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STUDY No. ~~29~~

ANGLO-AMERICAN TECHNIQUES OF STRATEGIC WARFARE IN THE AIR

A detailed analysis of the specifically Anglo-American techniques of strategic air warfare in World War II

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FOREWORD

The treatment of the subject material in the present study follows the general principle of placing the development of specifically Anglo-American techniques and methods of strategic air warfare in two separate categories for examination:

1. Original ideas introduced by the Anglo-American Command;

2. Techniques and methods developed in reaction to German defense measures.

The first category is linked directly with the strategic objective aimed at. It calls for ideas and considerations on the subject of which techniques and methods should be applied to achieve the desired ends.

The second category is the second component in the dynamic interplay between action and reaction in air warfare, and at any time represents the effects caused by German defense, which made certain results on the opposing side a compelling necessity in the form of a modification of existing techniques and methods.

An exhaustive treatment of the subject would necessitate the inclusion of all theaters of war in which the Anglo-

Americans actually conducted strategic air warfare. The time allowed for completion of the study compels the author, however, to confine his treatment to the Anglo-American conduct of air warfare against German territories, against German-occupied territories in Western Europe, and against the Balkan oil regions.

In strategic air warfare the term "techniques" as used in this study must be taken in a very broad sense to include the entire complex of implications between the strategic objective aimed at and the ways and means to achieve that objective in air warfare. This means that it will also include tactics, since it is usually combined with the use of technical means.

Two possibilities presented themselves to the mind for an organization of the treatment:

1. Organization by individual subjects;

2. Organization by chronological sequence.

Contrary to the original author, the final author decided to adopt the chronological organization. The reasons were twofold:

1. In point of time, operations by the British and by the US Air Forces in Europe in strategic warfare against Germany only commenced in August 1942 to coincide.

Up to that time the Royal Air Force alone conducted strategic air warfare against Germany.

2. The whole complex of strategic air warfare against Germany at various times and differing distinctly between the Royal Air Force and the US Army Air Forces reveals innumerable technical details and characteristic features in the most widely varying fields. A chronological treatment was thus the only possible way to develop a plastic presentation of the whole complexity of techniques in strategic air warfare from the innumerable details on the various time periods.

The author had available as source material the data accumulated for compilation of the two studies on German air defense together with the text of those two studies, one of which he himself had compiled. Very copious, but not complete, material was thus available for the present study.

This explains why the treatment of the various time periods and part subjects is uneven in point of detail.

In many cases the final author was able to rely on his personal recollections of experience during assignments in the war, namely, in command of Fighter Command Holland-Ruhr Region from August 1942 to November 1943, and in command of the 3d Fighter Division, with headquarters at Deelen, from November 1943 to April 1945.

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PART I

THE ANGLO-AMERICAN CONCEPT FOR STRATEGIC AIR WARFARE AGAINST GERMANY

For an examination of the techniques employed by the Anglo-American air forces in strategic air warfare against Germany it is necessary first to consider the basic factors which determined those techniques.

The factors are as follows:

(1) The concepts ruling in the British and US air forces concerning the objectives of strategic air warfare.

(2) The development of air power to put these concepts into effect.

CHAPTER 1

THE ROYAL AIR FORCE

In Great Britain, just as was the case in Germany, the theories expounded by Generals Douhet and Rougéron concerning the role of air power in any future war were the psychological factors which formed and developed concepts in the period around 1930 on the subject of strategic air warfare.

The essential features of these concepts were as follows:

(1) The concept of air power which was to make it

possible from the start of war to operate against the enemy sources of military power throughout enemy territories;

(2) The concept of air supremacy over enemy territories as the essential condition for the successful conduct of land and naval warfare;

(3) A strategic bomber force capable of annihilating action against all types of militarily important targets.

British Field Marshal Montgomery summarized these principles as follows:

> One must win the air battle before one begins the battle on land and at sea.[1]

In Britain demands made since 1933 were in line with this concept. These demands were for an operational air force with a long range of striking power and capable of crippling action in night attacks against area targets by means of stick bombing with heavy calibers.

To meet these demands the bomber forces program established in Britain in 1933 provided for the development of large four-engine bombers with a total loaded weight of 30 tons, and twin-engine models with a total loaded weight of

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1. Source 1.

2 15-20 tons. In 1937 the latter were redesigned for four engines, which produced the Avro Lancaster Model (27 tons) and the Handley-Page Halifax (26 tons). Apart from these the Short Stirling (total loaded weight 31 tons) designed from the start for four engines remained in production.

The Stirling made its first factory trial flight in October 1939 and was delivered to the troops in 1940.

The Halifax was used in strategic missions on the night of 10-11 March 1941 for the first time, the Lancaster on the night of 3-4 March 1942.

At the start of the war Britain thus had none of the large bomber models available which were provided for in the established program. For strategic air warfare the Royal Air Force initially had to rely exclusively on the available twin-engine medium bomber types. The bomb carrying capacities and range capacities of these models necessarily determined the strategic objective; their equipment determined the technical execution of their missions.

The bomber types available to Britain in September 1939 were as follows:

> The Bristol "Blenheim," the Vickers "Wellington," the Handley-Page "Hampdon," and the"Whitley."[2]

Sources 2 and 3; Appendixes 1-7.

After the first sizable daytime operational missions by Royal Air Force units, an attack on 4 September directed against Ger man Battleship Scheer at Wilhemshavem and one on 18 December 1939 directed against the naval post of Wilhelmshaven itself, had failed at heavy cost due to German defense action, the British drew the logical conclusions and changed their entire plan for bombing operations to one of night time strategic warfare; at the same time they developed the principles of area bombing since the aiming devices and means of navigation available at the time were inadequate for precision attacks at night.

This meant logically that the only strategic targets for night attack were the large German industrial centers. They were the only targets which held out any prospects of of possibilities to inflict serious damage even if the bombing was not very accurately aimed.

In a radio address to the German Nation in 1943, British Air Marshal Sir Arthur Harris, in command of the Bomber Command, endeavored to justify this strategic concept with the following words:

> I shall be quite frank with you, whether we are bombing individual military targets or whole towns. Naturally we prefer to strike factories, shipyards,

and railways, but the people who work there live near by. Therefore we strike your houses and you. Hitler wanted it that way.....[3]

In respect to the British strategic concept it is therefore necessary to establish here that the desire to reduce the risk of losses and to secure air supremacy over enemy territories (Germany) , which in turn means to secure superiority of the attack weapons over the defense, initially resulted in the principle of area attacks at night and thereby logically in the selection of a certain category of targets which held out prospects of success in such a system of attack. By placing homes on an equal level of importance with industrial works in the matter of their significance for overall manufacturing processes, every industrial town in its entirety became a military target, the bombing of which could not be described as contrary to international law.

The Royal Air Force therefore devoted all efforts to increasing the effectiveness of nighttime area bombing attacks continuously, which required a very flexible system of balancing the strength and capabilities of their bomber forces against the capabilities and performances of the defenders.

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3. Sources 2, 4.

5 . There could hardly have been any room for doubt, however, that with these techniques the Royal Air Force could not completely achieve the objective of strategic air warfare, namely, destruction of the German military potential. A large complex of military targets still existed outside of the large industrial towns, which could only be neutralized by means of precision bombing attacks. It was left to the US air forces, with their 4-engine bombers, to execute this mission in daylight attacks.

It was this combination of daylight and night attacks, with each of the two partners specializing on a specific type of operations and with the forces divided accordingly for action against specific targets, which actually introduced the perfect pattern of total air warfare, in which the side with the strongest air power necessarily had to achieve absolute air supremacy. Once this state of absolute air supremacy was achieved in the autumn of 1944, the Royal Air Force, without lengthy preparations, was also able to dis-

6 patch its 4-engine bomber units on daylight precision bombing attacks against point targets, such as hydrogenation plants in the Ruhr region, and thereby vary their strategic objectives.

Precision bombing attacks at night only became possible after the necessary control and navigational means had been

6 introduced for the purpose. With the Oboe or Boomerang navigational instruments introduced in January 1943 the Royal Air Force,from stations in England,was able to direct attacks against targets within the Ruhr region with a margin of accuracy of 200 by 200 yards.in bombing. This enabled the Royal Air Force to expand its strategic objective to include night time air attacks against any point targets within the operating range of the new instruments. However, technical considerations made it necessary to restrict use of the new methods to the twin-engine De Haviland Mosquito type bomber for single plane attacks, since this was the only British model which could operate at the necessary altitude of between 30 000 and 34 000 feet.

In these operations it was found that it will not always be the strategic concept which determines the means used for its application, but at times on the contrary the available means and their specific features which determine the strategic concept.

On the whole the views of the various powere hardly differed. The reasons for any differences were to be found in each case in the specific position and interests of a power. Great Britain, as an island kingdom and a naval power logically always considered the greatest threat to be the German

Navy with its concentration of power in submarines (arousing fateful memories of World War I) but also with a number of ultra modern surface units, all of which would threaten sea routes. Therefore, nothing could have been more natural than that Britain should have started operational air warfare only one day after the declaration of war against Germany, on 4 September 1939, with an air attack by 20 Blenheim and Wellington bombers directed against German Battleship Scheer, which was in port at Wilhelmshaven.

The attack failed at the cost of twelve bombers destroyed by the German defenses, and this caused the Royal Air Force to be more cautious for some time.

When the Royal Air Force finally, on 18 December 1939, decided on its second attempt at large scale daylight operations, the target again was the German Navy, this time to be struck by damage to its base at Wilhelmshaven.

This operation also failed completely, with 34 of the 52 attacking aircraft destroyed, compelling the Royal Air Force to postpone further strategic operations of any size until its build up of a fleet of 4-engine bombers was completed.

Practically speaking, this waiting period lasted until the spring of 1942, and was used by the Royal Air Force to accumulate the necessary experience in night operations, under

7 all conditions of weather and in all seasons of the year, in navigation, and on the German defense system, for the large-scale operations which were to follow later.[4]

The era of British strategic air warfare was opened with the large-scale attack against Cologne on the night of 30-31 May 1942, an attack recorded in the history of World War II as the "1 000-Bomber Attack."

Because of the conditions imposed by the system of area bombing, attacks by the Royal Air Force until the beginning of 1943 were directed against the following target categories:

(1) Naval bases and their sources of supply;

(2) Areas showing a concentration of key industries, such as the towns of Duisburg, Essen, Oberhausen, Bochum, and Dortmund;

(3) Other industrial centers, such as Cologne, Duesseldorf, Kassel, Frankfurt, Mainz, Wiesbaden, Mannheim, Stuttgart, Nuremburg, and Muenchen;

(4) Traffic centers, such as Cologne, Duesseldorf, Muenster, Osnabrueck, Hanover;

(5) Berlin as the Capital city of Germany, and as a center of industries and traffic and communications.[5]

When the US strategic air forces based in England had

4. Sources 5, 6, 7. 5. Study 164, Vol. II and III

8 completed their phase of test operations against the German-occupied territories in the west and had gathered enough experience to carry strategic air warfare directly to the German homeland, it was necessary to coordinate the Anglo-American strategic objectives. This coordination was formulated in the Casablanca Directive of 21 January 1943.

The mutual objective in air warfare was declared to be

> .....continuous operations to destroy and eradicate the German military, industrial, and economical systems, and to undermine the morale of the German Nation until a point was reached at which Germany's capabilities for armed resistance are threateningly weakened.

The relative importance of the various types of strategic targets was stated in the following sequence of priority:

(1) Submarine construction yards;

(2) The industries supporting the German Air Force;

(3) Traffic and communication centers;

(4) Installations of the fuel producing and processing industries;

(5) Other targets important to the German armament program.[6]

Initially, there was no division of specific targets between the Royal Air Force and the US Army Air Forces. This

6. The Army Air Forces in World War II, Vol.II, pp. 305/307.
7. Ibid, p. 375.

lack of clarity was only remedied, and then only to some extent, by a modifying new directive issued on 10 June 1943 to insure cooperation between the Royal Air Force and the US Army Air Forces by means of the Combined Operational Planning Committee. All efforts to achieve complete agreement and complete coordination between the two air forces failed because theories on the proper system for strategic air warfare differed too widely. While the Royal Air Force held the opinion that destruction of the German war potential could be achieved primarily by means of action to destroy the morale of the civilian population, those directing operations of the US air forces continued to adhere to their method of daylight precision attacks directed specifically at the resources of Germany's armament potential.[7]

Assignment of the British and US strategic air forces in Europe under General Eisenhower as Head of Supreme Headquarters, Allied Expeditionary Forces in Europe, on 17 April 1944 for the first time brought about a complete coordination of strategic planning between the Royal Air Force and the US Army Air Forces. Initially, this planning concerned preparations for and execution of the invasion in the west. It resulted in establishment of the Combined Strategic Targets Committee which assumed responsibility for the selection and assignment

of targets and remained in existence practically until the end of the war.

When action against the German output of fuel oils was given top priority shortly before the invasion in the west, the Royal Air Force was specifically assigned ten hydrogenation works in the Ruhr region as targets and also received the mission of mining the Donau River in the Hungarian-Jugoslav areas for the purpose of interrupting the transportation of crude oils from Rumania to Germany.

Finally, the directive dated 25 October 1944 assigned to the Anglo-American strategic air forces, in order to bring the war to an early end, the following target categories:

(1) Fuel oil producing and processing installations;

(2) Traffic installations and media.

This basic order remained in force up to the end of strategic air warfare against Germany on 26 April 1945.[8]

Within the scope of this stated objective, operations of the Royal Air Force at any given time were directed at those targets which, with due regard to weather conditions and German defense capabilities, appeared best suited to its methods of attack. The extremely flexible definition "traffic installations," provided justification even for massed

attacks against all large towns in Germany, since all such towns were at the same time centers of traffic.

In principle, the Royal Air Force continued to adhere to the system of massed night attacks right up to the end of the war. The impossibility to achieve real bombing accuracy under this system necessitated the selection of large area targets. Under these conditions, the 4-4ngine bomber was the weapon best suited to achieve maximum results.

In its efforts to achieve its strategic objective of systematically destroying all large German towns, the Royal Air Force held the basic opinion that the damage thus done to Germany's military potential would be serious enough, when combined with the impact on the morale of the civilian population, to aompletely achieve the purposes of air warfare.

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CHAPTER 2

THE US ARMY AIR FORCES

The geographical position of the United States of North America and the great distances which separated it from any possible future enemy contributed already at an early stage towards directing interests towards development of a large bomber with an operating radius of approximately 1 000 miles and a payload of four to five tons. The first model produced under this concept, the Barlin 6-engine bomber with a payload of 20 tons, proved a failure. Only one pilot model or test model of this type was ever manufactured.

In 1933 contracts were awarded for development of a non-stop flight capacity large bomber with a ~~xxxxxxxxxxxxxxx~~ of 5 000 miles, a speed of 200 miles, and a payload of 2 000 pounds. The outcome was the 4-engine Boeing XB 15 in 1937 with a speed of 200 miles and a total weight of 30 tons. Efforts to achieve the specified striking radius of 2 500 miles failed. The XB 15 remained the only test model of this type.

Another model designed for more modest performances by Boeing, the B-15, so impressed US Air Force circles by its test flight performances in 1935 that the firm was awarded a contract to manufacture a series of 65. In the same year the first plane of this series crashed and burned, whereupon

the contract was reduced to a series of only thirteen. The last of these 13 B-17s was delivered to the US Army Air Forces in August 1937.

At that time opinions differed in American military command circles on the subject of the principles of a strategic bomber. The Army did not consider the need acute for a large long-range bomber. Instead, it preferred that the Army Air Forces should have "aircraft with reasonable performances," over the unpredictable results of any large bomber development program. A supporting argument here was that the US Navy with its eleven carrier based bomber squadrons was able to operate adequately within the vitally improtant strategic areas to meet all requirements of safety for the United States.

It was 1938 before President Roosevelt succeeded in establishing a program for the buildup of a strategic air force relying on large bombers. At the time of this decision the USA had only thirteen 4-engine bombers, namely the thirteen Boeing B-17-As delivered in August 1937. In 1938 this model was placed in production under a high priority program.

In 1939 a model developed parallel with the B-17, namely the Consolidated B-24 Liberator was included in the production program.

In 1939 the US Army Air Forces took delivery of another 39 B-17 Fortress bombers. The available strength in 4-engine

13 bombers increased again in 1940 by another 53 B-17s plus 7 B-24s, and in 1941 by 144 B-17s and 169 B-24s delivered to the air forces and placed in service in the strategic arm.

Of the above 4-engine bomber models the units in the European theater of operations were equipped with planes starting from the E-Series, but more largely with planes of the F- and G-Series. In these models the altitude performances of the prewar series had been improved by 10 000 feet through the installation of compressors, while the striking range had been increased considerably by the installation of additional fuel tanks.

Compared with the 1 600-mile striking range and 2 500-pound payload of the B-17 models of the C- and D-Series, those of the F- and G-Series had a striking range of 2 000 miles carrying a payload of 4 000 pounds. With a correspondingly reduced fuel load, these bombers could carry up to eight 1600-pound bombs.

Compared with the five machine guns mounted in the former series, bombers of the B-17 F- and G-Series mounted twelve 127-mm machine guns.

The net weight of the B-17-F was 15.4 tons, compared with the 12.2 tons of the C-Series. The increased weight was due to the increased number of weapons and to the strong 8-10-mm

14 armor plating which protected all particularly sensitive parts, such as the engines and the fuel tanks.

Powered by four Wright R-1820 engines each with 1 200 horse power, the B-17-G had a maximum speed of 300 miles and could operate at a peak altitude of 33 000 feet.

The Consolidated B-24 Liberator also underwent a number of modifications. Serial production began with the B-24-D Series. Powered by four P & W R-1830 engines of each 1 200 horse power and with ~~XXXXXXXXXX~~ turbo-compressors, the B-24 achieved a maximum speed of 300 miles and a peak altitude above 33 000 feet, and was armed with ten 127-mm machine guns.

The advantage of the B-24 over the B-27 was its greater striking range when carrying the same bomb load; its weak

15 points were its weaker defensive fire power and its restricted field of fire rearward due to its dual tail assembly (Doppel-Leitwerk).

Due its greater operating range, the B-24 was particularly suitable for operations in the Pacific theater.

At the time when the United States entered the war against Germany in December 1941, the US strategic air forces had a total strength, in 4-engine bombers, of not quite 300 aircraft.[9]

9. Sources 18; The AAF, Vol. II, pp. 193 ff. See also Appendixes 8 and 9.

15 The advance echelons dispatched to organize the US Eighth Air Force arrived in Britain on 22 February 1942. On 17 August of the same year the air force for the first time dispatched twelve B-17 bombers from a British base to attack the Rouen rail depot in France. This operation did not constitute the opening of strategic air warfare against Germany; it was merely the beginning of a phase of experiments with the American methods of daytime precision-bombing attacks.

All of the missions flown in 1942 by units of the US Eighth Air Force against targets in France were planned primarily to test and prove sound in practice the American theory that success in strategic air warfare can only be achieved by means of precision bombing attacks during daylight. The small losses incurred in these operations gave the personnel of the units engaged a quite considerable feeling of confidence in their ability to cope with the German defenses.

The 21 January 1943 Casablanca Directive was the deciding factor which brought the experimental phase to an end and initiated the phase of actual strategic air warfare by US forces against Germany herself. The attack against Wilhelmshaven and Emden by 55 B-17 bombers of the US Eighth Air Force opened this phase.

16 Up to the summer of 1943 the US Eighth Air Force directed its attacks, steadily increasing the size of the units dispatched, primarily against the above two targets and against the naval bases at Kiel, Bremen, and Cuxhaven, as well as against the railway marshalling yards at Hamm.

Occasional missions were also flown with growing frequency against the submarine bases at Brest, Lorient, and St. Nazaire, and against individual rail centers, factories, and airfields in France. However, these attacks were of smaller strategic importance, their main practical importance being that they served to test out and modify tactical methods already being used and to try out new methods devised to achieve greater accuracy in bombing.

It was late June 1943 before it became evident that the US Eighth Air Force in its strategic objectives governing the selection of targets for attack within Germany was directing its efforts specifically against one target category: against factories engaged in the manufacture of aircraft, and primarily against Germany's fighter output, including the more important industries producing accessories.

This target category included all factories manufacturing Me-109, FW.190, Me-110, and Ju-88 aircraft, plus the ball-bearing factories in Schweinfurt.

16 This phase of strategic air warfare against German territories reached a peak in what was called the "Big Week" February in 1944, when a series of heavy attacks struck all important works engaged in the manufacture of fighters. The whole series of attacks was carried out in accordance with a pattern preplanned mutually by the US Army Air Forces and the Royal Air Force for daytime and night operations.

17 In the meantime the Western Allies had found a solution to the problem of how to provide fighter escorts to protect their 4-engine units throughout their missions. This, and the introduction of blind bombing techniques enabled the US strategic air forces to systematically attack all targets of strategic importance within the German homeland, in the Balkans, and in the western German-occupied territories.

In these operations the precision bombing tactics of the US forces were incomparably more effective than the system of area bombing followed by the Royal Air Force. For example, when the major issue prior to the invasion was to interrupt German communication routes to the west, it was the 4-engine bombers of the US Army Air Forces which accomplished this mission with machine-like precision.

In the oil offensive, which commenced on 12 May 1944, the US strategic air forces received the mission of

17 attacking all installations of the German fuel producing and processing industries outside of the Ruhr region.

After capture of Foggia Air Base, in Italy, by Allied forces, there was no target of strategic importance, even if it was as far distant as Eastern Poland or Rumania, which could not be reached by units of the US Eighth Air Force from English bases or by units of the US Fifteenth Air Force from Italy.

The Combined Operations Planning Committee and the Combined Strategic Targets Committee did thorough work in recording all targets of decisive importance for the outcome of the war and in checking the destruction achieved in attacks against them as well as the possibilities for their repair. The data necessary for these purposes was procured

18 by means of systematically conducted air reconnaissance. Here it was the British high-performance De Havilland Mosquito aircraft, against which the German defenses were practically helpless, which insured the continuity of reconnaissance coverage for the British as well as for the US conduct of strategic air warfare against Germany.

From 1944 on the Anglo-American strategic air forces gave a classical demonstration of air power and air supremacy in operations over the German homeland and over the terri-

territories under German occupation. Enjoying complete freedom of action and unlimited possibilities for the deployment of their forces, it was now merely a matter of techniques to inflict the necessary degree of destruction on any current target to insure its permanent elimination.

The development of these specifically Anglo-American techniques of strategic air warfare will be dealt with in greater detail in the chapter which now follows.[10]

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10. Sources: Study 164, Volumes II and IV; The AAA, Volumens II, pp. 841, ff.

PART II

CHAPTER 1

19

THE ROYAL AIR FORCE FROM THE BEGINNING OF THE WAR TO MAY 1942

1. ~~1939-1940; The Polish Campaign and the 1940 Campaign in France~~. In its first strategic action, the British bomber arm dispatched 20 medium bombers of the Blenheim and Wellington types to attack German Battleship Scheer at Wilhelmshaven. Plans for this operation were obviosuly premised on the assumption that an approach across the North Sea and the Bight of Helligoland would take the German defenses by surprise because of the inadequate depth of the warning area.

This appraisal of the tactical situation proved false because of a factor unknown to the Royal Air Force at the time and which therefore could not be taken into consideration at planning: the existence of the first models of the Freya radar instrument installed on the Ea t and West Fresian islands.

On 18 December 1939 the Royal Air Force staged its second attempt, this time employing a strong force of bombers to attack the German naval base of Wilhelmshaven. This attack also failed because the Freya instruments of the Navy detected the bombers early on the approach route, so that the

German fighter defense received an early warning. In this operation the Royal Air Force lost 65 percent of the units committed.

This proved finally that the techniques of daylight attacks for strategic air warfare were too costly for the British Bomber Command and could no longer be applied.

The most important targets for attack by the Royal Air Force were situated along the German North Sea and Baltic Sea coastline. Because of the neutrality of Belgium and Holland the only approach to these targets at the time was across the North Sea. This circumstance created serious navigational problems which could be solved during daylight by means of compound navigation (Koppelnavigation) supported by visual observation once the coastline was reached, but which it was difficult to cope with at night.

The transition of the British Bomber Command from daylight to night strategic operations, rendered necessary in the light of the experience of 18 December 1942, thus involved a mission of comprehensive training. Besides the matter of target locating, solutions had to be found here for the problems of determining the best methods of attack, the most favorable flight altitudes, weather conditions, flight control, and the best ways and means of coping with the German fighter

20 and antiaircraft artillery defenses.

This explains why the Royal Air Force in the period following its costly operation of 18 December 1939 showed so little activity in strategic air warfare, and why the few aircraft which did penetrate over German territory dropped more leaflets than bombs.

In January 1940, for example, only nine British aircraft

21 penetrated over the western German border areas and over the northwestern coastal areas. Three of these penetrations were at night, and only two aircraft dropped bombs. Out of thirteen penetrations in February 1940 three were at night and only one plane dropped bombs. In March 1940 the number of penetrations increased to 23, seven of them at night and with six bombs dropped on ~~XXXXX~~ occasions. In April there were no night penetrations and seven of the 22 aircraft penetrating during daylight dropped bombs. In the 1-10 May period eight aircraft penetrated, three of them at night and three dropping bombs.

After the Western Campaign opened on 10 May 1940, the Royal Air Force became increasingly active in daylight and night harassing attacks by single aircraft.

On the night of 17-18 May 1940 the Royal Air Force for the first time again staged a sizable strategic attack. The force of 40-50 bombers dispatched on this operation attacked

21 the Hamburg and Bremen areas and inflicted the first heavy losses among the civilian population.

This reveals clearly that the operations of the Royal Air Force against the German homeland during this period were primarily for the purposes of training in air warfare. There can be no question of strategic air warfare during this period.[11]

2. ~~Royal Air Force Operations Against Italy in 1940~~.

When Italy declared war on Britain and France on 10 June 1940 the Royal Air Force retaliated by dispatching a force of 36 Whitley bombers to attack the Fiat works at Turin. The attack was executed on the night of 11-12 June 1940, after the aircraft participating had stopped over on the Canary Islands to refuel.

The inadequacy of the British techniques for night attack at this juncture is evident from the fact that of the 36 bombers committed only nine bombed the assigned target, while two bombed alternate targets at Genoa, and the rest failed completely in their mission.[12]

3. ~~Royal Air Force Operations~~ against the German Zone of Interior from the Summer of 1940 on. When the German air offensive against Britain commenced in August 1940 with main concentration against the London area, the Royal Air Force

22 gave a demonstration of its strategic capabilities by staging an attack with a small number of Whitley bombers against Berlin on the night of 25-26 August 1940. Given a moonlit night and a cloud cover not exceeding 5/10, a mission of this type was not too difficult for a small number of experienced crews even at that stage of imperfect techniques for night operations.

It is obvious that the attack by a number of Whitley

23 bombers against the Skoda Works at Pilsen on the night of 27-28 October 1940 was a far more difficult matter, since only one of the planes dispatched reached and bombed the target.

At that time the success or failure of British night operations hinged on three factors: accurate compound navigation by the crew members, moonlight, and favorable weather. The most uncertain factor here was that of weather, which could not be predicted with certainty for long routes.

With the night attack by Royal Air Force bombers against Mannheim on the night of 16-17 December 1940, the last month of the year witnessed the first real area attack against a major German city. A total of 100 bombs fell within the city limits, inflicting serious losses among the civilian population and badly damaging buildings.

11. Source: Study 164, Volume I. 12. Source 2.

23 3 In all of the attacks mentioned above the tactical unit involved was the individual aircraft. The duration of the attacks was relatively long, consisting of a succession of attacks by individual planes against one and the same target.

In the winter of 1940-41 the Royal Air Force concentrated its night operations against hydrogenation works in the Ruhr region. All attempts failed completely because the techniques for night operations had not yet been adequately developed to detect and strike point targets of this type located within densely built up town complexes.[13]

In early 1941 the British achieved some progress in de-

24 veloping their night attack techniques:

a. On the night of 24-25 February 1941 the British twin-engine Avro Manchester, a forerunner of the Lancaster, was used for the first time in an attack against Brest;

b. Wellington bombers attacking Emden on the night of 31 March-1 April for the first time delivered a 4400-pound bomb.

It is thus necessary to note that at this point the capabilities of bombers had improved and that the size of bombs had increased considerably.[14]

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13. Sources 2, 8.
14. Source 2; See also Appendix 7a.

The problem of target locating at night still remained to be solved. As had been done by the German Air Force, the Royal Air Force now learned by experience that the methods of compound navigation and astro navigation could never be precise enough to find with certainty and identify a target located in the enemy interior. Dependence on moonlight and good conditions of visibility unobscured by clouds continued to impose restrictions on operational possibilities of strategic warfare at night.

This was logically an unsatisfactory state of affairs for the Royal Air Force. One of the remarkable feature of World War II is that it was the German Air Force which gave the Royal Air Force its first help in the search for a solution to its problems of navigation.

Prior to the war Germany had been in the lead in the field of radio guide beam navigation. The British at the time had no such instruments with the exception of the German Lorenz radio beacon installation for blind landing, which was manufactured under license in Britain for use in civilian air traffic.

For night operations by German bombers against Britain in the winter of 1940-41 use was made, in addition to the X and Y guide methods, for the "Pathfinder" and "Marking" units, of the "Knickebein" ultra high frequency guide system

for navigational purposes in the German bomber units.

The Knickebein system consisted of an ultra high frequency guide beam installation with rotating directional antenna operating in the 30-centimeter waveband region. This guide beam was directed at the targets, and visual or acoustic signals in the aircraft informed the pilot whether he was on the beam or to left or right of it. Arrival over the target area had to be computed by dead reckoning.

German bombers shot down over England gave the Royal Air Force possession of the aircarried signal instruments. Nothing of this type having been developed in Britain, an immediate start was made at copying the German Knickebein installations. This was relatively simple, since the aircarried component of the guide system was the Lorenz E-Bl-1 radio beacon signal receiver, which was manufactured under license in Britain. All that remained to be done was to copy the the available Lorenz radio landing beacon with a correspondingly higher ~~frequency~~ transmitting power.

This radio guide beam system of navigation was used by the Royal Air Force for the first time in the air offensive which commenced in March 1941 against the German fleet consisting of Battleships Scharnhorst and Gneisenau and Heavy Cruiser Hipper while entering port at Brest.

Simultaneously with contracts to construct the above guide beam instruments, the Royal Air Force awarded contracts to develop a new system which, while retaining the features of independent fix-taking was to make long-distance surface navigation possible. This principle had also long been developed in Germany, first by the Telefunken Company in its Ingolstadt instrument. Later this system had been improved in the fan guide beams (Faecherleitstrahl) of the Sonne and EleKtra instruments, and in the automatic position line finder (~~Standlinienpeiler~~) Hermine (acoustic) and Bernhardine (visual telereceiver) instruments. All of these instruments were in use already in 1941 on the German side as navigational aids in bombing operations against England, and the British gained valuable information for their research activities from the German bombers shot down.

Finally, British research resulted in development of the R-1324 "Gee" instrument, which established the system of what was called the hyperbol system of navigation and became a basic factor in British techniques in night operations as part of strategic warfare against Germany and the German-occupied terrttories. This system was subjected to its first test in actual practice in a night attack against Essen on the night of 8-9 March 1942.

The instrument functioned on the following principles:

26 While tuned on the instrument measures the receiving (or time-distance) distance/from of the aircraft from two separate ultra-short-wave senders operating on wave lengths around 4.2 meters. The aircraft then steers into a course equidistant from the t two senders. Given a constant time-/distance-difference this line will appear in the form of a hyperbola.

Any point in terrain can be determined by the time-distance xxxx difference between two senders. The mission of the aircraft navigator is to find the hyperbola referring to Target X and to so guide the aircraft that the time-distanc difference between the two sending stations is adhered to

27 precisely. When this was done the aircraft followed the exact course of the hyperbola , which also intersected Target X. When a rough dead reckoning showed that the aircraft was close to the target, the navigator computed the hyperbola and time-distance difference resulting from the position of the target in relation to a third sending station. The point of intersection of the two hyperbolas at target X corresponded to two specific time-distance differences. Once these factors were achieved the aircraft was exactly over the target.

The data received was registered optically in the aircraft by means of cathode ray tube marked with three light point gradings. The time- distance difference of the target

27 computed by the navigator was set on the one scale. A second dot showed the corresponding hyperbola. The time-distance signals coming in through the receiver produced sparks in the cathode ray tube indicating the position of the aircraft in relation to the hyperbola. Once the aircraft was on a course following the first hyperbola line, the navigator tuned the receiver to the second hyperbola. This informed him continuously on the exact distance to the target, which showed as a zero as soon as the time-distance difference correspomding to the hyperbola was reached.

Using captured data, German authorities (the Telefunken Company) determined that the Gee instrument functioned with an accuracy degree of 0.3861 square mile (1 square Kilometer) with a range of 300 miles (500 Kilometers) from the three transmitters stationed at the southeast coast of England. This navigational equipment thus permitted complete coverage of the Ruhr region with this degree of accuracy. The center line of intersection of the three transmitters was in the approximate direction of Dortmund.

In May 1942 the German Air Force became aware of the new method by way of the instruments and navigational data found on British bombers shot down. After an investigation of its manner of functioning, the problem of ways and means

28 of interference came under examination, prompted by memories of the bitter experience made in this field during the bombing offensive against England. Effective interference was only possible by jamming the powerful British aircarried transmitters by the use of still more powerful German ultra-short wave transmitters. The only transmitters in Germany which were powerful enough for the purpose were those in use by the Post and Telegraph Service, and since measures first had to be taken to make these available, immediate German action to interfere with the Gee system was not possible.[15]

The fact that it took up to early 1942 to find the Hyperbola system as a solution to the navigational problem was one of the important reasons for the small activity of the Royal Air Force in the field of strategic air warfare against Germany in 1941. Another reason was that the British Bomber Command was heavily engaged against German submarines and naval surface units in the Atlantic.

It was July 1941 before the British made a new attempt to intensify their attacks against the industrial towns in the Ruhr region , and against Hamburg, Bremen, Hanover, Frankfurt, and Stuttgart. The results achieved were so unsatisfactory for the British Command, because of the too great

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15. Source 9

29 inaccuracy of bombing, too great dependence on weather conditions, and mounting losses, that strategic air warfare against Germany had to be seriously restricted in the winter of 1941-42.

As part of the air offensive against the Ruhr region, the Royal Air Force on 12 August 1941 again attempted a large scale attack during daylight. The attacking units lost 42 bombers, which was added proof that the execution of daylight attacks for purposes of strategic air warfare against targets within Germany was too costly for the Royal Air Force.[16]

In broad outline the following can be said of the techniques employed by the Royal Air Force in strategic air warfare in 1941:

a. In the first half of 1941 the ratio of daytime to night penetrations by Royal Air Force units over Germany was 1:40.

The strategic objective was limited to the execution of harassing attacks to disturb the civilian population and hamper work. The operations were in the form of continuous sequences of single-aircraft attacks against one specific target and lasted a considerable time.

Besides this system of concentrated attacks against

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16. Sources: 8; Study 164, Volume II.

29 one target, the British also carried out scattered single-aircraft attacks against targets in various areas of Germany for the purpose of causing unrest in large areas. At irregular intervals, attacks also struck localities outside of areas protected by antiaircraft artillery in efforts to bring about a dispersion of the German antiaircraft artillery forces.

30 b. In mid-1941 the Royal Air Force changed its past methods of attack. The single target attacks were concentrated within a shorter space of time by having the attacking aircraft make their bombing run from two or three different directions and from different altitudes between 15000 and and 20000 feet. Individual aircraft in the meanwhile attempted in glide-flight attacks against point targets to mislead the sonic detectors of the antiaircraft artillery.

c. In 1941 the efforts of the Royal Air Force to find satisfactory solutions to the problems of safe target locating, accurate bombing, and dependence on weather.

The Royal Air Force attacks against Luebeck on the night of 28-29 March 1942 marked the beginning of a new phase of the British conduct of strategic air warfare.

30 With the new system of hyperbolic navigation by means of the R-1324 Gee instruments, and with a steadily mounting number of 4-engine bombers available, the Royal Air Force now had the opportunity to dispatch large forces and achieve concentrated target effects.

Luebeck was not a target of real strategic importance. Situated in the midst of lakes and watercourses, however, its geographical position made it easily identifiable at night. It had no strong antiaircraft artillery defenses, and was barely within operating range of the German night fighter defenses. These same condition applies to Rostock, which a few days later served as a target for another and exceptionally heavy attack by the Royal Air Force.

The two attacks obviously were more in the nature of what might be called realistic exercises (scharfe Uebungseinsaetze), designed to try out the new systems of navigational and attack methods under not too difficult conditions.

The real meaning of these two operations became clear two months later, on the night of 30-31 May 1942, in the "1000-bomber attack" against Cologne, which in practice heralded in the new phase of systematic strategic air warfare by the Royal Air Force against the German homeland.

31 If the British Bomber Command still had any doubts that no technique existed whi h would have made the successful execution of daytime attacks against targets within Germany possible, this fact was proved definitely on 17 April 1942.

In a bold attempt, the Royal Air Force on that day dispatched twelve Lancaster bombers to bomb the MAN works in Aggsburg, which manufactured Diesel engines for the German Navy. In planning this attack the British obviously assumed that the German aircraft reporting services would not be able to detect the unit accurately enough to insure a successful commitment of German defense fighters, so that the attacking bombers would achieve complete surprise.

32 The whole operation was a complete failure. German defenses brought down four of the bombers during the approach flight and another seven during the return, so that only one bomber returned from this mission.

The courageous squadron leader commanding the bomber force was awarded, posthumously, the highest British military decoration, the Victoria Cross.

After this experience the Royal Air Force finally ceased committing its strategic forces in daylight operations against targets within Germany. The British resumed operation of this type only as late as in the autumn of 1944, after

32 the US Army Air Forces had achieved absolute air supremacy over all German territories.[17]

4. Royal Air Force Operations against German-Occupied Territories in the West: 1940-1942. It was only in 1941 that the Royal Air Force commenced to conduct strategic air warfare against the German-occupied territories in Western Europe, employing various systems adapted to the current onjectives:

a. Interdiction of Shipping along the Channel and Atlantic Coast. In the Channel areas the Royal Air Force usually committed bombers and fighters in low altitude operations, ~~xxxxxxxx~~ Whese occasionally operated in small units of bombers or torpedo bombers with fighter escorts. The operations were carried out at low altitudes to escape detection by the German aircraft reporting instruments and thus achieve the advantage of surprise.

Against shipping in the Atlantic, the Royal Air Force long-range bombers operating singly as "armed reconnaissance"units, also usually at low altitudes.

b. Operations against German Naval Bases on the Atlantic Coast. The presence of two German battleships and one heavy cruiser in the port of Brest from March 1941 on caused lively activities by the Royal Air Force

17. Sources 2, 8, 10.

33 against this port. Most of the attacks were carried out by 4-engine bombers at night.

Twin-engine and 4-engine units with strong fighter escorts also attacked occasionally during daylight. However all of the daylight attacks proved u nprofitable because of the heavy losses incurred.

A special daytime air offensive, lasting from 22 to 24 July 1941 was directed by the Royal Air Force against the more important ports along the Channel and Atlantic coast. As part of this offensive a force of unescorted Halifax and Stirling bombers attacked the port of La Pallice. Concentrated action by the defending German fighter and antiaircraft artillery forces scattered the attacking force of bombers completely.

The German antiaircraft artillery forces proved highly successful in their operations, even at night. This forced the Royal Air Force to realize that operations of the kind carried out in the past against strongly defended targets must necessarily remain unprofitable as the attacker had to depend om favorable weather and visibility conditions in order to identify and bomb the target, conditions which were also particularly favorable for the defenders.

33 For this reason the British Bomber Command from August 1941 on strongly curtailed its operations against the German naval bases in western Europe.

c. Operations against Land Targets in Holland, Belgium, and France. Here, the activities of the Royal Air Force had no particular strategic significance.

All British air attacks here were carried out only when the weather was fair. The primary purpose here was, by dispatching small forces of twin-engine bombers with strong fighter escorts, to force the defending German fighters off the ground. With numerical superiority and with the advantage of position the escort fighters were then to engage the German fighters in battles of attrition, in order gradually to wear down the German fighter defense as a whole.

The British made great expenditures in these operations and continuously devised new tactical and technical methods and combinations. For example, a force of 6-12 Bristol Blenheim bombers would approach a near-coast target in northern France, coming from North at a medium altitude and under direct escort by fighters. At the same time two strong fighter forces would fly in at a great altitude and on a wide frontage to form prongs, while another fighter force would patrol the coast at

the point of penetration by the bombers to cover their return. In such operations a force of roughly twelve bombers frequently had an escort of more than 300 fighters. The bombing targets were usually such objects as rail depots, industrial works, and airfields, targets which could be considered as of secondary importance for the real purpose of the operations.

During periods of unfavorable weather, the Royal Air Force restricted its action to daytime attacks by fighters, using bombs and weapons fire, against targets in the immediate vicinity of the coast . The approach, attack, and return were all carried out at low altitudes.

From the autumn of 1941 on the Royal Air Force showed a marked preference for attacks by fighter-bombers, with strong fighter escorts, in place of the medium bombers formerly used. The attacking units usually operated at low altitudes and , in accordance with the current weather conditions, were covered by strong ~~xxxx~~ fighter escorts against attack from above.[18]

On the whole it can be seen that the Royal Air Force techniques for strategic air warfare against targets in the German-occupied territories of Western Europe during the 1940-42 period were still in the experimental stages.

35 The lack of a reliable system of point navigation at night made night attacks against relatively small targets unprofitable. Owing to the German fighter defenses at the Channel coast daytime precision bombing attacks required an enormous expenditure of escort fighters. However, the operating range of British fighters was limited and would not permit long-range operations against targets of strategic improtance. Even the port of Brest, a target of the first order because of the presence there of a German naval fleet in 1941, was barely within the extreme operating range of British fighters, so that it was at no times absolutely certain that attacking bombers could be given adequately strong fighter protection over the target area. This made daytime attacks against Brest at all times an extremely hazardous undertaking.

Within the striking range of British fighters there were in the German-occupied territories of Western Europe no targets of particular strategic importance which would have made large-scale air warfare worth while. Aother factor was that the Royal Air Force had to take into consideration the feelings of the French, the Belgians, and the Dutch as their allies.

5. Royal Air Force Reconnaissance Activities. Realization

36 of the superiority of the German fighter defenses during daylight compelled the Royal Air Force at the beginning of the war to be very cautious in its commitment of reconnaissance aircraft.

The impossibility of any planned and logical conduct of strategic air warfare against Germany, revealed by experience in the unsuccessful operation on 4 September 1939, also served to restrict the missions of air reconnaissance.

This explains why penetrations by British reconnaissance planes in 1939-40 did not occur more frequently than once or twice monthly. It also explains why they did not, as a rule, penetrate beyond the western border areas.

In efforts to solve the complicated problem of air reconnaissance against a territory where the defending enemy fighter forces had air superiority, the Royal Air Force tried out the following methods:

a. Exploitation of Cloud Cover. In weather conditions with a closed cloud cover adequately high to permit flying altitudes, twin-engine light or medium British bombers, usually Blenheim aircraft, flew visual reconnaissance missions at an altitude just below the clouds, in order to be able to disappear into the clouds immediately if they encountered German fighters or heavy ground defense fire.

37 On very rare occasions reconnaissance operations of this type were combined with the bombing of chance targets.

b. Low-Altitude Air Reconnaissance. On the whole, this type of reconnaissance remained restricted to areas over the sea or coastline. The units employed avoided areas with strong ground defenses, and kept their stay over enemy territory to such a short time that there was no possibility for a timely commitment of enemy fighters against them.

Frequently this form of reconnaissance was combined with attacks against ships and chance shore targets. The units usually employed were fighters, using bombs and weapons fire, since their maneuverability made them less exposed to the hazards of defensive counteraction.

c. High Altitude Air Reconnaissance. This form of air reconnaissance could only be conducted during favorable weather conditions suitable for air photography. The units used were usually special type Spitfire aircraft adapted for higher altitude performances than the usual model. They operated at altitudes of 33 000 feet and more, so that the German aircraft reporting services were rarely able to track these targets with adequate reliability to send up fighters against them.

38 To keep down their weight and improve their flight performances, these British reconnaissance aircraft were unarmed, relying for safety exclusively on their ability to operate at high altitudes, their speed, and their climbing abilities.[19]

19. Sources 11, 12, 13, 14, 15.

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CHAPTER 2

THE ROYAL AIR FORCE IN THE MAY 1942-JULY 1943 PERIOD

1. Air Warfare against the German Zone of Interior in First Half of 1942. The phase of strategic air warfare which the Royal Air Force opened with its "1000 bomber attack" against Cologne on the night of 30-31 May 1942, which strictly speaking can be considered as the actual commencement of strategic air warfare against Germany by the Royal Air Force, was marked by three characteristic features:

a. Considerably larger numbers of aircraft participated in the individual attacks;

b. The bomb-load per aircraft was considerably larger than in the past because of the increased use of 4-engine bombers;

c. Bombing was far more accurate in the areas covered by the Gee system of navigation.

Following the initial attack against Cologne came another of equal size against Essen on the night of 1-2 June, followed in the same month by an attack in the size of 960 bombers against Bremen on the night of 25-26 June.

A comparison of the bombloads carried by Royal Air Force bombers in July 1942 compared with the bombloads of July 1941 shows, for example, that approximately the same

number of aircraft attacking Hamburg in July 1942 as was the case in the same month a year ago delivered on their targets double the weight in demolition bombs and ten times the number of incendiary bombs that the forces attacking in the previous year had delivered.[20]

In spite of the considerably increased number of aircraft committed, the Royal Air Force for the time being continued to adhere to its former system of attack, the component features of which were as follows:

a. Each plane bombed individually and did its own navigation;

b. Each attack was carried out in accordance with a precise plan specifying the approach route, the bomb-release time, the bombing altitude, and the home route for each individual plane;

c. The signal to commence bombing was given by especially experienced crews, known in air force jargon as "shifters", by means of bundles of flare signals and a mass release of incendiary bombs to make the target clearly visible from great distances.

d. The bulk of the bomber force attacked with demolition bombs combined with oil bombs;

e. The return flight was carried out in a swift downward slope until the Channel coast was reached in

40 order to complicate counteraction by the German night fighters;

The following features were introduced in the summer of 1942 to improve the system:

a. Elements were detailed to take action against the German night fighter arm by attacking their airfields;

b. Elements were detailed to attack the antiaircraft artillery defense in the target area with bombs and weapons fire while the main attack was in progress;

c. The duration of the attack was shortened by combining the individual bombers to form attack waves.

41 The improved accuracy in target locating due to the Gee system of navigation provided two possibilities to increase the effectiveness of attacks and reduce the risk of losses due to German defensive action:

a. Planes manned by the most experienced crews and equipped with Gee instruments could mark the target with incendiary bombs;

b. Attack operations were less dependent on good weather and moonlight, a factor which at the same time placed the defense at a disadvantage.

The Gee system was the first approach to the possibility to bomb a target with accuracy at night, without any need to actually see that target. It was thus the first technologi-

41 technological step towards the tactics of blind bombing. 21

The Royal Air Force recognized the chances held out by use of the Gee system and immediately started on a new course of action to make these navigational instruments available for use by all of its bomber forces. Possibly, the search for new techniques of attack was also a forced measure due to mounting losses inflicted by the steadily growing German night fighter defenses. The loss of 52 bombers in the attack against Bremen on the night of 25-26 June 1942 was a factor which the Royal Air Force could not afford to ignore.

In view of the fact that the new instruments for navigation and target marking played such a decisively important role but could not be provided in adequate numbers from current output to equip each aircraft in the British Bomber Command, and furthermore because the handling of these instruments was still a complicated matter, the idea was taken up of supplying them to a limited number of specialized personnel who could proceed ahead of a bomber formation to mark the route and target.

Against opposition from the Bomber Command, the operations staff of the Royal Air Force on 15 August 1942 instructed Group Captain D. C. T. Bennet, an experienced Atlantic aviator, to activate the first four special squadrons of

42 a "Pathfinder" system, and to try out such a system. Under this system a small number of highly specialized crews in aircraft with up-to-the minute equipment, and acting completely on their own responsibility, were to assume the mission of locating the target, and marking the route and the target in a manner which would enable the main body of an attacking force to orient itself exclusively by these marking and thus achieve maximum effectiveness in their attack against their assigned target.[22]

2. ~~The Royal Air Force Pathfinder System in 1942~~. Only two months after the initial order to activate Pathfinder squadrons, the Royal Air Force on the night of 13-14 October 1942 staged its first Pathfinder-guided large-scale attack. The target of attack was the German naval base of Kiel, a target easy to identify by its conspicuous geographical position.

43 The target was marked by a 4 000-pound ground marker bomb with a burning duration of two hours, and in the air by special red and yellow marking bombs giving off colored starlight.

In the period which followed it still happened frequently that the Pathfinder units failed to mark the target precisely enough, causing failure of the entire attack operation.

43 The whole idea of Pathfinder-guided operations was regarded with skepticism by the Bomber Command. This skepticism was due primarily to the success achieved by the German side in systematic operations with powerful radio transmitters in the autumn of 1942 to jam the Gee navigation system over Germany. This meant that the Pathfinder units also would again have to depend on the limited possibilities of dead reckoning and adequate ground visibility in their mission of accurately identifying the target and marking the route and the target. These conditions did not always exist and were indispensable even for the most experienced crews.[23]

However, the British operations staff did not allow initial failures to deter it on the course it had entered and by the end of 1942 activated four Pathfinder squadrons. Each squadron had 24 aircraft of the Stirling, Halifax, Lancaster, and Wellington types. In January 1943 these four squadrons were consolidated under the British 8th Bomber Command. This made it possible to insure uniform training and equipment, and an immediate central exchange and processing of experience, and to translate new ideas into action immediately.[24]

In test operations carried out by the end of 1943 with

20. Sources 2, 17.
21. Source 10.
22. Sources 8, 18.
23. Source 16.
24. Source 1.

44 Pathfinder-guided attack forces it was found that the Pathfinder units could best accomplish their mission in three stages:

a. Locating; b. Illuminating; c. Marking.

A first echelon of locator or search planes, manned by the most experienced crews and using Gee instruments, flew along three separate but parallel route approximately 3 300 yards apart dropping flares over the target to be taken under attack. Within these roughly marked target areas the next echelon, the " illuminator" units, placed a dense ring of light bombs more precisely around the actual target. The third echelon, the "target markers", then placed incendiary bombs inside the target circle thus lit up, to serve as ground markers for the first wave of the main attack force which, in turn, marked the target more effectively by mass bombing with incendiaries for the next waves of bombers, which carried demolition bombs.

In too cloudy conditions colored flare rockets were placed over the target as air markers in place of the usual ground markers.

For precise target marking the Gee system proved just as indispensable as it was found unreliable when its functioning was disturbed by German jamming stations. Its normal effective range of 300 miles was reduced to about 180 miles

44 during German interference action. If the targets were beyond this distance, the whole Gee system was useless during interference operations on the German side.

Other weak points evident in the Pathfinder system during its initial stages were as follows:

a. The light bombs used had too serious a dazzling

45 effect on the bombing airmen;

b. In strong winds the air markers drifted off position too fast and frequently could not be replaced soon enough. This caused confusion and faulty bomb releases;

c. If the target was lit up too brightly, this improved conditions for the defense, since the attacking air aircraft stood out clearly against the sky as dark silhouettes;

d. The incendiary bombs used for marking soon became indistinguishable from other fires burning on the ground. This facilitated an effective use of simulated fires by the defenders to mislead the attacking air craft. Even the 4 000-pound incendiary bombs had a burning duration which was too short in comparison with the duration of the attacks and left no recognizable traces.

Between 15 August and 31 December 1942 the Pathfinder units flew a total of 26 test missions over Germany. In six

of these missions they failed completely to find their targets because of bad weather. In average weather conditions they failed one out of every four times to find their target. In favorable weather conditions they succeeded in accurately locating and marking their targets. Compared with the techniques employed in 1940 and 1941, this new Pathfinder system represented a considerable improvement of attack methods.

The losses among Pathfinder units remained far lower than those incurred by the main attack forces, which at times reached a figure of 13 percent of all aircraft committed.

For the Royal Air Force the major problem for the conduct of strategic air warfare at night remained that of accurate target locating and marking completely independent of weather conditions in the target area. In 1942 the Royal Air Forces devoted particularly strenuous efforts to find a solution to this problem.

3. ~~Royal Air Force Operations against Italy in 1942~~.

Because of the preparations being made and the responsibilities assumed by the Royal Air Force in support of the Allied landings in North Africa planned for November 1942, the conduct of strategic air warfare by the Royal Air Force against

46 the German Zone of Interior became only a secondary mission. From then on strategic attacks were directed primarily against the Italian industrial towns of Genoa, Milano, and Turin, the purpose being to prevent the movement of antiaircraft artillery and fighter forces by Italy from there for action against the Allied forces participating in the invasion of North Africa.

The first attack against Genoa was on the night of 22-23 October 1942 by 100 Lancaster bombers. The moon was almost full and ground visibility was good. A Gee control station had been established in southern England for the specific purpose of supporting navigation, so that the Pathfinder units participating in the attack had no difficulty in accurately identifying and marking the target.

On 24 October 88 Lancaster bombers carried out a hazardous daytime attack against Milano, losing only three bombers.

47 On the following night the Royal Air Force again directed an attack against Milano, which was only partially successful, however, because of unfavorable weather conditions.

From the night of 18-19 November 1942 the Royal Air Force placed main emphasis on attacks against Turin. By the end of the year this town came under attack seven times, by forces each time around 200 Lancaster bombers.

47 All of these attacks were guided by Pathfinders, and were carried out on dark, moonless, nights, some of them at low altitudes.

The above shows that the Royal Air Force was exceedingly flexible in its techniques of attack, finding in each case a solution to the problem of targetlocating and marking adapted to the Italian defenses and the current weather situation, and thus staging its attacks during daylight and relying on ground visibility, at night during moonlight and good conditions of visibility, or on dark nights guided by Pathfinder units.

A particularly salient feature is the tactics employed in the operations against Milano, where a daytime attack on 24 October was followed up immediately by a night attack, obviously on the assumption that the fires still burning from the day attack would provide the best possible target marking for a night attack.

4. Royal Air Force Daytime Operations in the Second Half of 1942. Besides the daytime attack against Milano on 24 October, the Royal Air Force conducted only a few daytime operations in the second half of 1942, relying in each case primarily on the element of surprise.

On 17 October 1942, for example, 94 Lancasters flew

48 in at evening dusk to bomb the Schneider factory at Le Creusot, in France. This operation was not a very hazardous undertaking. The German defense fighters were concentrated along the coast between the mouth of the Schelde River and Brest, and it was relatively easy for the attacking force to bypass Brittany and penetrate south of the Loire River. The return flight would be during dark, and could therefore be considered safe , because there was as yet no German night-fighter defense system in France.

A more hazardous undertaking was the penetration of 76 Boston, Ventura, and Mosquito medium bombers around midday on 6 December to attack the Philips Works at Eindhoven in Holland. The operation was carried out at a low altitude to complicate tracking of the force by the German defenses. The strategic purpose of these attacks was obviously to prevent a German withdrawal of daytime fighter and antiaircraft artillery forces for transfer to the invasion front in North Africa.

The De Havilland Mosquito bomber had made its first appearance on the night of 31 May-1 June 1942 in an attack against Cologne as a completely new type of bomber aircraft.

With its quite considerable bombload capacity of 2 tons this model could achieve a maximum operating altitude of

48 33 000 feet and more, and a speed of around 370 miles at optimum altitudes because of its light wooden structure. Its striking range was from 1 600 to 1 800 miles.

Relying on their natural protection of speed and high altitude capabilities, small units of these aircraft were also dispatched on daylight bombing missions, at very high altitudes, in 1942-43. One such attack was against Oslo on ~~XXXXXXXXXXXXX~~ 25 September 1942, one against a manufacturing works at Copenhagen on 27 January 1943, and one against the Berlin Broadcasting Station on 30 January. The latter attack was so timed that it delayed the opening of an address by Reich Marshal Goering by more than one hour. Of the six aircraft participating in the attack only one was lost.

In spite of the favorable outcome of these experiments with daytime operations by the Mosquito, this model was used primarily as a night bomber. It was also used as a daytime reconnaissance plane and a long-range night fighter. Furthermore one squadron of the Pathfinder Group exchanged its Wellington for Mosquito aircraft.[25]

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25. Sources: 2, 18; See also Appendix 10.

49 5. New Means of Navigation Introduced by the Royal Air Force In 1942-43.

a. Improved Gee Instruments (Model TR-1355). The German methods of interfering with the operations of the Gee (Hyperbolic) navigation instrument Model TR-1324 by means of jamming operations with four powerful transmitters, which commenced in August 1942, was a source of grave concern to the Royal Air Force. It is also obvious that the first Gee instruments were by no means simple in operation. Otherwise no explanation can be found for the fact that when the German interference operations first commenced in mid-August 1942 a Stirling 4-engine bomber, although equipped with Gee instruments, landed at Doordrecht, in Holland, on the assumption that it was in England.

At the end of November 1942 German interference with the functioning of the Gee system over the German Zone of Interior was exceedingly effective, and measures were just being taken to extend the interference zones into France.

This situation caused the Royal Air Force to improve its existing model, the TR-1324. The new TR-1355 model, which first became available early in 1943 had five screened (rastbare) frequencies, which could be tuned in as desired. The frequency in use at any given time was fixed in special codes.

By exchanging the tuning mechanism, the instrument could also be used for other frequencies.

Any effective system of interference with the operations of this new instrument would require the establishment of such a large number of jamming transmitters that the Royal Air Force felt that use of the Gee system of navigation would again be safe for some time to come.[26]

b. ~~The Oboe or Boomerang Instrument~~. Since 1941 this instrument had been developed by the British Telecommunications Research Establishment specifically as a navigational instrument of such high precision that it would make blind bombing possible.

The Oboe instrument was tested out for the first time in an attack by six Mosquito aircraft on the night of 20-21 December 1942 against an electric power station in Holland. Following further tests it was finally ready for the field in early March 1943 for use by Pathfinder units to insure accurate target marking and by individual aircraft for blind-bombing attacks against point targets within its operating range.

The Oboe instrument functioned on the following principles:

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26. Source 16.

51 A first ground station (known as mouse station) directed a guide beam across the center of the target of attack. The aircraft followed this guide beam, with a constant buzz (a tone after which the instrument was named the Oboe) informing the pilot when he was on the right course, dash tones informing him if he had deviated to the right, and dot tones if he was left of his target course.

It was based on the same system in which the German Lorenz landing radio beacons were used in combination with the "Knickebein" system.

The message received on the aircraft from Mouse was reflected by the aircraft receiver and picked up by a second ground station, known as Cat. From the time-distance difference it was possible to determine the precise distance of the aircraft from the ground station.

When the aircraft reached the vicinity of the bomb release point, he received a warning signal, similarly to that received when landing blind by radio beacon, consisting of the letters a, b, c, d in Morse code, followed by a sequence of dash sounds, and then by a sequence of dot dounds. During this stage the pilot had to concentrate his attention completely on keeping to the precise course indicated by the constant tone at the altitude ordered at takeoff. When the dot sound sequence ended the bomber released his bombs.

The bomb release point was determined by the ground station in computations using the factors evolving from the speed at which the aircraft covered the ground, its ordered altitude over the target, and the speed and direction of the wind as calculated when the aircraft approached the target, and all necessary signals, including that for the bomb release, were sent out also by the ground station. For the aircraft crew this system was as simple as could be conceived.

The instrument operated on ultrashortwave frequencies and its range was the same as that of the Gee instrument, approximately 330 miles. One disadvantage of the new instrument in comparison with the Gee was that the aircraft reflected a radio wave and that this could be located precisely by the German defense system. Another unfavorable factor was that, in order to achieve accurate bombing, the aircraft during the last four to six minutes of the approach run had to fly on a straight course and at a fixed altitude. This gave the defenders certain advantages once the system was analyzed.

The first large attack in which the Oboe system played an important role was that directed at the Krupp Works in Essen on the night of 5-6 March 1943. Eight Mosquito Pathfinder aircraft equipped with Oboe instrument served as target markers. Plans fixed the time for bomb release at

52 at 2100 hours. The eight Oboe-equipped Mosquito aircraft of the Pathfinder Group were to guide the attack force, and were to be relieved by another 22 Pathfinder aircraft, which had the initial mission of intensifying the first markers.

The first mission of the Pathfinders was to place and maintain yellow parachute flare bombs along the approach route starting at a point 13 miles f om the target. These flares were to be replaced until the attack was over.

The Oboe-equipped Mosquito aircraft then had the nission of identifying the target with red markers in accordance with a strict time schedule, the first to be dropped at Zero hour, the second lot three minutes later, the next at ten and the final at 30 minutes after Zero hour.

The mission of the relieving Mosquito aircraft, known as backers-up, was to fly in singly at intervals of two minutes and attack the target with sticks of demolition bombs and green markers until Zero hour plus 36 minutes.

During this period the main attack force of 417 aircraft arrived over the area, also guided by Pathfinder units. The first wave of Halifax bombers was to complete its bombing , which commenced at Zero Hour, within twenty minutes. The second wave followed at Zero plus fifteen minutes with an attack duration of ten minutes, and consisted

of Wellington and Stirling bombers. The third wave, Lancaster bombers, commenced at Zero plus 20 minutes and was to complete its bombing also within ten minutes.

The bombing units were informed specifically that the red markers were being placed by a new and very precise method. Theywere instructed to place their bombs on these markers with the utmost precision. If the red markers could not be seen for some reason or other, they were to place their bombs on the green markers placed by the follow-up or backers-up Pathfinders. The mixed bomb load was to be one-third demolition and two-thirds incendiary bombs, one-third of the demolition bombs armed with delayed action fuzes.

The whole attack proceeded according to plan, with only a few minor deviations from the set time schedule,and lasted 38 minutes instead of the planned 30 minutes. Never before had so many aircraft bombed a single target within so short a space of time. Both the red and the green markers were placed very accurately on the target and the damage done by the attack was considerable.

For the first time since the outbreak of the war the Krupp Works in this attack suffered serious damage.

Royal Air Force losses totalled only fourteen aircraft, 3.4 percent of the attacking number.

54 In the 5 March-29 June 1943 period alone the Royal Air Force staged 26 major attacks supported by Pathfinder units equipped with Oboe instruments against targets within or mear the Ruhr region. The attacks mounted in size to almost 700 bombers, and the bombs delivered by Royal Air Force units on targets within Germany totalled 17 400 tons in the first quarter and 36 700 tons in the second quarter of 1943.

Within the effective range of the Oboe instruments a perfect solution had thus been found for the problem of accurate target locating independent of weather conditions.

Within its effective range the Oboe instrument became the key factor also for individual precision bombing attacks against point targets by Mosquito bombers operating at altitudes between 30 000 and 33 000 feet, against which there was practically no p ossibility of defense.[27]

55 c. The "Home Sweet Home" H-2 (TR-3159 and TR-3191) Instruments. Konwn in Germany as the Rotterdam instrument, this instrument was also a development by the British Telecommunications Research Establishment and for all practical purposes could be considered as an air carried television receiver.

It operated on the 9-centimeter waveband and by means of a rotating antenna emitted impulses which were reflected

55 or bounced back by the terrain over which the aircraft was passing. The varying reflections from the varying contours of the terrain below produced on a cathode ray screen a rough picture of the terrain features, with characteristic differences between water and land, built-up and undeveloped areas, and so forth, from which a coastline, rivers, lakes, forests, railroads, and towns could be identified.

Under a carefully planned program of air reconnaissance photos were taken of all important strategic targets as they appeared on the screen, known as the H2S screen. These photos were used later by the Pathfinder units to facilitate identification of their targets.

The great advantage of the H2S instrument was that it enabled aircraft to navigate their way securely and precisely to large targets beyond the operating range of the Gee and Oboe systems and to see the target so plainly by television

56 that they could bomb it as accurately at night or during bad weather as they could have done under conditions of excellent visibility.

The H2S instrument came into use for the first time on the night of 30-31 January 1943 in an attack against Hamburg. As a coastal town with characteristic borderlines of land and water, Hamburg was an eminently suitable target

56 for operations of this type. Pathfinder units had first priority in the allocation of H2S equipment, but plans provided for all 4-engine and Mosquito units to have these instruments at a later date as standard equipment.

With these three systems, the Gee, the Oboe, and the H2S, known respectively as the Hyperbola, Boomerang, and Rotterdam instruments in Germany, the Royal Air Force was in possession of all prerequisites for the conduct of strategic warfare over Germany and the German-occupied territories at night practically independent of weather conditions and over areas which were unlimited so far as navigation was concerned.

The only factor which could still hamper large-scale attack was an upper cloud level higher than 16 500 feet in the target area. The tactics of concentrating the attacking forces for attacks of as short duration as possible, made it necessary to echelon them sharply in height. The lowest echelon had to be at an altitude of not more than 16 500 feet since the Halifax and Stirling types of bombers were difficult to maneuver with a bombload if higher than between 16 500 and 20 000 feet.[28]

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28. Sources: 2, 18; See also Appendix 10a.

57. 6. Royal Air Force Warning Instruments against German Night Fighters in 1942-43. The periodically heavy losses incurred by Royal Air Force units operating at night over Germany created the compelling necessity to develop instruments which would warn the crews of aircraft when they were in danger of attack and take measures to avoid the attack or make it difficult.

The instruments developed for such purposes fall into two separate categories:

a. Electronic equipment to detect approaching aircraft;

b. Electronic equipment to ascertain when ones own aircraft was detected by enemy electronic instruments.

Th first category included the T-3135/R-3136 instruments carried by British night fighters and known on the German side as Monica or Rozendael instruments. If a strange aircraft came within the operating range of these instruments the fact was recorded either acoustically or optically. The range was approximately 4 400 yards. The pilot thereupon would steer a zig zag course until his instrument again showed that the danger had been shaken off.

The disadvantage of these instruments was that there was no possibility to distinguish between enemy and friendly planes. The only possibility for the pilot was to draw

57 his own conclusions from the behavior of the strange plane as it appeared from the visual or audible signals he received through his instrument.

58 Another disadvantage was that the German defenses could intercept the rays emanating from the warning instrument and could use this data to track the British plane and guide night fighters to it.

The second category included the British R-1618 warning instrument, which registered when the plane carrying such an instrument was exposed to the rays of any electronic search instrument. This information was to serve the pilot as a warning against detection by the air-carried radar instruments of German night fighters or by the radar stations of the German aircraft reporting services or of the German antiaircraft artillery.

The system comprised a wide band receiver covering the wave ranges of the German Lichtenstein (air carried), and of the Wuerzburg (aircraft reporting service, night fighter, and antiaircraft artillery) instruments. The signal was given here by a lamp.

Besides serving to warn the pilot, this instrument also enabled him to judge the density of the German night fighter defense ground organization and to detect antiaircraft

58 artillery concentrations.

In 1943 the British introduced a newly developed night fighter warning instrument, known as the Fish Pond instrument. This instrument had a panoramic range of 8 800 yards but could only detect objects level with or beneath the carrying aircraft. The warning here was given on a 20-centimeter cathode ray tube . The ray transmitted by the instrument itself was registered by a blip in the middle of the tube and the ground echo at its edge. Targets picked up by the ray showed as blips 3 to 6 millimeters in size. From the it was possible to deduce direction and speed at which the blips moved whether the object showing was a German night fighter or one of the other British aircraft in the formation. The pilot was kept

59 informed by the radio operator concerning all observations thus made.

The instrument did not contain any device to register automatically whether the object detected was an enemy or a friendly plane, but it did serve, among its other purposes, to avoid collisions within bomber units flying in close formation.

The XXXXXX opinions of British airmen differed on the subject of the practical usefulness of the Fish Pond system.

59 The fact that friendly aircraft showed up in the tube during operations over enemy territory was a source of continuous uneasiness, particularly when too many blips showed when a position was reached close to or over the target, so that any identification was impossible. In such cases the pilot usually ordered the radio operator to switch off his instrument and come forward into the observers cockpit for visual observation.[29]

7. British Interference with German Aircraft Detecting Instruments; 1942-July 1943. When a German fleet in February 1942 left Brest to force its way through the English Channel into the North Sea, effective jamming of the British radar instruments stationed in the Channel coast areas was an important factor in the plans for this hazardous undertaking.

The German jamming transmitters were so effective that the British only detected passage of the German fleet when it was already too late for decisive combat action.

However, the success achieved in this German interference operation produced the adverse result that the British awoke

60 to the sognificant operational possibilities inherent in action to interfere with the functioning of German aircraft detecting instruments during their own operations over Germany and the occupied territories.

29. Sources: 19, 20.

60 On 2 September 1942 for the first time powerful British transmissions were noticed along the Channel coast which were evidently intended to jam the German Freya radar instruments there. Following the German pattern, these British interference operations from then expanded, initially along a wide frontage.

At the end of 1942 the British were already using air carried transmitters to jam the Freya radar instruments in the German interior. The following passages on this subject are quoted from an experience report of Fighter Command Southern Germany in March 1943:

> Freya Instruments (Night Operations):
>
> The results of the Freya interferencesreported in the monthly report for February leave nothing to add; the interferences occurred during all attacks and put the Freya instruments in the positions involved out of action....[30]

Another cause of interference with Freya radar instrument operations was the use of the British voice radio instrument TR-1145 and the American T-5043. These operated on frequencies which interfered with the operations of the Freya instruments.[31]

30. Sources: 21, 22, 23.
31. Source 16.

69 8. British Interference with German Night Fighter Radio Communications in 1943. In March 1943 the British for the first time made use of noise transmitters on their aircraft during large-scale attacks to jam radio communications of the German night fighter arm.

The installation used for this purpose consisted of one radio receiver to determine the voice radio frequencies in use by the German night fighters, and a transmitter which was then tuned in to the German frequency and through a microphone transmitted the noise from the aircraft engines.

The closer the German night fighters approached to the British planes the more serious the interference became. Frequently these interferences were so serious that the night fighter control positions failed to guide their units to within visual distance of their target, although conditions appeared favorable, because the night fighters were no longer able to hear and understand the directional and altitude data transmitted by the control stations.

If the German instruments were tuned in to an alternate frequency, the jamming started again on the new frequency within three to five minutes.

On some occasion British crew members transmitted misleading orders in German to the German night fighters, countermanding orders received previously from the control

61 station or ordering the units to cease the attack against the British units.

On the German side the best remedy here was found to be a transition to Morse code communications.[32]

62 9. ~~The British Operation against Valley Dams in May~~ 1943. On the night of 16-17 May 1943 18 Lancaster bombers took off from Britain on a mission which had taken two months of careful planning. The objective was to destroy the Moehne, Eder, and Sorpe River valley dams.

The strategic significance of these dams was that they were the reservoirs furnishing water supplies for the entire Rhine-Westphalian industrial region; if they were emptied suddenly, large areas would be flooded, industrial output would be reduced, and installations of the water supply for the civilian population would be destroyed.

On 20 March 1943 Wing Commander Gibson organized the 617th Squadron as a crack unit equipped with 4-engine Lancaster bombers specifically for this special mission. No information was given to the unit concerning the actual targets they were to attack. The goal in training was to strike a target with normal or mine type bombs or at least within a few yards of it while flying over a surface of water at an altitude of only 150 yards and a speed of 230 miles.

62 Early in April Gibson himself, as the only person, was informed that the mission was to destroy the three dams closing the Moehne, Eder, and Sorpe River valleys. He received three exact models of the dams enabling him to study
63 all possibilities for the attack, but was not yet allowed to show them to personnel of the squadron.

For some time the squadron practiced daytime and night low level flight over the surface of lakes in Britain and developed special aids to make a precise control possible insuring that the ordered altitude of 150 yards was maintained. The method adopted was that of mounting a light each under the nose and tail of the aircraft at such an angle that their two beams would form a single light spot on the water's surface when the plane was just 150 feet high. If the beams crossed each other the plane was too high, if they reflected in two separate spots the plane was too low.

The first test bomb had a diameter of 3.40 meters and was dropped over a British lake in mid-April 1943. It broke at impact on the surface of the water. The same thing happened with the second test bomb, which had a thicker casing.

It was thereupon decided that a more favorable altitude would be 60 feet, and the test bombings at this altitude proved satisfactory. Bombing sights developed with support from the squadron itself insured adequate accuracy even

63 at the newly required very low altitude of 60 feet.

After a final general test exercise, in which the 5 500 pound practice bomb was used, the night of 16-17 May 1943 was finally set as the date for execution of the actual mission, when the moon would be full.

It was only now that the crews were informed what their mission was to be and were shown the models of the valley

64 dams. In a last discussion every detail of the impending attack was decided.

Air reconnaissance over the target area had shown that the water level in the dams was high enough and that the Germans had not reinforced their antiaircraft artillery defenses. It was assumed with certainty that the German side had no knowledge of the coming attack.

Late in the evening on 16 May 18 Lancaster bombers took off to accomplish the mission. Under Wing Commander Gibson nine of them were first to attack the Moehne River valley dam as their main target and then the Eder River valley dam as their second objective. At the same time five bombers were to bomb the Sorpe River valley dam and by conspicuous use of light signals were to draw the attention of the German night fighter forces to themselves. Four bombers followed in reserve, ready at any moment to execute any remaining mission which might arise, in response to radio orders from Gibson.

65 Flying at a low altitude the unit followed a course through Great Yarmouth, Edmond oon Zee, Eindhoven, Duisburg, Dortmund, Hamm, and Soest.

Losing one aircraft to enemy action on the way over the Ruhr region, eight bombers of the first attack echelon circled the Moehne River valley dam, flying in individually as ordered to do so by Gibson, for their bombing run. Gibson attacked as the last unit. During the attack the other aircraft drew the attention of the antiaircraft artillery to themselves by attacking them with weapons fire.

After the fifth bomb had struck, the wall of the dam broke and the water flooded out into the Moehne valley. Of the five bombers which actually attacked, one was shot down by antiaircraft guns during the bombing run and one was so badly damaged that it crashed during the return flight across

65 the North Sea.

With the three remaining aircraft which still had their load of bombs Gibson proceeded to attack the Eder River dam. Three bombs were delivered on the target and at the third bomb the wall of this dam also broke, emptying the lake.

Of the five aircraft dispatched to attack the Sorpe River dam only one reached the target. Two had been shot down over Holland, one had touched water over the North Sea and had lost its engines and its bombload, and one was

66 so badly damaged by antiaircraft fire that it had to return to base.

Of the four aircraft flying in reserve two were shot down during the approach and two received orders from Gibson to attack the Sorpe River dam.

Finally this dam came under attack by three bombers, but all bombs missed the target.

An overall analysis of the whole operation showed that two of the three missions assigned had been accomplished at a cost of eight aircraft totally lost and two badly damaged.

The results of the whole undertaking did not measure up to expectations. Water supplies from the Sorpe River dam sustained the Ruhr region industries until the other dams were repaired. Four months work sufficed to repair the walls of the Moehne and Eder River valley dams, and by the end of January 1944 the damage was so far repaired that there was no longer any evidence of an attack ever having occurred.[33]

66 10. Summary of Characteristic Features in British Techniques of Strategic Air Warfare in the 1942-July 1943 Period. In summarizing, the following characteristic features are evident in the British techniques of strategic

33. Sources 24, 25; See also Appendix 11.

67 air warfare during the May 1942-July 1943 period:

a. Strategic air warfare was conducted primarily in the form of night attacks;

b. Daytime attacks by British 4-engine bombers remained restricted to surprise raids in weakly defended areas;

c. The British adhered steadfastly to the principle of mass area bombing at night introduced by the 1000-bomber attack against Cologne on the night of 30-31 May 1942. The size of these attacks varied between 500 and 800 aircraft;

d. Night attacks were carried out almost exclusively by 4-engine Stirling, Halifax, and Lancaster aircraft.

In June 1942 the De Havilland Mosquito was introduced as a fast bomber for day and night operations. Due to its great speed and high maximum operating altudes this aircraft created problem of defense which were exceedingly difficult to solve;

e. The problem of accurate target locating and largely accurate bombing was solved by introduction of the Pathfinder system, the Oboe and H2S instruments, and by improvement of the existing Gee instrument.

67

At the same time these three instruments made it possible to bomb targets completely withour regard for conditions of visibility;

f. In combination with the Pathfinder system, the former tactics of individual aircraft bombing runs developed into a system of attack waves which, compressed within a short space of time insured maximum effectiveness of the bombing done;

g. The effectiveness of bombing was increased by a larger inclusion of incendiary bombs in the bomb load and by increasing the caliber of bombs to 4 000 pounds;

h. While improving their own tactics of attack, the British at the same time commenced radio interference activities arranged systematically to jam the German Freya aircraft detecting instruments and operational communications of the German night fighter command;

i. Special warning instruments were installed in Royal Air Force bombers to safeguard them against attack by Ge man night fighters and to alert the pilot when his aircraft was being tracked by German radar;

k. Attacks against special targets which were

hard to strike were planned, prepared, and executed with extreme care and thoroughness;

1. Operations by British medium bombers and night fighters against the ground organization of the German night fighter command became a regular feature as part of Royal Air Force night operations against targets within Germany.

68

CHAPTER 3

THE US ARMY AIR FORCES IN THE AUGUST 1942 TO OCTOBER 1943 PERIOD

1. Tactical Formations of the Strategic Bomber Forces. For two reasons the US Army Air Forces devoted particularly close attention to the problem of which was the best tactical flight formation for the strategic air forces during operations:

a. The command held the fundamental view that success in strategic air warfare could only be achieved through operations during daylight, since unimpeded daylight vision of the target was the only factor which could insure adequate bombing accuracy. Complete mastery of close formation maneuvering was therefore considered an indispensable condition for operations by strategic bomber forces;

b. The US Army Air Forces attached the greatest importance to the safety of its personnel and aircraft during operations. Lacking adequate defenses against German night fighters, it was thought, would in a very short while compel the strategic air forces to confine themselves to night operations, forfeiting all advantages inherent in daylight bombing.

68 For the above reasons the point at issue was to develop a flight formation which would insure during operations that the defensive weapons of the individual aircraft making up a formation could be used unrestrictedly and with maximum concentration to repel attacks by German ~~xxgxx~~ fighters.

The realization came only after experience in operations against the German interior in the autumn of 1943 that no pattern of flight formation was suitable to provide adequate protection against fighter attack, and that this problem could only be solved by providing fighter escorts for the 4-engine bomber forces.

The US Eighth Air Force, stationed in England, opened its campaign of strategic air warfare against the Fortress of Europe with extreme caution, starting on 17 August 1942. A target not too far distant, namely, the Rouen rail depot, was selected for this first mission, and a small 4-engine bomber force comprising two units of each six B-17 Fortress instructed to execute it. The location of the target made it possible to give the bomber force strong escort protection by British Spitfire ~~fighter~~ units experienced in this type of operations.

The two 4-engine bomber squadrons flew with a space

69 a few miles separating them from front to rear. This gave them high maneuverability but precluded any possibility of mutual fire support against attack by German fighters. In view of the strong fighter escort provided, however, this presented no urgent problem.

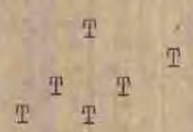
SIX AIRCRAFT SQUADRON FORMATION

August 1942

The squadron of six aircraft was organized as follows:

Lead pair in right line
Second pair in right line echelond to left and rear
Third pair in left line " " " " "

The lead planes of the second and third pair flew higher than the lead pair, the other two planes lower.



Because of the mounting losses inflicted by German submarines on Allied transport shipping in the Atlantic, the US Eighth Air Force in September 1942 increased the size of its forces committed and dispatched them beyond the range of escort fighters to bomb German submarine bases on the Atlantic coast.

The mounting strength of the German fighter defenses made it categorically necessary to consolidate a number of

70 squadrons to form a closed group formation making mutual support and the concentration of defensive fire possible in action to repel German fighter attacks.

GROUP OF FOUR 6-AIRCRAFT SQUADRONS

September 1942

The group of four 6-aircraft squadrons, making a total of 24 aircraft, operated in rhombus formation:

First or lead squadron

Second Squadron 3300 yards left of and 2200 yards behind 1st Squadron, echeloned to the left at intervals of 330 yards;

Third Squadron in same formation and position as second squadron but on the right;

ond Fourth Squadron 5500 yards behind lead squadron and 330 yards higher.

GROUP OF 24 AIRCRAFT IN RHOMBUS FORMATION

September 1942

The desire to achieve greater maneuverability on the one hand and a more compact formation on the other hand in September 1942 led to experiments with two other basis formation patterns:

71 a. The group of two squadrons, each 9 aircraft, making a total group strength of 18 aircraft;

b. The group of 3 squadrons, each 12 aircraft, making a total group strength of 36 aircraft.

In the eighteen-aircraft group each squadron formed a V of 3 flights, each flight forming a V of 3 aircraft. The nine aircraft of each squadrpn all flew at the same altitude, with the two front units of the 3d Flight flying level with the third aircraft of the flights in front.

The 2d Squadron flew abreast of the 1st Squadron but echeloned towards the sun and 250 feet higher(170 meters).

GROUP OF TWO 9-AIRCRAFT SQUADRONS

September 1942

1st Squadron 2d Squadron

T T T T T T T T
T T T T T T T T
T T

Although this was a former organization than the rhombus formation it was less easily maneuverable, since the flank units could easily lose sight of the lead plane when wheeling. Furthermore, if any of the flights were unsuitably placed in the formation they obstructed defensive fire from the other flights and thus increased the vulnerability of the entire group to attack by German fighters.

The 36-aircraft group was another step in the direction

72 of firmer command control. It had three squadrons of each twelve aircraft, each squadron in turn organized in four flights of each three aircraft. The three squadrons flew in closed formation:

1st or lead Squadron

2d Squadron on right, echeloned to rear and 550 feet higher than 1st Squadron

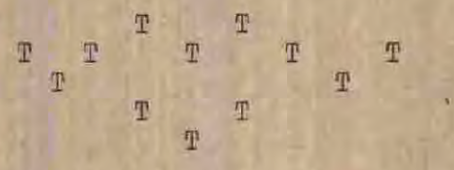
3d Squadron on left, echeloned to rear and 1100 feet (350 meters) higher than 1st Squadron.

The inside planes in this formation were well protected against fighter attack, but the formation as such provided no solution to the problem of maneuverability, nor did it as a whole achieve any increase in defensive strength.

It was also difficult to maneuver, since the lead aircraft was out of sight for a large number of the units.

73 GROUP OF THREE 12-AIRCRAFT SQUADRONS

September 1942



The size of attacks by units of the US Army Air Forces increased rapidly in the autumn of 1942. The largest, numerically, in September was by 75 4-engine bombers, the largest in October by 115 4-engine bombers. In November the size of attacking forces dropped again to between sixty and seventy, but increased again in December 1942 to between 80 and

73 100 4-engine bombers.

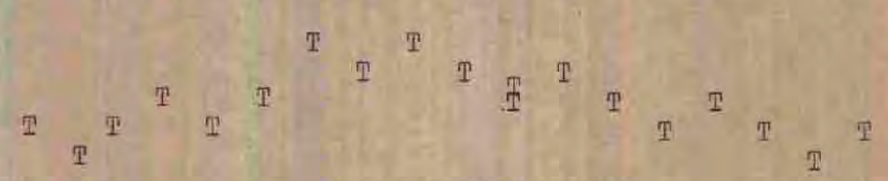
As their strength in strategic bomber units increased, the US Army Air Forces dispatched their bombers farther afield in the German rear. In October 1942 units were already attacking as far as Lorient, in November as far as St Nazaire and La Pallice, and in December as far as Romilly s. S. in Central France. All of these targets were beyond the range of British fighters. This increased the time during which the bombers were exposed to German fighter attack and called for a formation pattern which would permit maximum use of defensive fire and mutual fire support.

74 These requirements led in December 1942 to the development of a new formation, known as the javelin formation, in which the group had three squadrons of each 6 aircraft, namely a lead squadron flanked on each side by one squadron, one at a higher and one at a lower altitude. Each squadron was organized in two flights of each 3 aircraft.

GROUP OF THREE 6-AIRCRAFT SQUADRONS

December 1942

LEAD SQUADRON



74 This formation brought a considerable improvement in maneuverability and flexibility, but did not considerably increase defensive strength against fighter attack.

When operating in larger forces, the individual groups flew in column line, above the lead group and echeloned to the rear and in the direction of the sun. This column formation admittedly complicated mutual fire support against fighter attack, but at the same time it reduced the areas exposed to fighter attack. Its greatest disadvantage was the flight difficulties it created, which were due to the long distance which the columns extended towards the rear and the consequent speed differences between the units at different altitudes.

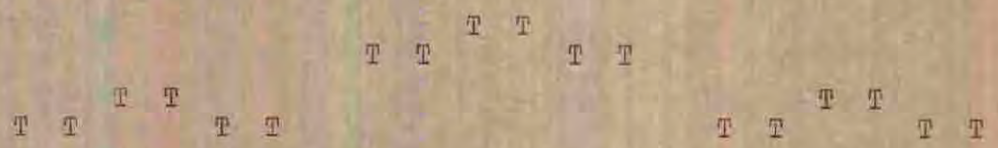
75 Due to the increased number of bomber units available to the US Eighth Air Force in February 1943, the javelin formation was dropped and the wedge formation introduced in its place. The main purpose here was to prevent lagging, which was unavoidable in the javelin formation and was particularly dangerous when German fighters were encountered.

In the division formation of five groups the command group flew in the middleflanked on either side by two groups, echeloned up- and sidewards on the one side, and down- and sidewards on the other side.

75 Each group had three 6-aircraft squadrons, also flying in wedge formation.

GROUP OF THREE 6-AIRCRAFT SQUADRONS IN WEDGE FORMATION

February 1943



This pattern reduced the length of the column considerably, but because of the pronounced altitude difference between the high and low echeloned ~~units~~ groups did not quite remove the lag tendency. It nevertheless did reduce the speed differences between the leading groups and those following.

One advantage of the wedge formation was its increased forward fire power. This had becomeanecessity to counter the German fighter tactics of attacking the point of 4-engine bomber forces in order to avoid the heavy fire power these aircraft had in their rear.

An analysis of losses incurred and their causes revealed however, that a still tighter organization of the units was essential for forward defense against fighter attack.

For the above reasons a new closed unit formation pattern was devised in March 1943 in the form of what was called the Combat Wing of three groups, each group having 3 squadrons of six aircraft, making a total combat wing strength of 54

76 aircraft. Each flight of three aircraft flew in wedge formation, the lead plane in the middle, one plane lower on its left rear the other higher on its right rear. Within the squadron the 2d Flight flew echeloned to the left or right rear.

The group flew with three squadrons in wedge formation, the lead squadron in the middle, the other two squadrons in its rear, one on either side and echeloned ~~xxxx~~ upward and downward respectively. This was called the "Combat Box" formation . The difference in altitude between the lowest and the highest aircraft in the group was roughly 830 feet.

The "Combat Wing" had three combat boxes: a lead group in the center and one group on either side, one at a higher and one at a lower altitude. In larger forces Combat wings flew in column at intervals of six miles.

COMBAT WING OF THREE GROUPS, EACH GROUP WITH THREE 6-AIRCRAFT SQUADRONS

March 1943

77 During the spring of 1943 other variants of the combat wing formation were tried out:

a. 1 lead group with one group echeloned higher and one lower, one on either side of the lead group; each group in wedge formation;

b. 1 lead group with two groups in its rear, one echeloned higher, the other lower, each group in wedge formation.

The latter pattern above improved defensive capabilities because of the possibility of mutual support fire. However, the unit was more difficult to maneuver, particularly when curving, when the upper group was very apt to lose visual contact with the lead group. Experience showed that this pattern of the combat wing formation was also too unmaneuverable and in technical respects to difficult to handle. Another weak point was that the units in position on the

78 outsides of the formation were not adequately protected by the combined formation fire.

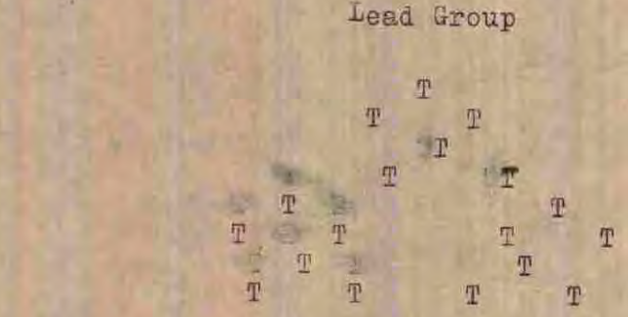
From April to December 1943 a modified form of the combat wing pattern, now with 54 aircraft, was used in operations. To reduce sideways extension, the following changes were made:

a. The squadrons within themselves were echeloned

78 in a pattern reverse to that of the group echelon pattern, or

b. This box echeloning remained limited to the top and bottom squadrons.

COMBAT WING OF TH EE GROUPS, EACH GROUP WITH THREE 6-AIRCRAFT SQUADRONS
(Box Formation)
March-December 1943



both in same formation as the lead group.

This pattern, known as the box formation, secured more concentration at the flanks and increased the number of machine guns which could be brought to bear in defense action. However, it provided no satisfactory solution of the problem of loss of contact by stragglers during any change of flight direction. Elements lagging behind the whole formation in

79 this way were the first targets of German fighters and in some operations accounted for 50 percent of total losses.

From April 1943 on bomber units dispatched against targets within Germany flew at least a part of their approach

79 and home routes under protection by escort fighters, which were able to concentrate particularly on protecting units which lagged behind the main body of the formation. However, the problem of evolving a practicable flight formation pattern which would allow optimum use of the defensive weapons mounted in bombers remained acutely urgent as long as it was not possible to provide fighter escorts throughout the entire mission, including the whole approach and home routes.

After the very heavy losses incurred in the attacks on 17 August 1943 against Schweinfurt and Regensburg, and on 14 October 1943 against Schweinfurt, the 54-aircraft combat wing formation was finally discontinued as too unmaneuverable.[34]

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34. Sources: 26; The AAF, Volume II, p. 332.

80 2. The US Fighter Escort System. Although US 4-engine bombers of the B-17 and B-24 types had exceedingly heavy fire power for defense against fighter attack, the first operations by units of the US VIII Bomber Command from bases in England--during the 17 August to end of October 1942 period--, were coordinated strictly with the possibilities of providing protection by US or British escort fighters throughout the entire operation.

For this reason the operating range of fighters determined the selection of targets. The operations of 17 August to 21 October 1942 against targets in Holland, Belgium, and France not more than 36 miles from the Channel coast permitted the assignment of strong fighter escorts to protect the bombing forces.

The US VIII Fighter Command at that time had only four fighter groups, all equipped with British Spitfire aircraft. The Royal Air Force therefore had to furnish the bulk of the escort fighters needed, and was able to assign units well experienced in operations of this type against targets near the coast.

For the above reasons the US 4-engine bombers during their first operations had no direct or serious encounters with the German fighter defense system, and in nine bombing

missions up to 6 September 1942 lost no aircraft.

Their first direct encounter with German fighters occurred on 21 August 1942, while a unit of US 4-engine bombers was on its way to attack Rotterdam, and this encounter was due exclusively to a malfunctioning of the fighter escort plans. The force of twelve B-17 bombers arrived at the point where it was to join its fighter escort with a delay of 16 minutes. The escort fighters thus had to turn back when half way across the Channel owing to fuel shortage, and the bomber force had to continue on its way without escort to attack Rotterdam.

On receipt of reports from the fighter units that they had been compelled to break off their escort mission, the command immediately radiod orders to the bomber force to break off its mission and return to base. By this time, however, the force was already over the coast of Holland, where it encountered 20-25 German fighters. After jettisoning their bombs over the sea, the bombers remained exposed to attack by the German fighters for a period of twenty minutes during their home route. Apart from a few crew members wounded the bomber force suffered no losses in this encounter, and thus demonstrated for the first time the ability of the 4-engine bomber to defend itself against fighter attacks without support by friendly escort fighters.[35]

55. Source: The AAF, Volume II, pp. 217, 841.

81 During operations by units of the VIII US Bomber Command in October 1942 German fighters repeatedly succeeded in breaking through the defense offered in some cases by as many as 400 escort fighters for direct attacks against the 4-engine-bombers. However, the exceedingly heavy defensive fire power of these units precluded any possibility of sizable successes for the German fighters. Out of three operations involving a total of 284 4-engine bombers, for example, only seven of the bombers were brought down.

These results considerably strengthened the confidence of US bomber crews and of the VIII US Bomber Command in the ability of the bombers to defend themselves with their own weapons fire against German fighter attack. Apparently it

82 was this increased confidence which encouraged the bomber command on 21 October 1942 to commence carrying out attacks also against targets outside the striking range of escort fighters.

For a start, the bomber command first selected targets in southern France, in areas where it could be assumed that German fighter defenses would not be very strong.

In addition to the above, a surprise attack on 21 October 1942 against the submarine base at Lorient compelled the

82 German command to withdraw some of its fighter forces from the Channel areas for transfer to Normandy, a circumstance which generally weakened the German fighter defenses at the Channel coast and caused some dispersion of the German effort.[36]

In the period which followed up to 27 January 1943 attacks by US 4-engine bombers with strong fighter escorts against close range targets in the Channel coast zones alternated with attacks flown without fighter escorts against the German submarine bases on the Atlantic coast.

During this period units of the bomber command executed only one attack against a target farther in shore . In this case a force of 72 4-engine bombers attacked the German Air Force depot of Romilly s. S. on 20 December 1942. The attacking force lost 6 bombers, the heaviest loss suffered so far. This was probably due to the fact that the approach and home routes of the force were over the Channel coast area between Calais and Cherbourg, where the Germans had concentrated the largest defensive fighter forces.

Although this loss did not represent any dangerous ratio, it nevertheless served to confirm the pronounced view of the US Eighth Air Force that it was urgently necessary to adapt the operating range of escort fighter forces

82 to the striking range of the strategic bomber forces.

83 All available British fighter types lacked adequate range capabilities for penetrations far into the German-occupied territories of Western Europe. The only aircraft that held out any prospects at all in this respect was the US Lockheed P-38 Lightning fighter.

In August 1942 the US VIII Fighter Command had four groups of fighters, two of them--the 31st and 52d, equipped with Spitfire, and two--the 1st and 14th, with P-38 fighter aircraft. On 14 September 1942, however, the VIII Fighter Command received orders to release all four groups for transfer to the XII Fighter Command to support the Allied invasion of North Africa.

On 29 September 1942 US pilots hitherto assigned in British fighter squadrons were used to form a new 4th Fighter Group. The new group received Spitfire aircraft and was placed under the VIII Fighter Command.

The necessity to concentrate US air power for the invasion in North Africa from November 1942 on delayed measures to build up a separate US fighter fleet in Britain for use in strategic air warfare in the theater of Western Europe. Furthermore, it led at the end of 1942 to a reduction of the strategic bomber forces stationed in Britain, from where four

83 groups were released to the XII Bomber Command for commitment in North Africa.

For the above reasons strategic plans of the US Eighth Air Force at the beginning of 1943 provided for continuation of the operations by the 4-engine forces, with strong fighter escorts, against targets within striking range of the British fighters, in addition to operations against more distant targets in areas not so effectively defended by the Germans. In such operations fighter escorts were to be provided on the approach route to the limit of the fighter ranges, and fighters were to proceed, again to their utmost range, to support the bomber forces on their return route.[37]

Extension of the operations by the US VIII Bomber Command to targets within Germany, commencing on 27 January 1943 with an attack against Wilhelmshaven, proved initially hardly any more hazardous than the long-range attacks of the past against targets in Southern France. In an attack against Bremen on 17 April 1943 the attacking bomber force of 107 aircraft lost 16 4-engine bombers. This was the first time that losses exceeded tolerance ratios.

It was a stroke of good fortune for the US VIII Bomber Command that the first three groups of American type long-range fighters of the Republic P-47 Thunderbolt type had just become available in the field at this juncture and had

84 already gathered their first experience in combat against German fighters during operations taking the form of fighter drives towards the Channel coast. The experience thus gained was encouraging: at altitudes above 30 000 feet the P-47 showed climbing abilities and speed performances superior to those of the German Me-109 and FW-190. This superiority was due to the powerful thrust of the American engines at high altitudes, which was achieved by means of exhaust-driven turbo compressors. The performances of German aircraft engines, in contrast, fell rapidly at anything above optimum altitudes. Here again, the optimum altitude of the American engines was about 3 300 feet higher than that of the German engines.

The following are the more important technical data on the Republic P-47 Thunderbolt:

Power Unit: One Pratt & Wittney "Double Wasp" R 2800 - 21 engine with exhaust-driven turbine.

Take-Off HP: 2 025 HP.

Maximum : 2 025 HP at an altitude of 25 000 feet.

Rated Power: 1 645 HP " " " " 25 000 "

Brief Booster Margin (3x5 minutes) by injection of an alcohol-water combination: approximately 20 percent.

Flight Performances: Maximum Speed at an altitude of 27 000 feet: 380 miles. With booster (3x 5 minutes) 400 miles.

Maximum operating altitude: 42 000 feet.

85 Weapons: Six 127-mm machine guns mounted in wings, each with 250-300 rounds of ammunition.

Non-Stop Flight Capability: fully tanked with 225 US gallons: 510 miles, giving a tactical penetration range of 200 miles.[1] [58]

On 4 May 1943 the US Eighth Air Force for the first time carried out an attack involving bombers with an escort made up exclusively of American P-47 Thunderbolt fighters. The operation was by 65 4-engine bombers, and was directed against Antwerp, the bombers operating under continuous fighter escort from takeoff to target and back to base. Although German fighters were encountered, the force lost no bombers.

At this time the US Army Air Forces had developed the following system for the execution of fighter missions serving as escorts for bomber forces:

a. The view was that secure protection could only be given if the escort fighters remained constantly with the escorted bomber force. Fighters were not allowed to leave the bomber forces they were escorting in order to pursue and shoot down an enemy fighter. The escort mission was restricted exclusively to one of close and direct protection of the escorted bomber force in the form of action to repel enemy fighters which represented an immediate and acute threat to that bomber force.

86 b. Escort missions were executed in compliance with the "canopy principle also adhered to by the Royal Air Force, namely, the fighters maintained positions over the bomber force they were assigned to escort;

For the US fighter units there was a second factor which gave added justification to this requirement for a high altitude, namely, the fact that their performances were only superior to those of the German fighters at altitudes above 30 000 feet.

c. At this stage the smallest tactical unit in the US fighter forces was still the flight of three aircraft, with the lead aircraft of each flight flying in the center.

Experience gained in the first phases of operations in April 1943 resulted in the following modifications in the operational tactics for US fighter forces engaged in escort missions:

a. In order to counter the tactics of the German fighters, which attacked the flanks and point of bomber escort forces and ignored the fighters stationed very high above the force, the escort fighters now flew level with

36. Source: The AAF, Volume II, pp. 221-2, 842.
37. Ibid, pp. 230-231.
38. Source 27; See also Appendix 12.

86 the bombers they were to protect;

b. As the Royal Air Force had done as early as in 1940, the US Air Forces now also recognized the advantages of and adopted the German pattern of fighter pairs and swarms (four aircraft), and unit organization was adapted to this pattern for improved maneuverability

The four aircraft of a swarm flew in line abreast:

a. T T T T, spaced in accordance with current requirements;

b. In line astern: T
T
T
T;

c. In box formation: T T
T T;

d. In wedge " T
T echeloned to right
T
T

or T echeloned to left[39]
T
T
T

The most pressing problem in the matter of fighter escort protection was that of increasing the penetration range of the P-47 Thunderbolt. The US fighter forces were stationed on tactical airfields in the Norwich area, and their current penetration range, after deduction of a certain time as a safety factor, was 200 miles. This restricted their use as escort fighters to as far as a line from Terschelling to Zwolle to Arnheim to Brussels to

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39. Source 19.

88 Amiens. This was not much of an improvement over the striking range of the British fighters.

Carrying 225 gallons of fuel all space available in the P-47 was already taken up by fuel tanks. The only possibility to increase its range was therefore by the use of outside tanks.[40]

On 17 April, 21 May, and 29 May 1943 units of the VIII Bomber Command had suffered heavily in attacks, losing between 5 and 10 percent of the 4-engine bombers committed, then followed an attack against Bremen on 13 June 1943, in which the attacking force lost 26 of the 182 4-engine bombers committed. This finally made it unmistakably clear that the execution of daytime bombing missions by 4-engine units against targets beyond the range of escort fighters had become a difficult and costly matter.

The tactics of providing fighter escorts on the outward route to the limit of the range of the fighters, and then assigning fighters to await the returning bomber force on its way home proved less and less effective; the German fighters had detected this weakness in the US escort system and withheld their attack against the 4-engine bombers until the escort fighters had reached their extreme range and turned back to return to their bases.[41]

40. The AAF, Volume II, p. 336.
41. Ibid, pp. 670, 844.

89 It took up to 28 July 1943 to equip the aircraft of six P-47 fighter groups of the VIII US Fighetr Command each with two 75-gallon expendable reserve fuel tanks, which extended their striking range to 246 miles (410 kilometers). From their tactical bases on the British east coast this enabled them to operate as far as a line from Emden to Dortmund to Koblenz to Metz.

The advantages of this considerably increased escort fighter striking range became strikingly evident in the attack executed on 28 July 1943. On that date the VIII Bomber Command dispatched a force of more than 300 4-engine bombers to attack aircraft works at Kassel and Oschersleben. Of this force more than two-thirds abandoned their mission and returned to their bases after encountering bad weather after passing the coast of Holland. A force of 95 continued on their course, relying on their own defensive power in spite of opposition by German fighters. They reached and bombed their assigned targets, thus carrying strategic daytime air warfare to the central regions of Germany for the first time. On the home flight a force of 105 P-47 fighters met the returning bombers in the Muenster area to cover their withdrawal. From this point on the bomber force, which had already lost 22 4-engine aircraft to German fighter action, suffered no further losses.[42]

42. Ibid, pp. 6-9, 847.

89 In September 1943 new expendable reserve fuel tanks with a content of 108 gallons made their appearance. With two of these the US P-47 Thunderbolt had a theoretical radius of action of 375 miles. Making proper allowances for safety factors, such fighters could now escort 4-engine bombers a distance of 300 miles each way.

90 This extended the range of P-47 fighters on escort missions as far as a line from Wesermuende to Bielefeld to Frankfurt to Saarbruecken, operating from their bases on the east coast of Britain.

However, the installation of these 108-gallon tanks on the outside of P-47 fighter aircraft remained an unsatisfactory solution to the fighter escort problem. In the 8-15 October 1943 period the US Eighth Air Force in four attacks against targets within Germany lost a total of 148, or 12.7 percent, of the total number of 1174 4-engine bombers committed. In addition, a large number of the remaining bombers were so badly damaged by weapons fire that they crashed over England or at landing and were beyond repair. On 14 October 1943, for example, a force of 229 4-engine bombers attacking Schweinfurt lost 60 of their number over German territory plus another 17 totally lost at sea or in England, and 121 aircraft with

90 reparable damage. The aircraft totally lost thus made up alone 33 percent of the total number committed, which by far exceeded tolerance limits.

Realization that continuation of large area strategic air warfare against Germany depended on the availability of escort fighters with a longer operating range had resulted already in October 1943 in the transfer from the African theater to England of a fighter group equipped with P-38 Lightning aircraft.

Committed in escort missions the P-38 hada penetration range of 500 miles with two 75-gallon reserve tanks, and of 561 miles (935 kilometers) with two 108-gallon tanks.

Equipped with P-38 aircraft the US 55th Fighter Group arrived in England at the beginning of October 1943 and from there was to be committed in the attack against Schweinfurt on 14 October as its first mission. The distance by air from Hwrwich to Schweinfurt is 400 miles, and plans provided for the fighter group to provide escort protection for the bomber force over the target area at Schweinfurt. However, all efforts to ready the units of the 55th Fighter Group for action by that date failed, so that it was unable to participate in the escort mission. Therefore, the only units which could be assigned were those equipped with P-74 aircraft, the majority of which still had 75-gallon

91 reserve fuel tanks, and could only escort the bombers as far as Aachen and meet them on their return at a line level with Cambrai and Amiens.[43]

The technical data of the Lockheed P-38 Lightning fighter aircraft were as follows:

Power Plant: Two Allison J-10-R engines with exhaust driven turbines.

Take-off thrust: 2 x 1340 HP

Maximum thrust: 2 x 1340 HP at an altitude of 25 000 feet

Rated thrust : 2 x 1115 HP at an altitude of25 000 feet

Short booster (3 x 5 minutes) with a mixture of alcohol and water gave an increased speed of 20 percent.

Performances : Maximum speed: 360 miles at an altitude of 25 000 feet (with booster 378 miles)

Maximum Aititude: 34 000 feet (10300 meters)

Armament : 1 20-mm+cannon with 150 rounds

4 127-mm machine guns with each 300 rounds, mounted centrally in the cockpit

Sustained flight capability: With normal fuel load of 300 gallons 780 miles; with two 150-gallon reserve tanks 1500 miles.[44]

43. Ibid, pp. 703-705, 850
44. Source 27 and Appendix 13.
\+ probably should read 20-cm.

92 The overall strength of all US fighter units consolidated under the US VIII Fighter Command, status 15 October 1943 for the mission of escorting bomber forces was as follows:

5 groups equipped with P-47 Thunderbolt aircraft
2 " " " Spirfire aircraft
1 " " " P-38 Lightning aircraft

making a total of eight groups with an overall authorized aircraft strength of 384.[45]

At the same time the average overall strength of all 4-engine bomber forces under the VIII Bomber Command totalled 290 aircraft.

Although the available strength in Us fighter aircraft thus already exceeded the number of bombers available, strong Royal Air Force fighter forces were committed to protect the bomber forces on their outward and home routes to the limits of their striking range in addition to the US fighter units thus committed.

Already at this early juncture the tendency was clearly evident to commit escort fighters in numbers exceeding the number of bombers they were to protect.[46]

45. Source 28.
46. AAF, Volume II, pp. 702, 850.

93 3. US Army Air Force Measures to Deceive, Divert, and Disperse German Defenses. In efforts to reduce hazards to the lowest possible minimum, the US strategic air forces when the commenced operating in the European theater of operations exploited various possibilities to deceive, divert, and scatter the German defenses.

For example, the operational plan for 6 September 1942 besides the main attack force of 41 B-17 aircraft dispatched to bomb the primary target, namely, the Potez aircraft works at Meaulte,included the dispatch of two other attack forces, one of 13 B-17 and one of 12 medium DB-7 bombers, both with strong fighter escorts, These two forces had the special mission of attacking the German fighter airfields at St. Omer and Abbeville for the purpose of hampering German fighter action and decoying German fighters from the main attack force.

However, these plans failed. The German fighters were not lured away from the main target, so that the main attack force encountered the German fighter defenses at full strength over Meaulte. It was due exclusively to the strong fighter escorts with the main attack force that only two 4-engine bombers were shot down in this operation.[47]

From then on diversionary attacks were an almost

47. The AAF, Volume II, p. 219

94 regular feature in plans for US 4-engine bomber operations. These diversionary actions were designed to serve two purposes:

a. To cause the enemy to commit fighters in wrong areas;

b. To provide opportunities for newly assigned units in England to obtain practical experience in the application of operational tactics.

These diversionary actions were always so planned that there was no possibility of an encounter with German fighters. For this reason they were usually carried out in the North Sea area to create the impression of an intended attack against targets in the Bight of Helligoland.

The 14 May 1943 operation introduced a new phase in the tactics employed by the US air forces in Europe. The purpose in the new methods was to scatter the German defense fighter forces by coordinating a number of separate attacks against separate targets so timed that they would compel the defenders to decide which approaching force they must consider the main attack force. This made the decision where to place their main effort in fighter defense action exceedingly difficult.

94 On 14 May 1943 the US Army Air Forces dispatched the following forces simultaneously:

a. A main attack force of 126 4-engine bombers to bomb Kiel;

b. A force of 38 4-engine bombers escorted by fighters to bomb Antrwerp;

c. A force of 34 4-engine bombers under fighter escort to attack Courtrai;

d. A force of 11 twin-engine B-26 Marauder bombers under fighter escort for a low altitude attack against Ijmuiden.

The purpose of causing a scattering of the German fighter defense effort was not achieved for the following reasons:

a. There was no possibility that the 11 B-26 bombers approaching and attacking at a low altitude might decoy German fighter forces, since German aircraft detecting instruments could only detect such targets just before they reached the coast, and since past experience indicated that approaching enemy force was probably composed of fighter-bomber or medium bomber aircraft. If an assembly of US 4-engine bombers was detected in any such case, German fighters were committed against it only if it was to be expected that they would

95 attack fighter airfields;

b. Defense action against the force approaching Courtrai was an exclusive responsibility of the fighter defense system under the German Third Air Fleet, which committed its fighter forces against enemy aircraft penetrating into the zone of German Air Command Center only under exceptional circumstances;

c. Commitment of the German fighters stationed in Western Holland against the 4-engine bomber force approaching Antwerp was the only action these fighters could take, since their operating range made it impossible for them to take action against the other force approaching in a wide sweep northward over the North Sea. Furthermore, responsibility for action against enemy forces approaching over the mouth of the Schelde River rested with Air Command Center.

The outcome of the whole coordinated operation by forces of the US Eighth Air Force was that the main attack force dispatched to bomb Kiel encountered the greatest possible areal concentration of German fighters and lost eight 4-engine bombers, while German fighters in Holland shot down one 4-engine bomber and a number of fighters out of the force attacking Antwerp, and the fighter units

96 of the Third Air Fleet shot down two 4-engine bombers and a number of fighters out of the force attacking Courtrai.[48]

From the tactical viewpoint plans for the attack by Us air forces against the Buna synthetic rubber works at Huels on 22 June 1943 were more favorable. The plan of operations provided as follows:

a. A main attack force of 235 4-engine bombers was to bomb Huels;

b. A second force of 42 4-engine bombers under strong fighter escort was to attack Antwerp;

c. A third force of 21 4-engine bombers was to fly over the North Sea for diversionary purposes;

d. Twelve Royal Air Force Mitchell twin-engine bombers under fighter escort were to carry out a diversionary attack against Rotterdam.

In view of the fact that this was to be the first sizable attack during daylight against a target in the Rhine-Westphalia industrial region the whole operation was planned with particular care and thoroughness.

As was to be expected, the attack by the twelve Royal Air Force bombers against Rotterdam drew ele-

48. Sources: 29; The AAF, Volume II, pp. 338, 844.

97 elements of the German fighter units stationed in Holland which failed to make contact with the enemy. This secondary action was so timed that the German fighters taking off to defend Rotterdam would not have time to reach the force approaching Antwerp or to refuel and go into action against the forces returning from the mission of bombing Huels.

The force dispatched against Antwerp thus diverted to itself further German fighter elements stationed in Holland and Northern Belgium, namely, approximately 70 single-engine and 8 twin-engine fighters from areas under the Third Air Fleet and Air Command Center.

During the first part of its approach, the main force of 235 4-engine bombers followed the same route as that usually followed in former attacks against targets in the coastal areas of the Bight of Helligoland. To simulate an actual intention to carry out such an attack, the diversionary force of 21 4-engine bombers was to continue on this course while the main force was to turn sharply southeast at a fixed point in the North Sea level with Vlieland Island and proceed directly to Huels.

This latter part of the plan of operations failed because the diversionary force was delayed. The result

97 was that the diversionary force was very far behind the main force, and only came within range of German instruments when the German Fighter Command had already made all decisions on what fighter defense action to take. Consequently, the main force encountered very heavy resistance by concentrated fighter forceswhich shot down 16 of the 183 bombers.

The force attacking Antwerp also incurred losses. In spite
spite of its strong fighter escort, German fighters shot down four of the 39 bombers.

Not counting the force dispatched on a purely diversionary mission and which did not participate in combat action, the whole operation thus ended with a loss of almost 10 percent of the total number of 4-engine bombers committed. Losses probably would have been even higher but for the fact that particularly strong fighter forces were sent out to meet the returning bombers and escort them back to their bases. For this purpose the Royal Air Force dispatched 23 Spitfire and 3 Typhoon fighter squadrons while the VIII Fighter Command of the US Eighth Army Air Forc e dispatched 8 P-47 fighter squadrons to meet the main bomber force returning from Huels on a westerly route in the coastal areas of Western Holland.

98 The results of the bombing of Huels were significant for a special reason:

The German air raid warning system was taken completely by surprise, since all attacks by US forces during daylight in the past had been directed exclusively at targets in the coastal regions of the Baltic, the North Sea, and the English Channel. The air raid warning was only given at Huels when the bombing had already started, for which reason losses among the factory personnel were exceptionally heavy, namely, 186 killed and approximately 1000 wounded.

After another penetration by units of the US Eighth Army Air Force on 25 June 1943 into the northwestern areas of Germany during bad weather in which the units could only bomb chance targets through gaps in the clouds but nevertheless lost more than 10 percent of the 167 4-engine bombers participating, the US command realized clearly that the methods adopted hitherto were inadequate to eliminate or at least seriously weaken the German defenses.

A whole month passed before the US Eighth Army Air Forces resumed operations against targets within Germany.

In the operation of 25 June 1943 the 218 4-engine bombers participating were split up into four separate

99 attack forces against four areally separated targets,namely, Hamburg, Kiel, Rerik, and Heide. The obvious purpose here was to weaken the German defense by compelling the command to separate its available strength for action in four different areas.

The loss of 19 4-engine bombers, or 9 percent of the total number committed, showed that these tactics were not successful.

A similar operation on 26 July, with two separate forces attacking two widely separated targets, namely, Hamburg and Hanover, ended with the loss of 24 or 11 percent of the total number of 4-engine bombers committed.

The increased penetration range of the US P-47 fighter aircraft from late July 1943 on enabled the US Eighth Army Air Force to dispense with the necessity to devise more successful measures to deceive, divert, and scatter the German fighter defenses. On the contrary, it served the purposes of the US air force if the Germand command was fully informed on the current air situation and sent up its fighter units as soon as possible, since this enabled the US fighters to be brought into full action while still within their effective range of operations. The German defense command, on the other hand, could not afford to station its fighters too far rearward, since the possibility always existed

that the target to be bombed by the approaching force might be within the striking range of US fighters, and that if the German fighter forces were withheld too long, counteraction might be too late.[49]

The German antiaircraft artillery defenses presented a very especial problem for the US strategic air forces. The damage done to 4-engine bombers by shell fragments was exceptionally heavy. Just as the Royal Air Force had done, the US Eighth Army Air Force at an early stage carefully considered what measures might serve to reduce the effectiveness of German antiaircraft fire.

The basic principle was adopted of always operating at the highest possible altitude. A most important requirement was to disable the German electronic target detecting apparatus. For this purpose a jamming radio transmitter was developed, designated the "Carpet," for installation in 4-engine bombers. This transmitted on the 50-60 meter waveband and caused such serious interferences in the German Wuerzburg and Mannheim instruments used by the German antiaircraft artillery that it was no longer possible within their range to accurately locate or track a target in the air. In all conditions of visibility under which

49. Sources: 26; The AAF, Volume II, pp. 672, 845, 846.

101 the antiaircraft artillery batteries had to rely on electronic equipment for firing data, the use of the Carpet could serve to considerably reduce their effectiveness.

The Carpet instrument was used on 8 October 1943 for the first time by two groups of the 3d Bomber Division, participating with units of the 1st Bomber Division in an attack against Bremen, which was strongly defended by antiaircarft artillery batteries. While 75 percent of the 1st Bomber Division aircraft were damaged, only 60 percent of those of the 3d Bomber Division, which had Carpet radio transmitters, were damaged by antiaircraft artillery shell fragments.

However, it was not safe to assumer with certainty that this difference was due exclusively to the results of radio jamming with the Carpet transmitter.

Experiments with the Carpet instrument were therefore continued in another six large-scale attacks in October 1943. The results were so favorable that a comprehensive program was established on the basis of this experience and with support from the Royal Air Force and the US Eighth Army Air Force and their testing installations to develop radio and radar interference methods which would disable both the electronic target locating equipment of the German

50. Sources: The AAF, Volume II, pp. 694, ff.; Impact 2/45; See also Appendix 14.

101 antiaircraft artillery forces and the radio communications equipment of the German fighter control system.[50]

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50. Sources The AAF, Volume II, pp. 694, ff.; Impact 2/45; see also Appendix 14.