Steel on Target

by Wolf Prow

During World War II, the world's most potent air defense force placed all the steel on target that Krupp and Rheinmetall barrels could endure, but the bombardiers won the air war hands down. Can modern air defense artillery do any better?

A British Avro Lancaster caught in heavy flak trails smoke from a port engine. German anti-aircraft crews made the word *flak* part of the English language, but were unable to save German cities from destruction.

The Air-Land Battle Concept readily concedes that U.S. forces may not enjoy aerial superiority in a future conflict. This compels an assessment of struggles ground-based air defenses have waged against superior numbers in the past.

The most applicable lessons come from World War II Germany where the Allies enjoyed a 61-to-one air superiority, and where air defenses were almost entirely in the hands of the defenders on the ground.

Studies of the air war over Germany emphasize the glamorous exploits of fliers, but have so far paid little attention to the achievement of the ground defenders. Yet the word *flak* (literally *flieger abwehr kanone* or anti-aircraft gun) became an international synonym for ground-based anti-aircraft defenses. The Germans also left the legacy of surface-to-air missiles which evolved into successive generations of anti-aircraft weapons on both sides of the Iron Curtain.

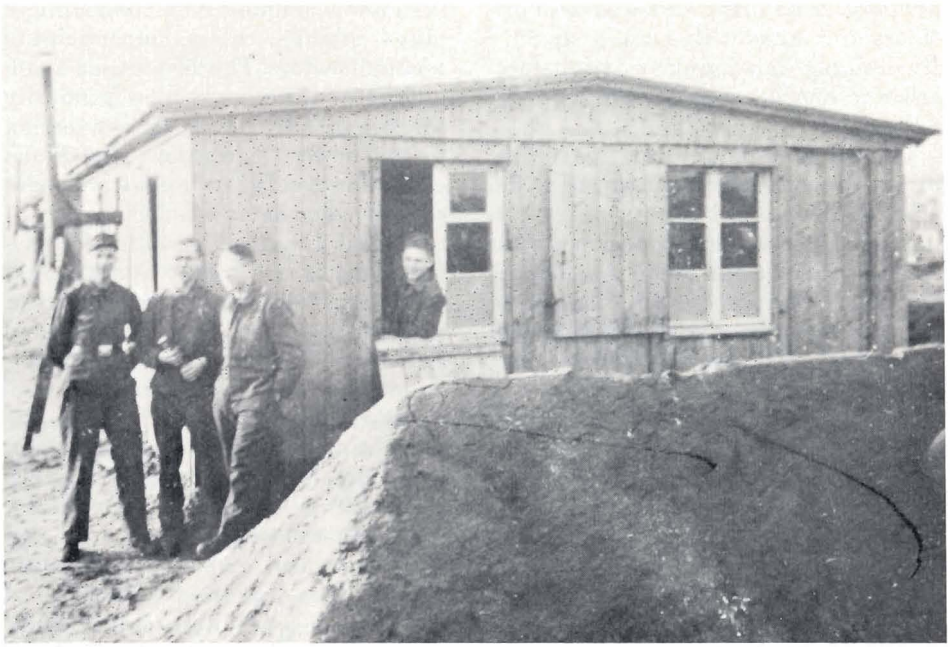
Defense against air attacks was an awesome task that rested with defenders on the ground and the population at large. Air defense represented a vast, national effort. Weapon systems were operated by about 900,000 men. In addition, expanded warning networks and control systems had to be devised. Shelter projects and underground facilites were needed and had to be constructed. There were also problems of administration, production and law-and-order to wrestle with. In short, air operations had imposed total war.

The Weapons

The ground-based air defense of World War II Germany, backed by about 10,000 anti-aircraft guns, was predominantly operated by the *Luftwaffe*, the German air force. However,

each service had its own organic air defense systems and its own procedures. For example, the flak batteries of the *Luftwaffe* based data on a 400-degree circle, whereas the German army and navy clung to a more traditional 360-degree circle. Light, automatic anti-aircraft weapons of all services included machine guns and guns with calibers of 2.0, 3.7 and 5.7cm. A few 4.0cm Bofors and captured Soviet 2.3, 3.0 and 5.7cm weapons were also pressed into service.

The famous 8.8cm (*Acht Komma Acht*, or Eighty-eight) "Ack Ack" was used extensively against ground as well as aerial targets by *Luftwaffe* gun crews. Its high muzzle velocity of 880 meters per second permitted its shells to reach altitudes of about 10,000 meters and made the Eighty-eight highly effective in penetrating tank armor. The navy also used a version of this dual-purpose gun on destroyer-class vessels. Towed or platform versions of the Eighty-eight were deployed behind the protection of earthen walls to defend the perimeter of cities or installations. Fire direction centers were placed 100 meters from the center of six-gun batteries.



Four LwH assigned to a heavy anti-aircraft artillery battery are shown in front of their temporary building in this 1943 photograph. Note the berm, wooden shutters and stove pipe. Only one of the four boys survived the war. The author is the one with the cap.

Ideas and Tactics

There was no shortage of ideas about how to employ anti-aircraft weapons. The basic organization of batteries into *Geschuetzstaffel* (gun sections) and *Messtaffel* (control sections) remained unchanged throughout the war. But batteries were shuffled around and were frequently assigned different sectors or given new missions. High mobility and the ability to entrench were considered important. The ineffectiveness of flak bursts with thousands of tiny fragments led to the development of preformed projectiles of greater lethality. Metal shortages compelled the substitution of aluminum for copper in rotating bands.

Additional weapons were made available by using captured equipment, primarily Soviet 85mm guns rebored for German 88mm fixed munitions. The German navy converted light cruisers to flak ships. These flak cruisers also served to integrate and coordinate fire and provided highly mobile defenses. Another problem was the shortage of ammunition. Initial demands for "*Eisen an den Feind*" gave way to curt orders to save ammunition. Batteries were allowed to fire only when definite data were available. Firing on receding targets was eventually prohibited.

Tactics changed dramatically. Placing radars, guns or missiles on mountaintops was tantamount to suicide. The valley side to be defended gave better protection and permitted better spacing. Instead of selecting the lead plane, gunners found it more effective to track an aircraft in the middle of formations. The reliance on optical tracking was replaced by new confidence in radar-derived data. Allied radar jamming and the practice of dropping strips of aluminum foil (chaff) caused the German air defender to adopt targeting techniques based on many sources. The navy developed an anti-aircraft tactic using regular ship artillery. Time fuzes were set by directions from on-board computers, or were preset to cover zones of approach. The 28cm guns aboard battleships were quite effective firing such barrages. This tactic was also applicable to field

Occasionally the Germans gave firepower demonstrations for propaganda purposes. Here the tracers of light AA weapons are shown in a time exposure over a German city. In reality, the "heavies" carried the lion's share of urban defense.

artillery. Zone firing endowed field artillery and tanks with a crude capability to engage low-flying aircraft before lesser caliber weapons could be brought to bear.

There was no doubt that light anti-aircraft weapons would continue to be effective if appropriate tracking and aiming devices could be developed and suitable munitions were available. However, weapons, equipment and manpower were tied up for long periods just to be available for critical, but fleeting, moments.

Radars and Controls

The brain of the German World War II air defense system was the "Opera House" where all actions of the air war were orchestrated. Regional subdivisions and tactical controls augmented this central command post. A combination of numerous sources of information provided accurate and redundant data for the German defenders. The approach of bomber formations was known, at the latest, when Allied aircraft assembled over the North Sea. The Freya radar gave early warning, but the Allies countered with the Mandrel jammer. When the bombers passed over the cordon of German patrol vessels, the size of the formations, their composition and course were definitely known. Unfortunately for the Germans, their targets could not be determined, and Allied diversionary tactics compounded the problem. Anti-aircraft batteries along the expected flight path went on alert and remained on alert in the event that returning formations might come within range.

Inside Germany, the big dish Wuerzburg Giant radars tracked and plotted aerial targets as well as friendly fighters to integrate control and defense efforts. These big radars were not totally impaired by countermeasures because of the large size of Allied bomber formations. On the other hand, the two types of radars at the battery level were either crude, but more impervious to chaff and jamming, or very accurate but highly susceptible to electronic countermeasures. The early battery radar was the solid-dish radar of 1939. The more accurate was the wire-mesh, P-band radar of 1942.

This new battery radar was effective up to 15 kilometers, but chaff and, especially, the carpet-jamming device carried by American bombers virtually neutralized these P-band radars.

A partial solution to this problem was devised by a Major Malis. He invented a simple device consisting of maps, strings, rulers, paperweights and protractors. The device used available data from other sources, primarily the Wuerzburg Giants, for conversion to the battery's location. The Malis crews directed fire by voice when more sophisticated devices failed.

Optical tracking was suited for daytime targets, but worked at night only when searchlight beams converged on a single aircraft. When two or more searchlights concentrated on a target, angulation and visual tracking provided reasonably accurate data, depending on the effectiveness and training of *Messtaffel* team members. Night vision devices were still in their infancy.

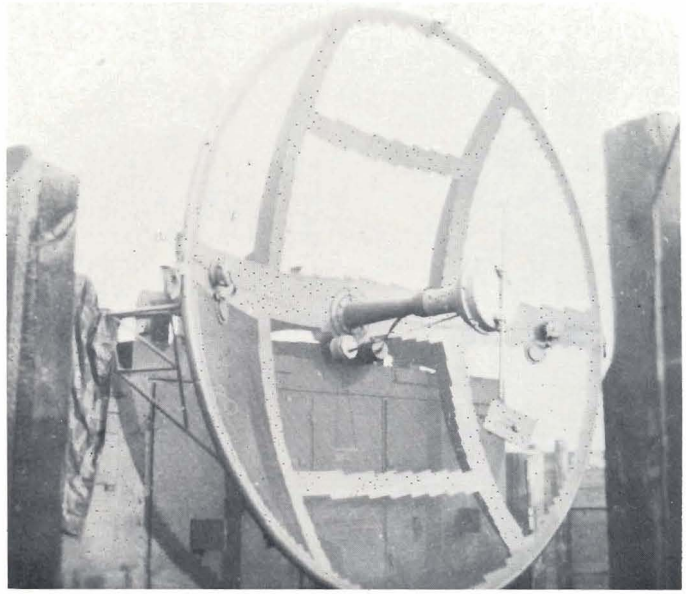
The inner defense of cities consisted of 10.5cm and 12.8cm heavy anti-aircraft guns organized in batteries of four. The heavies were protected by revetments, earth berms, or were mounted on flak bunkers or railroad cars. The navy put the heavy caliber weapons on heavy cruisers or battleships. These systems were mechanically loaded. As the war progressed, the heavy anti-aircraft guns were assigned to perimeter defense.

Improvements were made in gun design throughout the war. A long-barreled version of the Eighty-eight with a muzzle velocity of 1,050 meters per second, developed in 1941 and fielded late in the war, was very successful. A new heavy 150mm gun was under development but never saw action. Despite these and other tactical and technical innovations, it became evident that the heavy anti-aircraft gun was no longer effective against fast, high-flying targets.

There was excitement when the command *"Eisen an den Feind,"* or "Steel on target," galvanized gun crews to put as much steel on target as Krupp or Rheinmetall gun barrels could endure. Yet it was frustrating to see groupings appear in the contrails of American bomber formations. It was even more unsettling when occasional well-placed flak bursts were on target and nothing happened except that the Flying Fortresses and Liberators, completely undaunted by the clouds of flak, droned relentlessly on toward their targets. Soviet TB-3s and PE-8 heavy bombers also began carrying out massive air raids toward the end of the war and were equally undeterred by anti-aircraft fire. The effects of anti-aircraft barrages on British aircraft, which attacked by night, remained invisible unless a fireball briefly flashed in the sky.

In low-level attacks, the effects of fire were observed, but often seemed to leave the attacker unscathed. American and British fliers seldom broke off an attack. Sorties of one or two aircraft were common and their aim was usually good. The only way to stop attacks of American or British planes was to disable or destroy the aircraft, or kill the pilot. To achieve this was no easy task, especially when flak-supressio missions were flown.

Soviet fliers were less adroit and not as accurate. Shells from light anti-aircraft guns glanced off the armored *Ilyushin Shturmoviks* and the *Yakovelv* ground-support aircraft. Soviet resurgence in the air brought flocks of these Ils and Yaks to the scene with a corresponding rise in aggressive spirit on the part of the Soviet pilots. When scores of Soviet aircraft attacked from several directions, the sheer number of bombs, rockets and machine-gun



The P-Band Wuerzburg radar was fielded in 1942. The battery radar was accurate to 15 kilometers, but was seriously affected by chaff and Allied jamming devices.

bursts eventually scored successes. The Soviets did best when attacking targets, such as hospital ships, that did not shoot back.

Rockets and Missiles

The Germans devised an interim solution with unguided Taifun rockets. These were fired from conventional gun tubes and proved quite effective. Insufficient quantities, however, precluded a significant change in the deteriorating situation.

High hopes were placed on the weapons developed at Peenemuende, the most famous of which were the V-1 "buzz bomb" and the terrifying V-2 rocket, the forerunner of today's intercontinental ballistic missile. The German scientists at Peenemuende, many of whom worked at Fort Bliss, Texas, following the war, also added to Germany's air defense arsenal. The surface-to-air missiles developed at Peenemuende were either subsonic, aerodynamic vehicles exemplified by the Schmetterling and the Enzian, or ballistic designs which included the Wasserfall and Reintochter.

The Wasserfall had the greatest promise. It was a scaled-down version of the army's V-2, traveled at Mach 2 to altitudes of 20 kilometers and attained a horizontal range of up to 25 kilometers. These first-generation, surface-to-air missiles flew at 400 to 500 kilometers per hour and were employed against bombers. They might have tipped the scales in favor of the defenders. But again, they came too late.

The shiny aluminum skin of American bombers at 7,000, 8,000 or even 10,000 meters made optical tracking difficult. This was one reason for selecting an aircraft in the middle of the formation. British night bombers were painted dark colors to blend with the night. German night fighters were equipped with airborne radars and occasionally transmitted data to Malsi crews. The countermeasure was the 88kw Tuba transmitting diversionary signals from the British coast.

The German fire-direction device was primarily the EM2mR40. This was essentially a stereoscopic rangefinder with a two-meter base that was wedded to a computer. A crew of five operated this fire-direction device. The E-1, E-2 and E-3 determined range, azimuth and elevation, respectively. Each of them could substitute radar information transmitted by data link simply by matching dials. After the initial fix and data surge, the computer held the target and automatically followed it along the predicted flight path.

The B-4 operated the computer while the B-5 controlled outgoing firing data transmitted to the guns. The B-5 saw target speed, altitude and course on his instrument, recognized changes and initiated the computer process to fire on turning, ascending or descending targets. Confidence in this device was so great that wild boasts about the invincibility of German flak were publicly aired. The older, 1934 fire-direction device was widely available, was smaller, more rugged, but much slower and less accurate.

Manpower

The manpower shortage was met by drafting boys from German secondary schools. By 1943, entire classes were conscripted and 10th and 11th grade students from small towns which had not yet felt the impact of war were brought to the cities threatened by air attacks. These highly motivated boys were called *Luftwaffenhelfer* or *LwH*. They were air force auxiliaries in baggy and threadbare uniforms salvaged from air force depots. The youngsters were initially assigned to light duties. As the manpower shortage worsened, they began to operate radars, fire direction centers, Malsi devices and even took to the seats of the heavier guns to set azimuth and quadrant. Flak-suppression attacks by Allied fighter-bombers exacted a heavy toll, but strengthened the resolve to fight.

In upper Silesia, air force auxiliaries defended their batteries against the onslaught of the Red Army. Their flak islands were ringed by the carcasses of burned out Soviet tanks and continued as pockets of resistance while nearby factories still cast guns. The flak islands fell one by one only after the Red Army had bypassed them and was approaching Berlin. The Silesian *LwHs* suffered bitter casualties or died in Soviet prison camps.

Other manpower augmentations included Russian prisoners who performed menial chores and carried ammunition. Skilled Russians worked hard in jobs they knew, such as operating diesel generators, earthwork construction or repair of facilities. These Soviet citizens worked well and reliably when treated fairly and when fed the same rations as the rest of the battery.

In 1944, some batteries were manned by physically strong women. They operated guns with efficiency and equaled any crew, even when loading Eighty-eights at the maximum elevation of 85 degrees. Soviet women demonstrated the same determination when defending Soviet cities against German air attack.

Conclusions

During World War II, it became obvious that ground-based air defenses were at a disadvantage. It required an enormous effort to warn, control and manage resources, and to recover from attack. The air war affected every facet of life of the entire population. Technical innovations introduced during the war set the pace for decades to come. Dual-purpose weapons firing fixed munitions offered alternatives. Munitions became more lethal. Automatic loading and data linkage of anti-aircraft guns became standard. Advances in electronics and computers brought sweeping changes and revolutionized the conduct of war. Electronic warfare, with endless countermeasures and counter-countermeasures, reached a climax in phases of the air war, and the technical or tactical advantage seesawed between attacker and defender.

The fundamental lesson of World War II anti-aircraft weapons was the realization that, all boasts notwithstanding, determined air attacks cannot be stopped. The awesome legacies of World War II still haunt the world with today's almost invulnerable air and space vehicles containing nuclear warheads. Surface-to-air missiles offer an excellent chance to defeat manned aircraft and aerodynamic vehicles, but have not equaled the reliability and versatility of guns. Air defense efforts must transcend not only service rivalries; they must integrate the resources of an entire nation. It was also demonstrated that attempts to standardize procedures in wartime are costly and inadequate.

The example of boys from secondary schools, together with women and prisoners of war serving in anti-aircraft batteries, amply illustrates that the human element is the ultimate determining factor in the effectiveness of air defenses. As long as ballistic missiles, air-breathing missiles, long-range bombers and other aircraft pose a threat, these lessons are critical in assuring our national survival in the event that America and Americans become targets.

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