102 4. Bombing Techniques of the US ARMY AIR FORCE in Strategic Air Warfare. In the German Air Force the principle of individual bombing was always dominant, with each plane individually responsible even when operating within a unit formation. In the US bomber forces, in contrast, the bombing system adopted from the very outset was that of the combined unit bomb release, with the unit commander solely responsible.

The decisive reason here was probably the American view that this served better to preserve the cohesion of the unit and could improve its capabilities for defense against fighter attack.

The mission of the unit commander under this system was to identify the target, lead his unit in the bombing run, determine the point for the unit bomb release, and give the order to release bombs after appropriate warning orders.

The mission of the individual aircraft crews was to maintain the ordered unit formation as precisely as possible and to achieve as simultaneous a bomb release as possible with the unit leader.

The advantage of this system was that it left all crew members, with the exception of the bombardier, of

103 all aircraft in the unit free to concentrate on maintaining their right position within the unit formation and on defense against fighter attack. The disadvantage was that any error by the unit leader was immediately multiplied. Possibly there was also a psychological disadvantage, since the crew members of the unit during the decisive phase of an operation, namely at the moment of bombing their target, were reduced to robot-like action, so that there was no possibility to develop a feeling of personal responsibility in them.

In the matter of the development of bombing techniques the operations of the US VIII Bomber Command during the August 1942-February 1943 period were governed principally by the need for experimentation to gather practical experience on the best methods to achieve maximum accuracy in bombing. From the outset it was assumed that aircraft would operate at altitudes between 20 000 and 27 000 feet as a precaution against antiaircraft fire from the ground.

Initially, emphasis was on the testing of target aiming devices, fuze setting, and the techniques of the bombing run, but with the growing size of the forces available emphasis shifted to the problem of the size of the unit in which the principle of combined unit bomb release was

103 to be adopted, whether at the flight, squadron, or group level.

After a close study of the results hitherto obtained, the US Eighth Army Air Force came to the conclusion in March 1943 that the method of simultaneous unit bomb release was most advantageous in the combat box size force, with the combat box leader giving the bomb release order. The standard size of the combat box was eighteen aircraft. To increase bombing effectiveness the requirement was stated that the unit must be in very tight formation and that all aircraft must react as speedily as possible to the bomb release signal given by the lead plane.

The command of the US Eighth Army Air Force did not order any rigid pattern for bombing. Frequently the size of the unit required to adhere to the simultaneous bomb

104 release principle was decided by the nature of the target to be attacked. Small targets, for example, could be bombin this manner by a flight, larger area targets, such as airfields, might even require this bombing method by a number of combat boxes in a combat wing.

In March 1943 a new instrument was introduced in the units of the US Eighth Army Air Forces to imrpove course and altitude stability prior to the bomb release. This was

105 the Automatic Flight Control Equipment, an automatic pilot system which synchronized the two factors of flight direction and altitude with mechanical precision and insured a better regulated target approach and bombing run than even the most experienced pilot could achieve through manual steering.

The few sedonds which preceded the bomb release were the most decisively important of a whole mission, it was in these seconds that the bombardier had to determine the bomb release point, a decision which would determine the bombing results achieved by an entire unit. It was therefore essential to keep the lead aircraft as steady on its course and altitude as possible during this crucially important process. A mechanical instrument could do this better than any human pilot, who involuntarily would react to antiaircraft fire or fighter attack, or might even succumb to general nervousness, factors which it was particularly necessary for the US Army Air Force to consider because of a lack of experienced pilots due to the rapid build up of the bomber forces.

The first results obtained with the new instrument were disappointing. After some practice and some improvements to the instrument the system was used for the first

105 time on 18 March 1943 in an attack against the aircraft factory works at Vegesack with excellent results. The 305th Group, releasing its bombs in response to the signal from the group lead plane, which was equipped with automatic flight control instruments, placed 76 percent of its bombs within a radius of 1 000 feet of the target center.

Although many doubts were still expressed, the new equipment from then on proved an important aid to secure greater accuracy in bombing and was installed in all unit lead planes.

Success or failure in bombing naturally did not depend alone on the technical aids available to the bombardier. Very important factors were also the degree of optical target visibility and the degree of accuracy with which meteorological influences on ballistics could be computed. Poor visibility, wrongly computed wind conditions and defense circumstances frequently caused ineffective bombing in spite of even the best technical conditions.

I In an attack against Rouen on 8 March 1943, for example, German fighters shot down the US unit lead plane just as it was making the target bombing run. The rest of the bombing unit became so confused that they released

106 their bombs at random within a circumference of twelve miles.

In many other cases the bombing sights in the lead plane did not function properly, causing an entire unit to bomb ineffectively.

On numerous other occasions poor bombing results were due to neglect or inexperience on the part of the unit aircraft crews.

In spite of all these adverse factors, however, the US Army Air Force continued to adhere to the principle of unit simultaneousl bomb release in response to a signal from the unit lead plane. The recommendation to reduce the bomb volume lost in false bombings by restricting simultaneous unit bombing to forces not larger than two groups, a recommendation submitted in the spring of 1942, was balanced by the requirement, which was considered more urgent, to combine more than two groups in formation in order to secure a better concentration of defensive fire against fighter attack.

The American system of daylight precision bombing techniques remained a latent source of conflict with the opinions held by the Royal Air Force. The latter held

107 the opinion that its own system of area bombing at night held out better prospects of final success in strategic warfare, and this opinion found support in certain American circles.

The experience of the US air forces in strategic warfare against Germany in 1943, however, served to confirm t the realization that it was essential to first destroy the German Air Force and its supporting industries, in particular factories producing fighter aircraft, before it would be possible to achieve any other strategic purposes of the bombing offensive.

Armament factories were point targets which, the Americans considered, could only be hit effectively by means of precision bombing during daylight, and never by means of the uncertain results achieved in area bombing at night.

In the autumn of 1943 the US Army Air Force therefore devoted its main efforts to the development of new methods which would insure accurate bombing by sizable units even in periods of bad weather with poor visibility or none at all. The point at issue here was to develop a bombing device functioning independently of weather conditions and thus make it possible to achieve the strategic objectives without regard for weather conditions.

107 A solution of this problem was found in the H-2-S instrument developed by the British in 1943 and known in Germany as the Rotterdam system. British experience showed that this instrument could be used as the basis for a system of complete blind bombing techniques, a subject which will be dealt with later in the present study.[51]

---

51. Sources: The AAF, Volume II, pp. 266, 332, 342-347; See also Appendixes 14a, 14b, 14c.

107 5. Bomb Types and Mixed Bomb Loads Used by the US Strategic Bomber Forces. When the units of the US VIII Bomber Command in August 1942 commenced their operations with 4-engine bombers against strategic targets in France, the bombs generally used for high altitude bombing were of the high-explosive type, namely 1 000-pound, 500-pound, and 250-pound general purpose bombs.

These bombs had a high-quality steel casing, so that even the heavy calibers did not break on impact. Because of the stability of the casing it was possible for these bombs to have an explosive charge making 50-percent of their total weight. In German and British bombs the casing was of lower quality, so that their explosive charge could only be 36 percent of their total weight.

The only disadvantage of the American bombs was the high percentage of duds. This was due to the fact that the bomb stabilizers were inadequate to prevent serious wobbling during their fall. The result was that in frequent cases only the side detonator was set off at impact without igniting the explosive charge. If the center detonator was not set off simultaneously with the side detonator, the primer charge, which extended through the whole bomb, failed to ignite, and the bomb was a dud. American

108 bombs had this flaw for a long time, and it was only remedied to some extent in 1944.

109 Heavier calibers with more effective explosive charges only came into use in 1944.[52]

In the first few months of 1943 units of the US Eighth Air Force made only occasional use of incendiary bombs together with their load of explosive bombs, and no special experience is available on this subject for that period.

It was May 1943 before the US air forces, on recommendations by the Royal Air Force, commenced considering whether the use of a larger percentage of incendiary bombs would not produce more telling results in attacks against industrial targets, since it could be assumed that the heat generated by the fires thus caused would render all steel parts, and thus the machine tools of factories, useless.

In three test missions, against Kiel on 14 May, against Emden on 15 May, and again against Kiel on 19 May some of the attacking planes dropped large quantities of incendiary bombs. Certain difficulties were encountered here in the matter of bombing accuracy, since the ballistic properties of the incendiaries differed from those of the demolition bombs.

52. Sources 30, 31.

109 For the incendiary bombs the release point had to be closer to the target, and the bombing run had to be longer. This meant that in his target bombing run the lead plane had to adapt itself to that unit of his force which was carrying incendiaries. It was also necessary to place the unit carrying incendiaries last in line in order to avoid the danger of following units becoming entangled with the fastenings dropped with the incendiaries. The tail end of the line was simultaneously the least defensible and the most difficult to protect. Furthermore, due to its longer bombing run the unit carrying incendiaries was apt to lag and therefore was most seriously exposed to fighter attack.[53]

The incendiary bombs used by the US air forces were partly of American and partly of British origin. Use was made of the stick-type and the fluid type, incendiary bombs long in use by the Royal Air Force in night bombing.

At no time was the accuracy achieved with incendiary bombs equal to that achieved when using demolition bombs. However, this disadvantage could be accepted as not too serious in view of the extensive damage frequently caused

The percentage of incendiary bombs included in the mixed load varied according to the target to be attacked.

53. The AAF, Volume II, pp. 345, ff., and 479.

110 For highly flammable targets the percentage was larger, for more resistant targets it was smaller.

The following information is available on this point:

a. On 8 October 1943 314 4-engine bombers of the US Eighth Army Air Force attacking Bremen used 634 demolition bombs, 3 000 stick-type, and 2045 fluid incendiary bombs;

b. On 10 October 1943 236 US 4-engine bombers attacking Muenster used 1 045 demolition bombs, and 2 000 stick-type and 9 000 fluid type incendiary bombs; In this attack fires caused very serious damage. Within Muenster 245 houses were destroyed and 280 badly and 2 600 less seriously damaged.[54]

111 c. On 14 October 1945 228 US 4-Engine bombers attacking Schweinfurt dropped the following quantities:

1 122 high-explosive bombs with a total weight of 395 tone

Incendiary bombs with a total weight of 88 tons. Out of the total number of 1 122 demolition bombs 143 were placed inside the factory area of the ball-bearing works, 88 of them as full hits on buildings. The incendiary bombs were less accruately placed.[55]

Four types of incemdiary bombs were used by the US

54. Source: Study 158-160, Volume I; The AAF, Volume II, p.850
55. The AAF, Volume II, p. 703.

111 strategic air forces, as follows:

a. 4-pound stick-type. These had an electron casing with a thermite filling and were packed in containers of ninety. They were dropped with the container and when dropped at an altitude of 660 feet scattered over an area between 400 and 660 feet long and 100 to 230 feet wide.

At impact they had a speed of only 120 meters per second. Owing to this small speed and their small weightthey usually could not penetrate deeper than the roofs of houses. However, the timber usually used in roof structures provided the best conditions in attics for the starting of what might develop into major fires.

From the autumn of 1943 on the US air forces used stick-type incendiary bombs with an explosive charge on a steadily increasing scale. One end of them had a powder instead of a thermite filling. Externally there was no difference between these and the normal type, a fact which seriously complicated fire extinguishing activities.[56]

b. 88-pound phosphorous incendiary bombs. These contained a compound of crude benzole and an artificial

56. Source 33.

112 gum, the latter used f om March 1942 on in place of the rubber preparation formerly in use. The phosphorous content made up 17.4 percent of the bomb. Part of this, 25 grams, was mixed in with the detonator and 600 grams of volatile phorphoraus was around the detonator, so that it would spray upon detonation.[57]

XXXX c. 32-pound (14 kilogram) phosphorous incendiary bombs packed in containers of eight.

This bomb was 83-centimeters long and had a steel casing containing 400 grams of solid phosphorous near the detonator plus between three and four liters of a viscuous burning fluid--a mixture of artificial gum and crude benzole with an admixture of phosphoraus.

Owing to its weight, its stability, and its high velocity at impact, which was 250 meters per second, this bomb could penetrate through several floors of a building and because of the burning spray it ejected could cause fires in all premises it passed through. The vapors from the phosphorous were toxic, and the drops of fluid sent flying through the air could ignite time and again besides causing serious burns, so that action against these bombs was particularly difficult.

d. Phosphorus cannisters. These had a thin metal sheet casing and a content of approximately five gallons

57. Source 33.

113 (20 liters). They were filled with a burning fluid with an admixture of phorphorus. These were in less frequent use by the US air forces because of their small penetration power, and because of the complications resulting from the fact that their ballistical properties were too different from those of other types of bombs for use in high-altitude bombing.[58]

In the development of incendiary bombs the British were clearly in the leadand provided all supplies of these types of bombs required by the US air forces.

Overall operational planning of the US Eighth Army Air Force in July 1943 provided that units would carry incendiary bombs on 85 percent of their strategic bombing missions, and that the mixed bomb load was to include 33 percent incendiary bombs.

58. Source 33.
59. Source 31.

114 6. ~~The US Type YB-40 Escort Bomber; May - July 1943~~.

Lacking a real long-range escort fighter type of aircraft, the US Army Air Forces in the summer of 1942 established plans providing for the assignment of special "escort bombers" of the B-17 Fortress type with their 4- engine bomber units. In place of the bomb load normally carried, these escort units were to have heavier armor plating, and more weapons and ammunition to give them increased fire power for action against fighters.

The idea was to have composite units with a ratio of one escort bomber to three or four normal bombers.

The first YB-40 units were initially expected to arrive in England in March 1943, but only arrived in May.

A few of the new aircraft participated on 29 May in an attack by units of the US VIII Bomber Command against St. Nazaire. No important experience was gained in this mission, since the German side had only weak fighter defenses in this region.

On 22 June the US VIII Bomber Command dispatched a force of 183 B-17 aircraft, including 11 of the YB-40 model, to bomb Huels. The fact that the bomber force lost 16 4-engine bombers in this mission cast some doubt on the efficacy of the new escort bomber. Further missions flown

114 with YB-40 escort bombers participating convinced the US Eighth Army Air Force that these "air cruisers", as they had become known, could not justify the hopes placed in them. Its recommendations that no more aircraft should be equipped as air cruisers, and that the B-17 aircraft already available for such equipment should be equipped as normal bombers instead, was approved.

For a short while plans were also under consideration to equip twin-engine aircraft of the B-26 Marauder type as an escort bomber instead of the B-17. However, these plans were dropped after investigations had shown that by reason of its flight performances and range capabilities the B-26 could not be employed in units of B-17 and B-24 aircraft, and that it was just as vulnerable to fighter attack as they.

The result of the failures with YB-40 and B-26 "escort bombers" was that increased energy was devoted to efforts to find a solution to the problem of escort fighters for the strategic bomber forces by increasing the range of the P-47 (Thunderbolt), P-38 (Lightning), or P-51 (Mustang) fighter models.[60]

60. The AAF, Volume II, pp. 268, 336, 337, 655, 671, 674, 680.

146 7. The Bombing of Ploesti by Units of the US Ninth Air Force on 1 August 1943.

a. Background Information. Oil production in Rumania ranked high on the Allied list of strategic targets for air attack. The American command estimated that Germany relied on the refining of crude mineral oil for two-thirds of her fuel supplies, and that 60 percent of this crude mineral oil came from the Ploesti oil wells. This meant that deliveries from Ploesti represented one-third of the basis for Germany's total output of motor fuels.

The opinion was held that these oilfields, with their annual capacity of 9 000 000 tons, were a factor of decisive importance for the German conduct of warfare, particularly in the eastern theater. It was thought therefore that air attacks by the Western Allies against this target could be counted as an impressive direct support for the Soviets.

Initially, the greatest difficulty here was that of reaching Ploesti with aircraft operating from the airfields available at the time to the Western Allies. In 1942 there was no Anglo-American bomber type with a flight range adequate to reach Ploesti from Britain, the only base area for air operations in Europe.

The only type of bomber aircraft that could be taken into consideration at all in 1942, so far as flight range

117 capabilities were concerned, for operations against Ploesti was the US B-24 Liberator. The first unit equipped with these aircraft was slated originally for strikes against Tokio from bases in China. Because of the high significance of Ploesti as a strategic target, however, the unit was finally released to commence an air offensive against the Ploest oil fields.

For the first attack, the unit was to take off from the British airfield Fayid at the Suez Canal, and after execution of its bombing mission was to land on the Persina airfield Habbaniyeh.

The first attack against Ploesti was staged from Fayid airfield on 12 June 1942, with thirteen B-24 4-engine bombers participating. The bombing was done from an altitude of roughly 11 000 feet (3 300 meters) through a closed cloud cover and achieved no important results. Only seven of the thirteen aircraft participating reached their landing airfields in Iraq; two landed in Syria, and four in Turkey, where they were interned.

These results had to be considered as an important failure of the mission and necessarily led to the temporary abandonment of all further plans in this direction.

It was April 1943 before US General Arnold ordered the preparation of plans for another attack against the

117 Ploesti installations. Two plans were submitted for this second attack:

aa. A high-altitude bombing attack by a medium sized unit to take off and land in Syria;

bb. A low-altitude attack by a strong force to take off and land in the Benghazi region in Lybia.

In June 1943 General Eisenhower and the Chiefs of Staff approved Plan bb.

The available 4-engine bomber forces available were urgently needed at the time for the impending invasion of Sicily. In order therefore not to weaken too seriously the 4-engine forces currently in the Mediterranean Theater through withdrawals for the operation against Ploesti, the following arrangements were made to organize the attack force, which was to have a strength of five groups:

aa. Two B-24 groups (the 98th and 376th) were to be taken from the North African Theater;

bb. Two B-24 groups (the 44th and 93d) were to be taken from the US Eighth Air Force in England. These were transferred under the US Ninth Air Force and were to displace to air bases in Lybia;

cc. One B-24 group (the 389th), intended for transfer to England, was to transfer directly from USA to Lybia instead.

118 The Commanding General, US Ninth Army Air Force was assigned responsibility for direction of the whole operation. After another review of the possibilities of both basic tactical plans, he decided finally that the attacking forces were to take off and land in the Benghazi area and were to carry out their bombing at a low altitude.

A tactical staff created specially for the purpose examined carefully the specific problems involved in using the existing bomb sights for a low altitude bombing attack of this type, and the various problems of target reconnaissance, weather intelligence, the selection of the most appropriate bomb and detonator types, and the defense situation

119 in the target area.

Expendable exterior reserve fuel tanks were provided for all aircraft participating in the operation.

The 93d, 44th, and 389th Groups arrived at airfields in northwest Africa on 8 July 1943. For training purposes and to reinforce the bomber forces already available they were committed first in support of the forces invading Sicily and advancing in southern Italy.

This phase in preparing the five B-24 groups for their special mission against Ploesti ended with their participation in the large-scale attack by 4-engine bombers against Rome on 19 July 1943.

119 On the following day, 20 July 1943, all five groups were pulled out of line and transferred to bases near Benghazi for intensive training. There they practised low-altitude flying and bombing, and received precise instructions concerning their route, their targets, the German defenses, and all details necessary for the successful accomplishment of their mission against Ploesti.

Replicas of the targets at Ploesti were set up in the African desert, and the crews bombed these so frequently in practise missions that "they could have hit their targets in their sleep."

In a final rehearsal on 28 and 29 July 1943 the entire force of five groups attacked the target replicas, and 1 August was fixed as the date for the attack against Ploesti.

b. Execution of the Operation against Ploesti. The bomber groups participating were assigned the following individual targets:

376th Group (in the lead):		Romana, Americana
93d Group	:	Concordia, Vega, Standard, Unirea, Speranza
98th Group	:	Astra, Romana, Unirea, Orion
44th Group	:	Colombia

120 44th Group : Colombia Aquilla, Creditul, Minier

389th Group : Campina.[61]

The planned approach route was by way of Korfu, Albania, Yugoslavia, Lom (in Bulgaria) to the first Initial Point of Pitesti, roughly 54 miles (90 kilometers) west of Ploesti. There the 389th Group was to leave the main body to attack Campina.

The rest of the force was to continue on its way to the second Initial Point of Floresti, 12 miles west of Ploesti, from where each individual group was to proceed to its assigned targets.

After completing their mission all units were to reassemble and the whole force was to return to its bases by the same route.[62]

The whole operation did not proceed according to plans.

With the 376th Group in the lead, followed successively by the 93d, 98th, 44th, and 389th Group, the entire force of 175 B-24 Liberators reached Korfu and turned northeast to cross the mountainous terrain of Albania and Yugoslavia on a course set for Lom, Rumania. On reaching the Danube Valley reagion the force became separated owing to heavy clouds, and the strict orders to maintain absolute radio

---

61. Appendix 15.
62. Appendix 16.

121 silence in order to take the German defenses by surprise precluded any possibility of transmitting orders or locating signals to restore cohesion.

The first two groups therefore reached the first Initial Point considerably sooner than those following, which frustrated the plan that all seven targets were to be taken under attack simultaneously.

At Pitesti the 389th Group, bringing up the rear, turned off on its assigned course and bombed the Campina installations according to plans with demolition and incendiary bombs from an altitude of 800 to 1 000 feet. Some degree of surprise was achieved, so that this group did not suffer considerable losses.

The 376th Group, in the lead, mistook Targoviste, 30 miles west of Ploesti, for Floresti and, with the 93d Group in its wake, proceeded from there on a southeast course towards Bucharest. Recognizing there the error it had made this force turned north and, coming from the south, bombed chance targets in the Ploesti area not in accordance with plans. Owing to the long route this force had taken by way of Bucharest the entire German fighter and antiaircraft artillery defense system of the oil region had timely

122 warning, so that all groups with the exception of the 389th (bombing Campina) encountered exceedingly fierce resistance, which threw the entire attack plan into confusion, and suffered very heavy losses.

The assigned targets actually attacked were as follows:

Campina
Astra Romana and Unirea Orion
Colombia Aquilla
Concordia Vega (by six aircraft)

The following assigned targets escaped attack:

Romana Americana
Standard
Unirea Speranza
Creditul Minier.

On the credit side of the operation, the US command estimated that it had achieved a 40 percent reduction in the Ploesti mineral oil output for a period of between four and six weeks. In actual fact the Ploesti output in August 1943 dropped to 269 000 tons compared with 407 000 tons in the previous month.

Us losses were as follows:

376th and 389th Groups:	11	aircraft.
93d "	11	"
98th "	21	"
44th "	11	"
Total losses	54	4-engine bombers.

On the home route another three bombers crashed into

122 the Mediterranean Sea.

Of the returning bombers 92 landed at Benghazi, 19 on the islands of Malta, Sicily, and Cyprus; 7 landed in Turkey, where they were interned.

123 This figure of 64 4-engine bombers totally lost represented a loss of 37 percent of the whole force committed.

The German side succeeded in remedying the damage done to the installations at Ploesti speedily by the use of installations hitherto not in operation and by the quick repair of others.

The whole operation, which had been planned with such great thoroughness and at such great expenditure had failed to produce the expected result of halting the Ploesti oil output for a lengthy period.

The primary reasons for this failure were as follows:

a. The detour by way of Bucharest caused by an navigational error of the leader of the entire force alerted the whole German defense system and sacrificed the advantage of surprise, the achievement of which had been the sole purpose of the low altitude at which the operation was planned;

b. The effectiveness of antiaircraft fire by light and medium guns against large aircraft operating at low altitudes had been seriously underestimated;

123 c. Low operating altitudes were e tremely unfavorable for defense against fighter attack.

The outcome of the operation against Ploesti on 1 August 1943 was so disappointing for the US air forces, that they staged no further attacks against Ploesti until the spring of 1944, placing other tactical and strategic targets higher on the priority list for attacks by the US strategic air forces stationed in the Mediterranean Theater.[63]

63. Sources: The AAF, Volume II, pp. 477-482; Impact 12/44.

124 8. US Eighth Army Air Force Operation against Schweinfurt and Regensburg on 17 August 1943.

a. Background Information. Besides the operation against the oil center of Ploesti, the US air forces in the summer of 1943 planned another large-scale strategic operation, namely,

the execution of a large-scale attack, in coordinated action by the US Eighth and Ninth Army Air Forces, against the Messerschmitt Works in Regensburg and Wiener-Neustadt, designed to deal a severe blow to German fighter aircraft production.

The view was held that a coordinated action with units of the strategic forces stationed in the Mediterranean Theater (Ninth Army Air Force) and of those stationed in England (Eighth Army Air Force) striking in unison would produce resounding results because it would compel the German side to split up its fighter defenses, and because of the impact such a demonstration of Allied air power would have on the German nation. The operation was expected to take the German fighter defense system by surprise, since it was assumed that the German fighter command did not anticipate such deep penetrations or simultaneous operations by strong 4-engine forces from south and west.

124 Views varied in US air command circles on the subject of whether the Ploesti attack, known as Operation Tidal Wave, or the Regensburg/Wiener Neustadt attack, known as Operation

125 Juggler should be staged first.

Decisions made at the highest level placed the attack against Ploesti first on the list. First priority was given to this operation because it was expected that it would cost less losses.

After execution of the Ploesti attack on 1 August 1943, 7 August 1943 was fixed as the deadline for Operation Juggler.

Plans provided for the US Ninth Army Force to commit the same five B-24 Groups which had executed the attack against Ploesti. Their target was Wiener-Neustadt, while the units to be dispatched from the US Eighth Army Air Force would bomb Regensburg.

Unfavorable weather over the northwestern areas of Germany on 7 August 1943 prevented execution of the operation on that date. After several more postponements because of unfavorable weather conditions, the plan for a coordinated operation by the Ninth and Eight Army Air Forces was cancelled and the two air force command headquarters received instructions to direct attacks independently of each other at their assigned targetsimmediately weather conditions

125 permitted.

Units of the Ninth Army Air Force attacked the Messerschmitt Works at Wiener-Neustadt on 13 August 1943.

The Eighth Army Air Force prepared a new plan of operations which provided as follows:

aa. Its 3d ~~AXX~~ Bomber Division, all of its aircraft equipped with reserve fuel tanks, was to bomb Regensburg, depart from the target area on a southerly course and land at designated airfields in North Africa;

bb. Its 1st Bomber Division was to attack works of the ball-bearing industry at Schweinfurt and then return to bases in Britain;

cc. Eighteen squadrons of P-47 Thunderbolt and sixteen squadrons of Royal Air Force Spitfire fighters were to escort the bombers, primarily the units of the 1st Bomber Division, which were to cross the hostile coastline approximately ten minutes after those of the 3d Bomber Division. Approximately level with Eupen the fighters were to return to their bases, refuel, and then return to meet the bombers of the 1st Bomber Division at the same line on their way back from their mission.

b. ~~Execution of the Operation~~. On the basis of weather reports on 16 August 1943 the following day was set for

126 the US Eighth Air Force to execute its mission. The take-off did not proceed according to schedule.

After the units of the 3d Bomber Division and the escort fighters had already taken off information arrived that weather conditions over the takeoff airfields of the 1st Bomber Division had delayed the takeoff of that division's units.

Since the units of the 3d Bomber Division had to reach their landing fields in Africa before dark and therefore could not be withheld for longer than one hour after the prearranged takeoff time, a speedy rearrangement was necessary.

The fighter units assigned to escort the 1st Bomber Division received orders to return to their bases and refuel. Those units of the 1st Bomber Division which had already taken off received orders to wait 3.5 hours over the assembly area, to enable the fighter units to take off again and reach them

Consequently, the 3d Bomber Division, in a strength of 127 B-17 Fortress aircraft and the smaller part of the escort fighter forces left England at 0935, followed by the 1st Bomber Division force of 188 B-17 aircraft with the larger part of the fighter escort at as late as

127 1314 hours.

This lag of 3.75 hours between the two attacking forces enabled the German Fighter Command to commit its forces in a second takeoff for action against the second bomber force. In this way the change in the American time planning caused by the unfavorable weather conditions became an important factor in creating an extremely favorable situation for the German fighter defense system.

In all other respects the operation proceeded according to plans.[64]

Although under heavy attack by German fighters, the US 3d Bomber Division bombed the Messerschmitt Works at Regensburg and caused considerable damage.

In contrast, the bombing of Schweinfurt by the 1st Bomber Division achieved relatively small results.

The 3d Bomber Division lost 15 4-engine aircraft during the approach, and another 9 after leaving the target area on its way to landing fields in North Africa, some brought down by German fighters, some by antiaircraft fire.

The 1st Bomber Division had the heaviest losses, namely, 36 4-engine aircraft, plus another 6 totally destroyed during its return over the Channel or during the landing

---

in England due to technical damage.

---

63. The AAF, Volume III, pp. 684-687, 848
64. Appendixes 17, 17a, 17b.

128 All in all, the losses of the US Eighth Army Air Force thus totalled 66 4-engine aircraft, or 21 percent of the total number of 315 committed.

In yet another respect the operation on 17 August 1943 was a disappointment to the US air forces:

It had been hoped that the flight by the 3d Bomber Division to landing fields in North Africa would serve to initiate a system of "shuttle bombing," in which advantage could be taken of the generally better weather conditions in the Mediterranean areas, and which would cause serious confusion and a serious scattering of effort for the German fighter defense system.

When the units of the 3d Bomber Division landed on the airfields in North Africa it was found, however, that numerous bombers were damaged, and that their proper servicing on the non-American airfields was impossible without properly trained US personnel and adequate stocks of spare parts. The airfields in Africa were still too inadequately developed and too inadequately equipped for such purposes. Under these circumstances, the effective strength of any units employed in a shuttle service would necessarily decline seriously. A lengthy stay at the African airfields under primitive conditions would also have proved a serious strain on the aircraft crew members.

128 For the above reasons the operation on 17 August 1943 remained the only "shuttle bombing" operation carried out between bases in England and bases in the Mediterranean areas.[625]

65. The AAF, Volume II, pp. 684-687, 848.

129

CHAPTER 4

THE ROYAL AIR FORCE FROM JULY 1943 TO THE END OF THE WAR

1. British Measures of Interference with the German Night Fighter and Antiaircraft Artillery Target Locating Equipment. By the spring of 1943 the Royal Air Force with its improved Gee instruments, its Oboe guide system, and its H-2-S or Rotterdam instruments for the hyperbola system of navigation, had developed methods of target locating and target marking which were adequately independent of weather conditions for its conduct of strategic air warfare against Germany. The sometimes heavy losses still inflicted by German night fighters still made it a compelling necessity, however, to develop special measures which would serve the direct purpose of decisively hampering German defensive action.

It had been known long since to the Royal Air Force that operations of both the German night fighter defense system and of the German antiaircraft artillery were based the use of the Wuerzburg radar instrument, which operated on the 50-60 centimeter waveband. The inference that any decisively effective measures which could interfere with these frequencies used by the German antiaircraft artillery

and night fighter defense systems would decisively hamper the whole German defense was a logical one.

A carefully planned British commando operation carried out according to plans on 28 February 1942 had given the Royal Air Force possession of the essential frequency setting elements of a German Wuerzburg instrument which had been stationed at Bruneval on the Channel coast.

During the retreat of the German Africa Corps from the El Alamein line in November 1942 British troops had captured another three or four of these instruments.

The appropriate British technical services were just as aware as their German counterparts of the fact that the dropping of what were called dipolas could interfere seriously with the functioning of high-frequency target locating instruments. The best method here was the use of tinfoil, and according to the laws of physics, this tinfoil had to be used in a size one-half of the wave length on which the instrument whose functioning was to be disturbed operated.

Once in possession of the frequency setting elements of the Wuerzburg instrument it was merely a matter of time before the Royal Air Force would determine the proper shape of the tinfoil to be used and would procure the necessary quantitied.

---

130 During their reserach processes, however, the British research agencies had been successful in their offorts to find at the same time a countermeasure to prevent such interference. This was important, sich it was logical to s-sume that the German side would use the same interference method once it became known.

At the end of July 1943 preparations had progressed so far that the Royal Air Force could initiate a new phase of strategic air warfare at night with a crippling blow against the German defense system , making use for the first time of the new means of interference with the functioning of the German Wuerzburg and Mannheim target locating instruments functioning on the 50-60-centimeter waveband.[66]

On the night of 24-25 July 1943 740 Royal Air Force bombers attacked Hamburg. The German Wuerzburg and Mannheim instruments within the areas affected were so blinded by a constant rain of tinfoil, named"Dueppel" on the German side, that they could not serve their purpose of providing data for the direction of night fighter operations or faring data for the antiaircraft artillery.

In this operation German night fighters downed ten bombers, the antiaircraft artillery three.

This loss ratio of only 1.6 percent was decisive proof

66. Sources 8 and 34.

131 that the new means of electronic interference was a factor of paramount importance for the conduct of strategic warfare against Germany.

The tinfoil used in this first operation was in strips between 1.5 and 2 centimeters wide and 25 to 30 centimeters long. The one side was covered with black paper, the other with a coat of black paint. This interfered with all frequencies in the ultrashortwave range between 50 and 60 centimeters. In the cathode ray tubes of the target locating instruments these strips caused such innumerable blips that it was impossible to determine any real target in the air.

The Royal Air Force followed up the first attack with two more against Hamburg, by 739 bombers on the night of 27-28, and by 726 bombers on the night of 29-30 July 1943.

In these three major bombing operations against Hamburg the Royal Air Force lost a total of 57 or 2.6 of the 2 205 bombers committed.

Taking into consideration that the overall average losses of the Royal Air Force calculated over the whole of July 1943 totalled 6.4 percent of all aircraft committed, it is obvious that operations before the use of tinfoil had been far more costly, and that the use of tinfoil had considerably

132 reduced the loss ratio.[67]

The British operations with tinfoil struck the German defense a crippling blow in two of its important elements:

a. The night fighter "waiting position" (~~Himmelbett~~) system. Here the ground station guiding a defense fighter to its target--the enemy bomber--had to depend on the proper functioning of its two Wuerzburg instruments, one of them tracking the target and the other tracking the defense fighter.

German night fighter operations at that time depended almost exclusively on this method, so that elimination of the Wuerzburg instruments destroyed the essential condition for such operations;

b. In weather conditions which made optical ranging and the illumination of targets impossible, the German antiaircraft artillery had to rely on its electronic equipment for firing data.

Here, the use of tinfoil had particularly serious results, since the Royal Air Force by using its Gee and H-2-S or Rotterdam instruments could identify and successfully bomb targets without visual sighting, using its Pathfinder units to mark the route and the target for its bomber forces.

Under the impact of the catastrophic results of the

67. Sources 36-37; RAF, Volume III, pp. 1- 1_.

133 British bombing of Hamburg on the night of 24-25 July 1943

German reaction to the use of tinfoil by the British was swift and comprehensive:

a. In the case of the Wuerzburg instruments measures were taken to expedite action initiated already early in the year to change the frequencies of the instruments in position in the German interior. The only instruments excepted here were those in the coastal areas. The reason for this exception was that these instruments in the coastal areas had the exclusive mission of detecting targets approaching from England, so that the British would have easily determined the new frequencies;

b. Measures were also taken to accelerate another process also already initiated, that of installing socalled "Flottmann-Eidechsen" silent transmitter attachments in the Wuerzburg instruments. These were set at an alternate frequency, the use of which was only permitted during periods of very serious interference on the normal frequency.

c. The German Night Fighter Command developed two new methods for action against enemy air forces:

aa. Direct target defense by fighters. Under

134 this method night fighter units not equipped with their own target locating instruments were guided to the target under attack by enemy bombers. There they could exploit the enemy airmarkers and fires burning on the ground in order to themselves establish visual contact with the enemy aircraft

It was due to the state of extreme emergency which had developed from the new British methods that heavy pressure was placed on the build up of single-engine night fighter units, already in process at the time, for what was called "Wilde Sau"+ operations independent of ground control;

bb. The method of directing night fighter units with Lichtenstein B/C equipment into the approaching enemy bomber force at an early stage for independent fighter pursuit action during the approach, over the target area, and during the return flight of the enemy bombers;

d. New regulations were issued for night fighter-antiaircraft artillery cooperation over the target area. These regulations imposed severe restrictions on the antiaircraft batteries to insure the fighters freedom of action;

e. In connection with industrial research, the German Air Force initiated an extensive program aiming

134 at:

aa. The development of means to clear the Wuerzburg and Mannheim instruments of interference;

bb. The development of new types of ground and air carried locating instruments with better performances and more secure against interference.[68]

The initial successes achieved by the Royal Air Force through the use of tinfoil were soon followed by operations in which the units involved suffered extremely heavy losses, which served to prove that the neutralization of the German defenses had been only of temporary duration.

For example, on the night of 17-18 August 1943 the Royal Air Force dispatched a formation of 571 bombers on a very carefully prepared attack against the German Rocket research station at Peenemuende. Although the approach route was in a wide sweep north across the North Sea and Denmark, and although the attacking force returned by the same route, it lost 47 bombers or 8.2 percent of the number committed, most of them downed by night fighters.

Another costly Royal Air Force operation was that on the night of 23-24 August, when out of 700 4-engine bombers attacking Berlin 76 or 11 percent were totally destroyed

+ "~~Wilde Sau~~"-in every-day speech something uncontrolled.
68. Sources 38, 39, 40, and 41.

69

135 and 21 badly damaged.

These successful German defense actions were due primarily to the following factors:

a. The Freya instruments were not affected by the tinfoil used because they operated on considerably higher frequencies, namely, on waves in the 2.4 to 7.5 meter range. They therefore furnished adequate air intelligence data;

b. The aircarried instruments of the night fighters were not seriously affected by tinfoil. These instruments being in motion, reflection from the tinfoil showed up as relatively stationary blips. With some experience they could therefore be distinguished from the aircraft blips in the Cathode tube, which moved much faster than the tinfoil blips;

c. Some of those Wuerzburg instruments which had attachments permitting the use of alternate frequencies were soon able to resume the mission of altitude detection and of directing night fighter aircraft, particularly durinf the return route;x

d. The German night fighter forces adapted readily to the new tactics of direct target defense and pursuit, which tinfoil could not interrupt.[70]

70. Sources 29 and 45. 71. Source 36

136 The initial British reaction to the recuperation of the German night air defense system took the form of measures to interrupt the alternate frequencies of the Wuerzburg and Mannheim instruments. The tinfoil now used was in a greater variety of sizes and thicknesses, ranging between lengths of 25 to such of 30 centimeters, which covered the entire frequency range from 50 to 60 centimeters. The tinfoil no longer had a backing of paper and was in 4 millimeter instead of 1.5-2 millimeter widths, and was slightly thicker. Small quantities in lengths of 60 centimers were also used.[71]

By the autumn of 1943 the Royal Air Force had so far increased the quantities and improved the mixing ratios of the tinfoil used that German defense operations were again seriously hampered.

In October 1943 the impact of these interferences on

137 German electronic locating equipment was as follows:

a. The instruments operating along the Channel Coast on frequencies between 2.40 and 7.5 meters were smothered almost daily by powerful ground-based jamming transmitters along the south coast of England without regard for the current operational intentions of the Royal Air Force;

71. Source 36.

137 b. During operations over the German interior the Royal Air Force made increased use of special transmitters in the bombers to so jam the Freya frequencies, on the 2.40 meter band, that the aircraft reporting instruments used there could no longer furnish intelligible air data, so that air intelligence had to rely almost exclusively on the use of reconnaissance planes;

c. The aircarried Lichtenstein B/C target locating instruments were so seriously affected by the increased masses of tinfoil that it became almost impossible to track targets with them. This destroyed the basic condition for the hitherto highly successful methods of night fighter pursuit operations;

d. Efforts to eliminate interferences in the 50-60 centimeter range band made no progress. Now that the alternate frequencies were also interrupted by tinfoil, the Wuerzburg and Mannheim instruments failed completely when large quantities of tinfoil were used.

Because of this situation, antiaircraft artillery batteries found no opportunities for action against targets unless optical range finding conditions existed and had to confine themselves to barrage fire, which was not very effective.

The only chance for successful night fighter action

137 was in direct target defense, provided the ground control stations and the aircraft crews were able to achieve a correct interpretation of a current air situation and that the night fighters could arrive over the target area simultaneously with the attacking enemy force.

Just when British radar and radio interference measures had reduced the efficiency of the German night air defenses to the lowest possible level of performances, a newly developed instrument brought about a complete change in the night fighter situation. This was the newly introduced Lichtenstein SN-2 instrument, which went into serial production in October 1943 and which was found to be completely proof against tinfoil interference. Furthermore, with its operating range of up to 8 800 yards, almost double that of the former Lichtenstein B/C instruments, it created entirely new possibilities for a successful exploitation of the tactics of night fighter pursuit.

One disadvantage of the new aircarried target locating instrument was that its close range diffusion as at a distance of around 500 yards (Nahaufloesung). On dark nights this was too great a distance to establish visual contact with the tracked target. It was for this reason that introduction of the Lichtenstein SN-2 instrument did not

138 produce immediate success in night fighter operations.

The results of the increased British interference with German radio and radar operations is evident from figures showing how British losses declined.

Whereas the overall average loss ratio in July 1943 was still 6.4 percent and in some operations in August 1943 even reached the high figure of 11 percent, figures on Royal Air Force operations in October 1943 against targets within Germany, show that only 3.5 percent of the 3 800 aircraft committed were lost. In November 1943 approximately the same number of aircraft were committed and the loss ratio sank to 2.2 percent. In the latter month, however, the low loss ratio was not due to interference with the German radar instruments alone, but in part also to the fact that

139 German defense activities were seriously hampered by weath- conditions, conditions, which the Royal Air Force intention- ally exploited.

Towards the end of 1943 two factors of positive value for the German defenses evolved in efforts to eliminate radar interferences:

a. The favorable results obtained with the Lichtenstein SN-2 aircarried target locating instrument, which functioned without interference;

139 b. The ability achieved to interpret the current air situation without having to depend on the functioning of the aircraft reporting instruments. This ability was due to establishment of the so-called Korfu network, a radar organization of the Radio Intercept Service to monitor the British navigational and target locating H-2-S instruments, and to the establishment by the Night Fighter Command of night air reconnaissance squadrons of aircraft equipped with special apparatus to detect British aircarried radio instruments by means of target locating method (Zielflugverfahren). The following instruments were used in this system:

Naxos Z and Flensburg Z against the British H-2-S;

Rozendahl Halbe against the British Monica night fighter detector;

Freya-Halbe against British jamming transmitters on the frequencies used by the German Freya instruments.

The combined result of these measures was that out of 2 600 aircraft dispatched against targets in Germany in December 1943 the Royal Air Force lost approximately 5.3 percent.[72]

140 At this stage only the German antiaircraft artillery was still face to face with the unsolved problem of how to eliminate interference in its electronic target locating

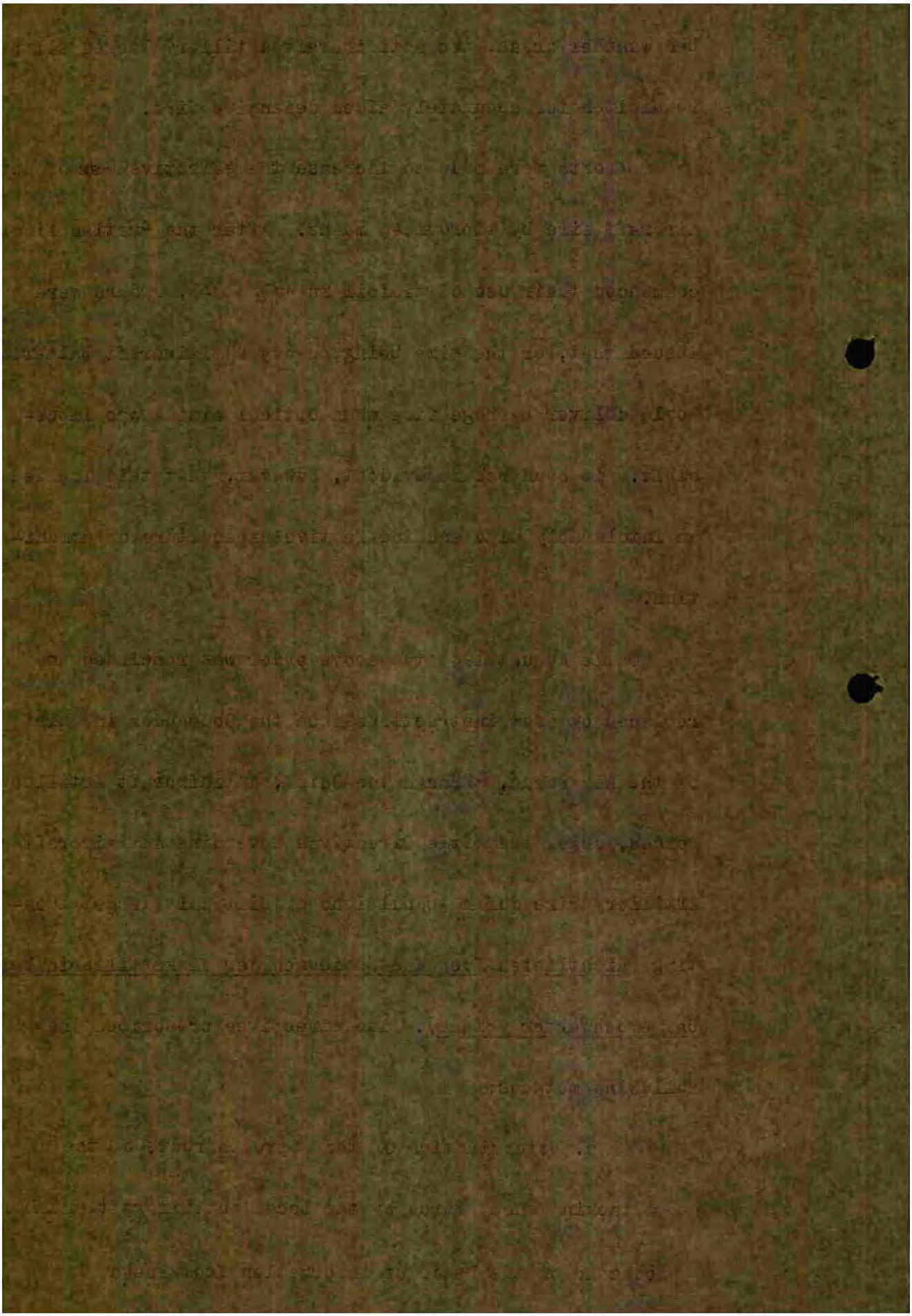
72. Study 158-160, Volume I.

140 instruments , which were hopelessly incapacitated by the British use of tinfoil. Since the Royal Air Force at the time usually selected its targets for attack in Germany in bad weather areas, the antiaircraft artillery lacked all prerequisites for accurately aimed defensive fire.

Efforts were made to increase the effectiveness of antiaircraft fire by improvised means. After the British first commenced their use of tinfoil in July 1943, orders were issued that, for the time being, heavy antiaircraft batteries would deliver barrage fire when optical aiming was impossible. It soon became evident, however, that this implied an intolerably high and ineffective expenditure of ammunition.

On 18 August 1943 the above order was rescinded and replaced by new instructions from the Commander in Chief of the Air Force, through the Chief, Antiaircraft Artillery Forces, under the title Directives Governing Antiaircraft Artillery Fire during Conditions of Difficult Target Locating (Richtlinien fuer das Schiessen der Flakartillerie bei bei erschwerter Ortung). The directives prescribed the following methods:

a. Determination of the approach route of the attacking enemy force by the local antiaircraft artillery command on the basis of information from Freya



140 instruments of the antiaircraft artillery forces still functioning in fringe areas, on information from searchlight units, and reported bombings;

b. Fire action against individual aircraft or attacks waves within the approach route, using the Type 40 fire-control director for the purpose and computing the lead with makeshift means;

c. The use of radio transmitters of the antiaircraft artillery forces to keep night fighters currently informed on the route of the attacking aircraft, the main areas of attack, the target altitude, and, if applicable, the ceiling for antiaircraft fire.

The delivery of barrage fire was permitted only when all target locating instruments were completely inoperable.

The directives of 16 August 1943 also contained precise details on the technically most favorable execution of fire missions with the Type 40 fire-control director, and with the Malsi instrument with fire director attachment, as well as for the delivery of barrage fire controlled by a central radio transmitter.

This gave the antiaircraft at least limited opportunities for defensive action at night and during periods of bad weather., but it could no longer be considered as an effective defense weapons once the British initiated their

141 tinfoil operations. This must be considered as an important and lasting success of the British measures to neutralize German target locating instruments in 1943.[73]

Since the disastrous interruption of electronic target locating operations in July 1943 the German high-frequency branches of industry had worked feverishly to develop means to eliminate interferences with the Wuerzburg instruments.

The first practicable method was discovered on 31 August 1943. This was the so-called Wuerzlaus system, based on the principle of isolating what was called the "Double-Effect" (Doppler-Effekt) meaning that itt made the difference between the reflection from a stationary object (such as tinfoil) and a rapidly moving object (such as an aircraft) visible.

142 First tests with this new attachment gave satisfactory results when the British used medium quantities of tinfoil, but less satisfactory results when large quantities of tinfoil were used or during high winds, which necessarily increased the dirft speed of the tinfoil.[74]

In October 1943 the Night Fighter Command had the impression that complete success had been achieved in interference suppression in the Wuerzburg-Riesen instrument.

73. Source 46. 74. Source 47.
75. Sources 38, 48, 49.

142 However, this optimistic view was soon disproved in a conference at the Office of the Chief of Special Supplies and Procurement on 14 December 1943 by Dr. Rottgardt, Director of the Telefunken company, who stated at the same time that there was no way known in the technological sciences to find a satisfactory solution for the wave lengths which could currently be used. It was considered in technological circles, he said, that a lasting remedy could only be found by transition to the 10-centimeter wave range for ground and aircarried stations, and reasearch on the use of these frequencies at the time was still in the incipient stages, so far as Germany was concerned.[75]

The Royal Air Force apparently was aware of the difficulties encountered in Germany in efforts to find a solution for the problems arising from interference with electronic target locating equipment: at the end of 1943 British efforts to find still further ways and means of electronic interference c ased completely.

143 Already from November 1943 on British electronic interference measures no longer seriously hampered German night fighter operations, since the entire night fighter system had in the meanwhile become largely independent of the disabled target locating instruments. The Korfu

75. Sources 38, 48, 49

143 network and the special instruments installed in reconnaissance aircraft furnished adequate data for the interpretation of the current air situation, while the aircarried Lichtenstein SN-2 instruments, still free of interference, sufficed for independent action by night fighters flying within the enemy bomber forces without any need for ground controls.

The only areas in which British electronic interferences still complicated night fighter operations were those in which the Korfu network was still under development, a fact which became clearly evident, for example, in southern Germany and over the territories of France as late as in February 1944.

So far as night fighter operations were concerned it could be considered by the end of March 1944 that the disruption due to British electronic interferences had been completely remedied. This fact the German night fighter arm demonstrated strikingly by achieving its numerically largest defense success of the whole Second World War on the night of 30-31 March 1944. Out of 700 Royal Air Force bombers attacking Nuremburg on that night, the German defense shot down 107 bombers, or 15 percent, against a loss of only five German fighters lost.

To this German defense success the Royal Air Defense in its attacks against targets within Germ

143 in its attacks against targets within Germany in April 1944 responded with increased tactical maneuvering to mislead the German defenses.

From May 1944 on Royal Air Force strategic attacks were concentrated on supporting the invasion in the west, and were thus directed against targets in the German-occupied western territories.

There, British electronic interferences were still more effective than over Germany, since the western territories had been treated as of secondary importance in the introduction of new frequencies and new attachments to render electronic target locating equipment interference proof.[76]

It was September 1944 before new and special British activities in the field of radio and radar interference again created a series of serious problems for the German defense:

a. The use of new types of tinfoil so seriously disrupted operations with the hitherto interference-proof Lichtenstein SN-2 instruments that the tactics of night fighter pursuit became impossible;

b. During all operations powerful ground stations in England and in the areas of Western Europe now under

76. Study 158-160 Volumes II and III.

144 Allied control, plus aircarried transmitters overcrowded all frequencies used by the Freya and Wuerzburg instruments, that it was impossible with these instruments to obtain the data necessary for an interpretation of the air situation, or firing data for the antiaircraft artillery, or to perform the necessary functions in the ground control of night fighters;

c. Systematic jamming operations so disrupted the German command radio and telegraphic communications that intelligible contact from ground to air or from air to air was almost impossible.

The German defense continuously devised new and complicated communication channels, so that finally more than a dozen frequencies were in use. Messages were transmitted by ultrashortwave and shortwave radio voice instruments, in telegraphic code, blended into the identification signals of heavy radio beacons and the radio beacons in night fighter control positions. However, in spite of all these devices, and although a complicated system of major and alternate frequencies was used to broadcast the messages, it was only a very short while, usually only a few minutes in each case before the new frequency in use was also jammed;

145 d. A new method of interference developed by the Royal Air Force and known as System Moonshine functioned on the following principles:

A single aircraft carrying a number of radio receivers tuned in to the frequencies used by the German Freya, Wassermann, and Wuerzburg radar instruments received the search rays, amplified them and so changed them that they were reflected in the cathode ray of the German radar instrument not as an individual target but as a large number of targets.

What made the techniques of this system particularly complicated was that the aircraft had to carry a receiver for each German instrument which might pick it up; otherwise the deception would have been detected as soon as the search ray of any one German instrument was normally reflected as a single target in the Cathode ray tube of that instrument. In its impact on tactics the new method of interference was exceptionally effective. The German night fighter command had to decide what action to take while the target was still on the approach across the English Channel or the North Sea. No possibility existed for a coastal station to check whether the "number of targets" were real or a deception, unless other instruments at the coast

146 reported only a single target.

The earliest moment at which it could be determined whether only a single "deception" aircraft or actually a large force was on the approach was when the target was over the coast, when ground air observers could do so by the volume of sound from the engine or engines. To withhold orders for interceptor night fighters to take off until then would have meant that defensive action against a force attacking targets in the industrial regions of western Germany would have come too late.

The purpose of the British Moonshine method was to cause German night fighters to take off in response to reports from the aircraft reporting service that a number of aircraft were approaching, in order to have the Royal Air Force bombers committed for the actual attack penetrate when it could beassumed that the German night fighters had discovered the deception and were on

147 the ground again refuelling.

The accompanying circumstances of such deceptive approaches were the same as those observed in genuine operations. They were preceded by the usual radio operations of British ground stations to interfere with the German coastal radar stations, by long-range night fighter units against German

147 night fighter airfields, and by diversionary mine-laying operations in the coastal areas of the North and Baltic Seas. 77

e. The British Mandrel Interference Method. At the end of 1944 the Royal Air Force introduced new techniques of electronic interference to conceal its offensive plans as long as possible. The new system was known as the Mandrel System and consisted of a mass application of the Moonshine system , placing a screen of "numerous object targets" in a north by south direction in front of and over the German aircraft reporting stations, which the German instruments were unable to penetrate. The Royal Air Force bombers actually dispatched on an attack mission approached behind this screen.

The Mandrel Screen was designed to divert German fighters in a wrong direction, so that they would be farther from the real target of attack when the real bomber force became evident.

The Royal Air Force attack against Essen on the night of 12-13 December 1944 is quoted here to illustrate how the Mandrel system operated:

On the night of 12-13 December 1944 a force of 633 Halifax and Lancaster bombers was to attack

147 Essen between 1930 and 1945 hours.

Mosquito units were to carry out a diversionary attack against Osnabrueck at 1925. They flew in formation with the four-engine bombers until 1845. Together with a number of special aircraft, which were to drop large quantities of tinfoil, they then wheeled sharply northeast in the direction of Osnabrueck.

Two "andrel screens were arranged lasting from 1800 to 1920:

One screen simulated forces approaching approximately 80 miles, the other a force approaching approximately 120 miles west of the Ruhr region on a north to south route, meaning that one simulated route was thrity to thirtyfive miles west of the coast of Holland, the other through Central Holland.

The actual bomber force crossed the east coast of England at approximately 1800 hours.

At 1805 German coastal radar stations reported "numerous object targets" in the sea areas west of the coast of Holland. They had picked up the outside Mandrel screen.

At 1817 the antiaircraft artillery received information that the enemy force was to be expected east of

148 the Wesel River.

At 1827 the German Aircraft Reporting Service reported the enemy force southwest of Aachen. This meant, however, that its instruments had picked up the second Mandrel screen.

At 1840 German night fighters received orders to take off towards Frankfurt. This meant that they had been misled by the second Mandrel screen, while the Royal Air Force bombers, under cover of this screen, were actually on an east coast over Holland in the direction of Essen.

At 1846 other German night fighters which had taken off in the meanwhile received instructions to proceed to the Moenchen-Gladbach area, roughly 36 miles southwest of Essen.

At 1906 the German Aircraft Reporting Service detected the bomber force at Aachen--this time it was the force of Mosquito aircraft, which had left the main force and was on its way to Osnabrueck.

At 1927, and thus only three minutes before the actual bombing, the real Royal Air Force bombers emerged from the second Mandrel screen and were detected by German aircraft locating instruments.

Right up to this moment the German defense command

149 remained completely ignorant of the position and intentions of the main enemy attack force. Because of the air target markings placed over Osnabrueck at 1925 for the Mosquito aircraft it was assumed that Osnabrueck was the target. All Night fighters at 1927 received orders to proceed at top speed to Osnabrueck.

When the main force commenced bombing Essen at 1930, the German defense command assumed this to be a diversionary attack. At 1937 the night fighter units received word that it was also possible that the attack was directed at Essen, but one minute later they again received confirmation that Osnabrueck was the main objective of the attacking enemy force. At 1939 the above instructions were cancelled and Essen was finally stated as the main target of attack. At 1941 all night fighters received orders to proceed at top speed to Essen. Since the attack only lasted until 1945 this order came far too late.[77a]

150 For the German night defense system these highly diversified British methods of interference and deception in the autumn of 1944 against the whole German radar organization introduced a phase of strategic air warfare in

77. Sources 23, 29, 50.
77a. Jean Calmel; Night Pilot, pp. 122-124, London 1955.

which success in the "radio war" became the decisive condition for success in defense operations.

The following ways and means were developed to counter British measures:

a. Interferences on SN-2 Instruments. No satisfactory device was developed by the end of the war to eliminate interferences on the Lichtenstein SN-2 instruments, used as aircarried target locating equipment by the German night fighters. The period of outstanding success in night fighter operations, which commenced with introduction of the SN-2 instruments, came to a final end when the enemy succeeded in interfering with their operation. All the night fighters could do from then on was to follow the tinfoil clouds by their SN-2 instruments in the hope that in this way they would encounter the bomber force, or at least to reach the target area in time to shoot down enemy aircraft in direct target defense action. However, the tinfoil could just as easily lead them on a wrong course to a Mosquito force carrying out a diversionary attack;

b. Interferences on Aircraft Spotting Instruments. The procurement of data for interpretation of the air situation to serve the purposes of night defense was based on the following means:

150 aa. Reconnaissance aircraft of the Night Fighter Command equipped with instruments tuned in to the British

151 H-2-S and aircarried jamming instruments so that a few of them would be able to reach the enemy bomber force as early as possible and follow it on its course. These reconnaissance units were tracked by the Benito method so that a constant check on their route was possible;

bb. The intelligence data procured on the British Rotterdam instruments through the Korfu network of the radio intercept service. Here the interception of "bunched reflections" (Rotterdam-Buendelpeilungen) asa rule could be taken to indicate the heaviest concentration in a 4-engine bomber force;

cc. The use of reconnaissance aircraft of the Night Fighter Arm equipped with Rozendaal receivers and Freya instruments with the Wismar attackment to establish the position of British Monica night fighter detecting instruments. The data procured by this means was transmitted as what were called "Torch" reports (Flammemeldungen) and served to identify definitely that the located target was composed of 4-engine bombers, since the Mosquito bombers were not equipped with the night fighter detectors;

c. Up to the end of the war no method was found to

151 eliminate interference with the electronic firing equipment of the antiaircraft artillery. In efforts to ameliorate the hampering effects of interference with the electronic target locating instruments on action on Royal Air Force units employing blind-bombinf techniques, the Negit Defense Command applied the following methods :

aa. The development of defense concentrations in the form of massed antiaircraft guns at vitally important targets, so that even if accurate target locating was not possible it could be assumed the massed fire would achieve some effects in view of the dense concentration of the enemy bomber force over the target;

bb. The organization of "super batteries" by combining three heavy batteries under a uniform fire control at important defense points;

cc. The installation of the Taunus attachment in Wuerzburg radar instruments. This made limited locating of targets possible even when the British used large quantities of tinfoil. The target data thus procured was not adequately accurate for point fire.

Efforts were also made to use sound locating in tinfoil areas. This principle was based on the difference between the metallic composition of the tinfoil and that of the aircraft. However, the Steinhaeger

152 attachment used for this purposes had to be operated by personnel with exceptionally acute hearing, and even the then could not be considered a completely satisfactory solution of the tinfoil problem for the antiaircraft artillery;

dd. An increased effective radius for antiaircraft ammunition to compensate in some measure for the lack of precise target locating. To achieve this increased effective radius efforts were made on the one hand to step up the production of the heavy caliber 105-mm and 128-mm antiaircraft guns and shells, on the other hand to develop the "double detonater for antiaircraft shells"(MaR-Doppelzuender).+

Double detonator shells only came into use towards the end of the war. That the principle was a sound one was demonstrated in an attack against Munich on 9 February 1945, in which the ratio of shell expended per bomber downed was only 350 compared with the former average ratio of 4 500 shells.

d. Interruption of the Night Fighter Command and Control Voice and other Radio Communication Networks. The serious interference with ground-air radio communications made it exceedingly difficult for ground

+ Double-action or time-and-percussion fuze.

153 control stations to guide young and relatively inexperienced crews to the enemy. An attempt was made to solve this problem by placing a number of less experienced night fighters under leadership by a thoroughly experienced pilot, with the aircraft thus led operating more or less in formation, to insure in this way that the inexperienced crews would reach the enemy force.

Contact with the lead plane was to be maintained by means of a locating signal given by the lead plane, each of which had a Naxos Z, Flensburg Z, Rozendaal-Halbe, or Freya-Halbe instrument, so that it could guide its "unit" directly into the enemy force independently of ground controls. If a large number of night fighters could be led into the enemy bomber force in this way, the chances were multiplied that visual contact could be established independently of the aircarried SN-2 instruments. The actual shooting down of bombers was the less difficult part of the night fighter mission.

However, this method was hardly used in practice. By the time it was introduced in the autumn of 1944 the air situation was such that the necessary daytime practice could not be carried out, and the general fuel shortage made it imperative to restrict night fighter operations to action by crack crews;

154 e. British Moonshine and Mandrel Techniques. The newly introduced British techniques of simulating the presence of numerous targets in order to deceive the German aircraft reporting radar personnel, could have been more successful but for the fact that the multiciplicity of methods already in use to disrupt the functioning of aircraft detecting instruments had in the meanwhile compelled the German defense command to develop other means to secure data on the air situation at night.

In the autumn of 1944, when the new British methods were first used, three possibilities existed to check the accuracy of electronic data showing "multiple object" targets over the English Channel or North Sea, admittedly not by direct, but nevertheless by indirect means:

aa. The daily weather reports of the British bomber bases, intercepted by the German Radio Intercept Service, in combination with the overall weather forecasts.

On the basis of the reports the German Night Fighter Command could estimate the operational possibilities for the Royal Air Force, could judge whether weather conditions would favor operations during the first or

155 second half of the night, and whether conditions would permit restricted or unrestricted operations by the 4-engine units of the Royal Air Force.

For example, if the weather estimate showed that conditions would be considerably better for Royal Air Force bomber operations during the second half of the night, night fighters were withheld for the time being if instruments detected "multiple object" targets during the earlier hours of the night until the initial report was confirmed by other instruments or by reports based on oral observation when the approaching target crossed the coastal positions of ground observers.

When conditions existed for unrestricted British operations no absolutely reliable standrads were available to differentiate between actual and simulated multi-aircraft forces. If a British force was attacking a relatively close target, the result of the delayed commitment of German night fighters frequently was that they reached operating altitudes and the target area too late for effective action.

Under these circumstances the all-important factor for a correct interpretation of the air situation was that the person responsible had wide experience and

155 what might be called an intuitive "feel" developed for a multiplicity of symptoms to sense what was beyond the range of what could be proved rationally;

bb. The Koriu Network of the Radio Intercept Service and the Wismar Network of the Aircraft Reporting Positions.[78] One factor which could be taken to indicate that a large force of Royal Air Force aircraft was approaching was reports of the interception of "bunched rays" from a large number of British Rotterdam or H-2-S instruments of navigation in operation. However, such rays could also come from Mosquito forces.

To confirm the presence of 4-engine bombers beyond doubt, it therefore required reports on interception of rays from the British Monica and Fish Pond night fighter detecting instruments. If these were picked up by the German Wismar Network, the approach of 4-engine bombers could be assumed with certainty.

If any doubts still existed, reconnaissance aircraft were sent up. Using their special locator equipment they flew towards the approaching force in order to ascertain from the number of Rotterdam and night fighter detector instruments detected whether a large force was approaching or only a simulated force.

78. Appendix 18.

156 During periods of good weather over England, reconnaissance units of this type frequently maintained patrols off the coast of Holland as a precautionary measure

cc. When reports came from one radar station that a "multiple object" target had been detected, a number of positions on either side of the reporting station received instructions to check the accuracy of the report.

Experience showed soon that radar instruments in flank positions were less apt to react to the deceptive reflections from the Moonshine and Mandrel screen system. If these radar positions reported only a single object on the screen, it was obvious, as a rule, that the first report was due to simulated operations.

Of all British measures to interfere with the functioning of German target locating instruments, those which disrupted operations with the aircarried Lichtenstein SN target locator equipment used by the German night fighters had the most serious results. British success here brought the most successful German night fighter operations based on the tactics of night fighter pursuit inside the enemy bomber formation to an almost complete end.

Apart from more or less chance occasions when German

157 night fighters flying inside the enemy bomber formation succeeded in establishing visual contact with a target plane, night fighters from then had to rely on the possibility of sighting and shooting down enemy bombers directly over the target because of the light reflections resulting there from the effects of the bombing. This very seriously restricted the number of night fighters which go into action.

The air directly over the target was at the same time the most unfavorable plac for night fighter operations. Although fire strictions imposed on the antiaircraft artillery provided theoretically for separate night fighter and antiaircraft artillery zones of action, application of this theoretical division was at all times found impossible in practice and resulted in numerous night fighters being shot down by German antiaircraft fire.

For the antiaircraft artillery interferences on the electronic target locators was not quite as decisive a factor. Frequent opportunities for optical target locating presented themselves at night with support from searchlights, and gun fire based on electronic data had never been as accurate as that based on optical locating.[78a]

78a. Sources 20, 29, 50, 51, 52, 53; Horst Albert Koch: "Flak," pp. 133-134, Podzun Verlag, Bad Nauheim, 1954.

158 2. Development of Royal Air Force Pathfinder Techniques from July 1943 to the End of the War. The importance of the Pathfinder system mounted with the progressive British transition to tactics of attack in which the largest possible number of bombers were to deliver bombs on the target within the shortest possible space of time, and with the greatest possible precision, regardless of weather conditions.

These stated requirements could only be fulfilled if the entire operation, from the take off to the landing after return from the executed mission, proceeded in accordance with a precise minute-by-minute schedule, and if there was no possibility of any of the crews having any doubts or misunderstandings concerning the route, the target, or the timing.

I. DEVELOPMENTS UP TO THE AUTUMN OF 1943.

By the autumn of 1943 the following missions evolved for the four Pathfinder squadrons consolidated under the British Eighth Bomber Group::

a. Marking of the assembly areas and turning points and of the initial point for the target bombing run.

These points divided an attack operation into different areal phases:

aa. The Focal Point. Following their prescribed routes along the esat coast of Britain, all bomber

159 units assigned for participation in the current operation converged on this point to take up position in the bomber formation. The point was located over the sea between the east coast of Britain and the west coast of Europe;

bb. The Concentration Point. As a rule the Concentration Point was located at the enemy frontier. All participating aircraft had to cross it at a presc ibed time in order to insure the intended concentration of bombers and in order to insure continued adherence to the set time schedule for the entire operation.

For this purpose the individual aircraft had to fly at what was called a "compensating speed" between the Focal Point and the Concentration Point. Those which c ossed the Focal Point later than prescribed increased their speed sufficiently to be at the Concentration Point on tim, those which crossed the Focal Point too early slowed down.correspondingly.

Because of the danger of collisions, units were not to circle around waiting.

The normal c uising speed was 60 percent of maximum speed performances;

cc. The Initial Point. The Initial Point was the last turning point on the course, approximately

160 30 miles before the target. Up to this point the route changed frequently in order to conceal the target from the enemy.

Each participating aircraft was required to cross the Initial Point at a precisely specified time in order to concentrate the whole bombing within the shortest possible space of time. Any difference noted between the time of actual arrival at the Concentration Point and the time of arrival prescribed for each individual plane in the planned time schedule had to be equalized by appropriate "compensating" speeds between the Concentration Point and the Initial Point.

The light signals used to mark the various points were changed for each operation;

b. Marking of the Target for Attack and Direction of Target Approach. As a rule the successive waves of bombers attacked either all from one direction or from two or three different directionsconverging on the target area marked by the Pathfinder units.

By forming the successive waves in proper concentration at the Initial Point it was possible to reduce the duration of an attack to ten aircraft per minute.

The approach run was indicated by various types of markers placed either in line with or at right angles

160 to the approach run. A particularly conspicuous marker was used to indicate the target center.

The target markers were renewed at intervals of between three and four minutes during the attack.

In conditions of ground visibility ground markers were used; otherwise the bomb-release point was indicated by air markers. Use of the latter was avoided whenever possible, since they were liable to drift with the wind and therefore had to be replaced frequently.

c. The Dropping of Flashlight Bombs to Secure Target Effect Photos.

The plurality of missions for Pathfinder units and the important influence they had on the success or failure of an entire bombing operation necessitated that the whole system was based on a careful selection of especially highly qualified personnel, and particularly high organizational, tactical, and technical standards.

The Royal Air Force took the following measures to achieve this purpose:

a. The selection of personnel was based on the rule of the best performances and the greatest combat experience. This gave assignment to a Pathfinder unit the character of a token of special recognition and developed a particularly high esprit du corps. Knowledge of

161 their high responsibility spurred each individual member to the utmost efforts in the excution of his assigned missions;

b. Pathfinder Units Received the Best Aircraft and the Most Up-to-Date Equipment. By the autumn of 1943 experience had shown that the most suitable aircraft types for Pathfinder operations were the Lancaster and the Mosquito.

In order to insure precise navigation, Pathfinder units were awarded the highest priority for the allocation of the most up-to-date instruments, such as the H-2-S (or Rotterdam), Oboe (or Boomerang) and improved Gee (Tr-1355) model instruments, the latter for hyperbola navigation;

c. In order to avoid disruptions or misunderstandings if Pathfinder aircraft were lost, during an operation, a number of Pathfinder aircraft were assigned for each individual mission, the number varying between four and ten. If any delays occurred, these units automatically renewed the markings at the appointed times.

Because of these multiple safeguarding measures, Pathfinder aircraft in major attacks made up 10-15 percen of the entire number of aircraft participating;

d. A special command was established to control during operations the large number of Pathfinder units participating.

This command organization consisted of xxxx a number of what were called "Masters of Ceremonies," one of whom was the Chief Master of Ceremonies. The attack was directed by the Masters of Ceremonies in the following manner:

Flying at a low altitude the Chief Master of Ceremonies first marked the target with a number of incendiary bombs at the appointed time. Lacking ground visibility, he placed the first air marker over the target.

By means of direct radio orders he then throughout the attack gave the other Pathfinders instructions concerning target markings and improvements, and also gave descriptions of the target for the main body of the bomber force. He also drew attention to the behavior of German night fighters and deceptive measures taken by the German defenses, such as simulated fires or dummy installations.

One of his missions here was to support the morale of the bomber crews.

If the Chief Master of Ceremonies was shot down or otherwise lost, the sequence of succession and

163 reallocation of his duties among the other Masters of Ceremonies participating in the operation took place in accordance with a precisely prearranged plan.

The Masters of Ceremonies flew Lancaster or Mosquito planes. For cummmunications with the bombers they had a radio transmitter with a very short operating range, which made it difficult for the German side to intercept their messages or jam their command communications.[79]

II. DEVELOPMENTS UP TO FEBRUARY 1944.

By February 1944 the following changes had been introduced in the organization of Pathfinder unit command:

a. Blind Markers. The blind markers were especially experienced Pathfinder pilots, who had the mission of placing the first markers on the target.

They did this marking blind, meaning without ground observation, by means of H-2-S navigation, and were required to be over the target five minutes before the actual attack commenced;

b. Backers-Up. These were less experienced Pathfinder personnel, whose mission was to renew the markers placed by the blind markers. They followed each other at fairly regular intervals of three minutes in order to insure

79. Source 43; See also Appendixes 19 2nd 20.

163 continuous marking of the target for the duration of the bombing attack.

c. Pathfinder Main Force. Units of the Pathfinder Main Force had no specific target marking mission. Their mission was to be over the target simultaneously with the Blind Markers, and bomb the target center withdemolition and incendiary bombs in order to light it up for the Main Bombing Force.

d. Visual Markers. In suitable weather conditions these units were to descend to altitudes around 4 500 feet. From this altitude, and guided by the flares dropped by the initial Blind Markers, they were to place ground markers on the target center, so that the bombing units at their higher altitude could identify the center of the target area precisely.

e. Blind Backers Up. Experience during Pathfinder guided attacks in Februar 1944 showed that bombing was likely to be scattered during conditions of closed cloud cover and strong high-altitude winds, since the Backers Up placed their renewal markers on the air markers placed initially by the first Blind Markers, which by that time had been blown seriously from their original positions by the force of the wind.

164 For this reasons a fifth groupment of Pathfinders was formed. These were called Blind Backers Up , and had their mission of placing their markers, as the initial Blind Markers had done, exclusivels by navigation using the H-2-S, or Rotterdam, instrument.

To facilitate accurate target marking during weather conditions with a cloud cover of 10/10, the Pathfinder units were given reference or check points, which were in the line of the assigned approach route, and which experience showed were easily identifiable on the screen of the H-2-S instrument. The reference point was usually a town, a lake, or some other salient feature on the ground. Before the take off the flight time from this reference point to marker drop or release point was computed carefully, with due consideration for wind conditions, so that the units knew to within seconds when they would be over the target after crossing over the reference point.

As a rule the wind condition data furnished during the tactical orientation conferences of Pathfinder units was accurate and reliable. Furthermore, experienced Patafinder personnel reported continuously to their ground control stations during flight on wind conditions as they actually found them. These wind condition reports were transmitted

165 each half hour by the ground stations oof the units currently committed in an operation, so that crew personnel on all aircraft participating could check their weather data along the route, and thus be prepared for the conditions they would encounter.

In February 1944 a large-scale attack involving between 600 and 800 bombers included the following Pathfinder units:

50 Blind Marker and Visual Marker aircraft
30 Backer Up aircraft
70 Pathfinder aircraft in the Pathfinder Main Force. 80

III. PATHFINDER ACTIVITIES SUPPORTING THE ROYAL AIR FORCE ATTACK AGAINST TOULOUSE ON THE NIGHT OF 5-6 APRIL 1944.

Pathfinder activities supporting this attack were as follows:

a. Prior to commencement of the actual bombing a few Pathfinder planes (Blind Ma rker Illuminators) dropped

166 hooded flares on the target to light it up.

These flares were carried by a spe ial type of parachute, the inner surface of which was specially treated to serve as a reflector for the light from the flare and thus increase its brilliance;

b. After the target was this lit up, one Pathfinder Blind Marker / flew in to place the initial target marker from a low altitude. The placing of the hooded flares referred to in (a), above, was so timed that the wind would carry the

166 flares to a position precisely over the target by the time set for placing of the first markers;

c. The Master of Ceremonies was required to check the accuracy of the placing of the markers and, when necessary, to call in by radio orders other Pathfinder (Visual Marker) units, or Backers Up, to improve or renew the markings;

d. The bulk of those bomber units which carried air mine type bombs had to await orders from the Master of Ceremonies at H-Hour plus 5 minutes before entering their target bombing run, those bombers which carried incendiaries followed another five minutes later, also on orders from the Master of Ceremonies.

It is obvious that the above plan of attack was adapted to the weak German night defenses in the area, which consisted of only eight heavy and two light antiaircraft artillery batteries.

IV! BRITISH DISCUSSIONS ON THE SUBJECT OF MASTERS OF CEREMONIES.

The Masters of Ceremony system for the direction of bombing attacks was introduced in the Pathfinder forces in 1943, temporarily discontinued at the beginning of 1944, and resumed in March of thesame year.

167 The reasons for the temporary suspension of the system were the different views held within the Royal Air Force concerning the practical value of the whole arrangements.

Those opposing the system supported their opposition with the following arguments:

a. In practice there was no possibility for the Master of Ceremonies to actually intervene in the execution of an attack;

b. Every aircraft crew was earnest in it efforts to execute its mission to the best of its ability;

c. Bomber crews considered the frequently repeated "encouraging remarks"made by Masters of Ceremonies incompatible with the severity of their missions and the serious nature of the war.

After reintroduction of the Master of Ceremonies system care was exercised to insure that these functions were assigned only to especially experienced officers who enjoyed the necessary prestige, as was the case, for example, with Group Captain Gibson, who had become widely known because of the successful attack against the German river valley dams on the night of 16-17 May 1943.[81]

V. DEVELOPMENTS UP TO THE END OF THE WAR!

The Pathfinder system as it existed in the spring of

81. Source 54; Flaklagekarte OKL, 24 May 1944; Fliegerlage-lageKarte OKL, 1 April 1944.

168 1944 remained in force up to the end of the war without any important modifications.

Certain improvements which were introduced involved primarily the means of navigation employed:

a. Oboe (Boomerang) System. In July 1944 the German defenses in the Ruhr region had 19 jamming stations with a total of 90 transmitters operating on the meter wave band against the British Oboe system.

These interference operations were successful when the Oboe frequency currently in use was identified in time and jammed by an interference transmitter.

Whenever German interference operations succeeded, the Royal Air Force was compelled to break off an operation if the force involved was to be guided by the Oboe system from its Initial Point to the target.

The Royal Air Force endeavored to prevent such interferences by changing to an alternate frequency during the approach. After some experience, however, German operators accustomed themselves to following such changes immediately

In addition to the above, the German defenses succeeded in producing complete confusion in the British Oboe system by the following measures:

(1) The establishment of 74 Olga jamming transmitters in the Ruhr region to jam a large segment of

168 the meter waveband range;

(2) The establishment of four detector instruments (Abtragegeraete) with deception transmitter attachments in existing jamming stations to transmit simulated commands from the British ground control stations. This attachment made it possible to mislead by means of false commands the pilots and bombardiers of Royal Air Force units controlled by the Oboe system;

(3) Installation of an additional fifteen Type Ball re-transmitting instrumentsto interfere with the transmistal of orders by the British ground control stations. These instruments received the waves emanating from the instruments on the Oboe controlled British planes and retransmitted them on the receiving frequency of the British plane in such volume that it was impossible to identify the messages coming from the ground control station in England.

The above German measures of interference with the Oboe system were highly effective, and the Royal Air Force failed to find any real remedy until it converted the instruments used in the system to operat on the 9-centimeter frequency range, the same range of frequencies used by the British H-2-S Instruments.

169 These new British instruments came into use in March 1944. With this development British research gained an important victory in radio warfare, since the German radio industry at the time was still in the experimental stages in the field of centimeter frequency communications.

In July 1944 the situation was such that the German side had only one transmitter type, the Roderich, available to jam electronic target locator instruments operating on the centimeter wavebands. However, this transmitter was found unsuitable for operations to interfere with the new British Oboe instruments, operating on the 9-centimeter waveband, because it could not be tuned in to such frequencies and also was not powerful enough.

Even the use of massed Roderich interference transmitters at important targets, a method tried later against the new Oboe instruments, failed to produce satisfactory results.

Other German instruments suitable for operations to interfere with the British Oboe instruments on the centimeter wavebands were still under developmentnamely, the Klystron, a transmitter developed by the Research Institute of the Reich Post and Telegraph Service, and the "Interference Transmitter with Cavity triode (Stoersender mit Scheibenrohr), the development of which was

completed in July 1944. A transmitter with these cavity triones with syntonization up to the 8.5 centimeter band was under construction at the time and was to be ready for the field by September 1944. However, general developments in the military situation prevented later practical use of this project.[82]

The progress made by the Allied invasion forces in the west in the summer of 1944 deprived the German radio interference services of a large part of their operating areas and necessitated a complete r organization of the whole interference system. At the same time a considerable expansion of the whole German interference organization became necessary , because the establishment by the Royal Air Force of new Oboe ground control stations in the eastern territories of France made controlled operations possible to a depth of 300 miles in the German interior.

In September 1944 the situation was such in the field of German interference with the Oboe instruments operating on the ecntimeter wavebands, that the German interference had only one transmitter in use, the effectiveness of which had not yet been proved.

In October the German interference services had five interference transmitters in the west operating on

170 the Ball retransmitting principle on the 9-centimeter waveband.

For interference with Oboe instruments operating on meter frequencies, the German side at the time had in position in the western and northwestern territories of Germany 13 detector and instruction posts (Abfrage- und Einweisungsstellen) besides 18 jamming stations with a total of 90 transmitters. This shows how decisively important it was for the Royal Air Force to change over to the centimeter wavebands for their Oboe instruments, which were of such extreme importance for precise navigation, target location, target marking, and precision bombing to insure success in the conduct of strategic air warfare against Germany in an important phase of the war.

So far as the interference-proof functioning of its Oboe system, was concerned, the Royal Air Force succeeded in maintaining its lead right up to the end of the war.[83]

b. Navigational Instrument Long Range. This new instrument operated on the 150 and 30 meter wavebands, and had an operating range of several thousand miles, with a margin of error three miles square. It first came into use in the autumn of 1944.

---

83. Sources 56, 57.

171 On the German side ground stations to interfere with with the functioning of this British system were still the f under construction in January 1945.

c. The GH (Discus) Instrument for Point Navigation.

This instrument functioned similarly to the Oboe instrument. Ground stations operated on the 4.5 meter waveband, aircarried stations on the 10 meter waveband. The operating range wasapproximately

210 miles at an altitude of 23 000 feet
288 miles at an altitude of 33 000 feet.

172 The margin of error was 330 yards square in western Germany, and 550 yards square in Central Germany.

Basically, the GH instrument was a reversal of the Oboe, since the initiating impulse came from the guided aircraft, was received by the ground stations in England, , and reflected back to the aircraft by two rotating antennae. From the returning message, the aircarried operator could read off the necessary lateral and distance factors and establish his position by means of special tables provided.

The advantage of the GH system was that it was not dependent on orders from and communications with only one ground station, so that it was less vulnerable to

172 German interference operations.

This new system was used by the Royal Air Force for the first time in an attack against Duesseldorf on the night of 3-4 November 1943, on which occasion the German methods of interference with Oboe operations proved ineffective against the new system.

In January 1945 German interference transmitters for use against the GH system were still being tested.

d. The Micro-H Instrument for Point Navigation.

This new instrument was used for the first time for operations over Germany on 1 November 1944. It operated on the 3-centimeter waveband, using the American H2X (Meddo) instrument against ground relay stations. Its operating range was approximately

210 miles at an altitude of 23 000 feet and
288 miles at an altitude of 33 000 feet

with a margin of error of plus/minus 220 yards.

Research by the German electronic industries at the time had not yet made much progress, so that no means were available for interference with the Micro-H system.[84]

The numerous improvements made to navigational instruments were one of the essential conditions enabling the

84. Sources 1, 16, 26, 28, 58, 59.

173 Royal Air Force to base its conduct of strategic air warfare against Germany on a reliably functioning Pathfinder system independent of weather conditions right up to the end of the war.

Measures taken to increase the number of Pathfinder units with the Royal Air Force Eighth Bomber Group to a total of 3 Lancaster, 2 Halifax, 1 Stirling, and 5 Mosquito squadtons, containing altogether 275 aircraft, by 1 Octover 1943 insured the availability of adequate strengths in the Pathfinder forces for the execution of the numerous and diversified missions of those forces.[84a]

84. Source 43.

174 3. Royal Air Force Night Fighter Participation in Strategic Air Warfare. As early as in the first half of 1943 attacks by individual medium bombers and night fighters against German night fighter airfields had become a regular feature of all Royal Air Force major strategic air attacks against targets in the German interior. Later in 1943, these tactics were employed on a considerably increased scale.

Under their new designation of "Intruder Planes" the British long-range fighters now represented a specific group within the strategic air force, and were assigned two distinct missions:

a. To keep German night fighter airfields under observation and take combat action there against German night fighters during their take off or landing by means of

aa. bombing the runways and other airfield installations;

bb. by attacking German night fighters during their take off or landing;

b. To escort strategic bomber forces to their targets in order to protect them against German night fighter attack. These escort night fighters flew in positions on the flanks, above, and within the bomber formation

174 currently under escort, and had electronic target location equipment.

For the execution of these missions the Royal Air Force employed Bristol Beaufighter and De Havilland Mosquito aircraft.[85]

175 The success achieved by the British during the initial stages of their night fighter operations proved how sound their tactics were. Of the 19 German night fighters lost in the 15 September-30 September 1943 period over Germany, British long-range night fighters alone shot down 9, or 47 percent. In October British night fighters of the long-range units shot down 8 German night fighters and another 5 aircraft lost were probably also due to their action.

Within a few months, however, the German Night Fighter Arm had adapted itself to aircraft take off during complete dark, and to landings by specially constructed landing lights which only became visible when the landing plane sloped down for its landing run. This made it so difficult for the British long-range night fighters to find the airfields, that they found very few opportunities for successful action.

In the October 1943-July 1944 period British Intruder units only once succeeded in so delaying the take off of German fighters from their night fighter airfields, that the German

85. Source 43.

175 night fighters arrived too late over the target under attack by British bombers for defensive action. This was on the night of 28-29 January 1944, when Intruder units bombed the night-fighetr airfields in the zone of the 3d Fighter Division.

In February 1944 the Royal Air Force intensified its night fighter activities with long-range units, and endeavored by means of bombing attacks against the German night fighter airfields in operation in Holland and Belgium to prevent participation of the units stationed there in defense action. However, the units committed in these bombing raids were too small to cause any serious disruption of German night fighter operations.

176 In March 1944 it became clear to the German Night Fighter Command that the Royal Air Force had adopted the pattern of preceding all major bombing attacks by long-range night fighter attacks against the German night fighter air fields. However, these attacks did little to interfere with German night fighter activities and served as as a reliable indication of an impending large-scale bombing attack by Royal Air Force units.

In ~~1944~~ April 1944 the German Night Fighter Command reported that only three of its planes lost in that month were definitely shot down by British long-range night fighters; at the

176 same time it reported a significant increase in British long-range night fighter activities.

It was only from July 1944 on that British long-range night fighter activities began to have an increasingly hampering effect on German night fighter operations. This was due in part to increasing numerical strengths, and in part to the increased use of the Mosquito aircraft with their superior speed in place of the Beaufighter models.[86]

The difficulties encountered by the British night fighter forces in the ex cution of their mission of escorting the bomber units of the Royal Air Force were due primarily to their inability to identify German night fighters flying among the British units. This in turn was due to the lack of a suitable aircarried target detecting instrument with a wide lateral operating range. For this reasonthe escort planes had to rely exclusively on the chance sighting of German fighters, for example when a German night fighter opened fire against a British plane and thereby disclosed its position.

177 In February 1944 the Royal Air Force made earnest efforts to remedy this weakness by introducing a new target detecting instrument with a longer range and the ability to distinguish the waves from British aircraft.

86. Source: Study 158-160, Volumes I-IV.

177 However, another difficulty developed, due to the fact that British bombers frequently fired on their own escorting night fighters because of the lack of air-air- means of identification. No immediate solution was found for this problem, since British bomber crews, once they realized that the German night fighters were tracking them by their Monica and Fish Pond night fighter detectors, preferred to switch off these instruments while engaged in operations and rely exclusively on visual observation to protect themselves against German night fighter attack. For this reason they opened fire on any twin-engine aircraft coming within visual range. Another complicating factor here was that the British Mosquito aircraft had coutours very similar to those of the German Me-110 and Ju-88 night fighter aircraft.

It was evidently due to the above reasons that the Royal Air Force discontinued the practice of assigning long-range night fighters to escort strategic bomber forces in March 1944. From then on the long-range night fighter units were committed exclusively to neutralize the German night fighter forces at their airfields and on patrol missions over particularly conspicuous points, such as concentration point signal lights or radio beacons.[87]

In May 1944 British long-range night fighter operations

87. Sturgis, p. 19.

17[illegible] were characterized by the following features:

a. Long-Range Escort Night Fighters. These aircraft had special electronic target detector equipment and during Royal Air Force major bombing attacks operated throughout the areas involved to engage German night fighters in air combat. A special mission here was that of patrolling over the concentration point radio beacons;

b. Intruders, or Harras Night Fighter Units. These aircraft had no electronic target detector equipment. They were employed exclusively to attack German night fighter airfields and all night air traffic with bombs and weapons fire. They were controlled by the Royal Air Force Fighter Command. The units directed their attacks against

aa. German night fighter aircraft;

bb. German bombers returning from missions over Britain.

As a rule Intruders were committed in units of between ten and twenty aircraft during major operations by the Royal Air Force Bomber Command. In each case the individual aircraft were assigned specific German airfields as their targets for attack. They approached their targets by the most direct route possible without crossing areas heavily defended by antiaircraft artillery.

178 Operating at altitudes between 1650 and 4 000 feet, they navigated by Gee data supported by dead reckoning and visual orientation, while over the Continent, by salien terrain features, particularly such features as lakes, rivers, river bends, and river estuaries.

Because of German interference operations, navigation by the hyperbola system, using data from the Gee system, usually became impossible once the Continent was reached. The Mosquito aircraft employed in these missions had no equipment for astro navigation. For these reasons Intruder operations were largely dependent on weather conditions and a high enough lower cloud bottom.

Having no electronic target detector equipment, the Mosquito aircraft used on Intruder missions had to rely on roving night fighter operations by means of visual observation. For these purposes the Mosquito units would circle at altitudes between 2 000 and 3 300 feet above their German airfields assigned as targets of attack. While thus circling the crews kept the air under constant visual observation for German aircraft taking off or about to land. If no such targets were detected within 30 to 60 minutes, the Mosquito units returned to their bases.[88]

On the whole British long-range night fighter

88. Source 54.

179 operations cannot be considered as having been a factor of any great importance for the successful conduct of strategic air warfare against Germany. However, this was due exclusively to the fact that the forces employed were numerically so weak. The tactics employed later by the Royal Air Force of exploiting conditions of bad weather to neutralize the German night fighter forces proved far more effective.

180 4. Royal Air Force Measures to Increase the Effectiveness of Attacks in Strategic Air Warfare.

A. Denser Concentration of Bomber Formations.

The circumstance that British night bombing techniques, so far as route and target marking was concerned, were based completely on the Pathfinder system automatically created the inescapable necessity to complete the bombing within the shortest possible space of time. Accurate target markings could not be maintained for any duration because of the influences of wind.

The tendency first became apparent in March 1943 to change from the past tactics of continuous attack to those of attacks by tightly concentrated bomber formations comprising several attack waves. This new system of attack reached its first apex in the series of bombing attacks against Hamburg in July 1943, in which between ten and fifteen bombers released their bombloads over the target per minute.

The Royal Air Force considered this bomber concentration still inadequate to reduce German possibilities for defense action to the lowest possible minimum and to achieve the greatest possible measure of concentrated bomb effect. In efforts to still further decrease the length of the attacking bomber formation, the Royal Air Force made greater

180 use of altitude echeloning and increased the number of attack waves making up an attack force, since this made it possible to achieve a greater vertical distribution of the total number of aircraft making up an attack force.

The formation patters changed frequently during operations in order to confuse the German defenses and to take full advantage of current weather conditions. For example,

181 an attacking force could be organized as follows:

		Altitude in Feet
First Wave	Lancaster and Mosquito Pathfinder aircraft	23 000-26 400
Second Wave	Lancaster aircraft	20 000-23 000
Third Wave	Halifax "	20 000
Fourth Wave	Stirling "	13 000- 16 500
Fifth Wave	Halifax "	20 000-23 000
Sixth Wave	Lancaster "	23 000-25 000

In addition to the Pathfinder units making up the entire First Wave, each successive wave included a number of Pathfinder aircraft. Owing to the altitude echeloning, the individual aircraft were widely spaced, so that there was little danger of collision.

Due to the above system of altitude echeloning, the Royal Air Force in its attacks against Berlin in November-December 1943 achieved a formation density over a target permitting between twenty and twentyfive bombers to deliver

182 their bombs per minute. One unavoidable disadvantage of the system was, however, the possibility that bombs from planes at the higher altitudes might strike those at lower altitudes, causing their immediate destruction or their loss during the home route.

Another tendency was to aim at including only one type of aircraft in an attacking force, the purpose being to increase the speed of the entire force, which had to travel at the speed of the slowest units it included.

For example, the forces attacking Berlin on the nights of 23-24 and 26-27 November, and 2-3 December 1943 contained only Lancaster units, those attacking Stuttgart on the night of 26-27 November 1943 only Halifax units. However, this principle could only be maintained for forces up to a strength of 400 aircraft, since larger numbers of any one

182 type of 4-engine bombers were not available.

In addition to this "concentration in time," the Royal Air Force in the autumn of 1944 also commenced what were called Water Fall (Wasserfall) tactics, which included a dense"concentration in space," meaning that while the duration of an attack remained unchanged, the number of planes attacking was increased to achieve more concentrated target effects. This greater formation concentration was achieved through increased altitude echeloning, made possible by

182 the fact that the installation of more powerful engines in the Lancaster and Halifax models increased their altitude performances.

These tactics represented an extremely complicating factor for defending German night fighters, because their only opportunity for successful defense action was over the target currently under attack. British interference with their aircarried Lichtenstein SN-2 target detector instruments had brought the hitherto highly successful tactics of night fighter pursuit to an almost complete standstill. The shorter the duration of an attack, and the denser the concentration of the bombing force over the target, the shorter was the time and the smaller the area in which the German night fighters might find possibilities for successful action against the attacking bomber force. Apart from this, success in night fighter defense action depended on the ability of the ground control stations to place the night fighters over the targetin time, before the actual bombing commenced[89] This became increasingly difficult as more and more of the early warning areas were lost, and as the British increased their innumerable measures of interference and deception, so that from the autumn of 1944 on the problem was exceedingly difficult to solve.

89. Sources 19, 29, 43, 59, 60, 61; See also Appendixes 21a, 21b.

183 B. INCREASED BOMBLOADS:

The second factor contributing towards the ability of the Royal Air Force to increase target effects in attack was the increased load of bombs aircraft could carry for delivery on a target.

The problem here was merely one of

a. The number of aircraft committed
b. The bombload each aircraft could carry.

On 1 October 1943 the Royal Air Force had the following strategic bomber forces available on bases in England for operations over the Continent of Europe:

Group	Aircraft Type	Squadrons	Aircraft Strength	Total
1st	Lancaster	5	125	
	Wellington	3	75	200
3d	Lancaster	2	50	
	Stirling	9	225	
	Halifax	2	50	
	Wellington	1	25	350
4th	Lancaster	1	25	
	Halifax	8	200	
	Wellington	2	50	275
5th	Lancaster	11	275	275
6th	Halifax	6	150	
	Wellington	5	125	275
8th	Lancaster	3	75	
	Halifax	2	50	
	Stirling	1	25	
	Mosquito	5	125	275

184 The Royal Air Force Bomber Command thus on 1 October 1943 had available in England a total strength of 1250 4-engine and 400 twin-engine bomber aircraft.

On 9 October 1943 275 Wellington bombers were withdrawn from the strategic bomber units and replaced by 4-engine aircraft.

Already by the summer of 1943 the Royal Air Force had built up an effective strength, in 4-engine bombers, of between 700 and 800 aircraft. Neither this number nor the number of strategic bomber units in existence at the time showed any considerable increase f om then on. It was only from the autumn of 1944 on that the Royal Air Force in a number of attacks during favorable weather over England dispatched forces containing more than 1 000 4-engine bombers.

There are no indications that the Royal Air Force achieved any material increase in the effectiveness of its attacks through a numerically larger strength of its attack forces.

In contrast, the Royal Air Force did succeed in achieving a considerable increase in the quantity of bombs carried by unchanged numbers of aircraft.

The normal bomb-carrying capacity of the Lancaster on missions r quiring maximum penetration range was 2.7

184 tons. It has been established that at the end of 1943 Lancaster bombers were carrying bombloads of up to 5.4 tons in attacks against targets in the Ruhr region and Frankfurt, and of up to 5.4 tons in attacks against Berlin.

In December 1943 Lancaster bombers for the first time delivered four 2 000-pound bombs on targets in Berlin, besides a small number which delivered 8 000-ton bombs.

1944-45 brought another increase in the bomb-carrying capacity of the Lancaster, which was now

185

4.5	tons	with	a	maximum	penetration	range	of	1000	miles
6.35	"	"	"	"	"	"	"	804	"
10	"	"	"	"	"	"	"	504	"

This marked improvement in the carrying capacity of the Lancaster was achieved in 1943 by the installation of Hercules engines, and in 1944 by the installation of Merlin-72 engines. Lancaster aircraft powered by Merlin-72 engines achieved a maximum operating altitude of 26 500 feet with a full load of bombs.

The Halifax had a normal bomb-carrying capacity of 2 tons with a penetration range of 720 miles. Performances here were improved in 1944 as follows:

Halifax III:	3.1	tons	with	a	penetration	range	of	1000	miles
	5.9	"	"	"	"	"	"	500	"
Halifax IV:	3.4	"	"	"	"	"	"	1060	"
	5.9	"	"	"	"	"	"	600	"

185 Halifax VII 2.3 tons with a penetration range of 1100 miles
5.9 " " " " " " 450 "

The smallest improvement achieved was in the case of the Stirling. Here the normal bomb load of 2.8 tons with a penetration ranged of 720 miles was improved in 1944-45 to 1.2 tons with a penetration range of 1000 miles or 6.35 tons with a penetration range of 300 miles. This model was at all times regarded as the weakest element in the 4-engine forces, and was considered incapable of improvement. It remained in production, however, because of the existing installations for its manufacture and because of the necessity to achieve the necessary strengths and maintain them.

186 Another increase in the bombload carried by Royal Air Force attack formations was the reequipment of 11 squadrons of the Bomber Command with 4-engine Lancaster bombers to replace the Wellington types these squadrons still had in 1943. This reequipment was completed by the end of that year.

The continuous increase in the bombloads carried in Royal Air Force attacks is illustrated by the following table showing the number of bombs delivered on targets in various attacks:

Date Night of	Target	Bombs delivered per minute (in tons)
4-5 March 1942	Luebeck	2

186

Date Night of	Target	Bombs delivered per minute (in tons)
30-31 May 1942	Cologne	10
28 Feb-1 Mar 1942	St Nazaire	22
30 Apr-1 May 1943	Essen	25
12-13 May 1943	Duisburg	30
11-12 Jun 1943	Duesseldorf	34
27-28 Jul 1943	Hamburg	51

The 627 Royal Air Force bombers attacking Essen on the night of 25-26 July 1943 dropped a total of 2 032 tons of bombs, giving an average bombload of 3.3 tons per aircraft.

The 571 Royal Air Force bombers attacking Peenemuende on the night of 17-18 August 1943 carried an average load of 3.4 tons of bombs, and while the attack lasted delivered 50 tons of bombs per minute on their targets.

On the night of 15-16 February 1944 806 Royal Air Force bombers attacking Berlin delivered 2 642 tons of bombs on their targets within 39 minutes.[90]

997

C. ROYAL AIR FORCE MEASURES TO DECEIVE AND SCATTER THE GERMAN DEFENSE EFFORT.

In major attacks by Royal Air Force bombers success depended largely on the ability to have the bomber force reach its target with as little interference from German defense forces as possible. Only then was it possible to

187 execute an operation in strict accordance with a plan of attack in which all phases were synchronized second by second. Otherwise, the slightest hitch, such as the loss of Pathfinder aircraft or a frequently repeated necessity for evasive maneuvers to escape pursuing German night fighters, could cause such serious confusion that the success of the whole operation was compromised.

In the case of an attack against Berlin at the end of 1943, for example, the German defense command had just placed ten pairs of flare bombs along the Potsdam-Berlin route to mark the way for single-engine night fighter units when the approaching Royal Air Force bombers crossed this route on their way to Berlin. The sudden exposure to the light from these flars so confused the British bomber crews that the entire formation was diverted southward; the intended attack against Berlin failed completely at a heavy cost[91] in aircraft downed by the German defenses.

The following is another example:

A British bomber force on its way to attack Nuremburg on the night of 30-31 March 1944 came under night fighter attack early on the approach route. Flying within the bomber formation the German night fighters shot down a number of bombers and thus left a trail of burning aircraft extending as far back as the Rhine River. This marked the

188 approach route of the British force so clearly that a record number of German night fighters found their way into the bomber formation. The resultant large number of bombers shot down (107 downed by German night fighters alone according to German sources, against 94 lost over Germany according to the Royal Air Force) so confused the bomber crews that the whole operation, which involved 710 British bombers, failed completely, and the population of Nuremberg remained ignorant of the fact that their town had been the target for a major Royal Air Force attack on that night.[92]

As long as the Royal Air Force adhered to its tactics of continuous attack, in which one and the same target came under attack for a duration of several hours at a time, there was no danger that the German defense command would remain ignorant for long concerning the target for attack. Whether the target aimed at by the approaching enemy force was recognized at an early or late stage was not a matter of great importance for the defending night fighters at the time; this was so because the waiting position (Himmelbett) tactics employed at the time were restricted to the night fighter control positions in the outpost or early

90. Sources 2,30,59,60,62-4; RAF, Vol.III,pp.1-18,258-264.
91. " 65, 69.
92. Study 158-160, Volume II; RAF, Volume III, pp. 21 ff.

189 warning areas and the only really important requirement was to have night fighters in time at the night fighter control positions whose areas the approaching enemy force would cross.

British transition in the spring of 1943 to the tactics of concentrated formation bombing produced new defense tactics on the German side. These included direct target defense by single-engine night fighters, and pursuit by twin-engine night fighters, which permitted a closer concentration of the night fighter effort, particularly within the target area.

It was in this phase that the matter of deception to conceal from the German defenses the route and target of a bomber force became a matter of immediate importance for the Royal Air Force. It was therefore a perfectly logical and sound move on the part of the Royal Air Force to make deceptive activities designed to mislead the German Night Fighter Command and cause a scattering of the night fighter defense effort an integral part of every sizable operation serving the conduct of strategic air warfare from then on. The first use of tinfoil to interfere with the functioning of the German Wuerzburg radar instruments combined with the use of air-carried radio jamming stations to eliminate the Freya aircraft detecting instruments of the German

189 Aircraft Reportin Service had already proved how effective such measures could be.

In the new campaign of deceptive operations, which commenced in August 1943, the Pathfinder forces played a major role. Without them it would have been impossible to to apply all the numerous methods of deception.

One method here was to avoid a direct approach to the target. Instead the attacking bomber forces followed an indirect course, marked by Pathfinder units, with numerous sharp turns, and so directed that the German defenses could only estimate very shortly before the actual time of attack what target the approaching bomber force was aiming at. Usually the Initial Point, the last turning point of the approach route, was approximately 30 miles distant from the target to be taken under attack. This meant that only between eight and ten minutes passed between the last turning and arrival of the first bombers over the target.

Another advantage of the indirect course to a target was that it facilitated the detouring of areas known to be strongly defended.

Another method of deception, used for the first time in the Royal Air Force attack against Hanover on the night of 22-23 September 1943 was that of dispatching a relatively small force on a diversionary mission. Given full

190 support with all route and target illuminating means, this force attacked some target distant from the main target of the day in order to lure the German night fighters from the main target area. In the case of the attacks against Hanover for example, Mosquito units bombed Oldenburg in Oldenburg, roughly 90 miles by air distance from Hanover, just prior to the main attack. This diversionary attack against Oldenburg was so timed that the German night fighters, if dispatched to defend Oldenburg, could not arrive at Hanover in time to repel the main attack there.

In this case, however, the diversionary attack failed to achieve its purpose. German reconnaissance fighter units had found their way into the main British bomber formation at an early stage in the approach, so that night fighters could be dispatched to Hanover in time, where they shot down 19 Royal Air Force bombers at a cost of only two night fighters lost.

Another variant of this type of deceptive operations

191 was that of arranging for certain elements, either 4-engine bombers or Mosquito units, leaving the main force at some point along the approach route still far distant from the main target of attack. Liberal quantities of tinfoil and route markers were dropped along this secondary route to simulate a route for the main attack force, in the hope

191 that this would draw the German night fighters from the actual main target area.

A typical case here is that of an operation by Royal Air Force units on the night of 17-18 August 1943, when elements of an approaching bomber force left the main force in the direction of Berlin, in order to conceal the target of the main force, namely, Peenemuende.

In this case the deception succeeded. The German Defens Command actually assumed that the main attack was directed at Berlin and ordered all night fighter forces to there. In the Berlin area the night fighters encountered heavy antiaircraft fire, which seemed to confirm their belief that the enemy force was over the area, while there were, in fact only a few Mosquito units over Berlin using large quantities of tinfoil. It was due exclusively to the fact that the fighter division stationed in the outpost area succeeded in guiding a number of night fighters into the British bomber formation at an early stage that the main Royal Air Force formation attacking Peenemuende lost 47 of the 571 bombers involved, or 8.2 percent, so that this was a costly operation for the British.

Another form of diversionary operations was that of dispatching Royal Air Force bombers on mine-laying missions

191 in the north Sea and Baltic Sea coastal areas. These operations were timed to cause the German Night Fighter Command either to commit its night fighters prematurely or to dispatch them in a wrong direction.

In February 1944 the Royal Air Force began to bring about considerable improvements in its system of diversionary attacks. The Mosquito units dispatched on such missions now were not only numerically larger, but everything possible was done to give the diversionary attack, carried out exclusively by Mosquito units, fetures corresponding exactly to those of a major attack. Large quantities of tinfoil were dropped to give the German aircraft detecting instruments the impression that a large 4-engine bomber force was approaching. Since mosquito bomber units had in the meanwhile received increased allocations of H-2-S (Rotterdam) instruments, the force carrying out the diversionary attack was not very different in this respect from a 4-engine bomber force.

Only one feature was lacking to create a perfect impression of a 4-engine bomber force: the Mosquito units carrying out the diversionary attack had no Monica or Fish Pond night-fighter detector equipment. The waves from these instruments were a regular feature of genuine 4-engine forces, and were always intercepted either by the ground

192 stations of the German Radio Intercept Service or by the Special Rowendaal/Halbe instruments installed in German night fighters. It was finally this prominent feature of 4-engine bombers, or its absence, which frequently caused the failure of this British method of deception, particularly after the German Freya aircraft reporting instruments had been adapted through installation of the Wismar receiver attachment to also intercept the characteristic waves for the 4-engine bomber radio instruments.

Another technique employed by the Royal Air Force was that of dispatching two separate bomber forces at different times to attack one and the same objective, and thus outmaneuver the German night fighters. Employing this technique for the first time, a British force of 500 bombers took off from airfields south of London at 1900 on the night of 24-25 February 1944 on a course overAmiens, Metz, and Karlsruhe to bomb Schweinfurt. When the first elements of this force left the target area after their attack, a second force of 300 bombers made its appearance over the mouth of the Somme River, flying on the same route, and carried out a second bombing of Schweinfurt.

The British tactics succeeded on this occasion, since the German Defense Command had only a small number of

193 night fighters available for action against the second bomber force, the bulk of these units being temporarily out of action for refuelling after their commitment against the first force.

In April 1944 the Royal Air Force introduced new tactics d signed to cause a scattering of the German defense effort:

The new system consisted of the dispatch of a number of separate forces simultaneously against widely separate targets within Germany. Use was also made here of the tactics of diversionary Mosquito attacks and diversionary mine-laying operations to conceal the main attack intentions.

The mounting numbers of aircraft committed in such diversionary operations, which were carried out at times by forces of up to 80 or 100 Mosquito of mine-laying 4-engine bombers, made it extraordinarily difficult for the German defense to recognize their secondary importance clearly and in time.

The size of units employed in diversionary operations showed a further increase in May 1944. So far as the use of light signals to mark the route and the target, operations by Mosquito units differed in no way from operations of 4-engine forces. The only possibility now to detect any difference was if a force was detected at altitudes above

26 000 feet, where it could always be identified as a Mosquito force. However, the Mosquito forces always crossed the coast of Western Europe at altitudes between 16 000 and 20 000 feet and only then climbed steadily along their route to higher altitudes. Their slower speed at the lower altitudes made it still more difficult to differentiate between them and 4-engine bombers.

An attack against Berlin on the night of 26-27 November 1943 is quoted here as a typical example of British tactics to deceive the German defense and cause a dissipation of the German defense effort:

The attack plan provided for elements of the first wave of the bomber force--the first wave consisted exclusively of Mosquito bombers--to bomb Frankfurt and then to return to their bases, creating the impression that the whole operation was directed against Frankfurt.

The rest of the first (Mosquito aircraft) wave left Frankfurt, dropping large quantities of tinfoil on its way, in the direction of Nuremburg and Wuerzburg, thus concealing from the German aircraft reporting services the fact that the 4-engine part of the whole force was continuing on a course towards Erfurt.

It was due exclusively to the fact that radio intercept

194 stations in the Erfurt-Gotha area identified "bunched Rotterdam waves" in a few cases that the German Night Fighter Command received the impression that a 4-engine bomber force was approaching from southwest towards Leipzin-Berlin. A clear interpretation of the air situation only became possible on the basis of data from the night fighter control positions southwest of Berlin.

Along the route of the British force between Frankfurt and the Leipzig area only one report was received from the visual and oral observation posts of the Aircraft Reporting

195 Services, and this was from the Gotha area. This report combined with the "bunched Rotterdam waves" picked up by the Radio Intercept Service caused the German Night Fighter Command to alert the 5th Night Fighter Wing held in reserve to defend Berlin.

In this operation German night fighters shot down 28 Royal Air Force bombers, 17 of them over Berlin alone (See Appendix 22a).

The British attack against Leipzig on the night of 3-4 December 1943 is another example of successful deception of the German Aircraft Reporting Services:

A British bomber force crossed the coast of Holland between Den Helder and Kattwijk and entered the Berlin area on an easterly course.

195 Isolated bombings, with the liberal use of tinfoil, by Mosquito units flying in the lead of the bomber force concealed the fact that the 4-engine bombers making up the main body of the force had wheeled southeast before reaching Berlin, and was on its was to Leipzig. The first intimation received by the German Night Fighter Command concerning commencement of the attack against Leipzig was a telephone call from the antiaircraft artillery commander in Leipzig.

However, a large percentage of the night fighters ordered to the Berlin area were able to recognize the attack against Leipzig from a long distance because of the light signals used by the British. On their own initiative these night fighters proceeded to Leipzig and, although weather conditions had limited the number of night fighters which could be committed to 70, succeeded in shooting down 21 of the Royal Air Force bombers.[93]

By the spring of 1944 British interference and deception operations had assumed such proportions in support of major attacks against targets within Germany that the Royal Air Force established a special bomber group, the 100th, to handle all such problems, and assigned to it all units with special equipment for the purpose. The units involved were as follows:

93. Sources 2, 29, 43, 66-7; Study 158-160, Volumes I-IV; See also Appendix 22b.

196 a. All aircraft with radio equipment to jam the German target detecting instruments;

b. All aircraft with equipment to jam the German command radio communications networks;

c. All Mosquito units employed in the execution of simulated and diversionary attacks supporting major strategic operations.

During the rest of 1944 the primary feature in operations of the German night fighter forces was the battle of the command against the numerous methods and combinations employed in operations by the Royal Air Force 100th Bomber Group, and the success or failure of the command in this battle decided the outcome of all German night fighter activities.

An impressive example of the British combination of interference and deception activities, diversionary maneuvers, and concealment measures to cover the intentions in major attacks was that of the Royal Air Force operation against Duisburg and Braunschweig on the night of 14-15 October 1944. The whole operation proceeded as follows:

a. Aircraft of the 100th Bomber Group monitored the German command communication channels, and disturb- all communication traffic by means of jamming and by interjecting false commands in the German language. Ig German women in the ground stations spoke orders,

196 officers of the British Womens Auxiliar Corps on board the aircraft immediately immitated the female voice with false orders;

b. At the beginning of a major operation, units of the Training Command took off for a simulated approach across the North Sea to Hamburg, turning back before reaching Helligoland. In the meanwhile a Mosquito force took the training unit and continued on the route to Hamburg, simulating a large force by dropping large quantities of tinfoil, and bombing Hamburg;

c. At the same time the first wave, comprising 675 aircraft, of the main attack force, which was to attack Duisburg, took off for a low altitude approach across France to climb to combat altitudes after reaching the front lines of combat.

It was only a this point that the German Aircraft Reporting Services detected this force, so that German night fighters arrived over Dusiburg too late for effective action;

d. While the German night fighters, after arriving too late at Duisburg, were in pursuit of the first attack wave, which escaped serious attack by returning at top speeds to low altitudes, a second Royal Air Force formation of 233 bombers crossed the Rhine farther

197 south and attacked Braunschweig practically without any opposition by night foghters;

e. While the force which had attacked Braunschweig was on its home route, a third force of 330 British bombers attacked Duisburg a second time, encountering no opposition by German night fighters, since these were on the ground refuelling;

f. The whole Royal Air Force operation on the night of 14-15 October 1944 was favored by the circumstance that a near hit by a bomb from the first wave attacking Dusiburg damaged the command post of the 3d Fighter Division, in command in the area. The damage was so serious that the division was unable to control and direct defense operations. Consequently, the I Night Fighter Corps received only incomplete information on the continued developments in the air situation during the night, and was therefore unable to direct appropriately the commitment of the night fighter units of the other divisions.

In this operation only one enemy bomber was shot down against five German night fighters lost, which can be considered as impreesive proof of the superiority of British operational methods at that time.[94]

94. Source 29; RAF, Volume III, pp. 258 ff.

199 5. The Weather Factor in the Conduct of Strategic Air Warfare By the Royal Air Force.

A. WEATHER CONDITIONS IN THE TAKEOFF AND LADNING AREAS.

In one respect the weather factor at all times played a decisively important role in the conduct of strategic air warfare by the Royal Air Force, namely,

The primary condition for any Royal Air Force operation of any considerable size was a weather situation which provided an adequate measure of safety in the intended landing areas for the number and types of aircraft committed at the time of their return from a mission.

This basic principle could produce various results:

a. Unfavorable weather at the time of take off could be accepted as an unavoidable handicap, and did not prevent the ex cution of a mission, if the prospects were adequate that the units committed would have improved weather conditions, such as the tail end of a bad weather front, at the time of their return from execution of their mission;

b. If unfavorable weather was predicted in some areas of England, this restricted the number of units committed to the number which airfields in more favorable areas could accommodate;

199 c. Landing difficulties of a general nature, if no alternate possibilities could be found, restricted operations to the dommitment of aircraft manned by crack crews, so that the size of the operation was determined by the degree of difficulty and the qualifications of aircraft crews;

200 d. The deciding factor in the timing of any operation was the time at which favorable landing conditions were predicted. If the weather was expected to worsen during the night, attacks were executed early, if weather improvement was expected, the units took off late for their missions.[95]

In the weeks preceding and following the winter months, foggy nights and generally poor visibility created serious problems for air traffic also in England. The moist sea climate of England was particularly conducive to the development of fog and haze. This imposed severe restrictions on air traffic for weeks at a time in large parts of England.

The Royal Air Force did not merely accept these difficulties and their hampering effect on the conduct of air warfare as inevitable. Instead, it expended great efforts on the development of systems which would enable its aircraft to find their way safely to their airfields even in conditions

95. Sources 29, 43.

200 of widespread fog.

After numerous tests at the Fiskerton and Gravely airfields equipment was developed to so far dispel fog and raise the fog ceiling that aircraft could make a bad weather landing with the use of the Loreny landing beacon. The system developed was known as the Fido (Fog Investigation and Dispersal Operation), and consisted of a number of kerosene burners placed along the landing strip, at intervals of 1.5 meters, while the aircraft were landing. The air heated by these burners generated an upward current and raised

201 the fog ceiling to about 80 feet, which provided adequate conditions for a landing by beacon.

Three main airfields were thus equipped, namely,

Carnaby airfield in Yorkshire, for the northern areas;
Manston " " Kent " " southern "
Woodbridge " " Suffolk " " central areas.

At each of these airfields the landing strip was 3000 yards long and over 250 yards wide. In addition, these airfields had the most up-to-date flight control and bad-weather landing installations.

With support f om these installations the Royal Air Force could afford to accept mo e serious weather risks than had been the case in the past, and could thus expand considerably the scope of its operational planning for

201 strategic air warfare.

Of the 4 120 aircraft landing at Woodbridge by June 1945, for example, 1200 landed by the aid of the Fido system. The Fido system was also the reason why hardly a night passed from the spring of 1944 on, on which no British aircraft penetrated over Germany or over the German-occupied territories because of weather conditions. The three airfields with Fido equipment always made it possible to commit Mosquito harrass bombers or a limited number of 4-engine bombers flown by crack crews for strategic attacks completely independent of current weather conditions.[96]

B. WEATHER CONDITIONS ALONG THE ROUTE AND IN THE TARGET AREAS.

Once the Pathfinder system was perfected and the Royal Air Force bombers had received navigational instruments which insured that they could with certainty find their routes and targets at night without ground visibility, weather conditions in the target area and along the route almost completely lost their significance as a factor restricting the execution of bombing missions. The instruments used here were the Oboe (Boo,erang), the GH (Discus) and the H-2-S (Rotterdam).

96. Sources 29, 68; RAF, Volume III, pp. 258 ff.

202 From the summer of 1943 on the fact that Royal Air Force personnel had complete mastery of the techniques of blind bombing made consideration of the weather conditions in the target area unnecessary so far as the selection of targets and the size of the forces to be committed were concerned.

The only factor which could complicate the execution of a major bombing attack by 4-engine units was an upper cloud surface which was too high. This was so because formation concentration was achieved largely by altitude echeloning, the possibilities of which were limited by the maximum operating altitude of the 4-engine bombers when fully loaded. It was essential to avoid blind navigation within clouds, because the bomber crews then could not see the route and target marking placed by Pathfinder units.

In practice, however, bad weather fronts of such large lateral and vertical extent that the entire area of operations had a cloud cover extending more than 16 500 feet upwards were a rare occurrence. Appropriately directed air weather reconnaissance could always furnish reliable information showing areas in which weather complications were not to be expected at high altitudes. In this respect the weather factor influenced Royal Air Force planning

203 insofar as target selection was concerned, with the areas showing weather conditions favorable for attack always exceeding by far the size of unfavorable areas.

The weather factor was of far greater significance for strategic planning by the Royal Air Force in another respect, that of the hampering effects of current weather conditions on the German defenses.

The fact that the introduction of instruments for blind navigation enabled its units to operate without visual orientation and without visual observation of their target had first of all caused the Royal Air Force to dispatch its 4-engine bomber forces during the dark period of each month instead of during the moonlit nights as had been the case formerly. Each month during the period from ten days before to ten days after full moon the Royal Air Force restricted its activities to high altitude operations by Mosquito units and attacks by 4-engine bombers against targets in weakly defended areas, or in areas not defended at all, such as southern France and Italy.

For the German night fighters, operations on dark nights meant that they had to depend largely on the reliable functioning of their aircarried electronic search equipment until they were close enough for visual contact with the

203 enemy planes.

The Lichtenstein B/C instrument, the first of its kind and installed in the majority of German night fighters in the summer of 1943 was seriously impeded in its functioning by the British use of tinfoil. The improved Lichtenstein

204 SN-2, which went into serial production in September 1943, was admittedly proof against tinfoil interference. However, it had the decisively important disadvantage of a close range diffusion limit of 550 yards, compared with the 80-100 yards of the Lichtenstein B/C. This meant that tracking with the instrument became impossible while the target was still too far distant for visual observation, except in clear moonlight.

It was spring 1944 before this weakness of the SN-2 instrument could be remedied by means of the installation of an attachment copied from a captured British instrument which reduced the close range diffusion to a distance of 275 yards. Until then, the shift by the Royal Air Force to the dark periods of the month therefore created disadvantages for the German night defense system.

In addition to the general difficulties resulting for the German defense from the fact that the Royal Air Force selected dark nights for its major operations against the German interior, the Royal Air Force f om November 1943 on

204 adopted a system of target selection in which the current weather conditions for take off and landing in the base areas of the German night fighter forces were taken into account as a positive factor in planning. Under this system the target was selected in areas where

a. The British force would not be hampered in its attack operations by a cloud cover extending too high;

b. The worst current weather conditions existed for operations by German night fighters. Such weather conditions included

205 Low cloud ceilings
Poor visibility
Thick and dense cloud covers
Ice formation in the clouds
Ground fog.

In November 1943, for example, there was a long period of ground fog in the northern, western, and central areas of Germany. In the matter of route and target detection such conditions presented no problems for the units of the Royal Air Force since the Pathfinder system had become properly adjusted to operating by the Gee, Oboe, and H2S instruments.

For the German night fighters, in contrast, a take off would have been possible for a small number of highly expert pilots even if visibility was inadequate, but the

206 available landing beacon installations were under no circumstances adequate for a completely blind landing during ground fogs.

Most of the night fighter units had Me-110 aircraft which had a total time of flight of 3.5 hours. This made it impossible to commit them when it was to be assumed that they would have to fly a long distance to find a landing field free of fog.

In many cases the Night Fighter Command also found itself compelled during periods of uncertain weather to restrict its action to waiting position (Himmelbett) tactics, keeping only a small number of aircraft in the air at a time. Owing to British interference measures the prospects of success with these tactics were small, but the possibility existed to recall the aircraft at short notice if there was any serious worsening of weather conditions at the nearest landing fields.

On the night of 18-19 November 1943, for example, the Royal Air Force dispatched 402 4-engine bombers to attack Berlin and 325 to attack Mannheim. Owing to widespread ground fog, the German I Fighter Corps could only send up a total of 23 night fighters to intercept these bombers, 22 of them in waiting positions, and one, which had no Lichtenstein SN-2 search equipment, for pursuit within

206 the British bomber formation.

The only results achieved by the German defense in this operation were one Lancaster bomber shot down by a night fighter operating from ~~XXXX~~ night fighter control position in Holland. In many cases the night fighters committed in waiting positions had to be recalled because of worsening weather conditions at the few airfields available for their landing.

On the occasion of the the attack against Berlin on the night of 22-23 November 1943 by approximately 700 Royal Air Force 4-engine bombers, ground fogs were so bad practically throughout Germany, that not a single night fighter could take off for defensive action.

The success of the Royal Air Force weather tactics finds impressive expression in the smaller number of losses incurred due to German night fighter action. In October, for example, night fighters of the German I Fighter Corps shot down ~~XX~~ 132 or 3.5 percent of the total number of British aircraft penetrating over Germany, in November only 66 or 1.75 percent.

The fact that their blind bombing techniques made ~~them~~ independent of weather and visibility conditions, also enabled the Royal Air Force to exploit systematically the advantages of the frequent bad weather front movements from northwest and west to southeast and east in the commitment of its units.

207 Taking off from airfields in Britain in the immediate wake of a bad weather front and thus always in fair weather conditions, the bombers arrived over their target areas simultaneously with the center of the bad weather front over those areas and the German outpost areas, bringing low-hanging clouds, poor visibility, amd ice formation in the clouds, all conditions which made it extremely difficult for the German night fighters to take off and climb to combat altitudes.

Under these circumstances the German night fighter forces frequently suffered heavier losses due to weather conditions than through combat. On the night of 1-2 January 1944, for example, the German I Fighter Corps lost a total of 15 night fighter aircraft, 11 of them due to weather conditions, while out of 20 lost on the night of 26-27 March 18 were due to weather conditions.

The main cause of these weather losses was the formation of ice in clouds. Whereas the Royal Air Force units flying behind the bad weather front could take advantage of gaps in the cloud cover to climb to operating altitudes, the German night fighters were unavoidably compelled to climb through the usually dense cloud cover of the bad weather front. German night fighters had no de-icing installations, and no means were available at the time to prevent the

207 formation of ice on propellors, which frequently became unbalanced and tore out the engine, causing numerous losses.

From this phase on the British in their strategic objective whenever possible selected targets for attack in those areas where the German night fighters would be hamp-

208 ered by current bad weather conditions.

In a few cases the German Night Fighter Command countered these British tactics successfully by moving its units during daylight from areas in which unfavorable weather was predicted for the night to areas where better weather was predicted.[97]

On the whole it can be stated that from the moment when the British had available navigational instruments which made their units independent of weather conditions in the finding of routes and targets, the weather became an ally of the Royal Air Force, which logically and cleverly exploited this factor to restrict the chances of the German night defense system for successful action.

---

97. Sources 29, 70; Study 158-160, Volumes I-IV.

209 6. Reaction of Royal Air Force Bombers to the German Night Fighter and Antiaircraft Artillery Defenses. In the techniques employed by the Royal Air Force for the conduct od strategic warfare a number of measures designed to reduce the risk of losses due to German defense action played a very special role:

a. Measures to Safeguard the Approach and Return Flight of Units. From 1943 on, when target marking had become a mission of the Pathfinder forces and the crews of individual aircraft had become independent of ground visibility for navigation, the Royal Air Force in plotting routes for approach to targets of attack premised it plans on a route which would pass over areas with the weakest German defenses. In doing so it did not mind planning a route in a wide detour, if possible, to have its units over neutral territory for at least a part of their course.

For example, units dispatched to attack targets in the southern areas of Germany frequently crossed over Swiss territory, both on the approach and home route, while those attacking targets in northern Germany frequently crossed Swedish territory, also on both routes.

209 In all cases the Royal Air Force avoided routing its forces over areas where the German side had the best developed night fighter system, such as Holland and the Bight of Helligoland, or areas with strong antiaircraft artillery defenses, such as the Ruhr region, unless the location of the target to be attacked made this unavoidable.

For operations over central and southern Germany the approach route was usually across France, because the aircraft reporting system there was always less well developed than in the areas of Holland-Belgium and within Germany.

For operations against targets in the northern parts of Germany and against Berlin, the approach and return route of the Royal Air Force bombers was usually in a wide sweep across the North Sea and/the Baltic Sea. This allowed the use of position light on at least part of the course, which facilitated the maintenance of close formation and prevented collisions;

b. Increased Operating Altitudes. It was standard practice for Royal Air Force bomber forces to operate at the highest possible altitudes in the execution of their strategic bombing missions in order to reduce the effectiveness of German antiaircraft fire.

210 In order to exploit bad weather fronts over the approach and target areas the units were compelled to operate at very high altitudes, anyhow, since the system of extensive altitude echeloning practiced required that the lowest echelon had to be at least slightly higher than the upper cloud limit, usually around 16 500 to 20 000 feet up.

The maximum altitude at which a 4-engine bomber force could operate with loaded aircraft was decided by the technical performance capabilities of the aircraft models involved.

The best performances in this respect were by the Lancaster in 1944, which could operate at an altitude of 26 500 feet carrying a bombload of five tons.

The next best was the Halifax, with a maximum operating altitude of 26 500 feet, while the Stirling showed the poorest performance, achieving a maximum altitude of only 20 000 feet under similar conditions.

Altitude echeloning within a bomber formation took up, as a rule, 10 000 feet, so that the highest echelon, made up of Lancaster aircraft, had to operate at an altitude of 26 500 feet if the lowest echelon, of Stirling aircraft, was not to operate below 16 500 feet.