction needed to cause a nuclear explosion. This detail of fission being discovered in Germany is quite important when it comes to assessing Nazi Germany's involvement in the race for the nuclear weapon during World War II. If it was in Germany that the breakthrough discovery in nuclear science was made (nuclear fission), why did Germany not build an atomic weapon?

Before World War II, the atomic bomb was just a concept. Already in 1933, before nuclear fission was discovered, Hungarian scientist Leó Szilárd proposed the idea of a nuclear chain reaction to produce an explosion; the only question was how to achieve that. At this time, however, the science for nuclear weapons was not very well understood, and the arrival of World War II only reduced the collaboration between the worldwide scientific community. Eventually, it was really each country (and their allies) for themselves in terms of figuring out how to apply nuclear fission to making a bomb, once that became the intended objective of achieving fission. At the same time that this science was still being understood, its potential for military application was certainly realized by several important scientists, such as Albert Einstein and Leo Szilárd,

who fled Nazi Germany in the 1930s.[111] Of course, during the war the military use of nuclear technology became a competition between enemies; Walther Gerlach, the physicist in charge of German uranium research for the final year and a half of the war, told his superiors that "the man who could threaten use of the bomb would be able to achieve anything."[112] However, despite the knowledge that a nuclear weapon was a possibility, in the early stages of the war the atomic bomb was really a hypothetical rather than a reality. The countries involved in the war could initially not realistically rely on nuclear weapons as instruments of war precisely because nuclear warfare was a new type of warfare that would have to first be invented; until that point, the war would have to be fought using the traditional methods. But while eventually nuclear weapons did become a reality that shaped the outcome of the war, there was no German atomic bomb during World War II. Clearly for Germany the bomb remained a hypothetical or at least far-off accomplishment throughout the whole of the war.

Why There Was No German Nuclear Weapon

The reason why Germany did not build a bomb can be summed up by referencing a meeting between Werner Heisenberg and Albert Speer in 1942, where he convinced Speer that German physicists felt that the effort to build an atomic bomb was "too big, too expensive, and too uncertain" because "[German scientists] lacked experience."[113] Heisenberg was pretty much

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[111] Einstein-Szilárd Letter, from Albert Einstein and Leo Szilárd to President Franklin D. Roosevelt, 2 August, 1939.
[112] Sir Charles Frank, *Operation Epsilon: The Farm Hall Transcripts* (University of California Press, 1993), 80.
[113] Albert Speer, *Inside the Third Reich* (Simon and Schuster, 1970), 225-226; Jeremy Bernstein and Peter D. Lax, Reply by Thomas Powers, *Heisenberg & the Bomb: An Exchange*, The New York Review of Books,

the leading authority in Nazi Germany on nuclear physics, having won the Nobel Prize in 1932 for creating quantum mechanics. Moreover, he was also one of the most important leaders of the *Uranverein*, or Uranium Club, which was created shortly after the discovery of nuclear fission and was the German Army Ordnance Group's secret nuclear weapons development project. As a result of his assessment to Speer that it would take years for Germany to achieve an atomic bomb (which was reinforced by other physicists' impressions that it would be three or four years before anything of value came to be), the nuclear weapons program was assigned continued yet minimal funding.[114]

The answer is more complex than just that, however. There are several basic factors that explain why Germany got to the point where a nuclear weapon was considered out of reach. First, there was the fundamental flaw of Nazi Germany that was persecution. This is not a critique of how to run a dictatorship, but the fact is that many of the brilliant minds who could have contributed to nuclear weapons research fled either Germany or its fascist allies before the war began because they were being persecuted.[115] Albert Einstein was probably the most famous of these cases, but he was one of many, such as Enrico Fermi, who was forced to leave Italy because its anti-Jewish laws affected his wife. As a result, Germany in essence enabled some of the men who were most capable of the kind of work involved in developing a bomb to join the

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November 6, 2003, http://www.nybooks.com/articles/2003/11/06/heisenberg-the-bomb-an-exchange/#fnr-1 (accessed 2 March 2016).

[114] Speer, *Inside the Third Reich*, 227; Mark Walker, *Eine Waffenschmiede? Kernwaffen- und Reaktorforschung am Kaiser-Wilhelm-Institut für Physik*, (2005) 25, http://www.mpiwg-berlin.mpg.de/KWG/Ergebnisse/Ergebnisse26.pdf.

[115] Walter E. Grunden, Mark Walker, and Masakatsu Yamazaki, "Wartime Nuclear Weapons Research in Germany and Japan", in *Osiris* 20. (Saint Catherines Press, University of Chicago Press, History of Science Society, 2005), 108. http://www.jstor.org/stable/3655253.

Allies and work against Germany. This had certain important implications. The racial purity laws affected around a quarter German physicists, greatly reducing university faculties and sending an endless list of now famous minds to Britain and the United States.[116] When it came to nuclear weapons research, *Uranverein* scientists sometimes struggled with certain aspects (such as how to explode a plutonium bomb), while Manhattan Project scientists like Enrico Fermi or Hans Bethe were able to solve such dilemmas.[117] This is not to say that German scientists could not have eventually resolved their shortcomings, it just means that the discriminatory laws made the task more difficult than it needed to be.

In addition to this, the constant possibility of being drafted into the military worked against effective research and development processes. The need for men at the front meant that selection was indiscriminatory, which it really should not have been. Paul Müller, for example, was one of Carl-Friedrich von Weizsäcker's students and a leader of the theoretical research on the use of plutonium under von Weizsäcker. In 1941 he was drafted, and later on killed in action on the Eastern Front.[118] Von Weizsäcker himself, along with Paul Harteck, was drafted into the military and only had his service requirement revoked because Heisenberg pulled some strings. Not only was the draft policy an oversight, but it also scared some scientists into feeling that although they had perhaps not been called up because of their profession, if they produced work that was irrelevant to the war effort that exemption would be cancelled out and they would be sent to the front.

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[116] Philip Ball, *Serving the Reich: The Struggle for the Soul of Physics Under Hitler* (University of Chicago Press, 2014), 55-56.
[117] N. P. Landsman, "Getting even with Heisenberg," *Studies in History and Philosophy of Modern Physics*, Volume 33 (2002): 319.
[118] Walker, *Eine Waffenschmiede?*, 11.

Furthermore, ideology drove practically all of Hitler's policies. This meant that there was limited academic freedom and science was essentially poisoned by the influence of scientists who subscribed to the Nazi ideology, such as 1920 Nobel Prize winning physicist Philipp Lenard, whom Hitler very much respected, and Theodor Vahlen, who was made president of the Prussian Academy of Sciences in 1938.[119] By contrast, in Weimar Germany, theoretical physics had thrived in a period of intellectual freedom and the absence of resources to fund experimental physics, and the country was the pilgrimage destination of many foreign physicists, such as J. Robert Oppenheimer.[120] As was mentioned above, nuclear physics research suffered from the *Gleichschaltung*, which was the Nazi policy that forced every part of German society to follow Nazi ideology. Not only were the actually capable scientists replaced and managed by fanatics, but the Farm Hall transcripts indicate that many of the German scientists feared they would be punished for any failure.[121] As far as the more specific arena of working on a nuclear weapon was concerned, the project was plagued by Gestapo and SS surveillance,[122] just like other exotic weapons programs. As such, the expectation of results in a sense ominously hung over the researchers. After the war, Heisenberg himself thought that even if German scientists had wanted to work on an atomic bomb the constant state surveillance would have made it a very difficult process.[123]

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[119] Mark Walker, "Twentieth-Century German Science: Institutional Innovation and Adaptation," in *Science in the Twentieth Century*, eds. John Krige and Dominique Pestre (Amsterdam, 1997), 803; Speer, *Inside the Third Reich*, 228.
[120] Grunden, Walker, and Yamazaki, "Wartime Nuclear Weapons Research in Germany and Japan," 108.
[121] Frank, *Operation Epsilon*, 77.
[122] Landsman, "Getting even with Heisenberg," 318.
[123] Frank, *Operation Epsilon*, 86.

When taking all of these factors into account, it is clear that certain conditions for a successful and full-on nuclear weapons program were not present. Again, Germany still possessed the scientific minds capable of building an atomic bomb, but so much more of a burden was placed on them by the reduction of the physicist population. The replacement of prominent, influential minds with diehard Nazis also hampered cooperation with the government on a nuclear program.[124] Furthermore, as was shown earlier, although the nuclear program was not considered *kriegsentscheidend*, or war-deciding, and thus did not receive the funding that befitted a program that was expected to produce a useful result within the timeframe of the war, the threat of the Nazi regime clearly never left the minds of the scientists involved. In comparison with the Manhattan Project then, the German scientists were at a disadvantage. The way everything was organized was not conducive to a focused effort. However, the aforementioned factors were actually only half of the situation, and they did not carry such weight that they alone excluded the possibility of a nuclear program. Heisenberg did not cite a lack of scientists or a disapproval of the leadership when he informed Speer that a bomb could not be built. Instead, he felt it was because the science was still evolving and they needed more time to figure out how to develop a bomb. As such, the real reason why Germany did not built an atomic bomb had much more to do with the latter fact than the Nazis' ruined society and flawed systems.

The Rationality of Not Investing In Nuclear Weapons

[124] Ball, *Serving the Reich*, 64.

The question now is whether it was in the end the right choice not to invest in a nuclear program despite the fact that Heisenberg and the other German nuclear scientists were capable of building an atomic bomb. As has been made clear, Heisenberg declared in 1942 that the possibility of an atomic device was several years away at the earliest. While this explains why there was no bomb, it was also the all-important motivator for Hitler when it came to considering whether or not to turn nuclear research into a full-scale, industrial-sized endeavor. By 1941, the *Uranverein* research efforts did not lag behind the American ones; both groups of scientists were achieving similarly important discoveries at that time.[125] However, whereas in the American case the results were presented as being worthy of further investment from the government, which was of course received, the German scientists interpreted their achievements as indicators that a nuclear weapon was still a long way away. In a sense, they were modest in appraising the importance of their work. Precisely this fork in the road to the nuclear bomb created the conditions for the American weapon and the lack of a German one. When it was clear to the Americans that they were making progress in their research, the effort to build a nuclear weapon became a race against the Germans. After all, it was in Germany that nuclear fission was discovered, so it was only reasonable to assume, no matter what the intelligence reports indicated,[126] that they were hard at work on building a bomb. This attitude also justifies the sabotage aerial bombardment of the Norwegian heavy water plant upon which the nuclear

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[125] Carl-Friedrich von Weizsäcker, "Eine Moglichkeit der Energiegewinnung aus Uran 238," 17 July 1940 http://www.deutsches-museum.de/archiv/archiv-online/geheimdokumente/forschungszentren/wien-heidelberg-strassburg/weizsaecker-energie-aus-u238/; Speer, *Inside the Third Reich*, 226; Walker, *Eine Waffenschmiede?*, 25; Werner Heisenberg, "Bericht über die Möglichkeiten technischer Energiegewinnung aus der Uranspaltung (II)," 29 February 1940, in Walter Blum et al. (eds.), *Wissenschaftliche Originalarbeiten* (Springer Verlag, 1989).

[126] R.V. Jones, *Most Secret War* (Penguin UK, 2009).

program so heavily relied. The timing of all of this is very important. In October of 1941, when the US government threw its full support behind nuclear weapons,[127] the Wehrmacht was only just encountering the harsh Russian weather. Other than that, the war was going very smoothly and victory did not seem far off.

With this in mind, one can return to the question: if German nuclear scientists were capable of building a bomb, why was the switch from modest funding to massive research and development not made? If the end result would come only once the war was over, all the more reason to just go for the really challenging, innovative projects. The German military did not need nuclear weapons to win its current war because it was all going so well; by this standard, it could afford to prepare for the future by allocating resources to a nuclear program. Hitler, however, was only interested in weapons projects that would provide a result during the timeframe of the war. Not only that, but he believed the war would end in a German victory. This meant that all serious weapons projects worth investing in should be producing something that would help guarantee victory. Rockets and jets, for example, were two new technologies with high potential for serious impact in the war. More importantly, these technologies had actual examples that could be demonstrated to Hitler; therefore, they were given a lot of attention.[128]

To say that Hitler wanted weapons that would be ready for use before the war ended does not, of course, mean that he knew when the war would end. But as was mentioned, the war was going very well in 1941, and even in Summer of 1942 things were still looking good. This was

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[127] Landsman, "Getting even with Heisenberg," 318.
[128] Allen, *The Business of Genocide*, 208; Frank, *Operation Epsilon*, 78.

around the time when the consideration of investing in nuclear weapons could be made, and based on the course of the war Hitler certainly was not under the impression that the war would finish as late as 1945 or 1946 (which was three or four years from the time of Speer's meeting with Heisenberg). Thus Hitler, while interested in nuclear weapons,[129] he did not see such a program as *kriegsentscheidend* or even *kriegswichtig*, a lower degree of priority that meant "important for the war." Albert Speer still offered the Heisenberg and his colleagues his support and some funding, but the result of the decision to delay the production of a bomb for after the war, when there would be peace and time to freely do so, the German nuclear research program became essentially a hobby, with more pragmatic, everyday uses[130] as the fruits of the scientists' labors.

By 1943, exotic weapons had become Hitler's solution to turning the tide back in Germany's favor. The Red Army had won in Stalingrad in February of that year and claimed another huge victory at Kursk in the Summer, and was pushing the Wehrmacht back towards Germany. But by the time the first rockets were fired at England and the first fighter jets flew over the Western Front, it was out of the question to add the atom bomb back to the list of exotic weapons Germany might use to win the war. Allied bombing raids were wreaking havoc on German industry every single day, and now the fact that the scientists were some of the best in the world was irrelevant. Germany no longer had the industrial capacity to sustain its conventional war efforts, let alone something as complicated and vast as a nuclear program. For example, imports from Portugal of wolframite, a key component in ammunition production, were

[129] Speer, *Inside the Third Reich*, 227.
[130] Speer, *Inside the Third Reich*, 228.

cut off in 1943, and uranium ore (which should have been being used for the nuclear program) had to replace it.[131] In 1945, Walther Gerlach detailed a status report of nuclear research in Germany. The analysis not only declined to mention nuclear technology for military purposes, but it said that despite intellectual ability and the numerous successes of atomic research, the lack of resources was being a massive hindrance to the process.[132] As a result of all of this, there just was no way Germany was going to build an atomic bomb. While German scientists had viewed the nuclear weapon as an eventual goal to be worked towards, the United States had seen it as a necessity, or by German standards, *kriegsentscheidend*.

In the end, however, the decisions made by Hitler and Speer to interpret the assessments of Heisenberg and his colleagues as a sign to put off nuclear weapons until after the war was won not only made complete sense given the time period but were the right choices to make. As was explained earlier, all of this has to do with when the option to go forward with a major nuclear program or not was presented. In 1941, there was no need for massive resources to be spent on something that, based on the information present at the time, still contained a lot of uncertainty. Germany had won all of its battles and was looking to be on its way to defeating its biggest enemy, the Soviet Union. As such, the small expenditure in military spending requested by Heisenberg at the time[133] was totally reasonable and proved enough to achieve modest yet

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[131] Speer, *Inside the Third Reich*, 228.
[132] Statusbericht Walther Gerlachs zum Stand der Atomforschung in Deutschland, January 1945 http://www.deutsches-museum.de/archiv/archiv-online/geheimdokumente/beurteilung/statusbericht-gerlach/dokument-7/.
[133] Speer, *Inside the Third Reich*, 226.

important results throughout the war.[134] Furthermore, while Heisenberg recognized that eventually there would come a time when the technology for nuclear weapons was figured out,[135] if the Germans were not that far, then there was no way the Americans were. Obviously, this arrogance had its consequences, but just like there was no way for Hitler to know Germany would start losing the war, there was no way for Heisenberg to have known at the time just how wrong he was.

[134] Brief Walther Bothes an Werner Heisenberg, 10 October 1944 http://www.deutsches-museum.de/archiv/archiv-online/geheimdokumente/alsos-mission/brief-bothe-heisenberg/.
[135] Walker, *Eine Waffenschmiede?*, 26.

Chapter IV: Comparing Failure Through the Lens of Rationality

The Prelude to the War

In comparing the rationality of investing or not investing in these three innovative military technologies, there are several important aspects to keep in mind: first, the pre-war history of each one; second, the need for and availability of materials during the war; third, the level of understanding of each technology; and fourth, the way in which each project was managed. These aspects all played into the final decisions that were made regarding investment in each program, and they help explain whether or not these decisions were rational.

The pre-World-War-II history of the three programs is very important because it influenced the ability of the proponents of each one to make a case for their technology. Rockets and jets, for example, both had results to show for their research. During the interwar period rocket technology was a fad that did not attract investment from the Weimar government. But rocket technology was already being tinkered with in the mid 1920s, which meant that by the time the war arrived in 1939 there had been over a decade of work done on them. Furthermore, the German Army was interested in rockets even before the Nazis took power in 1933, which meant that while there was not a significant amount of resources poured into rockets (because Germany, struggling through the Great Depression, could not afford to do so), the researchers had the backing of the Army to achieve success. Despite the effects of the Great Depression, this period of research and development did produced actual rockets, even if they were still

rudimentary. Once the Nazis seized power and the military took over all rocket research, what had already been achieved was demonstrated to the military. The case was then made for the use of the rocket as a military weapon, and eventually this culminated in a massive rocket program that was Germany's biggest military project throughout the war.[136] In the buildup to the war, however, Hitler and the German military were not looking for technologies that were way ahead of the time. The thinking at that point was that the weapons available to them at the present (or that were quickly being updated and improved every year in preparation for the impending war) would combine with *Blitzkrieg* strategy to defeat the weaker enemies after whom Germany would initially go. However, despite this, the rocket program retained its government and military support precisely because it was clearly making steps forward and that it was clear that a weapon of great potential would come of it. Had there not been so much work done by individual researchers and enthusiast groups, such as the VfR, in Weimar Germany the rocket program would not have received the degree of investment that it did under the Nazis.

Similarly to the rocket program, aviation had an extensive pre-war history. While jets themselves were not developed until during the war, they already had an industry that was clearly changing the face of the world behind them. Airplanes were used in World War I as a temporary weapon, they were an entirely new aspect to warfare that everyone involved, both military and industry, knew would define the 20th century. This precedent meant that jets were simply the next step in aviation, just like the monoplanes that most countries created in the post-WWI era were the successors to the biplanes used during the war. In fact, given how old

[136] Allen, *The Business of Genocide*, 208; Speer, *Inside the Third Reich*, 228.

aviation was by the time World War II began, jet planes actually had a longer history of research and development behind them than rockets. Throughout the interwar period, German industry was motivated by the ignominious defeat in World War I and the rotten deal that was the Treaty of Versailles to regain its position as one of the leaders in innovative military technology. Given, however, the pacifism and insistence on adherence to the terms of the Treaty of Versailles on the part of the Weimar German government, aviation development was almost entirely limited to civilian purposes. The Treaty not only dissolved the *Luftstreitskräfte* but also prohibited Germany from having an Air Force at all, and the Weimar government had no intention to defy this. This meant that German aircraft manufacturers had to shift their focus towards the commercial aspect to aviation. As was just explained, however, everyone knew that aviation was changing the way people lived, and German aircraft manufacturers certainly wanted to play their part, even if it was just in the civilian sector that they could do so. Because of the new role aviation took on in the world, this technology gained far more attention than rockets did, and this attention came from all areas of society.

A big difference between aviation and rocketry in Weimar Germany, from the civilian perspective, was that even though fantastical films were made about rockets and it was the dream of rocket scientists, for example, to go into outer space, in the end this was all just dreaming. There was not actually anything to really make Germans feel like rockets were going to become the new civilian technology of the future. That is why rocketry in Weimar Germany is really best described as it has been, as a fad. It is also why the only people who picked up on its potential were the military. But airplanes, on the other hand, had already proven their worth in

World War I and they were something that everyone could essentially understand and relate to; not everyone could afford to fly commercially, but they still knew that flight was the future of mass transportation. The fact that this was so big for average people is important when looking at why the Nazis pursued aviation innovation once they seized power. As was mentioned earlier, the Treaty of Versailles had banned Germany from having an Air Force. It only made sense for the Nazis to pick up on aviation as a rallying point for public support, both before and after Hitler rose to power. Hitler's main promise was that he would redeem Germany, and he could use the reestablishment of the Air Force and the development of impressive new planes as a way to assure people Germany would exact its revenge.

Like rockets, jets were worked on in the pre-war era, and were in fact essentially the Air Force's response to the Army's rocket program. Where the creation of aviation itself revolutionized warfare, jet engines were seen as revolutionizing aviation. This meant that when the time finally came to propose a plane for production, the justification for its creation was that the jet technology existed and could be used for a plane and so all that was left was for the plane to be built. The problem, of course, was that while jet research and development was underway before the war, like rockets jets were not what Germany needed at the time. Poland, the invasion of which marked the beginning of World War II, had an Air Force that was still equipped with biplanes. These aircraft were no match for German monoplanes, let alone a jet. After all, even without jets, the Germans fielded planes that became some of the most famous combat aircraft in history. However, for understanding how all of this impacts the rationality of the later decision to invest in a full-fledged jet program, there are is an important implication that the existence of a

pre-war jet program had for Germany: it meant that by the time the war was underway, thanks to the research and development that had already been done the option of a jet plane was always there.

Nuclear weapons are the outlier of the three technologies when it comes to pre-war history. The pre-war history of nuclear science and nuclear weapons is limited almost entirely to theory, and this was theory that existed and evolved over the course of only about four or five years before 1939. When compared to rockets and jets, the biggest difference is that unlike the other two technologies, there was nothing to show for all of the research that had been done before the war began. Obviously, this isn't to say that German nuclear science research was a failure before the war; it just points out the fact that German nuclear scientists had much less time to work than the rocket and jet scientists and engineers. In fact, as was explained, even though nuclear explosions were theorized in 1934, nuclear fission was not discovered until 1938, which meant that as far as building a bomb was concerned, there was only about a year between the major discovery that made a bomb possible and the outbreak of war. In this sense, the pre-war history of nuclear weapons is actually very important to determining the rationality of the decision not to invest in them because it fits with Hitler's standards for supporting certain new technologies. These standards included that there had to be a guarantee of a product that would affect the war if the program were to receive support, and since the possibility of nuclear weapons was so new, there was, in the eyes of German scientists, no way to make that guarantee. Under no circumstances could anyone expect the technology that was just discovered to provide

more results within the timeframe of the war than the ones that had already been worked on for many years beforehand.

Materials

In order to actually produce any of these weapons, Germany required important things like raw materials and manpower, access to which was contingent upon how well the war was going. In the case of each program, the effects of the Allied air raids and the gradual reduction of territory under German control played a big role in hampering their success. As far as rockets are concerned, the fact that they were the biggest program eventually meant that they were no secret to the Allies. To begin with, the Allies put German rocket production sites among their targets once heaving air raids began in 1943. The most notable effect of is this is the destruction of the Peenemünde research facility, as this incident is what forced the rocket program underground. Furthermore, in 1943 the Germany began losing a lot of ground, and new fronts opened up that stretched the German military increasingly thin. Although the metal and iron ore deposits in the Ukraine were still under German control in 1943,[137] this territory was eventually recaptured by the Soviet Union, which meant that the supply of materials key to programs like rockets was cut off. Leaving this lack of raw materials aside, in order to cope with the heavy losses suffered at the front, as many German males as possible were thrown into the service. The shortage of manpower in Germany that resulted from this ended up placing the construction of rockets in part in the hands of concentration camp prisoners recruited to perform slave labor.

[137] Tooze, *The Wages of Destruction*.

Not only was there a risk that the prisoners would commit sabotage, but they were also using poor materials to build technologically flawed devices.

All of this is of course the downside to the rocket program's need for important raw materials, and in Hitler's defense, since it was he who ordered the rocket program to be considered high priority as far as weapons projects were concerned, he thought that Germany would still win the war and that rockets were what would help this goal be achieved. Also, he assigned high priority in 1943, in which year, as was just mentioned, the German military still controlled important foreign iron and metal deposits. So from that standpoint, it made sense to give the program everything. But at the same time, the need for such materials also makes his decision irrational. Instead of focusing on ways to improve upon the currently failings of the military, he threw his support behind an audacious program that relied upon the war to keep going Germany's way in order for it to succeed, something which was definitely not happening in 1943.

The jet program suffered from raw material scarcity probably most notably of the three technologies because of just how many different raw materials were needed to build jets and airplanes. When examining the list of the most important raw materials for any country during the war for armaments production purposes, Germany had virtually none of them within the borders of the country itself.[138] This meant that the jet program's success relied heavily upon the ability to import materials like bauxite and copper (to name a few), and it also meant that once these imports were no longer possible because Germany was losing the war, substitutes had to be

[138] Dear and Foot, eds., *The Oxford Companion to World War II*.

used that were not as good as what was actually required. The main issue with the jet program was that the jet engines themselves were often deficient, and this was the result of a lack of the materials needed to build good engines. Allied air campaigns targeted Germany's raw materials reserves and supplies down to the very smallest ones; for example, the imports of wolframite needed to produce bullets were cut off in 1943.[139] If there was a reliance on imports just to make bullets, then there was certainly no way this same reliance could be expected to maintain a successful jet program. In this sense, there was clearly a lack of understanding, or an unwillingness to accept the reality of the situation, when it came to supporting the production of the Messerschmitt Me-262 fighter jet (among others) in 1943. And perhaps there was the same desire to ignore the situation on the part of the aircraft companies fighting for contracts. As Willy Messerschmitt's guarantee to Hitler that the Me-262 would be a bomber shows, the manufacturers all wanted their individual plans for a jet to be approved and supported, and so they promised whatever they could in order to get what they needed.

Nuclear weapons were not actually put into production, but there were still two valuable components that would have been crucial to a possible weapons program. First, there was uranium, significant deposits of which were in Belgium and Czechoslovakia, and second, there was heavy water, which was largely imported from the Norsk Hydro plant in Norway.[140] Again, while the uranium to which Germany had access in occupying those two countries was never used for a large scale nuclear weapons project, its very existence gave the Allies reason for

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[139] Speer, *Inside the Third Reich*, 228.
[140] Mark Walker, *German National Socialism and the Quest for Nuclear Power, 1939-49* (Cambridge University Press, 1992), 41.

concern. The same was the case for the Norwegian heavy water. After all, even the limited activity on nuclear weapons that Allied intelligence was observing did not convince them that the Germans were not somehow on their way to building a bomb.[141] Important, however, is the fact that these uranium deposits and the heavy water were just the like the raw materials needed for building rockets and jets, in that they came from abroad and needed to be imported. This meant that once Belgium and Czechoslovakia were liberated, uranium imports were no longer available. While the Allies could not do anything to stop uranium imports until the war was really going against Germany, they could have an impact on the Norwegian heavy water plant, and that is why the British Special Operations Executive planned and executed a sabotage attack on the plant that virtually destroyed it. Granted, this was not as big of a deal because it was not as though this really stifled Germany's hopes for a nuclear weapon, but it might have been if there had actually been a major atomic bomb program.

The thing that makes the nuclear weapons program different from the rocket and jets projects of course is that comparatively it was such a small endeavor, and this is where it appears that as far as rationality is concerned, the availability of raw materials does not really play a role in how rational it was to not invest in a nuclear program. Despite the threat of a nuclear weapon that the Allies perceived, the materials needed for a nuclear weapon were relatively secure and not in short supply for most of the war. In that sense, in comparison with the other programs, it was actually the one best suited for reliance upon imports, and it would therefore have actually

[141] R.V. Jones, *Most Secret War*.

made sense to invest in this one. But because that big investment was never made, the question of rationality does not have to do with this aspect.

Technological Understanding

The third important factor in considering the rationality of investing in these various programs is how well the technology was understood by those who were advocating for or against investment. All of the programs shared the trait of being understood in theory, but the rocket and jet scientists had an advantage over nuclear weapons, and this connects to the pre-war history of each technology. The technology of rockets was not only understood long before the war began, but it was also actually applied in experimentation. Rocket scientists, like Wernher von Braun, had years of testing under their belts before the first versions of the V-2 were demonstrated in the mid-1930s. Because of this, there was nothing in terms of theory or experimentation stopping the development of an effective ballistic missile. Jets were very much the same. As a result of the rocket fad, the *Luftwaffe* was interested in building jet aircraft, as the technology for rockets and jet engines overlapped. In fact, much of the early work in the mid 1930s on rockets and jets was done under cooperation between the Air Force and the Army. This meant that just like rockets, jet engines were long out of the theoretical stage by the time the war arrived. Regardless of their quality, there were actual jet engines in testing facilities. Nuclear weapons were only similar to the other two projects insofar as the concept of a nuclear weapon was understood. This means that German scientists, most importantly Werner

Heisenberg, thought that it was definitely possible to build a nuclear weapon[142] and that there was not a lot remaining in terms of figuring out how. But the little bit that did remain was exactly the key. The German nuclear scientists had no experience translating theory into experimentation because the theoretical understanding had only been around since one year before the war started. There had been no time for them to spend on gaining such experience because the science itself was so new, and the way these scientists interpreted the science meant that they felt the lack of such experience was reasonable. As was discussed earlier, Heisenberg believed very early on that German nuclear engineering was at a primitive stage in knowing how to build a nuclear weapon.

In comparing all three of the programs, it is clear that it was perfectly rational to invest in rockets and jets given the fact that these technologies were understood and that there were results that proved this understanding. At the same time, it was perfectly rational not to invest in nuclear weapons given the extreme recentness of the discovery that made nuclear weapons a very possible reality instead of just an idea and the fact that unlike the other two projects, there was nothing, and, according to Heisenberg, would not for a long time be, to show for the theoretical comprehension of an atomic bomb.

Management

Finally, there is the way in which each program was run. Rockets, as was mentioned earlier, were the biggest, most extensive Nazi weapons program, and therefore had a huge

[142] Speer, *Inside the Third Reich*, 226.

network of managing groups. This was how Hitler ran all of his programs. He liked to "scatter responsibility,"[143] insisted upon oversight from different organizations, and encouraged competition because he cared about who would get him the result he wanted. This is why the rocket program, despite initially being a German Army initiative, was partially run by the SS once the Mittelwerk facilities at Mittelbau-Dora were set up, and why the *Luftwaffe* fought the Army over access to its rocket scientists in the mid-1930s. The specific tug of war between the Army and the *Luftwaffe* over rocket scientists actually related to the jet program as well, and it bred a money war between the two branches that finally resulted in Wernher von Braun and his colleagues staying with the Army. However, the reason why both branches fought over which rocket scientists they could convince to work for them was because they were vying for legitimacy and priority in their efforts to acquire funding from Hitler's government, and this sort of infighting and lack of cooperation continued throughout the war. As far as nuclear weapons were concerned, part of the "management" aspect was really related to the expulsion of many prominent and brilliant scientists before the war, and their replacement by fanatical Nazis who only ruined German science.

As was the case with the raw materials and the nuclear program, in terms of all three of these programs, rationality is a questionable trait to assess because the management was ultimately influenced by Hitler and Nazi politics. The rocket program had a very effective leader in Walter Dornberger, just like Adolf Galland was a great aviation tactician and Werner Heisenberg was the leader of German nuclear weapons science, but in the end they were all

[143] Speer, *Inside the Third Reich*, 228.

subject to how Hitler ran his country and his institutions. Dornberger had to deal with the SS, favorites of Hitler of course, and high priority not being assigned to the rocket program until 1943 despite his knowledge that that status needed to come earlier. Galland was forced to accept that Hitler wanted a jet bomber and therefore ruled out massive jet fighter fleets even though Galland knew that the latter strategy was the one that was more realistic and might actually have had an effect on the war. Heisenberg and Hahn and others initially had to watch Hitler change the faces of the Kaiser Wilhelm Society and the Prussian Academy of Sciences, and would have certainly faced challenges similar to those of Dornberger and Galland if the nuclear program had been a full-fledged operation. With this in mind, how rational it was to invest in these programs given the state of the management is really dependent upon whether or not it is seen from Hitler's point of view. From the perspective of someone like Dornberger, Galland, and Heisenberg, the organization and administration of these projects was disastrous and not conducive to a truly successful undertaking, like the Manhattan Project, for example. But from Hitler's view it was perfectly reasonable.

The Rationality of the Decisions Made to Invest in Exotic Weapons

During World War II, Germany put a lot of effort into battlefield technology that was rightly considered to be the technology of the future but wrongly judged to be capable of winning the war because of that futuristic aspect. The rocket, jet, and nuclear programs were, in

the end, failures, because none of them achieved their overall purpose, which was to help Germany win the war. It is easy to call such exotic weapons programs irrational given this failure, but it is also important to understand that ideology often strongly influenced those in charge of making the important decisions, and that the Nazi political and military leadership viewed the war in a different light as they fought it. Therefore, in assessing how rational it was to invest in programs that did not do what they were expected to do, the thinking of those involved in the decision-making process at the time and the modern knowledge of how they had little to no effect on the outcome of the war were considered and compared.

Of the three projects, the rocket program was probably the biggest success in terms of how many were produced. The reason the production figures are important are because they show that the rockets suffered from fewer technical deficiencies than the jet engines, but even this is a bit misleading in terms of calling the rocket program successful in any sense, because the rockets were still not well-built and were really ineffective once they were deployed. Jets, while initially a scare for Allied pilots who came up against them, proved to be nothing more than an irrelevant glimpse of the future of aerial combat. Nuclear weapons never existed in Nazi Germany, so whatever hopes were pinned on them were little more than a distant dream.

The question that has been asked throughout this investigation is how rational it was for Germany to invest in these three exotic weapons programs as a way of changing the course of the war. The answer is that it depends on various factors, such as the pre-war history of each technology, the availability of raw materials, the level of scientific understanding of the technologies, and the way in which each program was carried out, as well on whether one looks

at each decision in the present day or in the time in which the decision was made. But in order to simplify this answer and provide a final analysis, it can be said that it made sense to go for exotic weapons programs, like jets and rockets, before the war, but not during it, and that it made sense not to invest too much in nuclear weapons given how German nuclear scientists assessed the state of nuclear weapons research. At the same time that it was a poor decision to invest in exotic weapons during the war, it can also be said that even if one considers the fact that the United States built an atomic bomb, it was not a mistake not to invest in nuclear weapons either. Even though by 1941 the science in Germany and the United States on nuclear weapons was at the same level, the US had the advantage of its industry not constantly being under attack from enemy countries and its economy being far more capable of handling the stresses of massive weapons programs like the Manhattan Project. Perhaps the policy of measured investment was the approach that should have been taken for the rocket and jet projects as well. The nuclear program was not shut down, it was just allowed to continue at its own pace, and at a low cost. Although by 1945 the Germans had rockets and jets and certainly wished they had a nuclear weapon in addition, it was wise not to waste even more money and resources on such a project, and after all, the rockets and jets didn't even do anything anyway.

It is clear why programs like jets and rockets were suddenly cultivated during the war: Germany ended up fighting a defensive war against enemies that became increasingly numerous and superior. The only way, in the eyes of Hitler and many of his associates, to win the war then was to do it with a miracle weapon: the *Wunderwaffe*. But in following this belief, they ignored the reality of the situation, which was that such weapons were impossible to be both improved

and produced in enough numbers to actually change the course of the war back in Germany's favor. They sacrificed quality for quantity, which was not exactly something they could afford to do given that the whole point of exotic weapons was that their quality was unrivalled by anything Germany's enemies had. In making the mistake to invest in such exotic programs, they left aside far more attainable goals, such as long range bombers, that could have played a valuable, decisive role earlier on in the campaign and perhaps prevented the need to fall back on a *Wunderwaffe*.