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# MILE STONES

# Early cruise missile operations

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The Fieseler Vergeltungswaffe Eins / V-1 / FZG-76 Flakzielgerät or Fi-103 'buzz bomb' was the first cruise missile to be operationally deployed and used, and in many respects set the pattern for future deployment and operational use of this now so important weapons technology. We have seen a wide range of cruise missiles designed, built and deployed, most of which share key aspects of their operational concepts with the very first design. Not surprisingly many of the difficulties encountered in intercepting cruise missiles in 1944 are now being confronted again as Tomahawk-lookalikes enter the operational inventories of many nations.

There is a wealth of excellent literature and more recently websites available that detail both the design and the operational history of the FZG-76/V-1 weapon system.

The FZG-76/V-1 was secretly developed under the cover designation of FZG-76 Flakzielgerät, which loosely translates to 'anti-aircraft artillery target drone 76', presenting a credible deception for the period given the plethora of different drone targets which have been built since then.

The impetus for the development of the FZG-76/V-1 was the increasing loss rate of Luftwaffe bombers over Britain, first in daylight and then at night, as radar-equipped Beaufighters and later Mosquitos took their toll of the KampfGeschwaders.

The enabling technology fore FZG-76/V-1 was the Schmidt pulse jet patented around 1930. This simplistic design used a combustion chamber with a long tailpipe and an inlet face covered with an array of spring loaded air inlet valves. Once started, the valves cycled open and shut 40-50 times per second – when open drawing air into the combustor, closing as the pressure equalised, upon which a spark would ignite the fuel air mixture, generating a pulse of thrust. As the pressure wave travelled down the tailpipe, the decreased pressure in the combustor would open the inlet valves and the cycle would be repeated. The Argus AS-014 pulse jet used in the FZG-76/V-1 was based on the Schmidt model, but it delivered barely enough thrust at 600 lbf to sustain the required climb rate and 350-400 KTAS cruise speed of the weapon. Range with 1,300 lb of aviation gasoline was around 150 nautical miles.

> While the economics of cruise missiles makes them a dubious choice compared to air delivered smart bombs, this equation changes when opposing air defences are good enough to inflict serious losses on manned aircraft.

*Fieseler FZG-76/V-1 on display in Germany. It was the first operational cruise missile and defined the "disproportiuonate response" strategy in use to this very day.*

Whilst a cheap sheetmetal mass production design, the FZG-76/V-1 suffered serious problems in development with its simple gyro based Askania autopilot, which was not well matched to the airframe's stability characteristics, and elevator/ rudder only controls. After the repeated loss of prototypes in 1943, a piloted variant, the Fi-103, was developed so test pilots could identify the stability problem, which was subsequently resolved.

Launching the FZG-76/V-1 presented problems in its own right since the Argus AS-104 did not have enough thrust to accelerate the airframe in a reasonable distance, and the added complexity required in the autopilot for a runway takeoff would have challenged the technology available. The Luftwaffe opted to use large fixed ramps, and a built in steam catapult system akin to those now used on carriers, powered by a hydrogen peroxide steam generator catalysed with potassium permanganate. A launch involved fuelling the missile, initialising the autopilot and compass, starting the engine with compressed air, and engaging the steam generator. When sufficient pressure was available, the catapult was released. Once airborne the FZG-76/V-1 slowly climbed to its cruise altitude, and attempted to maintain its heading to the target. A timer programmed for the target area was used to cut off fuel to the engine, upon which the elevators would be locked down and the weapon would dive until impact with the ground. The intent was to construct 100 such launch sites in the Pas De Calias area, all aimed at greater London, so as to effect a sustained large scale bombardment of the British capital.

Production did not start in earnest until April, 1944 at a large Volkswagen plant equipped to mass produce stamped sheetmetal parts. Operational launches against the UK did not begin until the 13th June, when only ten launch ramps were ready for use out of the fifty constructed.

The RAF and USAAC were bombing FZG-76/V-1 launch sites since late 1943, after identifying a prototype FZG-76/V-1 at Peenemunde parked on a prototype launch ramp. The size of the ramps made them difficult to conceal, and this launcher arrangement simply lacked the mobility and small footprint of the Wehrmacht's towed A-4/V-2 ballistic missile batteries. Nevertheless, launch ramps were used to fire most of the FZG-76/V-1s, and the problem was not solved until the Allied ground force overran the launching areas.

Well over a thousand FZG-76/V-1s were air launched by modified He-111H-22 bombers of KampfGeschwader 3, usually operating over the North Sea. There are numerous reports of launch accidents, including premature warhead initiation, resulting in a very high loss rate in KG3 during this period.

There is little agreement in contemporary sources on the number of FZG-76/V-1s built, with quantities varying between 10,000 and 24,000 rounds. There is closer agreement on the number of launches, these being put at around 8,000 rounds, with nearly 7,000 of these identified and tracked by Allied air defences. Unlike the A-4/V-2, which tended to detonate underground due to its high terminal velocity, the FZG-76/V-1 produced a powerful ground level blast wave, which levelled buildings and caused frequent glass splinter injuries even at considerable distances from the point of impact.

Like the A-4/V-2, the FZG-76/V-1 was an inaccurate weapon built primarily to attack an opponent's morale, rather than inflict material damage on military targets. As such, its use produced little direct operational effect and was unable to hinder the advancing Allies on the ground. However, aimed at the UK populace, the attacks elicited a 'disproportionate response' in terms of both operational effort in air defence and necessary new investment, thus producing a quite significant systemic strategic effect.

The FZG-76/V-1 flew at a cruise speed that challenged most piston engine fighters of the period, at an altitude of around 2,000 to 3,000 feet. As a result, the weapon was difficult to detect using the Chain Home early warning radar network and visual observers became the mainstay of early warning operations.

The combination of speed and altitude presented major difficulties for most of the anti-aircraft guns of the period, as the angular rates at which the guns had to slew and elevate often exceeded equipment design limits. Where the guns could track, the high speed presented difficulties for gunners when aiming and estimating range.

Interception by fighters also proved difficult, as only the fastest types like the Hawker Tempest V, Gloster Meteor and very late Spitfire XIV could sustain the speed to run down the bomb and effect an engagement. The large warhead presented genuine risks when hit with cannon fire, so some pilots opted to 'tip' the weapon to a roll angle from which its autopilot could not recover by flying alongside and using a wingtip to lift the missile's wing.

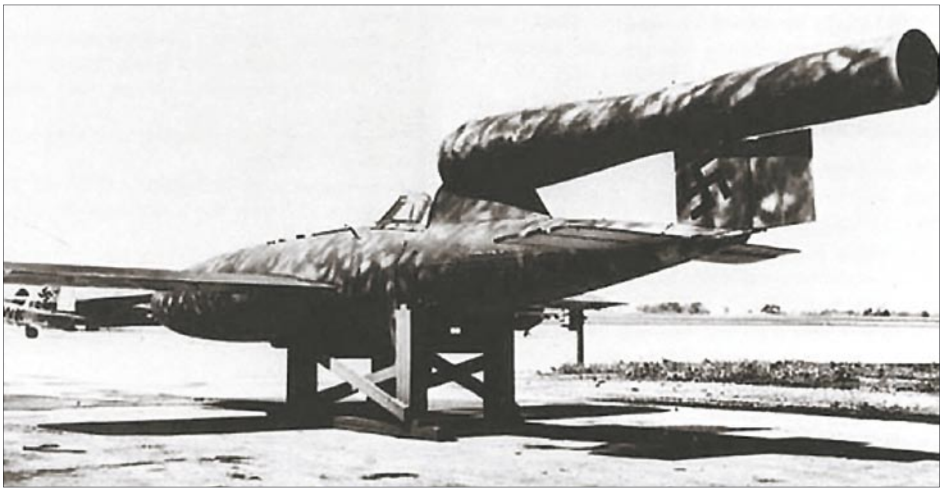
The British quickly ran into difficulties with friendly fire when fighters and gun batteries attempted to engage the same target. The result was a major redeployment into a layered defence, with 'belts' of gun batteries along the coast, and behind them a 'kill zone' set up for fighters to engage the missiles which 'leaked' through the gun defences. Nevertheless, 2,340 rounds are credited with hitting London, killing 5,500, injuring 16,000, and damaging or destroying almost as many buildings as the Luftwaffe did during the earlier manned bombing campaigns.

The redeployment of gun batteries to coastal areas, expansion of the early warning grid, upgrades of gun mounts to achieve effective tracking rates combined with the introduction of radio proximity fused ammunition for the AAA guns and SCR-548 gun laying radars eventually brought the kill rate against the FZG-76/V-1 to a viable 80 per cent or better. This was, however, achieved at a considerable expense in material and personnel resources, diverting these from offensive operations on the continent.

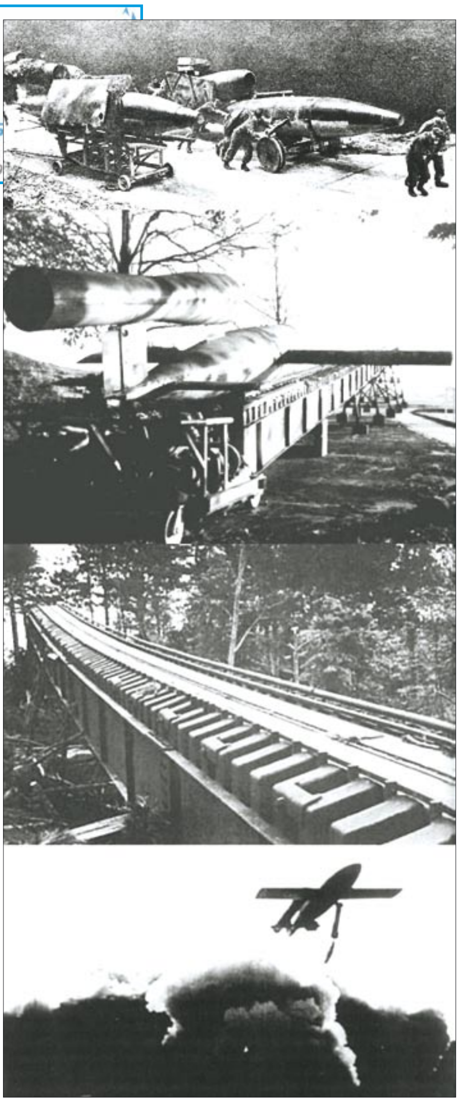
After the collapse of Germany the Allies quickly exploited the captured technology. The US reverse engineered the FZG-76 design as the JB-2 Loon, which was subsequently experimented with and introduced as a limited service weapon. The USAF Loon variant could be launched from a rack under the wing of a B-29 Superfortress. The US Navy subsequently equipped the submarines USS Cusk / SS-348 and USS Carbonera / SS-337 with launch ramps and used these to trial the Loon as a submarine launched weapon.

The nuclear arms race of the 1950s provided a major impetus, and saw both sides deploy a wide range of weapons. The US Navy developed the subsonic SSM-N-8A Regulus I followed by the supersonic RGM-15 Regulus II. The Soviets produced the surface launched Scudder and then Styx, the air launched Kelt and Kipper, followed by the massive supersonic Kangaroo. This evolution progressed to the RAF Blue Steel and its Soviet competitor, the Kh-22 Burya / Kitchen, and later KSR-5 Kingfish. The Soviets further evolved the line

*Modern cruise missiles like the US BGM-109G GLCM (upper) and Soviet Kh-55SM Granat (lower) produce much the same strategic effect as the FZG-76 did in 1944 – they force a "disproportionate response" in the deployment of air defence assets to stop them.*



*The Fi-103 Reichenberg was a manned derivative of the FZG-76 airframe, developed for flight testing purposes. There are numerous reports that a plan was being pursued to recruit committed SS personnel as kamikaze pilots to provide the Fi-103 with a "terminal guidance" system. Given the marginal stability and handling characteristics of this airframe, odds are that only experienced pilots would have actually been competent to hit anything with the Fi-103, and experienced pilots were the commodity Nazi Germany had the least of in 1945.*



*Left - top to bottom: Personnel handing FZG-76 rounds in shipping configuration, with stowed wings; FZG-76 on the ramp launcher, being prepared for a launch; ramp launcher viewed from the missile's position; an FZG-76 clears the end of the launch ramp in a cloud of steam produced by the hydrogen peroxide powered rocket catapult.*

of supersonic missiles to the current 3M80/Kh-41 Moskit / Sunburn and Kh-61 Yakhont / SS-N-26.

Subsonic air launched cruise missiles declined in popularity in the West during the 1960s, until the 1970s' development of the Boeing AGM-86 ALCM for the B-52, and GD BGM-109 Tomahawk for deployment on submarines and surface warships. With highly precise modern inertial, terrain contour matching and optical scene matching technology, nuclear and conventional cruise missiles gained in importance again.

The US then replayed the Luftwaffe strategy of 'disproportionate response' against the Soviets with air, sea and ground launched cruise missiles. Nuclear armed AGM-86/BGM-109 cruise missiles presented a serious threat to Soviet systems within the 1,500 nautical mile range of these missiles, and this compelled the Soviets to pursue a massive upgrade of the PVO-Strany air defence system. The new S-300P/SA-10 Grumble SAM system, modelled on the US Patriot, was developed, including the massive mobile 23 metre and 40 metre tall 40V6 series mast systems to extend the low altitude coverage footprint of these potent missiles. The massive MiG-25M/31 Foxhound was developed, armed with the Vympel R-33 Amos missile to counter the threat. US cruise missiles played a major part in bankrupting the Soviet Bloc, for all of the same reasons why the FZG-76/V-1 damaged the Allied war effort in late 1944 and early 1945.

While the economics of cruise missiles makes them a dubious choice compared to air delivered smart bombs, this equation changes when opposing air defences are good enough to inflict serious losses on manned aircraft. The big difference today is that most cruise missiles are accurate enough to produce real military effect when used operationally. What compelled the Luftwaffe to air launch its FZG-76 in 1944 remains a consideration today, and evidently enough of a motivator for China to develop the new turbofan powered H-6K Badger bomber and a range of indigenous cruise missiles.

Interestingly, the very characteristics which made the FZG-76/V-1 a headache for air defence planners and operators in 1944 present the same broad issues for contemporary air defence system planners. Low altitude flight at high subsonic or even supersonic speeds challenges most surface based radars, and defensive gun and missile systems. The low altitude, small size and relatively low radar signature of these weapons makes them difficult to track using most airborne radars, and difficult for air-to-air missile seekers to effectively lock on to. While most modern fighters will have no difficulty running down a subsonic cruise missile, the same can hardly be said for supersonic missiles, which can only be reliably intercepted by supercruising fighters like the MiG-31 Foxhound or F-22A Raptor.

While the technology of cruise missiles is today vastly superior to that of 1944, the deployment method by air launch differs only in detail. It is unclear why the Luftwaffe did not equip the FZG-76/V-1 with a rocket booster pack for launches from Transporter Erector Launcher (TEL) vehicles, as the Soviets promptly did during the 1950s, and deploy highly mobile batteries akin to the Wehrmacht A-4/V-2 force. The latter arrangement was used by the US and Soviets through the Cold War for a range of cruise missile types, including the P-15 Termit/Styx, 3K10 Granat/Slingshot and BGM-109G Ground Launched Cruise Missile (GLCM).

With ongoing technological evolution, which will see better warheads, higher accuracy, longer range, lower radar and heat signatures and more intelligent and autonomous guidance, what is abundantly clear is that the headaches experienced by British air defence planners in 1944 attempting to defeat the FZG-76/V-1 will continue for modern force structure planners.

*A key innovation introduced by the Soviets during the 1950s was the use of the high mobility 8 x 8 MAZ-543 as a TEL for ground launched cruise missiles, such as this 4K51 Rubezh system armed with the P-15 Styx antishipping missile.*

*Left - top to bottom: FZG-76 cruise missile under the wing of a modified He-111H-22 launch aircraft; FZG-76 clearing the launch aircraft; JB-2 Loon being loaded on a USAF B-29 bomber after WW2.*