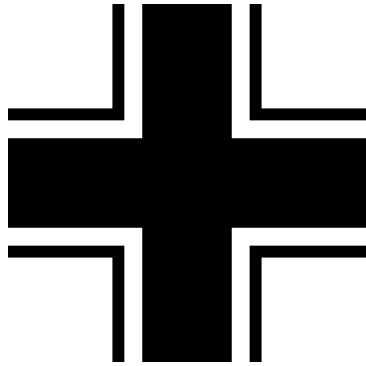


NACHTJAGD



IL-2 STURMOVİK
CAMPAIGN MANUAL

Berlin, 1944 - Since late 1939, British bombers have terrorised our cities. Unable to defeat the Luftwaffe during the day, the English retreated to the darkness of night. Although their bombs even today often fall miles from what can be surmised to be the intended target and their success is only ensured by massed waves of hundreds or even thousands of bombers, we cannot afford to ignore these blatant attacks into the heart of the German Reich.

As one of our experienced Bf-110 pilots, you will lead the front against the British night raids. You will fly in near-zero visibility conditions, having to rely on some of our latest technology to both find targets and return home. In the following sections, you will read more about the technology used and how to best employ it.

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1. METHODS OF NACHTJAGD

Over the years, various methods have been developed for the interception of bombers at night. These are presented in chronological order.

1.1. HENAJA (EARLY)

Helle Nachtjagd (HeNaJa - bright nightfighting) denotes the most basic method: the interception of targets lit up by searchlights. While this makes the acquisition and tracking of targets easy for pilots, it is dependent on the performance of ground-based searchlight crews. It furthermore requires a great density of searchlights in order to ensure a target can be passed from one searchlight to the next, lengthening the time window for the interceptor to reach the target. This makes early HeNaJa of practical use only over well-defended targets. Of further concern is that as the interceptor closes in on the target, it risks being caught in the searchlight beam itself, giving the target's defensive gunners the chance to retaliate. (1)(2)

1.2. DUNAJA

With the advent of accurate ground-based radar systems came Dunkle Nachtjagd (DuNaJa - dark nightfighting). In this method, a Nachtjäger is directed to a radar contact by ground control. An experienced radar officer is able to guide the interceptor to within a few hundred metres from the target, by which time the pilot and observer should be able to visually identify it and intercept it unseen. The main disadvantage of this method is that each ground radar is only able to guide a single interceptor. Before the recent advent of the Y-Verfahren transponder system, an additional radar was even needed to track the Nachtjäger. This makes it impractical for the interception of large groups of bombers, as employed by the RAF starting with the bombing of Köln on 31 May 1942, since these can easily overwhelm the few radars available. (1)(3)

1.3. HENAJA (LATE) / HIMMELBETT

The late version of HeNaJa combines DuNaJa with the advantages of searchlights. This was made possible by the establishment of the Himmelbett line (also called Kammhuber line by the enemy) in late 1940, which consists of a 20km wide zone spanning from northern France through Belgium and the Netherlands all the way up to the border with Denmark. As shown in Figure 1, each box of about 30km long contains around 24 searchlights and a radar station. Both the searchlights and the Nachtjäger assigned to the box are in direct communication with the radar station, ensuring that a target is often caught in a searchlight beam for durations of around 5 minutes, giving ample time for the interceptor to engage the enemy.

Although the combined advantages from HeNaJa and DuNaJa make for a lethal mix, this system also suffers from some of the disadvantages of both earlier systems. In particular, the narrow defensive zone is easily overwhelmed by larger bomber raids. As a result, Himmelbett fighter control is nowadays only employed against lone aircraft. (1)(2)(4)

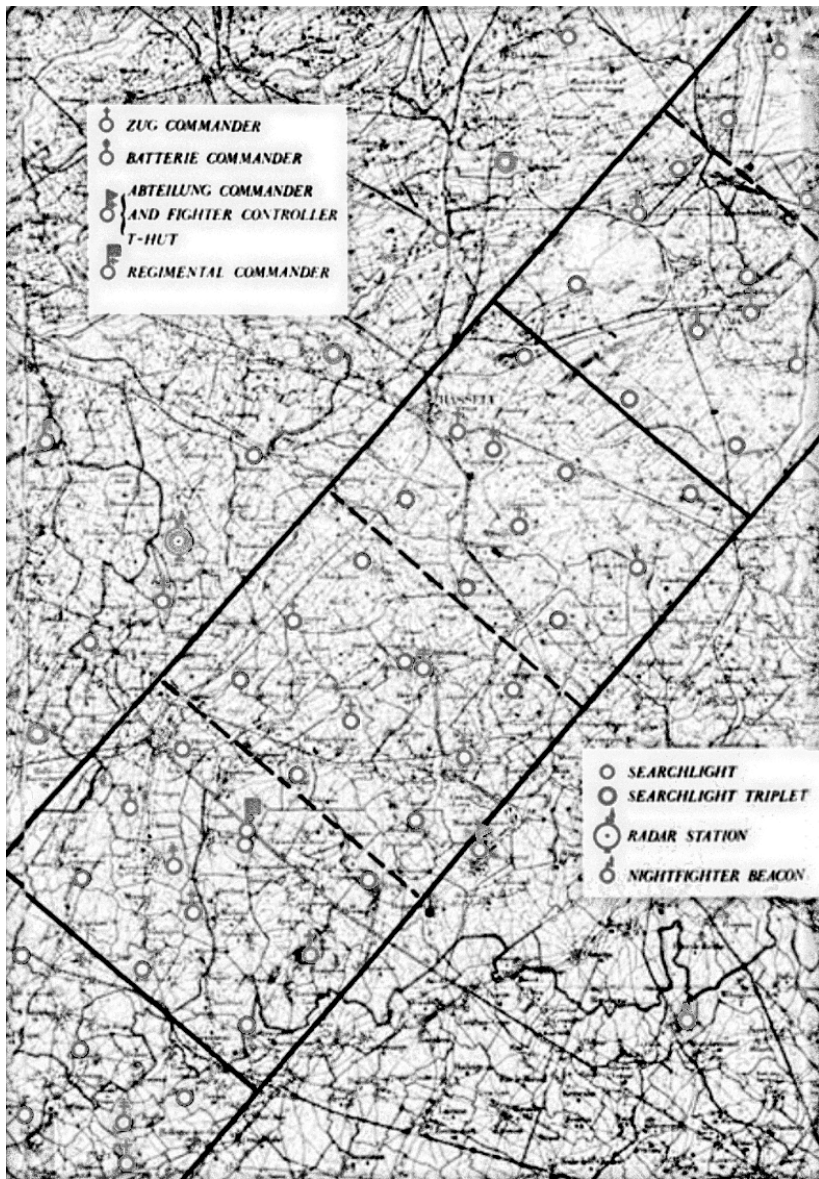


Figure 1: Map of box 6B of the Himmelbett line, corresponding to the Waremmе - St. Truiden (St. Trond) - Hasselt - Genk section in Belgium. (5)

1.4. WILDE SAU

The advent of increasingly large bombing raids as well as Allied radar jamming techniques such as "Düppel" (Allied codename "Window") rendered the above techniques mostly obsolete from the summer of 1943 onwards. In response to this, Wilde Sau (Wild Boar) was developed. By means of visual beacons such as pre-arranged searchlight signals and flares as well as a network of radio beacons, fighters (using especially single-seat daytime fighters) are guided onto the bomber stream and/or the determined target of the raid. Here, they attempt to visually identify the target against a backdrop of e.g. the fire of a burning city or clouds lit up by searchlights. Although met with initial success, such as on the night of 24 August 1943 when 56 British bombers were claimed, the fact that single-seat fighters are less suited for nighttime operations than our multi-seat dedicated Nachtjäger has led to unsustainable operational losses. (1)(6)

1.5. ZAHME SAU

Zahme Sau (Tame Boar) applies the basic concept of Wilde Sau to dedicated night fighters. Drawing the conclusion that the greatest concentration of Düppel corresponds with the center of the bomber stream, Nachtjäger are guided to these focal points of radar jamming. The night fighters are then left to hunt for themselves using their airborne radar systems while the use of ground-based radar is limited to keeping track of the bomber stream, supporting tactical decisions by fighter command. As the British have so far never succeeded in achieving complete jamming of our frequencies and experienced airborne radar operators are able to differentiate between Düppel and bona fide targets, Zahme Sau thereby ensures an optimal balance between operational freedom and high-level decision making. (1)(6)

2. GROUND-BASED RADAR

As noted in Section 1, DuNaJa and the Himmelbett procedure make use of a JLO (JägerLeitOffizier - ground controller) in the radar station to guide the interceptor to the target. The interception process from beginning to end goes like this:

1. The interceptor reaches a holding sector, generally above a radio beacon, and circles it until further notice.
2. The radar station identifies a target. The fighter is guided towards it on a more or less head-on course.
3. At the proper time, the interceptor is guided in a turn, ending up at some distance straight behind the target.
4. Small corrections are transmitted by the ground controller to keep the interceptor behind the target.
5. The Nachtjäger is guided to within a range of around 500m.
6. The interceptor makes visual contact and engages the target.
7. After interception, the fighter returns to the holding sector.

For optimal results, accurate flying is necessary. The JLO is trained with an interceptor speed of 400 km/h TAS and a turn radius of 2000 m so keep to this for optimal results. At the given speed, the turn radius of 2000 m corresponds to roughly the midway point on the turn indicator, as shown in Figure 2.

In order to ensure fast and unambiguous communication, radio communication uses pre-arranged codephrases as detailed in Appendix A, Table 2. As an example of the radio communications that you might receive, we look at the case shown in Figure 3. The communication between ground controller (G) and interceptor (I) during each of the depicted phases is as follows:

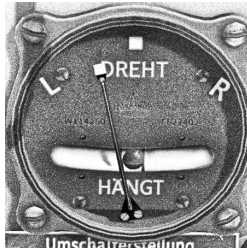


Figure 2: Turn rate to fly a 2000 m turn radius, at 400 km/h TAS

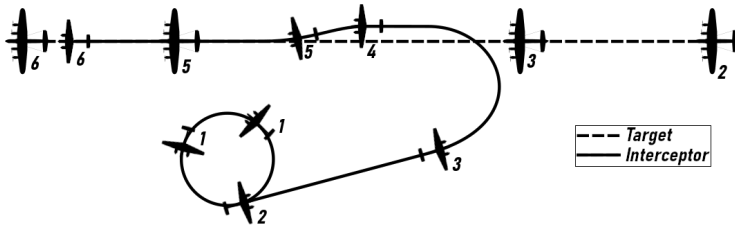


Figure 3: Simplified drawing of the DuNaJa/Himmelbett interception procedure. 1) The interceptor circles in the holding area. 2) A bomber is detected. The Nachtjäger is sent on an approximate interception course. 3) As the interceptor approaches the bomber's flight path, it is guided onto its tail. 4,5) Small corrections are given as the distance decreases. 6) The fighter makes visual contact and engages the target.

Phase 1: The Nachtjäger holds in the assigned sector while the radar operator scans for targets.

G: "Welle aktiv." ("Radar operation started.")
I: "Viktor." ("Roger")
I: "Stube ist zu." ("Arrived in holding sector.")
G: "Viktor." ("Roger.")

Phase 2: An enemy bomber is detected. The Nachtjäger is guided onto an interception course.

G: "Neue Kurier erfasst." ("New target acquired.")
"Kapelle 42." ("Target altitude 4200 m.")
"Postkutsche 270." ("Target flies heading 270°.")
"Express 70." ("Speed up on heading 70°.")
I: "Viktor." ("Roger.")

Phase 3: At the proper time, the interceptor is guided into a turn, ending up at some distance straight behind the target.

G: "Bitte antreten 270." ("Turn towards heading 270°.")
I: "Viktor." ("Roger.")
G: "Marie 50." ("Target is 5000 m ahead.")
"Kapelle 42." ("Target altitude 4200 m.")
"Postkutsche 270." ("Target flies heading 270°.")
I: "Viktor." ("Roger.")

Phase 4: Small corrections are transmitted by the ground controller to keep the interceptor behind the target. The Nachtjäger is continuously updated about the situation.

G: "Lisa." ("Turn 10° left.")
I: "Viktor." ("Roger.")
G: "Marie 50." ("Target is 5000 m ahead.")
"Kapelle 42." ("Target altitude 4200 m.")
"Postkutsche 270." ("Target flies heading 270°.")
I: "Viktor." ("Roger.")
G: "Rolf." ("Turn 10° right.")
I: "Viktor." ("Roger.")

Phase 5: Once straight behind the target, the interceptor is guided closer to the target. Once the range gets below 2000 m, the fighter is provided the measured enemy speed.

G: "Marie 30." ("Target is 3000 m ahead.")
I: "Viktor." ("Roger.")
G: "Achtung, Halten." ("Attention, slow down.")
 "Orkan 34." ("Enemy speed 340 km/h.")
 "Marie 20." ("Target is 2000 m ahead.")
I: "Viktor." ("Roger.")
G: "Marie 15." ("Target is 1500 m ahead.")
I: "Viktor." ("Roger.")
G: "Marie 10." ("Target is 1000 m ahead.")
I: "Viktor." ("Roger.")

Phase 6: After coming to within around 500 m of the target, the controller is not able to distinguish between the fighter and target on his display anymore. The interceptor makes visual contact on his own and engages the target.

G: "Marie 5." ("Target is 500 m away.")
 "Kurier genau vor ihnen." ("Target is right ahead.")
I: "Viktor." ("Roger.")
I: "Pauke Pauke." ("We're engaging.")
G: "Viktor." ("Roger.")
I: "Sieg Heil." ("Enemy shot down.")
G: "Viktor." ("Roger.")
G: "Stube anschliessen." ("Return to holding sector.")
I: "Viktor." ("Roger.")

3. AIRBORNE RADAR

As of late, the interception of enemy bombers is greatly helped by the application of Aircraft Interception (AI) radars, installed in the nose of our fighters. Currently, there are two types of AI radars in use: the older Funk-Gerät (FuG) 202 "Lichtenstein

B/C" and more recently, the FuG 220 "Lichtenstein SN/2". The angular characteristics of these radars are shown in Figure 4.

As can be seen in Figure 4a, the FuG 202 features a narrow detection lobe that is effective up until about 30 degrees on either side of the interceptor. This necessitates flying a zig-zag course through the enemy bomber stream in order to cover an as great as possible area. On the other hand, the sharp angular responses of both lobes make it easy to very accurately pinpoint and track a target, once it has been acquired. A very short minimum detection range of 150m ensures that the target can be tracked until visual contact is made.

The main lobes are greatly enlarged in the FuG 220 as shown in Figure 4b, making it possible to detect targets in almost the entire forward hemisphere and at nearly double the range of its predecessor. The downside is that the large lobes per antenna make it harder to pinpoint the exact location of the target until the range has significantly decreased. This is further exacerbated by an increased minimum detection range of 900m, necessitating visual detection during the final stages of the interception process. Overall however, it is felt by the Oberkommando der Luftwaffe (OkL) as well as pilots that the improved detection qualities outweigh the somewhat worse tracking. (7)

3.1. TUBE OPERATION

The received radar signals are plotted on two (FuG 220) or three (FuG 202) tubes. The FuG 220 configuration is shown in Figure 5. First, a reference line is drawn along with distance markings at multiples of 2000m as shown in A). If no targets are detected, the result is a static, noisy line as shown in B). At distance, the reflection from the ground is visible in C); below a flight altitude of 1000-1500m, this reflection is so strong and so near the origin that it renders the radar effectively useless. In D), a strong peak indicates the minimum range of the radar system. E) and F) show a contact at 4000m, where the relative

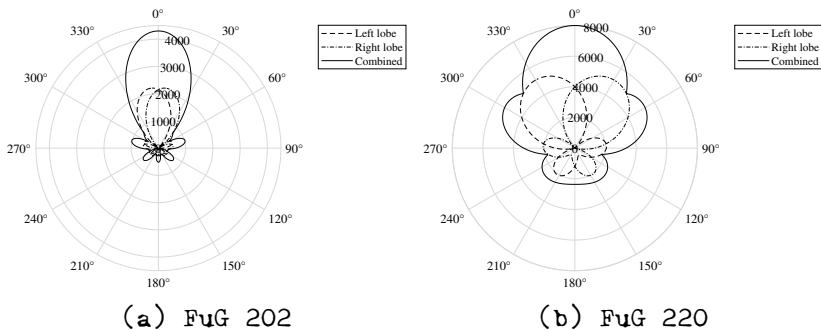


Figure 4: Theoretical detection range against a four-engine bomber as a function of angle w.r.t. the interceptor's forward axis.

size of the left vs. right and upper vs. lower spikes indicate the position of the target. In this case, the left peak in E) is slightly larger than the peak to the right, indicating the target is slightly to the left. In F), the downward spike is clearly larger than the upward one, indicating the target is below the own aircraft.

In addition to the two tubes described above, the FuG 202 features a circular range tube that can be used to more accurately determine the range to the target.

3.2. INTERCOM

The Bordfunker operates the radar and communicates detected targets to the pilot using the intercom. For fast and unambiguous communication, codewords as presented in Table 1 are used. A full transcript of the Bordfunker's communication from the acquisition of a target until its interception might go something like this:

"Emil Emil." ("Target acquired.")
 "Ente 40." ("Distance 4000m.")
 "Frieda." ("Descend.")
 "Lisa Lisa." ("Turn sharp left.")

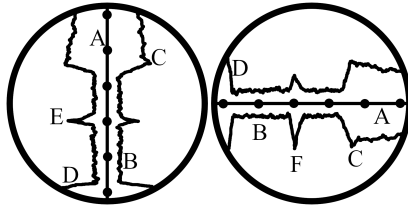


Figure 5: Operation of the FuG 220 tubes. The azimuth tube is on the left, the elevation tube on the right. A) Reference line with 2km markings. B) No targets. C) Ground reflection at 7000m. D) Peak at minimum range. E) Contact at 4000m, indicating a target slightly to the left. F) Contact at 4000m, indicating a target below.

"Ente 30." ("Distance 3000m.")
 "Marie." ("Target is now straight ahead.")
 "Kirchturm gleicher." ("Reached target altitude.")
 "Marie 20." ("Distance 2000m.")
 "Marie 15." ("Distance 1500m.")
 "Rolf." ("Turn right.")
 "Marie 10." ("Distance 1000m.")
 "Berühren Sie." ("Target lost; make visual contact.")

Note that as the target gets below the minimum range of the radar set (900m for the FuG 220), it disappears from the radar tubes. By this time one should however have a good enough idea of the target's location to enable visual interception.

4. NIGHT OPERATIONS

Flying at night brings its own set of challenges and solutions, that are detailed in this chapter.

4.1. RADIO NAVIGATION

Since it is often not possible to navigate on visual landmarks at night, it is necessary to rely on

a combination of blind reckoning and radio navigation to determine one's position. For this purpose, a network of Non-Directional Beacons (NDBs) has been established. In each mission briefing, you are provided with an up-to-date list of all active beacons and their corresponding frequencies, that you should familiarise yourself with.

Roughly speaking, radio beacons used in Nachtjagd operations can be divided into three distinct types, to wit:

1. Permanent beacons for long-range navigation (see Section 4.1.1).
2. Holding beacons near important Nachtjagd zones (see Section 4.1.2).
3. Beacons for blind landing (see Section 4.1.3).

In addition, there exist additional radio signals within the bomber force to help with targeting, e.g. Knickebein or X-Gerät. Since these are not used in Nachtjagd operations, these are not treated in this document.

4.1.1 Long-range navigation: Across Germany and the occupied territories, long-range beacons have been established. A map of the relevant theatre of operations is shown in Figure 6. One or several of these beacons can be relied upon to be active and in range at any time. When travelling long distances, it is recommended to follow the marked routes between the beacons as much as possible.

Although the location of these long-range beacons is fixed, their frequency may change between missions to deny their navigational use to the enemy. Always refer to your mission briefing for an up-to-date list of frequencies.

4.1.2 Target beacons: In addition to the semi-permanent beacons described above, there are a number of smaller beacons designating holding sectors. For instance,

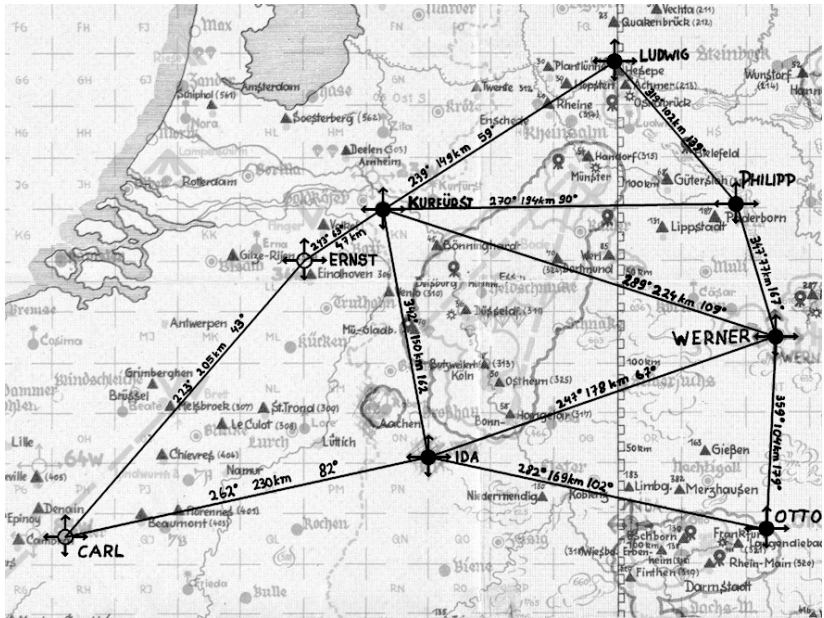


Figure 6: Permanent navigation beacons and airways in western Germany and the Low Countries. (8)(9)(10)

radar stations used for DuNaJa as discussed in Section 1.2 generally have a radio beacon close by. The guided fighter can hold here while waiting to be guided towards a target. Similarly, the Himmelbett boxes discussed in Section 1.3 have a beacon on either end of the box. These beacons are only active when the corresponding box or radio station is active. If applicable, any such beacons are detailed in your mission briefing, and shown on your map.

4.1.3 Airfield beacons: Similarly, most airfields have a nearby navigation beacon that is only active when the airfield is in operation. If in use, these beacons are detailed in your mission briefing and drawn on your map.

Fully-equipped nightfighting airbases, such as Venlo, in addition have a Lorenz blind landing system (see Section 4.3). In these cases the NDB - the so-called Blinkfeuer - is located in line with the runway, at a distance of 10 to 15 km. One should start the approach by flying to this beacon; upon reaching it, tune into the Lorenz frequency to start the landing procedure.

4.2. INSTRUMENTATION

For navigation to an NDB, the AFN/1 (Anzeigerät für FunkNavigation - indicator for radio navigation) or AFN/2 instrument is provided. This consists of a horizontal and vertical needle and an indicator light. As shown in Figure 7, the horizontal needle shows the approximate distance to the beacon, with markings at 20, 50 and 100km. The vertical needle shows the approximate direction to the beacon, with a deflection to the right indicating the beacon is located to the left, and vice versa.

In addition, the Bordfunker/gunner has a Funkpeil-anzeigergerät FA/R2 at his disposal, located just forward of his position next to the radio set. The greater directional accuracy compared to the AFN/1 or 2 can be used to triangulate one's position by comparing the directions to two or more beacons.

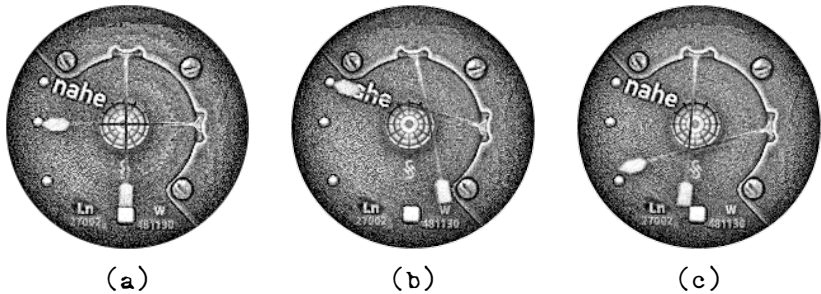


Figure 7: Three examples of the AFN/2 operation. (a) indicates a beacon straight ahead, approx. 50km away. (b) shows the beacon is to the left at a distance of 20km or closer. (c) displays a beacon slightly to the right at approximately 90km distance.

4.3. LORENZ BLIND LANDING SYSTEM

At night, it's often very hard or downright impossible to see the runway. In order to land in these circumstances, it is necessary to use the Lorenz system. This technology was first developed before the war for the civilian aviation industry, but has more recently seen extensive use for nighttime Luftwaffe operations suffering from blackout rules.

The Lorenz system uses the same AFN/1 or 2 indicator as detailed in Section 4.2. Any deviation to the left or right of the runway is shown by the movement of the vertical needle: if the aircraft is to the left of the runway, the needle jumps to the left and vice versa. At the same time, an 1150 Hz audio tone is played over the headphones; directly in front of the runway this is a continuous tone, which transitions into morse dots as you move left of the proper glide path. Conversely, if you move right of the intended path, the signal changes into morse dashes. This is illustrated in Figure 9.

The entire Lorenz approach procedure is as follows:

1. Tune into the Blinkfeuer, as detailed in Section 4.1.3.

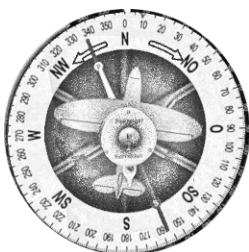


Figure 8: The FA/R2 instrument. In this example, the aircraft flies a course of 9 degrees while the receiver is tuned into an NDB that is at a heading of 337 degrees.

2. Set the altimeter to the runway height.)))
3. Descend to 150m above ground level as you continue towards the Blinkfeuer.
4. When above the Blinkfeuer, tune into the Lorenz system and turn into the runway heading.
5. Relying on the audio signal and AFN/2 indicator, adjust your course to remain in line with the runway.
6. As you get within 3000 m of the runway threshold as indicated by the VEZ, start a descent of around 2 m/s.
7. You should reach the HEZ at an altitude of 20 to 50m. If you still have no visual with the runway by this time, abort and go around.

If you follow the above procedure calmly and accurately, it should be possible to land in all but the very worst weather conditions. If you nevertheless are not able to find the runway after one or two aborted attempts or if you or your aircraft are in such a condition that you cannot afford a go-around, consider requesting the runway lights to be switched on. (11)(12)

4.3.1 Runway lighting: Most hard-surfaced airfields in western Europe have a runway lighting system in

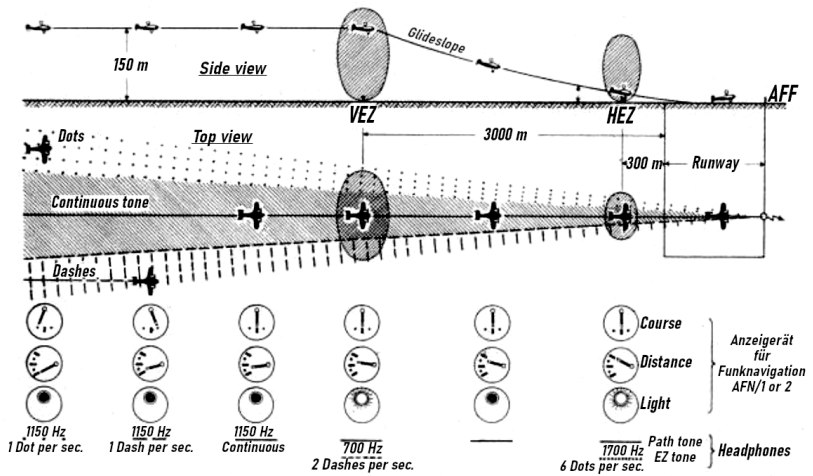


Figure 9: Audiovisual feedback during a Lorenz approach. Corresponding AFN/2 indications as well as audio signals are shown for six different aircraft positions. In order from left to right: left of the runway near the Blinkfeuer; right of the runway between Blinkfeuer and VEZ; on course near the VEZ; on course above the VEZ; on course between the VEZ and HEZ; on course above the HEZ. (12)

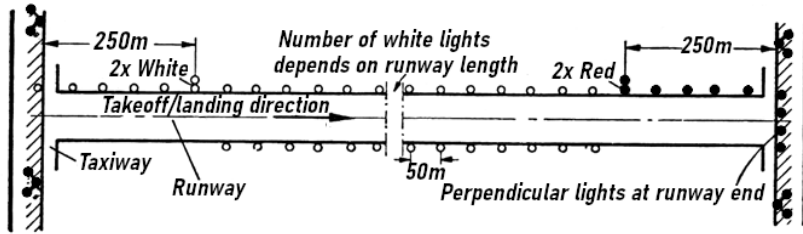


Figure 10: Runway lighting system. The runway is bordered on the left side by white lights every 50 m. The centre of the runway is additionally lined on the right side. The final 250 m are marked by red lights. A doubled white light marks the touchdown point. (14)

place - even if they do not have a Lorenz system. The lighting system is illustrated in Figure 10. The first 250 m of the runway are marked by white or green lights on the left. Two white lights indicate the end of this section and the intended touchdown point. The centre section is marked by white lights on both sides of the runway. The final 250 m are indicated by red lights on the left, with the runway threshold marked by an additional line of red lights.

It should be noted that runway lights can be used by enemy aircraft as navigation landmarks. This includes bombers but also, even more worryingly, British night fighters that are known to loiter around our bases. Runway lights are therefore kept off except in cases of emergency. If any such emergency takes place, you can request the runway lighting to be switched on by firing a red flare when on approach. Always be aware of enemy night fighters in these cases! (13)(14)

5. DANGERS

Flying in difficult conditions with minimal visibility brings its own set of challenges. It is imperative that you familiarise yourself with the dangers

presented in this section, so that you shall not fall victim to them.

5.1. DISORIENTATION

At night, a lack of visual orientation points means that it is easy to become disoriented. Much more than during daytime flying, one needs to watch compass, altimeter and artificial horizon to ensure stable and coordinated flight. Fly more smoothly than you are used to and avoid sudden pulls or turns. Secondly, care should be taken to keep track of your position. If possible, a radio beacon should be tuned into, as discussed in Section 4.1. Alternatively, on moonlit nights and if weather allows it, bodies of water glistening in the moonlight may provide for easily recognisable landmarks.

5.2. ENEMY GUNNERS

All of the bombers used by the enemy feature a number of defensive gunners. Although their firing arcs have blind spots, most notably below the belly, the best defence is to remain unseen. This is helped by the fact that our fighters present a relatively small target compared to British bombers and are hence harder to spot, as well as by our more advanced camouflage compared to the RAF which still relies on dark colour schemes. Still, stealth should not be completely relied on, so care should be taken to minimise the time spent within shooting range of the target. Once detected, many Nachtjäger crews prefer to disengage and find a new victim rather than continue against an alert enemy.

Enemy gunners are especially dangerous when Nachtjagd is performed in concert with searchlights. If you get too close to the enemy, it becomes increasingly likely that your aircraft is similarly caught in a searchlight cone, enabling instant detection by the enemy.

5.3. ENEMY NIGHT FIGHTERS

Lately there have been increased reports of attacks by enemy night fighters, mostly Mosquitoes although other types such as Hurricanes and Bostons are also employed. While some of these loiter around our bases hoping to catch departing or landing aircraft, others have been found to use airborne radar and passive receivers tuned to home in to our radar systems.

To defend against the latter type, it is recommended to not use the Lichtenstein systems for longer than necessary, i.e. only while inside the bomber stream. Against other intruders, vigilance is the best defence. Always scan the area around you for signs of enemy activity, even if none is expected.

6. CONCLUDING REMARKS



"Don't act so silly, kids. Follow the example of the German Nachtjäger." (15)

For years, the RAF has bombed our cities at night, indiscriminately targeting women and children while our men fight on the Russian steppes. Although the balance of strength has variously favoured both the Luftwaffe and the enemy at times, it is hoped that the latest developments in both technology and tactics ensure the final demise of the RAF bombing command.

By familiarising yourself with the operational procedures and technical details presented in this document, you have the opportunity to play a vital role in the destruction of the RAF and ultimately the conclusion of a favourable peace with the Western forces.

For Victory!

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A. OPERATIONAL BREVITY CODE FOR NACHTJAGD

In order to ensure fast and unambiguous communication, Nachtjagd employs a set of pre-arranged code-words in the communication between ground, Bordfunker and pilot. It is imperative that you familiarise yourself with these words, so that you can act upon them with speed and confidence.

Because of slight differences in the terminology used for airborne "Lichtenstein type" interception vs. ground-based "Himmelbett type" interception, the code word lists have been divided into, respectively, Tables 1 and 2.

Table 1: Lichtenstein operational brevity code. (16)

Codephrase	Translation	Meaning
Emil Emil	Emil Emil (name)	Radar contact
Ente XX	Duck XX	Distance to target XX hm.
Frieda	Frieda (name)	Descend
Ich suche	I'm searching	Target lost
Kirchturm Gleicher	Church steeple equal	Target at equal altitude
Lisa	Lisa (name)	Turn 10° left
Marie XX	Mary (name) XX	Distance to target XX hm.
Rolf	Ralph (name)	Turn 10° right
Siegfried	Siegfried (name)	Climb

Table 2: Himmelbett operational brevity code. (16)(17)(18)

Codephrase	Translation	Meaning
Antreten 123	Line up 123	Turn to heading 123 deg.
Börsenschluss	Close of stock market	Ending transmissions
Ente 12	Duck 12	Distance to target is 12 hm (1.2 km)
Express (123)	Express (123)	Speed up (on heading 123°)
Halten	Stop	Slow down
Kapelle 12	Chapel 12	Enemy altitude is 12 hm
Kurier	Courier	Enemy bomber
Lisa	Lisa (name)	Turn 10° left
Marie 12	Mary (name) 12	Enemy ahead, distance 12 hm
Orkan 123	Hurricane 123	Enemy speed is 123 km/h
Postkutsche 123	Stagecoach 123	Enemy course is 123°
Rolf	Ralph (name)	Turn 10° right
Rollbahn 123	Taxiway 123	New course 123°
Sieg Heil	-	Enemy destroyed
Stube	Living room	DuNaJa zone
Stube ab-schliessen	Close the room	Ending DuNaJa guidance
Stube an-schliessen	Join the room	Return to DuNaJa zone
Stube ist zu	Room is on	We've reached the DuNaJa zone
Tiefe Trauer	Deep sorrow	Target lost
Viktor	Victor (name)	Understood / Roger

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Codephrase	Translation	Meaning
Welle aktiv	Wave active	Starting radio transmission

B. LIMITATIONS AND COMPROMISES

Although utmost care was taken to make everything in this campaign as historical as possible, gaps in the documentation have made it necessary to come up with educated guesses. Likewise, certain limitations exist caused by the codebase as well as the desire to have a negligible performance impact. Some of the resulting compromises are detailed below.

B.1. DUNAJA/HIMMELBETT PROCEDURE

Although I have found a great source in (17), programming the exact procedure still raises a few issues. Firstly, (17) explicitly states: "Keine mathematischen Berechnungen am Seeburg-Tisch, sondern blitzschnelles und gefühlsmässiges Handeln!" - "No mathematical calculations on the Seeburg table (the plotting table used by the ground controller), but only lightning-fast and intuitive actions!" Of course, computer code is the exact opposite of this, requiring me to still come up with mathematical calculations for deciding what course the player should fly.

The "intuitive actions" also mean that no fixed procedure is given for bringing the interceptor on the target's tail. In writing my code, I mainly based my solution on the following four sentences:

- "Da die Geschwindigkeit des Jägers oft nur wenig grösser ist, als die Feindmaschine, ist es wichtig, dem Jäger den Kürzesten Weg zum Treffpunkt zu geben." - "Since the fighter's speed is often only slightly faster than the enemy's, it is important to provide the fighter with the shortest way to the interception point."

- "Kann der Jäger erst angesetzt werden, nachdem die Feindmaschine bereits im Bereich des Seeburg-Tisches ist, so wird er dieser ebenfalls so weit wie möglich entgegen geschickt." - "If the fighter can only be guided after the enemy is already within the plotting range of the Seeburg table, it shall likewise be guided as far as possible towards the target."
- "Der Jäger soll dann so geführt werden, dass er bei etwa 6 km Abstand von der Feindmaschine 4 km rechts oder links vor deren Kursverlauf liegt." - "The fighter shall then be guided, so that at a distance of around 6 km from the enemy, it is 4 km to the left or right of the enemy's projected path."
- "Auf diese Weise kann er mit einer entsprechenden Kurve leicht auf Feindkurs hinter die Feindmaschine gebracht werden." - "In this way, with an appropriate turn, it can be easily guided onto the enemy's course, on the enemy's tail."

In short, the fighter is guided on the shortest path to the target, to a point somewhat to the side of the target's flight path. After that, the fighter is told to turn onto the enemy's course and the interception thereafter proceeds with only small corrections. I feel that my solution is a good approximation of this.

B.2. BREVITY CODE

Although most of the used brevity code is correct, there are a few instances where it may deviate from actual usage. These include:

- Although there was a large degree of standardisation, I can only conclude from the cited sources that various codephrases were used to denote the same concept, depending on the phase of the war, the section of the Luftwaffe and likely even the personal preference of the radio operator. Since I use only a single system, this might be incorrect for some time periods. Example: to an-

nounce a kill, "Sieg Heil" was used until 1944, after which it was replaced with "Horrido" although I've also seen a source claiming that the Nachtjagdwaaffe kept the prior terminology.

- As exemplified in (18), there seem to have been some occasional phrases in plain German (e.g. "Kurier kommt ihnen zunächst entgegen") as well as slight deviations from the formal brevity code (e.g. "Richard auf 120"). For reasons of code simplicity, there are no such deviations in this campaign.
- "Marie" vs. "Ente" - According to (16), "Marie" denotes the distance to specifically a target straight ahead and "Ente" is used for distance to target in general. However (17) and (18) seem to use Marie in a more general sense. I use the distinction made in (16).
- "Berühren Sie" - I have found no sources denoting the exact phrasing used when fighter and bomber were so close that no further guidance was possible (because the dots on the Seeburg table had merged), except that it must've been communicated. Since (16) gives "berühren" for "visual contact on enemy aircraft and within firing range," the codephrase "berühren Sie," i.e. "make contact" seemed a plausible choice.