Lost In Space: The Defeat of the V-2 and Post-War British Exploitation of German Long-Range Rocket Technology

By Wing Commander Bryan Hunt

Biography: Wing Commander Bryan Hunt was born in New Zealand. He read hydrology at Auckland University and International Relations and Law at Cambridge University. Following service in the RNZAF he transferred to the RAF as a specialist works officer. He subsequently transferred into defence engagement, serving in Italy, Germany and Turkey, operating in the British Embassy Ankara during his previous tour. He attended Staff College in Rome and Istanbul and served operationally in the Balkans, Middle East and Afghanistan. He has previously written articles on counter-insurgency intelligence, air power and psychological warfare, and on the failed Gallipoli campaign.

Abstract: In September 1944 the United Kingdom became the first country in history to be subject to a sustained ballistic missile campaign. The V-2 rocket was the culmination of a 20-year research programme in Germany, but the operational history was less than seven months and had no appreciable impact on the outcome of the war. Countering the missiles was a two to three-year British intelligence priority but despite the seismic technological change the missiles heralded, Britain remained cautiously interested in exploiting the technologies and the scientist behind them. This was, arguably, to cast a long shadow over British space ambitions and strategic capabilities. This paper considers the developmental and operational history of the V-2 from both an operational and intelligence perspective, and then considers the challenges - and outcomes - of taking advantage of the technologies, set against a background of post-war austerity and competing strategic requirements.

Introduction
Battle of London is over…sort of

On the evening of 7 September 1944, Duncan Sandys MP, chair of the government rocket and flying bomb countermeasures 'CROSSBOW' committee, confidently announced that the Battle of London, comprising the V-1 flying bomb attacks, was now over and that the public could now relax, and because of Allied advances through northern France, discounted the apocalyptic predictions of 'rocket' (ballistic missile) attacks.
The fear of these attacks had caused the Home Secretary, Herbert Morrison (1888 -1965), grave concern because of alarmist intelligence assessments of the size of warheads and predicted scale of attacks.[1] Starting in August 1943, Bomber Command and the US 8th Air Force had bombed research sites in Poland and dropped 120,000 tons of bombs on the monumentally large reinforced-concrete 'large sites' and 'rocket projector' sites on the Cherbourg Peninsula in northern France and in Belgium that were believed to be crucial to the operational deployment of long-range rockets.[2] Allied forces had now overrun the distinctive, curved assembly and launch 'ski site' buildings where V-1 flying bombs had been launched at Britain. The Chiefs of Staff Committee also believed that all potential rocket launch sites were now in Allied hands. However, a scant 24 hours later, a mysterious explosion occurred in Chiswick, west London, killing three people and injuring a further 20. A second similar explosion occurred a few seconds later in Epping, though with no casualties. Described officially as "gas leaks", these explosions heralded the first ballistic missile attack on the United Kingdom. The weapon was the A4, a 46 ft/14 m high single-stage liquid-fuelled rocket carrying a one ton high-explosive warhead. The A4 – *Aggregat* (experimental) Bombardment Rocket and later renamed by the Nazi Propaganda Ministry and universally known as the V-2 (*Vergeltungswaffen* - vengeance or retaliatory weapon) - had been launched from a mobile position in The Hague, in the occupied Netherlands.[3]
It took just under five minutes to travel the 200-odd nautical miles to southern England. Although the British Government maintained the story of gas leaks for several weeks on security grounds, it was recognised across Whitehall that this was the commencement of a ballistic missile (code word:'BIGBEN') bombardment that had been expected – and feared - from late 1943.[4]

Origins of the V-2

The A4 had been developed in great secrecy at purpose-built research facilities at the German Army Rocket Research Centre on the Baltic peninsula of Peenemünde, near the Polish town of Świnoujście.[5] The origins of the A4 can be directly linked to Germany's defeat in the First World War. The Versailles Treaty of 1919, which formally ended the Great War, imposed severe limitations on the rearmament of Germany, including the realms of artillery. To avoid these restrictions, covert research and rearmament commenced in the early 1920s, and contrary to popular belief, a decade before Hitler came to power. However, under the National Socialists, defence research and development 'was accentuated' and disinformation was used to disguise the true purpose of military materiel and technical developments.[6] Encouraged by Hermann Oberth (1894-1990), an astrophysicist and space-flight visionary, who had established links

with the National Socialists in Munich in the 1920s, amateur rocketry clubs were formed with state sponsorship.[7] By the 1930s, German scientists and engineers led in the field of ballistic rocketry to circumvent the ban on large calibre/long-range artillery. One of Oberth's students was a talented engineer, Wernher von Braun (1912-1977). On completion of his doctorate on liquid-fuel rockets in 1933 (and through Oberth's influence), von Braun was recruited by Colonel Walter Dornberger (1895-1980), the German Army's Director of Artillery, and put to work developing long-range artillery rockets. The pinnacle of these developments was the liquid-fuel propelled *Aggregat 4* and first successfully launched – after many setbacks – on 3 October 1942. Whilst Dornberger organised the development programme and marshalled military support and resources, von Braun used his charm, his technical knowledge and political astuteness to secure advancement and funding – and ultimately the endorsement from a doubtful Adolf Hitler – to turn an expensive and esoteric research programme into a new weapon of war.

The British Joint Intelligence Committee (JIC) was aware of a nascent rocket programme from 1942 (although intelligence pointing to a rocket weapons programme had been around since 1939) but understanding the extent of the programme and defeating it proved to be challenging. This lack of understanding was down to tensions across the scientific intelligence community, but through a combination of a dedicated intelligence-led investigation, involving photographic reconnaissance and signals intelligence, coupled with heroic espionage by the Polish Resistance movement, "torpedo like objects 38 feet [12m] long" were discovered confirming British suspicions of German development of 'remotely controlled pilotless aircraft", even though the items that were seen were probably long-range rockets.[8] This led to the Royal Air Force (RAF) conducting a devastating 600-strong bomber raid on Peenemünde on night of 17/18 August 1943 (Operation HYDRA), with a loss of 41 aircraft. Unknown to the RAF, Peenemünde consisted of two separate (and rival) research institutions. The V-1 was being developed by the *Luftwaffe* at Peenemünde West, along with rocket powered aircraft such as the ME-163 *Komet*, whereas long-range rocketry at an adjacent and larger site was being carried out by the German Army. Although research laboratories were largely undamaged, the destruction of production workshops and logistics facilities and the loss of several key propulsion staff, along with much of the housing, resulted in the near-immediate relocation of A4 production and some test facilities to underground centres.[9]

After the raid, which RAF Bomber Command thought had delayed the programme by four to six months, research continued at Peenemünde and at sites in Blizna, Poland, about 550 miles/900 km south east of Peenemünde. Although the damage was extensive, Dornberger (by now a Major General) believed that the delay in research and development was only four to six weeks, and elaborate camouflage techniques were applied to make the site appear abandoned.[10] Production moved to a former gypsum mine near Nordhausen in central Germany. A state-owned company was established for production of the V-2, with staff brought in from the engineering companies of Siemens and AEG, under the dynamic, yet deranged leadership of Gerhard Degenkolb (1892-1954).[11] Other major sites included the

Zeppelin Works, near Friedrichshafen, on Bodensee (Lake Constance), with sub-components built across Germany. The Nordhausen mine, which ultimately expanding to include several forced-labour camps, including the notorious 'Dora' camp, was known as '*Mittelbau*' (also known as '*Mittelwerk*'). Here A4 designs were put into industrial-scale production and testing, prior to the completed V-2 missiles being moved to launch sites. Reports vary, but it is thought that between 15,000 and 25,000 slave workers died at *Mittelbau-Dora* due to appalling living conditions and brutal treatment.

After the July 1944 assassination attempt against Hitler, on 8 August, Heinrich Himmler ordered that the V-2 programme was to be taken from German Army control[12] and moved across to the SS, under *SS–Obergruppenführer* Hans Kammler.[13] Kammler then directed production and V-2 operations from September 1944, whilst issuing up to 100 'ignorant, contradictory, irreconcilable' telegrams a day, and in doing so arguably damaging development, production and deployment of the weapon system.[14] From early 1945, Kammler also took over from the German Air Ministry and the *Luftwaffe*, direction of the V-1 programme, in addition to oversight of all jet aircraft production.

Rocket in a Bottle?

Debate amongst intelligence and scientific circles raged for 18 months, from early 1943 until autumn 1944, as to the size, range and potency of the rockets. This was only partially resolved when the first rocket landed to the west of London. The arguments were fierce and obtuse. Churchill's friend and scientific advisor, with the sinecure of Paymaster-General, was the German-born and irascible Professor Frederick Lindemann (1886 – 1957, later 1st Viscount Cherwell).[15] He was convinced that no single-staged liquid-fuelled rocket could reach out 150 – 200 miles and assumed (and contrary to the scientific intelligence and Allied research and development) that such a device would be launched from a projector – akin to launching a sky-rocket from a milk bottle. His protégé, Dr Reginald Jones (1911 – 1997, known universally as 'RV Jones'), who had been appointed to the Air Ministry in 1939 as a scientific advisor and in February 1941 became Assistant Director of Intelligence (Scientific Intelligence), challenged this and interpolated from scant intelligence and scientific input, that a liquid-fuel rocket could deliver up to a ten ton warhead on London. He was later to revise this in 1944 to a 12-meter-long body with a one ton warhead. Although Jones reported to Assistant Chief of the Air Staff (Intelligence), he combined this role with a more covert position as a scientific adviser to the Secret Intelligence Service (SIS/MI6), giving him immediate and privileged access to intelligence reports from agents[16] and ULTRA decrypts – intercepts of sensitive Nazi radio communications that had been encrypted using the Enigma machine encryption system.

Duncan Sandys MP, a former artillery officer and Financial Secretary to the War Office who led the BODYLINE committee established to counter the rocket threat, used his political acumen to persuade the government and the Chiefs of Staff of the threat. But Lindemann was bullish and to prove his theories on the method of launching long range rockets were right, he convinced the Chiefs of Staff, and in particular, the Chief of the Air Staff, Air Chief Marshal Sir

Charles Portal (1893-1971), probably with the intervention of Churchill, to search for these mythical projectors on the Cherbourg peninsula and around Calais. Many sites were incorrectly identified as rocket projector sites and received the attention of Bomber Command and the USAAF from August 1943 to early 1944. Post-war analysis showed that the heavy bomber campaign had almost no impact on the eventual operational deployment of the V-2, because of the rapid advance of Allied forces through France, coupled with delays in producing an operational variant, the missiles were not to ready to deploy in large numbers – from mobile convoys – until September 1944, and that the vast concrete structures were unlikely to have been used.[17]

Lindemann also remained unconvinced that the German war machine would invest so heavily in what he saw as a grossly inefficient and inaccurate weapon, given competing operational requirements and set against a deteriorating war situation. However, from 1939, the Nazi leadership – principally through the Propaganda Minister Josef Goebbels – had promised 'secret' weapons that would win the war and destroy 'England'. The V-2 was a manifestation of Nazi technological supremacy and a symbol of raw, unfettered power; as the situation deteriorated Hitler, who had initially been unconvinced by the V-2, saw the missile as a panacea to defeat the British, given that there were no defences against it.[18]

In addition to coping with Lindemann's bullying behaviour and his frequent attempts to undermine the BODYLINE Committee, the team had to contend with a dizzying array of conflicting intelligence. For example, a JIC paper on 'German Long-Range Rocket Development' dated 21 April 1943 variously reported that the rocket had been test-launched in South America, had a 100 (or 200) km range and with a five (or ten) ton warhead, was launched from a metal tube projector or could be fired from a ship. One German prisoner of war (POW), a tank expert who had provided otherwise detailed and reliable information on a variety of other technological advances, reported to interrogators a rocket of 120 tons with a 60-80 ton warhead (with a 30 km blast radius), propelled by hydrogen and with a range of up to 1,800 km, and guided by a 'direction finding' beam. Although this POW had provided useful information in the past, his credibility was doubted in a most colourful way by the JIC:

> [POW] 164 gives the impression of a one track, furiously working brain mounted on a neglected over-grown child's body…it is a case of morbid genius close to insanity by ordinary standards.[19]

A later BODYLINE report of 4 November 1943, outlining targets to interrupt the production and launch of the V-2 established that the 'projectile [would be] fired from a mortar tube of considerable dimensions…made up of multiple sections' and that 'the method of operation may require the incorporation in the design of a high-pressure pump or compressor driven by some form of motor of very high horsepower.' This high-pressure pump or compressor would be used to propel the missile from the projector. The source of these 'facts' is unclear but

helped to distract the intelligence collection and analysis effort for some months, searching for mythical launch tubes much favoured by Lindemann.[20]

Defeating the Unknown

Defeating the V-2 operational deployment proved to be very difficult for the British. The destruction by bombing of the huge assembly, storage and launch facilities in the Pas-de-Calais region of France, led to a wider belief that the threat from rockets had been eliminated, even though the Allies had little information to distinguish between the V-1 and V-2 programmes, having never encountered weapons of either type.

Air Chief Marshal Sir Roderic Hill, Air Officer Commanding-in-Chief Air Defence of Great Britain (ADGB) noted that by summer 1943 Ministry of Supply (MOS) scientists, working against a theoretical model of a rocket (as supplied by the BODYLINE Committee), determined that a rocket could be identified by modified early-warning radar during the boost phase and both points of launch and impact could be identified by use of both electronic and mechanical predictors, although the rockets could not be tracked in flight. Hill took over as the Air Defence Commander on 15 November 1943; coincidentally the role of devising counter-measures was moved from the Ministry of Supply to the Air Ministry on the same day. By that time, five radar stations between Ventnor and Dover on the South Coast had been modified to detect rockets fired from northern France, and "operators had been trained to identify the characteristic trace which a rocket was expected to produce."[21] Alongside the radar, the Royal Artillery anti-aircraft units employed sound-ranging and flash-spotting teams to observe for launches, as they were to do in Belgium from September 1944 when the V-2 campaign commenced. From early 1944, however, the rocket threat was assessed by the BODYLINE Committee as reduced, so the radar watch was dropped. Hill, concerned that such relaxation was premature, insisted that the radar operators should remain in place and train others; a further two radar stations were included in the chain from June 1944 as the V-1 flying bomb campaign commenced, in what Hill described in his-post war report as 'an intermittent drizzle of malignant robots [that] seemed harder to bear than the storm and thunder of the Blitz.'[22] Blitz Collier notes that ground-based electronic counter measures were established to jam 'control beams' that had been postulated, but were never employed.[23]

In the meantime, arguments still raged in London over the possible size of the warhead and, in July 1944, the Home Secretary Herbert Morrison urged the War Cabinet to commence the evacuation of one million people from London and the provision of over 100,000 'Morrison' table shelters. His Ministry estimated over 100,000 fatalities a month and, in August 1944, evacuations from London commenced.[24] Fortunately, a stream of intelligence derived from documents and prisoners captured in France independently confirmed that the warhead was about one ton, and *not* ten tons as was previously assumed.[25] Advancing Allied troops in northern France had discovered a number of sites, and as Hill noted, these did not resemble the 'large sites' but were merely rough concrete slabs.[26] But by August 1944 Jones had refined the rocket model and through intelligence – principally photographic intelligence and by

examining the remains of two A4s: one crashed in Sweden and recovered by the British Air Attaché, and another that had been launched from Blizna and fell in Poland and heroically smuggled back to Britain by the Polish Home Army. Jones and his team determined the size of the warhead and deduced that no special launch facilities were needed apart from a small concrete launch pad to hold the launch table and missile upright and the distinctive 'lemon squeezer' blast deflector, which sat underneath it; the latter two items had been identified on test stands in Peenemünde by photographic reconnaissance.

Contrary to intelligence reports reiterating the extant threat, but rather based on the assurance from the Chiefs of Staff that the tactical situation meant that there were no suitable launching sites left from where missiles could reach London, on 7 September 1944 Duncan Sandys felt comfortable enough to dismiss a large-scale attack. Five weeks before the JIC had outlined the continuing threat of attack in a Top Secret report:

> "We have no physical reasons preventing the launching of BIGBEN in the immediate future. It may well be that about a thousand of these rockets exist."[27]

The report detailed the training of personnel, launch procedures, the availability of liquid oxygen, anti-aircraft protection for storage and launch sites, and citing a 'senior source' (probably an ULTRA decrypt), that launches against Britain would start in 'mid-September [1944]'. Dornberger, separately, reported that a bombardment campaign would not start until September. Just two weeks before the V-2 campaign was launched – and Duncan Sandys' premature declaration of victory, the Security Service's (MI5) Deputy Director General, Guy Liddell (1892-1958) expressed his grave concern about the imminent V-2 campaign and suggested to the Chief of SIS (MI6) 'C', (Sir Stuart Menzies) that:

> "the uranium [atomic] bomb…be used as a threat of retaliation to the Germans if they used the V.2. 'C' said that he had no reason to think the V.2 was imminent although it was possible to think that it might start in the near future."

Menzies agreed to put the suggestion to the Prime Minister, Sir Winston Churchill, but his reply is not recorded.[28] At any rate, the British TUBE ALLOYS project (which, by now, had combined resources with the US Project MANHATTEN) to develop nuclear weapons was still eight years away from delivering a working British device and the decision to construct a viable warhead was not made until 1947.

Coupled with the worsening operational situation and with little faith in the invulnerability of monumental static launch sites so favoured by Hitler, by August 1944 von Braun and General Dornberger developed mobile Transporter-Erector-Launcher (TEL) convoys (*Miellerwagen*) which were easily camouflaged and practically impossible to locate. Now V-2s could be launched from any piece of open ground, although the movement and storage of the rockets proved to be difficult under the chaotic wartime conditions.[29] As observed 14 years later by

Constance Babbington-Smith, a senior RAF Photographic Interpreter who first identified the V-2 on its launch stand at Peenemünde, "General Dornberger's almost ridiculously simple concept of how the V-2s should be launched defeated Allied photographic reconnaissance."[30]

There was fierce debate in secret over whether to warn the public about V-2 attacks. However, the inaccuracy of the rockets, coupled with the limited warning time raised concerns that the public would soon lose confidence in false alarms. The Home Secretary believed that this would erode public confidence in the system; conversely, given the little warning time, public panic could result in chaos and injuries as people rushed to enter deep shelters. A missile attack warning system was developed with clusters of maroons (signal rockets) positioned across London and the south east of England that would be fired to alert of an impending attack. This, in turn, was the resurrection of an air raid alarm system that was belatedly introduced in London in July 1917, in response to Zeppelin and Gotha bombing raids on the capital.[31] However, the performance of the V-2 was so erratic (operational analysis showed that 50% fell within a 200 square mile/16 x13 mile box) that alerts would be vague and, furthermore, by the time the semi-automated system was activated, the public would have little time to react and public and private shelters offered scant protection in the event of a direct hit.[32] Morrison's other major concern was the event of a missile breaching the underground rail network, leading to extensive flooding and inevitable loss of life, as thousands of people were continuing to spend their nights in the deep tunnels because of the V-1 bombardment. Transport planners anticipated that up to 57 miles of tunnels of the Underground rail network would be inundated at a speed of 15 mph/24 km/h if the tunnels at Charing Cross or London Bridge were breached.[33] On receipt of a radar report of a V-2 launch, ADGB Headquarters at RAF Bentley Priory in Stanmore would alert the London Passenger Transport Board of an impending attack and the Board would remotely close water-tight doors on the underground network.[34]

General Sir Frederick Pile, commanding Anti-Aircraft Command and serving under Hill, proposed on a number of occasions a 'wall of lead' to disrupt the warheads during the terminal phase of flight. Scientific estimates of the number the number of shells, and therefore the number of AA guns, needed to fill the radar-predicted airspace varied widely and the proposal was eventually dropped as the V-2 campaign ended, but it should be remembered as the first attempt to develop an anti-ballistic missile system.[35]

The Deceptive Role of Intelligence

Intelligence was not only essential to understanding the V-2 and the impact it might have, it was also key to defeating it. MI6 and MI5 devised a complex and highly sensitive deception plan under the jointly-run Twenty or 'XX' Committee.[36] In this plan, 'turned' Nazi agents broadcasted false reports on the impact points and exaggerated the accuracy of the attacks, resulting in the mean point of impact being shifted away from central London, as had been done during the V-1 campaign. The plan also relied on the British press not publishing the rocket attacks in any detail, hence the need for initial official silence about the attacks.

The Ministry of Home Security assessed that a further 1,300 people would have died and a further 10,000 injured if the mean point of impact had not been moved from central London through an elaborate deception plan.[37] In a 1951 interview in the *New Yorker* magazine, von Braun described his unexpectedly pleasant treatment by the British during his visit to London in September 1945.[38] Demonstrating the on-going secrecy of the deception plan, when confronted by the damage caused in parts of London by the V-2, his only concern was the fate of the German agents who radioed damage reports back to the *Abwehr* (German military intelligence) who passed it on battery commanders and to von Braun. The range of the missiles were then adjusted by altering the burn rate and fuel cut-off of the engines, as well as setting the gyros used to tip the missiles, directly under the guidance of von Braun and his team. Even in 1951, he was unaware that all Nazi agents in Britain had been captured, imprisoned, been 'turned' or executed. This deception plan remained secret until the 1970s.

The RAF takes the Battle to the V-2

V-2 convoys were elusive yet vulnerable if caught in the open but attacking them presented Air Chief Marshal Hill organisational challenges. As part of the restructuring of Allied commands ahead of the invasion of Europe ('OVERLORD'), Fighter Command had reverted to the pre-war title of ADGB in late 1943 and was under the aegis of the Allied Expeditionary Air Force, commanded by Air Chief Marshal Sir Trafford Leigh-Mallory, who reported directly to the Supreme Allied Commander, General Eisenhower. ADGB, in addition to defending Britain's airspace against conventional attack, was tasked to provide air defence over Allied forces when they landed in France, as well as preparing for the expected V-1 attacks. Hill had at his disposal Anti-Aircraft and Balloon Commands, as well as fighter aircraft from Nos 11, 12 and 13 Groups. As the V-1 campaign began in June 1944 (just as OVERLORD landings commenced in Normandy), despite many requests, Hill was unable to draw fully on either the additional resources of Bomber Command or the Second Tactical Air Force to attack possible V-2 launch locations, as both formations had their own target priorities supporting OVERLORD, such as providing close air support to allied forces, paralysing the French rail network as well continuing the strategic bombing offensive. Hill also described his relationship with Air Chief Marshal Sir Arthur Harris, Air Officer Commanding-in-Chief Bomber Command, as being 'less than to be desired', which may have influenced the outcome of ADGB's request for heavy bombers. Hill, instead, relied on several groups of fighter-bombers assigned to ADGB, (Spitfires, Tempests and Typhoons) engaged in armed reconnaissance which could be tasked to reconnoitre possible V-1 and V-2 launching sites and attack targets of opportunity. However, the ongoing strategic bombing offensive across Germany would have had a major disrupting effect on missile production and distribution, as well as a second order effect on fuel and liquid oxygen production.

By mid-September 1944, it was clear that the V-2s were being launched from built-up areas in The Hague, so to minimise civilian casualties (and after consultation with the Dutch Government in Exile), his fighter-bombers practised accurate dive bombing in order to attack convoys and complexes believed to house missiles, equipment and personnel. They would be

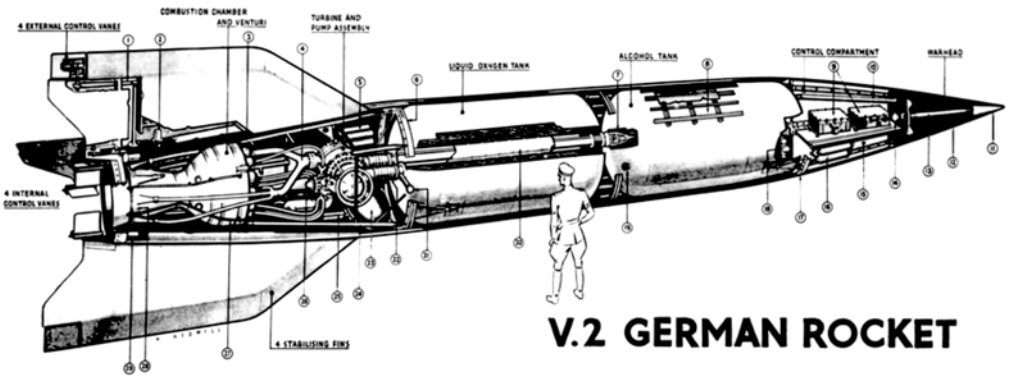
vectored on to possible locations based on radar plotting from a Royal Artillery Mobile Air Reporting Unit, and more frequently, by reports from Dutch operatives. But these attacks only had a limited, short-term effect; targeting was switched to the local rail network and possible storage areas which had a greater, long-term impact. Collier noted that on 7 March 1945 the "German Rocket Organisation in Holland reported its casualties since air attacks began as 51 dead, 117 wounded, and 58 lorries and cars, 11 oxygen-trucks and 48 missiles damaged."[39] Hill also sought assistance from 100 Group RAF, who flew electronic intelligence gathering missions up and down the Channel, with Hill's fighters escorting, in a vain effort to detect both 'control beams' and radio guidance to the rockets.[40] Post-war analysis showed that no such methods of guidance existed, although Dornberger acknowledged that unsuccessful attempts had been made to incorporate such control systems and that a remote guidance system had been installed in an A4 that fell in Sweden and was subsequently recovered to England.[41] This led investigators, including Jones, to conclude that remote guidance would be used.

Allied advances in the Low Countries in March 1945 forced Kammler to withdraw the V-2 batteries eastwards into Germany, where they were then broken up and personnel dispersed. From March 1945 the threat rapidly diminished. A JIC report of 23 April 1945 examining the continued threat posed by V-weapons, pointed out that as "V-weapons were produced in widely dispersed areas, many of which we have overrun…we do not believe that the enemy will be able to continue production on any considerable scale. Moreover, the provision of fuel would be extremely difficult."[42]

The Campaign – and the Costs

> *There is no siren warning now. No time to take shelter, for this is the most indiscriminate weapon of this or any other war. It is a sinister, eerie form of war.'*
>
> Daily Herald, London, January 1945.

The A4 was 46 feet (14 m) high, vertically launched single-stage liquid-fuelled rocket, with the production variant weighing 12.65 tons (12.85 tonnes), with a one ton/tonne (nominal) warhead, although this was later reduced to 1,650 lbs (750 kg). Maximum range of its ballistic trajectory was about 220 miles (350 km). Monthly production was 300 in May 1944 rising to 616 between September 1944 and March 1945, with a total of circa 6,000 launch bodies produced. Apogee (top of trajectory) was 38 to 60 miles (60 - 96 km) and achieved a maximum speed of up to 3,600 mph (1,600 m/s; 5,800 km/h) and due to atmospheric friction dropping to between 2,200-2,500 mph on impact. The missiles used an early two-dimensional gyroscopic stabilised inertial navigation system, that also fed the stability system. Fuel cut-off, and therefore trajectory and range, was pre-programmed although later (but unsuccessful) attempts of radio control were made. The rocket incorporated most of the design features that are seen in ballistic missiles of today.



Cutaway drawing of a German V.2 rocket. Air Ministry Collection, courtesy of Imperial War Museum. © IWM (C 4832)

Ruined flats in Limehouse, East London. Hughes Mansions, Vallance Road, following the explosion of the last German V-2 rocket to fall on Greater London, 27 March 1945. Courtesy of Imperial War Museum © IWM (HU 88803)

Chinatown (Limehouse, East London) V-2 combustion chamber and venturi which separated from missile on impact. March 1945. http://www.wikiwand.com/en/Limehouse_Causeway

German records show that up until 7 April 1945, 1,190 V-2s were launched against Britain (with a further 169 failures) with 501 of those falling on Greater London. However, the first operational launch was against Paris, on the morning of 7 September 1944, but batteries then withdrew as Allied troops advanced. Antwerp was the target for 1,610 V-2s.[43] Casualty figures vary slightly, but according to British Ministry of Home Security reports, 2,754 civilians were killed in Britain by V-2 attacks with another 6,523 injured. The single largest loss of life in the UK was on 25 November 1944 and saw 160 killed, with a further 108 seriously injured when a Woolworth's department store on New Cross Road in south London was hit. In greater Antwerp, missile attacks between October 1944 and March 1945 left 1,736 dead and 4,500 injured. Thousands of buildings were damaged or destroyed as the city was struck by 590 direct hits. The largest loss of life occurred on 16 December 1944, when the roof of a crowded cinema was struck, leaving 567 dead and 291 injured. The German offensive came to an end at 1645 hours on the 27 March 1945, when the last rocket fell to earth at Orpington, in Kent, with one fatality. The campaign had lasted seven months.[44]

Although the V-2 was a technical triumph over Allied developments and despite the terror imparted and the casualties inflicted, the V-2 had no demonstrable impact on the outcome

of the war. Indeed, the expense and scope of the programme diverted resources from conventional weapons production, such as fighter aircraft and surface-to-air missile systems. Furthermore, the synthetic fuel for the rocket required 30 tons of potatoes to distil one ton of alcohol, at a time of chronic food shortages in Germany. The relatively small warhead and a lack of a proximity fuse (to permit a more effective 'air burst') compared unfavourably with the mass effect of conventional bombing. The V-2, delivering a one tonne/ton warhead per missile was set against the Combined Bomber Offensive that could deliver *thousands* of tons of bombs every day – with considerably greater accuracy and effect. Even during the London *Blitz* (October 1940-May 1941), the *Luftwaffe* dropped over 35,000 tons of bombs in 70 separate attacks, equating to some 35,000 V-2 attacks. However, contemporary accounts of the V-2 'Blitz' in London graphically illustrate the fear, horror and destruction these weapons engendered. There was no public warning of their approach thus many casualties were civilians in the open who were unable to seek shelter, and a one ton warhead, travelling at between 2-3,000 mph created massive destruction, albeit localised (because of the deep crater), with the attendant shockwaves creating widespread structural and shock wave damage.[45]

Long-Range Rocket Development

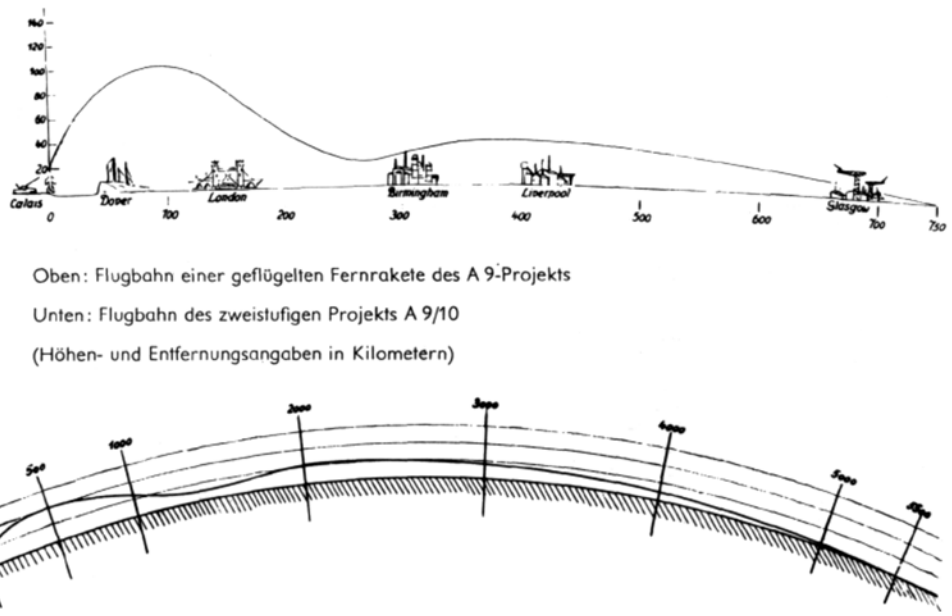
Greater Mobility. Towards the end of the war, even more radical – some might say desperate – weapons were considered by Dornberger, von Braun and their staff, reflecting the changing fortunes of war and Allied air superiority. One proposal – code-named Test Stand XII – envisaged V-2s being launched against New York City and Washington DC from U-boat-towed submersible canisters. In 1943, the *Kriegsmarine* conducted experiments towing up to three 100 ft/30 m long cigar-shaped submersible containers. Dornberger claimed that Bodo Lafferenz (1897-1974), Head of the Institute for Physical Research, visited Peenemünde in autumn 1943 and urged that they examine the possibility of launching the A4 from these floats, with the obvious strategic impact that this development would have.[46] Experiments had been conducted from the decks of submerged submarines (at a depth of between 30-50 feet/10-15 m) firing short-range *Nebelwerfer* solid-fuel rockets.[47] These tests in 1942 had been successful, though never deployed operationally because of the adverse effect on submarine performance and increased acoustic signature underwater caused by the on-deck structures. Further research at Peenemünde determined that a submarine could tow three V-2 missiles in floats - at a total weight of 500 tons - for 30 days at 12 knots. On arrival at the launch area, the canisters would be partially flooded to a vertical position, the gyro-stabilised missiles fuelled (the fuel was apparently to be carried in these cannisters) and then launched. Dornberger anticipated no major problems and he thought the work was promising; however, missile reliability in general (principally premature bursting of warheads)[48] delayed further work on this concept. There are no references to how liquid oxygen would be carried or produced for the missiles, given that LOX evaporates from storage very rapidly; perhaps Dornberger did not include this in his account given that both the US and USSR were attempting to develop submarine-launched missiles, and this would have been a key technical advantage.[49] Research recommenced in November 1944, but the progressive evacuation of personnel,

equipment and records from Peenemünde to Upper Bavaria from February 1945, ahead of the Russian advance, stopped further development.[50]

At about the same time, German agents captured in the US revealed under interrogation a supposed plan to deploy V-1 flying bombs from submarines against US East Coast targets; in early 1945, the US Navy launched Operation TEARDROP to counter this technically ambitious yet mythical threat, which had previously been discounted by the JIC in London.[51]

Work had been underway until 1942 to launch the V-2 from special railway wagons, envisaging missiles being prepared for launch in tunnels and then being wheeled out and erected on firing tables clamped on to the tracks. Greater cross-country mobility of the *Meillerwagen* Transporter-Erector-Launcher convoys and the inherent vulnerability of the rail network stopped development, but in late 1944 Kammler resurrected it. Dornberger claimed that he went about the work half-heartedly and the programme was abandoned in January 1945, but not before dry-firing trials from special trains took place.[52]

Greater Range. Despite the many setbacks developing a working A4/V-2 missile, von Braun's team had two research strands to increase the range of the A4. One test launch of an A4 reached an apogee of 118 miles/190 km, according to Dornberger, with a scaled increase of range anticipated. Documents and photographs held by US National Aeronautics and Space Administration (NASA), show wings were fitted to the A4, creating the A9 (sometimes designated the A4b) which had an extended range of 500 miles/800 km, with the same one ton



Oben: Flugbahn einer geflügelten Fernrakete des A 9-Projekts

Unten: Flugbahn des zweistufigen Projekts A 9/10

(Höhen- und Entfernungsangaben in Kilometern)

Captured diagram of potential ranges of the A9 and A10 rockets. Courtesy of NASA Historical Office.[53]

warhead. Work had commenced 1940 but ceased in 1943 because of ongoing problems with the A4, but demand for greater range from rockets caused by the deteriorating war situation saw work recommence in January 1945. After one unsuccessful launch, Dornberger reported that on 24 January 145 a swept-wing A4b (A9) with a wing area of 145 square feet/13.3 m² reached an apogee of 50 miles/80 km at 2,700 mph/4,350 km/h. The missile levelled out on the upper edge of the stratosphere at 12-16 miles/19-26 km and flew in a controlled glide, until a wing failed. A captured diagram shows the missile trajectory over the UK and landing just beyond Glasgow.

The final wartime research programme that got underway was the A10, a winged two-stage rocket that *could* have had trans-Atlantic reach of 3,500 miles/5,600 km, taking about 40 minutes to cross the Atlantic. The theoretical design consisted of an A9 carried by a booster with a projected all up weight of 100 tons/tonnes, with an engine delivering 200 tons/tonnes thrust (compared with a mere 25 tons/tonnes of the A4/V-2). The overall height was to be almost twice as high as the V-2 at over 80 feet/26 m but with only a one ton/tonne warhead.[54] As with the A9, there was insufficient time or resources to develop the concept further. Dornberger commented in 1952 on these developments, noting that "we had taken a long stride forward in developing the first intermediate stage preceding the space ship." He also tantalisingly referred to discussions in 1943 with the leading nuclear physicist Professor Werner Heisenberg (1901-1974) on the use of "atomic energy for rocket propulsion" but Heisenberg was uncertain.[55] Another proposal – which has captured the imagination of fantasists - was preliminary research commenced under the orders of Hitler on a 'ten ton' warhead rocket, nicknamed '*Amerika-raket*' – an order of magnitude bigger that those missiles in service. This theoretical work was also carried out in Oberammergau just prior to American forces overrunning the area.[56]

End of the War

As Russian forces swept into Germany in early 1945, von Braun and Dornberger gathered up 400-500 of their key technicians and engineers, and with their families made their way in stages to barracks in the Upper Bavarian town of Oberammergau by 1 April 1945, under the direction of Kammler.[57] Once established at the 'Upper Bavarian Research Centre', run by the Messerschmitt Aircraft Company (and now the site of the NATO School Oberammergau), his team were engaged on 'make work' tasks and conceptual development – such as the A10 multi-stage rocket - to keep them occupied. von Braun's team also evacuated a reported 16 tons of A4 reports, designs and other documentation from Peenemünde, hiding this archive in another disused mine north of Nordhausen before they moved to Oberammergau. Key research equipment, such as the Peenemünde supersonic wind tunnel, had been moved to a small lake resort town 20 km east of Oberammergau, where there was a hydroelectric plant that could have powered it.[58]

Von Braun was well-known in the nascent rocketry circles in the US and the UK, and secret British Air Ministry Technical Intelligence Summaries from 1943 onwards frequently referred

to 'Herr von Braun's' work on ballistic missiles, including references to the hitherto unknown launch of V-2s in late 1943 against Russian targets (although this probably referred to test launches from Blizna, in Poland).[59] von Braun was detained near the Austrian border on 2 May 1945 by US Counter-Intelligence Command (CIC) personnel and taken to Garmisch-Partenkirchen via Oberammergau in what was probably a pre-arranged event.[60] He was treated as a celebrity; in return, he later claimed to have hosted a champagne-fuelled party for his captors at his mountain retreat.[61]

Exploiting the Technology

Allied Tensions. As the V-weapon threat developed, one of the dilemmas facing BODYLINE was what information Britain should share with the Americans about the Nazi long-range rocket programme. In a JIC report of 26 October 1943, the opening paragraph made an appeal:

> "We feel that it is becoming necessary for a ruling to be given as to what information regarding our knowledge of German long-range rockets should be disclosed to the Americans, and by whom."[62]

The report pointed out that US scientists had been consulted by BODYLINE scientists (such as the potential of liquid-fuelled rockets) and that there had been inadvertent leakage from British personnel working alongside US staff; moreover, the US Army Air Force had carried out attacks against 'heavy sites' in France. It was agreed that each Service intelligence chief would brief orally their opposite number, and the respective service attachés in London would be informed by the permanent chairman of BODYLINE, Commander Ian Fleming RNVR. At the same time, although allied military cooperation was increasing, there was the concern of what to tell the Soviet Union. The advances on the Eastern Front meant that Soviet forces would soon encounter A4 test ranges and facilities. RV Jones minuted the Chief of the Air Staff, Air Chief Marshal Sir Charles Portal, recommending that Air Intelligence Officers should be sent to the range at Blizna, and as it was of such importance, Churchill should make a personal approach to Stalin. Stalin agreed in a letter of 25 July 1944, but at that point numerous bureaucratic obstacles were put in the way of the team by the Soviets. Blizna (also referred to as Dębica) was taken by Soviet forces on 6 August 1944 and their scientific teams scoured the site for material of intelligence value. The British team travelled via Teheran but, with visa delays and illness, they were unable to arrive at Blizna until about 20 September. Although the site was well-picked over, the team found and identified a number of components and impressed the Russians who accompanied them with their knowledge on guided missiles. However, crates of salvaged equipment were delayed en-route; when the cases were opened at Farnborough, the contents had been substituted with old aircraft parts.[63]

A curious report of the JIC sub-committee dated 6 February 1945 revealed a personal offer from a Soviet colonel to arrange for an Allied team to investigate the main research site at Peenemünde, once Soviet troops overran it. The colonel had assisted the "Anglo-American team working on the experimental rocket site in Poland [Blizna] last summer [and] had been

very impressed by the ability of some of the team members. The colonel had offered to facilitate a similar event in the future if he was approached direct." The sub-committee agreed that Assistant Chief of the Air Staff (Intelligence) would write the Head of the British Mission in Moscow, Admiral Ernest Archer, who in turn would write to the colonel and accept this offer.[64] As an aside, present at the meeting and representing MI5 was Major Anthony Blunt (1907-1983). Blunt was an officer in the Intelligence Corps but had been recruited as a Soviet agent in 1937 and was one of the five members of the infamous Cambridge Spy Ring. It is highly likely that Blunt would have passed this information to his Soviet handlers.[65] In any event, the Russians did not allow access to the Americans or the British when Peenemünde fell to the Russians in May 1945.

The Race for Space Scientists. From 1944, British and American planners sought to exploit after the war German technological advances across all fields resulting in the Combined Intelligence Objectives Sub-Committee (CIOS) set up between the US and the British Chiefs of Staff Committees. CIOS also prepared lists of what scientific and industrial intelligence would be shared with the Soviet Union. The British Intelligence Objectives Sub-Committee (BIOS) identified a bewildering range of industrial and scientific intelligence objectives for exploitation on a national basis. To collect this military-industrial technology, an *ad-hoc* organisation of regular army units was established to escort civilian experts, known as 'Investigators', to seize archives, equipment and personnel on a 'Black List' of prioritised targets. Commander Fleming – chairman of the BODYLINE committee - had been the driving force behind the Royal Navy's 30 Assault Unit (30AU) technical intelligence and exploitation team which had operated successfully in the Mediterranean and during the early stages of Operation OVERLORD. Fleming's team was the inspiration for T-Force, which was subsequently developed and directed by BIOS, and commenced work in early 1945. T-Force consisted of several infantry battalions, with Royal Engineer bomb disposal experts and extensive transport support, together escorting teams of civilian 'Investigators' and searched for equipment, archives and personnel. T-Force moved with the front-line and gathered material as they went; on some occasions, T-Force personnel engaged in combat as they got ahead of friendly troops, most notably accepting the surrender of the *Wehrmacht* and *Kriegsmarine* garrisons in Hamburg![66]

What were the British Prizes? In the British Zone, there were two great technical prizes. One was the *Walterwerk* complex near Hamburg. Here, under the mercurial engineer Dr Hellmuth Walter (1900-1980), air-independent propulsion systems were developed, principally for the *Kriegsmarine*, such as hydrogen peroxide-powered torpedoes and submarines, but also the turbo-pumps needed to deliver 50 gallons/225 litres of fuel per second into the V-2 combustion chamber. The second great capture was the *Luftfarhtforschungsanstalt Hermann Göring* (Hermann Göring Aeronautical Research Institute), four miles west of Brunswick. Ben Lockspeiser (1891 -1990), Director-General of Scientific Research at the UK's Ministry of Aircraft Production, after visiting the institute (which was a collection of semi-autonomous research establishments), described what he found:

> Aerodynamic, supersonic and high-speed equipment is far ahead of anything in this country…it is probably true to say that in several directions the technical equipment … is unsurpassed anywhere.[67]

He immediately requested a team be sent to Völkenrode to secure the site, equipment and personnel. Lockspeiser and his team realised the vital importance of swept-back wings for supersonic flight. This led him to cancel the UK's first supersonic experimental aircraft project, the straight-wing Miles M.52. According to his 1993 obituary, he was much criticized for this decision as he had been earlier castigated for placing the contract with the Miles Aircraft Company in 1943.[68] Scientists at Völkenrode, and indeed on other research and development sites, were immediately re-engaged in completing their research work and writing up their results in scientific monologues. Most, it seems, were happy to do this as it temporarily guaranteed food and safety for themselves and their families.

Meanwhile, after his capture von Braun was questioned at length at Garmisch about the rocket programme and his National Socialist beliefs by US officers, as well as personnel from the CIOS. On 15 May 1945, von Braun wrote a futuristic report for British investigators, led by Dr William Cook, outlining his aspiration for larger, multi-stage, longer-range, crewed and reusable rockets that could orbit the Earth.[69] Dr Cook (1905-1987), who was appointed in 1940 as Deputy Controller of the British Rocket Projectile Establishment under Sir Alwyn Crow (1894-1965), had agreed with Professor Lindemann in 1943 that a liquid-fuelled missile as proposed by RV Jones was impractical and a solid-propellant rocket would be unfeasibly large. Perhaps still influenced by this prejudice, Dr Cook seems to have reported little of what von Braun had said under interrogation. On 17 June 1945, von Braun was taken back to Nordhausen to locate other members of his team and to recover what equipment they could from the site before it was due to be handed over to Soviet forces. In addition to the archives, over 6,500 tons of equipment, including components to assemble 75 V-2 rockets, were to be shipped to the US.[70]

Von Braun and several of his colleagues were also taken to London for two weeks in September 1945 for further questioning by Ministry of Supply and JIC officials. Sir Alwyn Crow, who also doubted the viability and future of ballistic missiles, interviewed von Braun and reportedly made a half-hearted attempt to recruit him, which von Braun did not accept.[71] Unfortunately, no detailed records of his interviews in London have been found. When he was taken to an impact site in south London, for the first time von Braun was confronted with the damage that V-2s had caused. His observations were of a technical nature and he expressed frustration that debris had been cleared from one site and thus he could not get an accurate impression of the damage the warhead had caused. He seemed to demonstrate little remorse or emotion; this lack of emotion was also noted by von Braun's interrogators in Garmisch.[72] Although not mentioned in biographies of von Braun, during this period it appears that he was also taken to the Hermann Göring Aeronautical Research Institute at Völkenrode, and possibly to Cuxhaven, south of Hamburg. He demonstrated the potency of the A4 turbo pump steam

generation components (potassium permanganate and hydrogen peroxide), which had been developed at *Walterwerk*, to British T-Force staff, who subsequently reported on this meeting.[73]

At the end of July 1945, approval was given by the US War Department under Operation OVERCAST (later renamed Operation PAPERCLIP) for von Braun and 350 other scientists, engineers and technicians to be moved to the US and re-commence the development of V weapons for use against Japan. It appears that about 125 of his team in Oberammergau were selected, probably on von Braun's advice, to travel to the US.[74]

Von Braun was to enjoy celebrity status in the United States as a rising star in the National Advisory Committee for Aeronautics (NACA), culminating on leading the Apollo programme, which landed men on the moon in 1969. The US Authorities, although aware of his Nazi party and SS membership (he had been promoted to SS-Sturmbannfuhrer (Major) in June 1943), quietly ignored his background, and accepted his explanation of membership of both organisations 'as a political necessity' and he was granted US citizenship in 1955. He was last investigated about his Nazi links by the Federal Bureau of Investigation in 1971 and in recent years evidence has emerged of his complicity in the thousands of deaths of slave labourers by starvation, execution and ill-treatment at *Mittelbau-Dora*, forever damaging his reputation as the twentieth century's preeminent space scientist.[75]

Operation BACKFIRE

BACKFIRE was a British plan but authorised in June 1945 by General Eisenhower as Supreme Allied Commander, to test-launch captured V-2s. Under the War Office's Special Projectiles Operations Group, between July and October 1945, 30 unarmed launches were planned to take place at the Ministry of Supply (MOS) Establishment, Cuxhaven (MOSEC), south west of Hamburg. The War Office commented in the official account of the launches:

> [Backfire] might save years of development work, and…it was agreed that the launching and control of rockets was a complicated operation which it was necessary for the German technicians to demonstrate in the near future before they lost their skill.[76]

T-Force were tasked to locate V-2 components, documentation, support vehicles, equipment and technical personnel across the British and US sectors. This took longer than expected and many of the rocket components had been hidden, suffered from poor assembly, looting and corrosion from many months of open storage.[77] US authorities, who had earlier stripped *Mittelwerk* in Nordhausen of most of its useful equipment, delivered the British 640 tons of components by rail. The volatile hydrogen peroxide, used to produce steam for the turbine that drove the fuel pumps, was conveyed from the *Walterwerk* site near Hamburg.

Around 570 German personnel were employed to prepare and launch the rockets. However, competition with US authorities had made assembling the group more difficult. About 130 of the staff had practical experience of launching rockets and another 85 were

scientists or engineers who had worked at Peenemünde.[78] The first launch took place on 1 October 1945, but was regarded as a failure, but on 2 October a successful launch over the North Sea was made. A final launch, captured on film by the Army Directorate of Kinematography, took place on 15 October in front of a large Allied audience of senior officers. The film covers the whole process from receiving the rocket from the factory by rail, through its transportation to the technical storage site, preparation and transfer to the *Meillerwagon* TEL, erection on the launch pad, fuelling and the launch. The work was done by German personnel, still in uniform, but under the watchful eyes of the British soldiers, generally standing at a discreet distance.[79] Adverse weather and deteriorating components saw the operation draw to a premature close. The BACKFIRE project was summarised in a five-volume secret technical report and, after the test launches, the remaining equipment and five assembled rockets were shipped to the UK. The BACKFIRE reports noted that the V-2 heralded a new type of warfare, but only if the rocket was able to deliver an 'atomic' warhead to mitigate errors in accuracy.

BACKFIRE: A German V2 rocket at the moment of launch during British tests in Germany, 10 October 1945.
Courtesy of Imperial War Museum. © IWM (BU 11149)

Most of the German workers returned to a US internment camp Garmisch, with a number of them then recruited to work in the US or France. Fifty Germans were retained on site after the launches, but the MOS made it clear that no UK-based employment contracts would be offered. MOSEC wound up on 1 May 1946; in a reversal six days later, the MOS offered 15 contracts, but in most cases the team had dispersed: six joined the French programme, two refused the offer, two couldn't be found, one went to the USSR and only two readily went to the UK, joined by another two who had initially agreed to join the French. General Dornberger also assisted in the test launches, but instead of being welcomed to the UK, he was still held as a Prisoner of War (POW). He was transferred from Garmisch and detained at Farm Hall and Wilton Park detention centres in England, both special camps for senior German officers and scientists thought to be associated with the German nuclear programme. He was interrogated by the British War Crimes Investigation Unit and then held in a POW camp in Bridgend, Wales and not, it seems, offered employment. British and US

investigators were particularly concerned that the Nazi regime had hidden nuclear material and had developed nuclear warheads for the V-2 and went to great lengths to find out whether this was the case, under Operation EPSILON.[80] Coincidentally, cubes of uranium isotopes – part of a nascent Nazi nuclear weapons programme - were recovered by US forces in the river adjacent to the barracks in Garmisch, where both Dornberger and von Braun were initially held by US forces.[81] In 1947 Dornberger travelled to the US, ultimately ending up working for the Boeing Aircraft Corporation, and died in Germany in relative obscurity in 1980.

Another Ministry of Supply establishment was set up at Trauen, on the site of the former *Sänger Raketentechnische Forschungsinstitut* (Sänger Rocket Technology Institute) German scientists from *Walterwerk*, Peenemünde and Trauen were assembled there and conducted research into oxidising rocket fuels, producing reports that were subsequently published by the Royal Aircraft Establishment (RAE) at Farnborough.

By the time T-Force was wound up in 1947, it had seized huge quantities of documentation and equipment, which was shipped back to the UK. By the end of the removal phase, over 14,000 tons of equipment was removed to Britain, along with 4,600 volumes of aerospace research from Völkerode and 3,300 reports from the Focke-Wulf library. Anecdotally, it seems much of it was never exploited and was progressively destroyed in the 1950s. Amongst this equipment was a large number of high-speed, high-altitude test facilities which eclipsed anything available in Britain or the US. Most of these were delivered to the new RAE research centre at Bedford.

The Russian Dilemma

By early 1945, there was considerable hand-wringing in bureaucratic circles about the exploitation of German technologies and its proponents. BIOS noted the technological advantages that German industry and science offered, but there were equal concerns about the 'remunerated employment of ex-enemy aliens' and security aspects of employing former adversaries. The Deputy Chiefs of Staff Committee (DCOS) established in April 1945 Operation SURGEON, under which hundreds of scientists and engineers were held by the British and interrogated about their technical knowledge and their Nazi party affiliations. Yet, those who encountered the Germans – both British and American – noted a willingness to continue their research and work for the West. As the European war ended, the actions of US and British authorities were increasingly concerned with denying scientific knowledge and novel military technologies to the Russians, although this did not appear to become official British policy until December 1946.[82] However, a decision to actively employ 'alien scientists' in the UK was not made by DCOS until 31 August 1945, thus almost four months were lost after VE Day, during which many personnel were recruited by the US, USSR or France. Contrary to popular belief, although millions of German nationals streamed West, justifiably fearing occupation by the Red Army, many scientists willingly accepted very lucrative offers made by the Soviets, who were prepared to overlook previous Nazi affiliations.[83] This caused concern in Whitehall, as revealed by the JIC minutes of early 1946 regarding the disposal of

German scientists, based on the British interrogation of three naval scientists at 'DUSTBIN', the British interrogation and processing centre for senior Nazi officials and scientists detained under SURGEON. Three scientists were questioned by staff from the Directorate of Naval Intelligence attached to the British Naval Gunnery Mission. They were asked about scientists being transferred to the Soviet Union and they claimed that the Russians wanted all German scientists and technicians to work for them:

> "[The Soviets] Employed the Germans regardless of their political creed or antecedents and have placed them in positions of high authority with the right to issue orders to their Russian subordinates. Russians offer enormous monetary attractions in addition to houses and food on the most luxurious scale to the Germans who they need."
>
> "Experts in V weapons are among those whose services the Russians are anxious to acquire…The common belief in England that Russia will have its hands full with reconstruction is incorrect…the low standard of life for Germans in the American Zone and the absence of any unified Anglo-American policy will prove an inducement for the German scientists to seek service under the Russians."

The paper acknowledged that the US had first pick on scientists, and the UK second, but that the Russians were targeting scientists in the UK and US sectors of occupied Germany, as were the French. An 'atomic physicist', Dr Albert Joos, also held at DUSTBIN, stated that he was ready to return to the Russian Zone, and that a Soviet mission, led by a General, to recover a small number of Russian 'displaced persons' within the British sector was actively recruiting scientists.[84] In response to this, in January 1946, the JIC suggested policy options for the retention of key German scientists to the Chiefs of Staff:

1. To return to the United Kingdom for employment there.
2. To keep them under permanent detention in the British Zone.
3. To offer the conditions at least as attractive as those of the Russians and hope they will remain in our Zone.

The JIC noted, not surprisingly, that scientists preferred the third option.[85] A report six months later confirmed further Russian recruitment in the British sector.[86]

Progressively, observers both in Germany and London became concerned about the predations of the Soviet Union. The vast majority of experts in the British and American sectors were not well-treated; most were unemployed or misemployed as labourers and on near-starvation rations. A May 1946 letter from the Royal Navy's Flag Officer Schleswig-Holstein, concerning the loss of great technical knowledge, summed up the problem:

> Nine or even six months ago the idea of working for the Russians or going to the Russian Zone was completely abhorrent to virtually every German of any mental

> capacity in the British of American Zones…Many of the ablest scientists and technicians from the Western Zones have already entered the services of the Russians and many more are clearly contemplating doing so in the near future unless future prospects in the British or U.S. spheres improve considerably for them at a very early date. The food situation on the British Zone will undoubtedly accelerate this Russia-ward trend, but it is doubtful whether the prospects of physical starvation weigh heavily with these men as the virtual certainty of mental starvation if they remain in Western Germany.

From December 1946, coinciding with the 'denial' role of British technological exploitation, contracting of German experts began in earnest, but was a mere shadow of the American and Russian programmes. Numbers were low in comparison. By the end of SURGEON, 87 scientists had been contracted to work in the UK, of which 38 were in rocket-related technology areas.

Security Concerns. There was a clear shift in feelings and policy in the immediate aftermath of the War. Whereas there had been an unbridled desire to exploit Nazi technology long before the War finished through CIOS (for the US to potentially use V-1s against Japan), the morality and the security of employing former Nazis was questioned. Within JIC meetings, MI5 expressed obvious concerns about the loyalty of these individuals and the risk that they could return to Germany – or elsewhere – and share their knowledge of sensitive British programmes, and potentially help in covert German rearmament. Moreover, offering 'aliens' (as they became increasingly referred to from 1946) work was problematic. Most scientists in Britain were employed in the public sector across a plethora of civilian-run government research establishments or at universities. Civil Service employment rules specifically forbade 'aliens' from being employed on government work and there was considerable bureaucratic lethargy in having short-term contracts awarded to those scientists who wanted to come to Britain. The contracts were by no-means generous in an austere post-war Britain that was functionally bankrupt, and aliens were paid less than British equivalents and given particularly austere ration books. Those who came to Britain were deliberately separated from their previous colleagues and worked on highly compartmentalised projects. Living conditions could also grim: the Guided Projectile Establishment in Westcott, Buckinghamshire, was typical. Scientists were housed in damp, unheated wooden former-RAF dispersal hutments within a barbed wire enclosure, initially with little freedom of movement. They met hostility amongst the local populace (as recorded against naval scientists in Barrow, Cumbria)[87] yet in work they appeared to integrate well with fellow scientists and engineers.

There was a cultural bias as well, as demonstrated in a report bemoaning the lack of a suitable policy on the employment of aliens on defence work, reiterated in a 1948 report:

> The view of the JIC is that in principle no aliens should be employed on secret defence work unless it is essential to achieve a particular result and no British Subject of comparable ability is available. Aliens are…[an] undoubted security risk."[88]

Referring to an earlier 1947 study on the same subject, the JIC suggested that aliens engaged on defence work could move to less sensitive research-related projects or to "universities in the Dominions", rather than continuing to increase their knowledge of British defence secrets and technical skills that "they could take back to their native country." The report further noted:

> Even if not disloyal most aliens are temperamentally less discreet than British Subjects, while in the UK they tend to mix with and talk freely with their compatriots.

In the same paper, Polish workers were given special attention:

> The employment of Poles on defence work merits special treatment. It is not unfair to say of Poles generally, and particularly of those who are now in the UK that they are **temperamentally unstable**.

Heads of research establishments had voiced their collective concerns about removing key personnel and the damage that this would do to projects but were advised by the JIC to remove them from sensitive posts as soon as practicable. Nonetheless, a January 1947 report noted that of a group of Germans at the *Völkenrode* research facility who were offered contracts 'most had been members of the Nazi Party, but denazification was passed as a mere formality'.[89]

The MI5 warnings mainly came from Lieutenant Colonel Martin Furnival-Jones (1912-1997), later to become Director-General of the Security Service from 1965 to 1972. He may have been echoing concerns less about Nazi sympathies but more of Soviet penetration of the British establishment. Though not well-publicised at the time, MI5 had been active in breaking up Communist 'entryist' cells in pre-war Britain and remained concerned about Communists in senior government and academic positions.[90] Since the early 1940s, there had been an extremely sensitive Anglo-American programme to decrypt Soviet diplomatic traffic – VENONA – and, through this, by around 1947, a very small group of senior personnel within the FBI and MI5 learned of Soviet attempts to penetrate sensitive Western establishments. As an example, Klaus Fuchs (1911-1988) was a German *émigré* to Britain in 1933 and was recruited as a Soviet agent in 1941. He worked on the British TUBE ALLOYS and the American MANHATTAN nuclear weapons projects and felt a moral duty to share the research with the Soviets. Fuchs was unmasked in 1950, although his espionage had been identified several years earlier in VENONA decrypts.[91]

There was particular sensitivity around the pioneering technology of the V-2 and its accuracy. In a 1946 Top Secret report, a JIC sub-committee recommended that the time and date of particular V-2 falls of shot remained secret:

> "It is known that experiments in V-1 and V-2 weapons are being carried out by a certain Power [USSR] using captured equipment, and possibly, German personnel. It is,

> therefore, important that no information which might assist these experiments should be released."

In referring to the elaborate deception 'XX' plan run jointly by MI5 and MI6:

> "Certain measures were taken during the V-2 attacks to deceive the enemy as to the results of his firings. To conceal the fact that a cover plan was used, it would be necessary to avoid any publication of details which might be a link to a particular shot fired with a particular fall of shot marked [on an unclassified map]."[92]

Contribution to Astronautics

About 38 rocket scientists travelled to Britain between the end of 1945 and 1948.[93] Most were offered either a six- or twelve-month initial contracts to work in supernumerary appointments in government research establishments. They were split up between four main sites: the former *Walterwerk* staff went to Admiralty Department Establishment Barrow (ADEB), via Vickers-Armstrong, to work on underwater air-independent propulsion systems; five went to Waltham Abbey to the Explosives Research and Development Establishment (ERDE) established on the site of the former Royal Gunpowder Mills; 12 went to RAE at Farnborough; but the majority went to the newly-established Guided Projectile Establishment (GPE) at Westcott, Buckinghamshire. Others may have been directly recruited into industry, but details are scant. By 1950 about 23 were still in the UK. Those on longer contracts were permitted to bring their families to the UK, which led to an improvement in housing.

In 1945, Sir Alwyn Crow, as Controller of Projectile Development, produced a report on the future organisation of 'Guided Projectiles' within the Ministry of Supply. This report outlined areas of research, where it would be conducted and how many staff would be allocated. Liquid fuel rocket research was focussed on hydrogen peroxide systems and 'monofuels' that did not require an external oxidiser. Most of the projects were looking at short-range missiles for the Admiralty, but the General Staff had submitted two requirements: the first was for a long-range rocket with a 100 mile/160 km range with a three ton warhead (and high degree of accuracy); and the second requirement was for a "rocket for use as a strategical weapon" with a range of up to 300 miles/480 km also with a high degree of accuracy and a high rate of fire. A margin comment notes that the Army requirements were under review and that weapons with considerably longer ranges would be specified.[94]

GPE at Westcott was the hub of most British post-war rocket research and exploitation, and was responsible, under Dr William Cook, for guided missile development for the British Army and Royal Navy. The leading engineer was Dr Johannes Schmidt, who had been responsible for development of the 'Walter' rocket engine for the Me-163 *Komet* fighter, which first flew at the *Luftwaffe* Peenemünde East research centre. Unfortunately, there was to be a major setback. In November 1947, a German-designed Rocket Assisted Take-Off unit exploded during a test run, killing two British technicians and decapitating Dr Schmidt.[95] Perhaps the most significant

recruit was Walter 'Papa' Riedel (1902-1968) who was employed by the MOS at Cuxhaven and Trauen, emigrated to England in 1947 to work initially for the RAE at, Farnborough and later at the MOS establishment at Westcott, until his untimely (and slightly suspicious) death in a hit and run accident in East Berlin in 1968, shortly after his retirement. From 1937, Riedel had headed the Technical Design Office as Chief Designer of the A4 at Peenemünde and was probably the most senior scientist on the programme after von Braun.

In contrast with Westcott, RAE Farnborough was primarily interested in exploiting German aeronautical and trans-sonic technology, and in 1946, 26 Germans were offered contracts of varying lengths to work at RAE. Accommodation was reportedly better than at Westcott, but the staff were still dispersed and few of their names appear on research papers until the 1950s. However, their immediate impact, following on the cancellation of the M52 straight wing supersonic aircraft, was to design a 55º swept-wing transonic aircraft in 1948. Dietrich Kucheman became more prominent by contributing to supersonic research (in particular the Concorde) and others behind the 'swing wing' variable geometry which resulted in the Tornado design. But few at RAE were involved in rocketry and the Royal Air Force (RAE's major customer) had little interest apart from missiles used in various anti-aircraft and air-to-ground roles. One proposal for a long-range Ballistic Missile – Menace – which may have been the oblique reference to the General Staff requirement of 1945, was abandoned as being patently unaffordable.[96] An indication of the pervading atmosphere of austerity was measuring manpower down to just ½ person labour units in Alwyn Crow's paper on the guided projectile organisation. In contrast, and hidden from Parliamentary estimates until the 1950s, in 1947 the Labour Government committed £100 million to independently developing viable nuclear warheads.[97]

Perhaps the greatest rocket engineering technology transfer was the extensive use of hydrogen peroxide as an oxidiser in the Black Knight test vehicle rocket and the Black Arrow two-stage satellite launch body, which were developed in the mid-1950s. From 1958, 22 successful test launches were made in Australia until the programme was cancelled in 1965. The Gamma power-plants for both launch bodies were derived from an earlier design produced by the German staff at Westcott, under Walter Reidel.[98] The Black Knight was also considered as a launch body for the 'Blue Streak' indigenous Intermediate Range Ballistic Missile, carrying a British-designed thermo-nuclear device. The Blue Streak was derived from Air Staff Operational Requirement OR 1,139 of 1953 from a nuclear-armed ballistic missile with a 2,300 mile (3,700 Km) range, with design work commencing at RAE Farnborough in 1954. At Westcott, the vulnerability of missiles on the ground was studied, with launch options including V-2 styled trailers, floating or submerged platforms, and massive underground silos considered. In 1958 work started on designing 60 silos dispersed at 6 mile (10 km) intervals, ensuring survival of most missiles if there was 20 megaton strike within 800 yards/metres, and at Westcott, a one-sixth mock-up of a silo was constructed.[99] Partial construction of a full-sized silo is thought to have taken place at RAF Spadeadam in Cumbria, where rocket engines were also tested. However, inter-service rivalry, and spiralling costs saw Blue Streak cancelled in April 1960. Smaller, shorter range missiles using a bi-propellant system included the forerunner of

the Bloodhound surface to air missile (SAM), Red Duster, and the naval Sea Slug missile, were also developed at Westcott.[100]

Conclusions

The post-war exploitation of German technologies and scientists by Britain is often regarded as a signal failure compared with the achievements of German teams in the Soviet Union and America. Greater attention was given to the German presence in the US; indeed, von Braun's capture in 1945 was widely publicised in a positive light by the US Army. Similarly, the achievement of the Soviet Union's Sputnik satellite launch in 1957 was ascribed in the West to the contributions of German scientists and engineers; in reality almost all has been expelled in a fit of Stalinist paranoia in 1952. The reasons for the *apparent* lack of exploitation by Britain are many-fold.

Firstly, agency played a role. Professor Lindemann (now Lord Cherwell), who was hugely influential as Churchill's scientific advisor (and to return in the same role in 1951 in Churchill's first post-war government), doggedly saw little practical future in long-range rockets. Even at the height of the V-2 campaign, Lindemann wrote to Churchill and remained sceptical of the future of missiles:

> Although rockets may play a considerable tactical role as long-range barrage artillery … I am very doubtful of their strategic value.[101]

A scant two weeks after the last German V-2 was fired at the UK, Lindemann still remained unconvinced of the value of long-range rockets. Sir Alwyn Crow, Director of Guided Projectiles, like Lindemann, regarded rockets as a very inefficient form of artillery and did little to exploit von Braun and his team. In his defence, Crow focussed on improving accuracy through better guidance mechanisms, though did not exploit German scientist who had expertise in this area. In contrast, RV Jones wrote to the US Army Air Force in late 1944 outlining the potential for two-stage rockets with a uranium bomb (nuclear warhead) that had a range of 3,000 miles – mirroring work that Dornberger and von Braun were undertaking on the A9 and A10 projects.[102]

Additionally, two of the Service ministries showed little interest in the *need* for a long-range rocket system. The Royal Air Force had built a huge strategic bomber force (by this time being replaced by the Lincoln heavy bomber), which by the end of the War could deliver devastating bomb loads with relative accuracy at relatively long range, but the aircraft and crew remained vulnerable. In spite of garnering considerable technical information and assembling a V-2 at Farnborough from smuggled components in August 1944, there seemed to be no attempt to exploit this technology during the war for use against either Germany or Japan, unlike in the US. Perhaps, in Britain, it was seen that there was no need as Germany was all but defeated and the Pacific war was very much dominated by America. The Tizard Report of 1944, whilst urging the development of nuclear weapons, still envisaged that they would be delivered by fast,

high altitude jet-powered bombers. Ambitious Air Staff plans, such as Operational Requirement 230 of November 1946, led to the V-Force of nuclear armed bombers; ironically the V-Force would soon become obsolete in the strategic role because of surface-to-air missiles developed by the Soviets using technology in part developed from the German developments (such as the *Wasserfal* surface to air missile designed at Peenemünde). Furthermore, by 1946 given it was known that the Soviet Union was experimenting with ballistic missiles and considering the huge aircrew losses during the wartime strategic bombing campaign, it is equally difficult to understand why the Royal Air Force did not seek a long-range rocket that would be largely invulnerable to countermeasures – especially as the British TUBE ALLOYS nuclear programme was working towards a fission device that could be conceivably carried by a missile, largely obviating concerns about accuracy. It was not until 1953 that interest was shown by the RAF to develop a long-range missile system. The Royal Navy seemed to show even less interest even though the US Navy successfully test launched a V-2 from the deck of a carrier in September 1947. The only interest at the time in a long-range rocket came, as in Nazi Germany, from the British Army's General Staff. However, this interest was short-lived and the Army requirements for a long-range rocket described by the Director of Guided Projectiles in his 1945 report, did not progress beyond discussion papers.

Secondly, by the end of World War II, Britain's financial, industrial and intellectual resources were exhausted and the cost of debt servicing and of maintaining a huge overseas garrison was crippling. There was also a need to replace most key items of military equipment. This, along with US diplomatic pressure, in part, led to the rapid decolonisation of the British Empire. Additionally, an ambitious long-range rocket programme would have been financially demanding on a post-war Labour government which was more focussed on domestic reconstruction and social reform (such as creating the NHS) – but was also prepared to invest covertly in a domestic nuclear weapons programme, relying on aircraft delivery.

Thirdly, there was the paradox that although the Nazis were acknowledged as having advanced technologies, there was official resistance to harnessing them. MI5 were clearly concerned that UK defence technology secrets might be stolen but many reports contain a somewhat patronising view of the Germans, leading the few scientists and engineers to be kept at arm's length and not retained in their war-time teams. Furthermore, the financial inducements offered to scientists and engineers were unattractive compared with those offered by the USSR, USA and France, and coupled with a sclerotic bureaucratic lethargy, few Germans found it attractive. Security concerns about a re-emergent and belligerent Germany were unfounded, as were concerns over extensive Communist penetration of defence research and industrial community. There is no evidence to indicate any of those Germans who were brought to the UK posed a security risk, and the establishment of a 'Positive Vetting' system of assurance, introduced by MI5 in 1951, further mitigated the risk.

Authors Professor Matthew Uttley and Dr John Becklake have produced detailed studies of the net contribution to British aerospace research and development of the German infusion,

and paint a more positive picture. In the astronautic and rocketry fields it was primarily in the area of hydrogen peroxide liquid fuel engines, but the value of the intellectual property that was transferred across to the defence sector, is described as 'incalculable'. Dr Becklake, a former RAE scientist who has extensively researched the German contribution to aerospace technology in Britain, has written that although Britain received several very good general engineers they were too few in number, and as seen above, they were often kept at arm's-length, could not collaborate with former colleagues, and were compartmentalised from major defence research programmes. Work at Westcott, where most of the engineers and scientists worked, was focussed on projectiles rather than manned flight. Rockets – including the V-2 – were seen merely as projectile bodies and not aerospace vehicles. Furthermore, industry had little contact with these experts, although captured equipment was transferred to many companies and was often destroyed without exploitation. He believes that, overall, the German input saved "about 18 months R&D [Research and Development], they had little long-term influence on British rocket technology."[103] In sum, although there were significant contributions by German scientists in trans-sonic aerospace research and development and in liquid-fuelled rockets, Britain of the late 1940s had greater concerns. But, in a tired, war-weary and austere post-war Britain, there was no vision; there was simply no perceived need for strategic long-range rockets.

Epilogue

In a cruel, and rather late, turn of events, in March 1957 Duncan Sandys, now Minister of Defence, produced the White Paper on Defence, entitled the 'Outline of Future Policy'.[104] This paper recognised the parlous economic conditions at home, rapidly emerging military technologies deployed by the Soviet Union and changing geo-political landscape with pre-eminence of the US (especially in the wake of the Suez Crisis) and the importance of alliances such as NATO. The report recognised ascendency of long-range ballistic missiles with nuclear warheads and the vulnerability of manned aircraft to surface-to-air missiles. Sandys proposed progressive replacement of manned fighters with surface-to-air missile systems, strategic bombers to be supplemented by nuclear-armed ballistic missiles and to intensify research collaboration with America to develop anti-ballistic missile systems. In addition to swingeing reductions in the Royal Navy and the Army, as well as overseas commitments (which saw still saw 150,000 service personnel deployed overseas outside of Germany), his report forced the amalgamation of much of the British aerospace industry and cancelled most aircraft development programmes. The report concluded with assurances, in somewhat familiar terms:

> (a) The Government have adopted this new defence plan in the confident belief that it will not only give relief to the country's sorely strained economy, but will produce compact military forces of the highest quality.
>
> (b) All three Services will be provided with the newest weapons. The reduced Fleet will be composed of the most modern vessels; the Army will be equipped with atomic

> artillery and given a high degree of strategic mobility; the Air Force will be supplied with a British megaton bomb; a missile system of air defence will be developed; and ballistic rockets will be introduced to supplement the V-bombers.

As an interim measure before Blue Streak was expected to enter service, in February 1958 the UK and US governments agreed to deploy 60 US 'Thor' SM-75 missiles, which meant that US warheads could reach targets in the Soviet Union. Under code-name EMILY, 20 RAF Thor squadrons were established on wartime airfields the east coast of Britain from Yorkshire to Suffolk, and across East Anglia. The Royal Air Force provided the infrastructure and workforce, but the warheads remained under US Air Force control, with the launch of missiles controlled under a 'two-key' system.[105] The Thor had a range of 1,500 miles (2,400 km) and was designed by a colleague, and later rival, of von Braun from Peenemünde, Adolph Thiel (1915 – 2001). Like the V-2, the Thor missile was fuelled and launched from a transport-erector launcher system, however in Britain they were launched from fixed locations; the TEL and missile were stored under a shelter that would slide back prior to righting, fuelling and launching the missile. The first missiles – designed to be air-portable - arrived in September 1958 and the last left in August 1963. None were ever launched in the UK. The Blue Streak did not enter service; in its stead the British-designed 'Blue Steel' cruise missile was developed to be launched from the V-bombers. It entered service in 1963 (allowing the Thor to be returned to the US) and finally withdrawn in 1970. Subsequent missile programmes relied on US technology with the Polaris submarine launched ballistic missile, introduced in 1968, finally replacing the V-bomber force in the Deterrent role, albeit with a British designed enhanced re-entry vehicle and warhead system, Chevaline.

The reality was that by 1957 Britain was technologically and industrially at least a decade behind the America and the Soviet Union in missile development. Industrial and scientific resources committed to the UK rocket programme were orders of magnitude smaller that the US and USSR. As a hegemonic actor on the world stage, global leadership had slipped away since the early 1940s and Britain had to contend with being a second-order power, largely reliant on the US for strategic research, development and technologies.

Acknowledgements

I wish to thank Dr John Becklake for his support and detailed knowledge of German scientists employed in the UK after the war. I would also like extend my gratitude to the Mr Kevin Ball of Taylor and Francis Group, who have made National Archives *Secret Files from the Cold War* available on line to assist my research at **www.secretintelligencefiles.com**

Notes

[1] CROSSBOW was originally the codename for the committee looking at measures to counter the V-1 flying bomb and BODYLINE fulfilled a similar function to defeat rockets. The committees

were merged in November 1943 under the name CROSSBOW, although reports relating to BODYLINE continued to be produced until mid-1944. The term 'Operation CROSSBOW' is a post-war expression.

[2] Collier, Basil (1964) '*The Battle of the V-Weapons 1944-45*' Hodder and Stoughton, pp. 138-150.

[3] In this paper, the experimental models of the long-range rocket are referred to as the A4; operational use by the more recognised name of V-2.

[4] The A4/V-2 was code-named 'BIGBEN' by the BODYLINE Committee, but frequently referred to as 'Big Ben', 'long-range rocket or 'simply, 'rocket'. Hill para 148; CAB 176/2 'Most Secret' JIC/1737/43 'J.I.C. BODYLINE Intelligence Machinery'. The permanent chair of the BODYLINE Committee was Commander Ian Fleming RNVR, later author of the James Bond genre.

[5] Known at the time by its German name of Swinemünde.

[6] CAB/81/132 Confidential JIC(48) 33 report dated 20 Oct 1946.

[7] Biddle, Wayne (2009) '*Dark Side of the Moon*' W. W Norton NY & London, pp. 39 – 42. Oberth worked at Peenemünde during World War II. Between 1956 – 1961, Oberth worked with von Braun at the US Army Ballistic Missile Agency, developing multi-stage rockets.

[8] Constance Babington-Smith (1957) *'Evidence in Camera' Chatto* and Windus, London, p. 204 – 205. Initially Mr Duncan Sandys, Chairman of the War Cabinet Committee for defence against German flying bombs and rockets, led the belief that the V-1 'flying bomb' and V-2 missiles were part of the same programme. Although testing of both took place at Peenemunde, they were separate and uncoordinated projects. On p. 207 the V-1s are also referred to as 'airborne rocket torpedoes' (a direct translation of the German name from signals) revealing – inadvertently - knowledge of the rocket programme through signals interception and code-breaking, which was still 'Top Secret ULTRA' when the book was published in 1957.

[9] For technical aspects of the search for the V-2, see Robert V Jones (1978) *Most Secret*, Hamish Hamilton, London, pp. 430-461.

[10] Dornberger, Walter (1954): *V2*, Hurst & Blacket, London. pp. 151-168.

[11] Dornberger, pp. 79-83.

[12] Dornberger, p. 222.

[13] SS–Obergruppenführer Kammler (General) Dr-Engineer Heinz (Hans) Friedrich Karl Franz Kammler (1901-1945) was appointed by Hitler in July 1944 to be responsible for all missile technology, including the V-2 ballistic missile programme, and was additionally assigned the grandiose term of 'General Plenipotentiary of the Fuehrer for Jet Propelled Aircraft'. This gave him full control over the production, distribution and utilisation of jet aircraft and vengeance weapons. Kammler, a civil engineer, was infamous for directing construction of the gas chambers and crematoria at Auschwitz concentration camp. His rank was an appointment in the SS – he had no military experience and was known for his cruelty. He is thought to have died near Prague in May 1945 (although bonkers pro-Nazi conspiracy theorists suggest that he survived the war and moved to South America – or Antarctica).

[14] Dornberger, p. 224.

[15] JIC papers regularly refer to Professor 'Linstead', rather than Lindemann, perhaps avoiding awkwardness of his German origins. Occasionally his name is given the more Anglicised 'Linderman'.

[16] Known as 'CX' reports.
[17] Collier, p. 147.
[18] Collier, pp. 138-140.
[19] CAB 176/1 J.I.C./492/43 '*German Long-Range Rocket Development*', 21 April 1943.
[20] CAB 176/2 '*BODYLINE Targets in Germany*' 4 November 1943.
[21] Hill, para 152.
[22] Hill, Sir Roderic (1948): 'Air Operations by Air Defence Great Britain and Fighter Command in connection with the German Flying Bomb and Rocket Offensives, 1944-45.' *The London Gazette* Supplement 19 October 1948, para 66. **https://www.thegazette.co.uk/London/issue/38437/data.pdf** accessed 7 Mar 19.
[23] Collier, p. 404.
[24] Andrews, Christopher (2009) '*The Defence of the Realm: The Authorized History of MI5*' Allen Lane/Penguin, London. p. 313.
[25] R.V. Jones (1978): '*Most Secret War*' Hamish Hamilton, London. pp. 447-448.
[26] Hill, para 163.
[27] CAB 81/124 *Imminence of Attack by Bigben*. J.I.C (44) 366 (0) dated 31 July 1945.
[28] Guy Liddell Diary, vol 10, 25 August 1944. TNA KV 4/194 in Andrews, p. 313.
[29] Dornberger's book shows a V-2 being erected into the launch position from special railway wagons (p. 97). Work began in 1942 but it is thought that no operational launches were made; by late 1944 the railway network very vulnerable to Allied air interdiction, both in search of V-2 rockets but also as part of the wider Allied offensive against German forces. Dornberger, p. 235.
[30] Babington Smith, p. 232.
[31] Wright, Jerry (2014) '*Zeppelin Nights: London in the First World War*' Vintage Books, London, p. 250.
[32] This alert system would be resurrected in 1955 and initially operated by the Royal Observer Corps (ROC) and then from 1965 by the UK Warning and Monitoring Organisation – also based at Stanmore (RAF Bentley Priory) - and would be activated by ROC posts who would launch three 'maroons' to warn of the local approach of radioactive fallout. The system remained serviceable until about 1991.
[33] Longmate, p. 128.
[34] Collier, pp. 127-129.
[35] Hill, paras 220-221; Collier, p. 150.
[36] Perhaps the greatest intelligence coup in WW II after breaking the ENIGMA codes was the complete penetration of the German spy network in Britain by the 'Twenty (XX) Committee'. For accounts of the deception associated with the V-2 programme, see John Masterman's official report released in 1972: *The Double Cross System*, Reed, Wellington, pp. 180-183; Keith Jeffrey's official history (2010) *MI6 – the History of the Secret Intelligence Service*, Bloomsbury, pp. 571-572; Christopher Andrew's (2009) *The Defence of the Realm – the Authorized History of MI5*, Allen Lane, London, pp. 310-316. For technical intelligence on the V-2, see Jones, pp. 430-460.
[37] Howard, Michael (1990) '*British Intelligence in the Second World War*' vol 5 pp. 182-3, in Andrews, p. 316.

[38] Biddle, pp. 142-143.
[39] Collier, Basil (1957) '*The Defence of the United Kingdom*' HMSO, London, Chap XXV, pp. 418-419.
[40] Hill, paras 201-220.
[41] Dornberger, p. 248.
[42] CAB 81/128 J.I.C (SHAEF) (45) 18 (Final) '*Ability of Enemy to continue to use V-Weapons*'. 23 April 1945.
[43] Jones, p. 459.
[44] RAF Fighter Command counted 1115 missiles falling in the UK or within sight of shore. Hill, para 223.
[45] For harrowing contemporary accounts of the V-2 'blitz' against London, see Maureen Walker (2004): *London 1945*, John Murray Ltd, London, pp. 17-71.
[46] Part of the German Labour Front, a central economic planning function of the Nazi Party
[47] A short-range mortar-type rocket, normally in a multi-barrel arrangement, initially designed to deploy a smoke barrage. From images available, the tests were conducted using 28/32 cm rockets. http://www.uboataces.com/articles-rocket-uboat.shtml accessed 7 March 2019.
[48] Collier (1957) p. 399.
[49] Submarine Launched Ballistic Missiles typically have solid-fuel engines.
[50] Dornberger, pp. 231-232.
[51] Lundeberg, Philip K. (1994). "Operation Teardrop Revisited" in Runyan, Timothy J; Copes, Jan M. "*To Die Gallantly: The Battle of the Atlantic*." Boulder: Westview Press
[52] Dornberger, p. 235; picture p. 97.
[53] Schulz H.A (1965) '*Technical data on the Development of the A4* V-2' NASA Historical Office, George C Marshall Space Flight centre.
[54] Schulze, p. 54.
[55] Dornberger, pp. 236- 237. The Nazi nuclear programme was, at best, in its infancy and never posed a real threat, although considerable Allied resources were committed to dismantling the programmes and seizing both research documents and fissile material.
[56] Neufeld, Michael J (2007): *von Braun*, Smithsonian Institute, p. 188-189. Piszkiewicz, Dennis (1998) *Wernher von Braun*, Praeger, Connecticut., p. 39.
[57] Neufeld, p. 196.
[58] Biddle (2009), p. 129.
[59] A complete set of weekly Air Ministry Technical Intelligence Summaries are held by the MOD Air Historical Branch, RAF Northolt, London.
[60] During General Dornberger's internment in Farm Hall, Wilton Park and other POW detention centres in England between 1945 and 1947, he disclosed in a secretly-recorded conversation with another German general that he and von Braun had travelled to Lisbon in October 1944 for secret talks with two officials who claimed to be from the General Electric Corporation, about the surrender of all Germany's top scientists to US forces. Although there may have been some bravado on Dornberger's part, and none of von Braun's biographers refer to any visit to Lisbon during the war (an event he was likely to keep quiet), it is most likely that von Braun's

surrender was carefully orchestrated.
[61] Biddle, p. 129.
[62] CAB 81/118 'German Long-Range Rocket Report' JIC.
[63] Jones, pp. 440-442.
[64] CAB 81/93 JIC(45) 9th Meeting Air Intelligence Targets under Russian Control. Para 8.
[65] Andrew, Christopher (2009): '*Defence of the Realm. The Authorised History of MI5*.' Allen Lane, London, p 173. Blunt (1907-1983) was unmasked by MI5 in the 1950s and publically exposed in 1979.
[66] Longden, Sean (2009) 'T-FORCE: The Race for NAZI war secrets, 1945.' Constable, London.
[67] AVIA 15/2216 minute by DSR 11 May 1945. In Uttley, Matthew (2002) 'Operation 'Surgeon' and Britain's Post-War Exploitation of Nazi German Aeronautics' in *Intelligence and National Security, v17 No 2 (Summer 2002) pp. 1-26*.
[68] https://royalsocietypublishing.org/doi/pdf/10.1098/rsbm.1994.0015 accessed 20 March 2019.
[69] Neufeld, p. 205. In Thom Burnett's 2005 work, he is erroneously referred to as 'Colonel William Cook'. British investigators reportedly wore uniform in the field, however Dr Cook never formally served in the British Army.
[70] Longmate, p. 376.
[71] Burnett, Thom (2005) '*Who Really Won the Space Race?: Uncovering the Conspiracy That Kept America second to the Russians*.' Collins & Brown, London, p. 154.
[72] Biddle, pp. 142 – 143.
[73] Longden, p. 273. Von Braun reportedly spent two days at the former *Luftwaffe* airfield at Völkenrode under British guard.
[74] Biddle, p. 142. This group did not include the 'father' of the V-2 programme, General Dornberger, but did include the much less experienced brother of Wernher, Magnus von Braun.
[75] Piszkiewicz, Dennis (1998) *Wernher von Braun*, Praeger, Conneticut, pp. 50-54.
[76] '*Official Report on Operation Backfire*' v 1-5, War Office, London, January 1946, in Becklake, 2014.
[77] Longden, pp. 271-274. The Operation *Backfire* reports noted that the V-2 heralded a new type of warfare, but only if the rocket was able to deliver a nuclear warhead.
[78] Becklake, John (2006): *German Rocket Engineers in Astronautic Acta* V 49, updated 2011, 2014.
[79] https://www.iwm.org.uk/collections/item/object/1060020906.
[80] Much of what was said by the POWs and captured nuclear and missile scientists at Wilton Park and Farm Hall camps was secretly recorded under Operation *Epsilon*, and some of the recordings and transcriptions were declassified in the 1990s.
[81] Sayer, Ian & Douglas Botting (1984) '*NAZI Gold*', Granada, London pp. 239,240.
[82] Uttley, p. 9.
[83] The terms Soviets and Russians are synonymous in the reporting, and this convention is followed.
[84] The Soviet title for their equivalent operation to SURGEON was 'OSOAVIAKHIM', an acronym.

[85] CAB 81/132 '*Disposal of German Scientists and Russian Activities in connection therein*.' JIC (46) 8(0) 18 January 1946.
[86] CAB 81/133 JIC (46) 51 'Russian Attempts to Entice German Scientists and Technicians from the BRITISH Zone of Germany.' 2 July 1946.
[87] Barrow News, 12 January 1945 on Becklake, 2002.
[88] CAB 158/4 JIC (48) 73 (0) '*Employment of Aliens on Defence Work*.' 3 August 1948.
[89] Uttley, p. 9.
[90] Sir Ben Lockspeiser, previously Director-General of Scientific Research within the Ministry of Supply was apparently investigated in the 1950s by MI5 because of pre-war Communist associations.
[91] https://www.mi5.gov.uk/klaus-fuchs accessed 7 March 2019.
[92] CAB 176/11 '*Publication of Details of Fall of Shot of V.1 and V.2 Weapons*.' JIC/953/46 10 July 1946.
[93] Becklake, p. 6; Uttley, p. 9.
[94] CCGP (45)2, November 1945. www.peoplescollection.wales/item/381651.
[95] The Ministry of Supply assessed Dr Johannes Scmidt, amongst others, as an 'active Nazi' during security screening. Uttley, p. 9.
[96] Becklake, p. 10.
[97] Andrews, p. 325.
[98] Hunt, Bryan (2013); '*The Most Beautiful Barracks in Germany' A History of the Barracks in Oberammergau 1935 – 1975*. Unpub MSS; NSO.
[99] Cockrocft, Wayne & Roger Thomas (2003) '*Cold War: Building for Nuclear Confrontation 1946 – 1989*', English, Heritage, Swindon. p. 46.
[100] Uttley, p. 12.
[101] Longmate, p. 377.
[102] Longmate, p. 378.
[103] Becklake, p. 12.
[104] CAB/129/86 1957 Statement on Defence, March 1957.
[105] Cockroft, pp. 47-51. The US designation for the Thor missile was PGM-17.