Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

NLR-CR-2010-236-Rev

Effects of runway extension Geilenkirchen

Study of impact on noise, spatial planning and obstacle limitation surfaces

Revised edition

R.H. Hogenhuis, A. Kurlanc, J. Scheele-Goedhart and S. Zeelenberg

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Executive summary

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Problem area
This report describes the effects of a possible runway extension of the NATO airbase in Geilenkirchen, Germany. This runway extension will affect the spatial planning in the vicinity of the airbase, the noise load produced by aircraft flying to and from the airbase and the obstacle limitation surfaces around the airbase that ensure safe flight operations to and from the base.

Description of work
The report describes the noise load and peak noise levels after the runway extension and compares these results with the current situation. Also the obstacle limitation surfaces are investigated for the situation with runway extension and compared with the current surfaces. The effects of the runway extension on the spatial planning in the vicinity of the airbase are studied in order to find out what objects, such as roads and rivers, are in the runway extension area, what the estimated costs of the runway extension are and what the estimated required time for the runway extension is.

Results and conclusions
This study shows that the noise load in the Netherlands will decrease due to the runway extension, while the noise load in Germany increases. The effect on the peak noise level differs per flight procedure and per location. Not all peak noise levels do increase in Germany and not all peak noise levels do decrease in the Netherlands. The largest increases in peak noise levels are found in the German village of Teveren for departures and approaches to and from the Netherlands.
In case it is decided to extend the runway, the extension is not expected to be finished before 2020 and its costs are estimated to be 45 to 90 million Euros.
After the runway extension, the approach surface for approaches from the west, the take-off climb surface for departures to the east, the inner horizontal surface and the conical surface are shifted 900 metres eastward. Therefore an assessment has to be done to verify whether any objects penetrate the shifted surfaces.

Applicability
The presented study offers an approach to investigate the effects of a runway extension on the noise impact in the vicinity of the NATO airbase in Geilenkirchen, on the spatial planning and on the obstacle limitation surfaces.

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Samenvatting (Nederlands)

In dit rapport worden de effecten van een verlenging met 900 meter in oostelijke richting van de huidige baan van de NAVO basis te Geilenkirchen onderzocht. Het doel van de baanverlenging is het mogelijk maken van alternatieve vliegroutes van en naar de basis. Deze aangepaste routes zouden moeten leiden tot een lagere geluidbelasting in de omgeving van de dorpen Schinveld en Brunssum. De baanverlenging zal niet alleen invloed hebben op de geluidbelasting in de omgeving van de basis, maar beïnvloedt ook de ruimtelijke ordening en de obstakelvrije vlakken.

De Duitse regering heeft een analyse uit laten voeren om deze effecten te onderzoeken. Deze analyse toont aan dat het geluid ten gevolge van vliegverkeer van en naar de basis zal toenemen op Duits grondgebied en dat het aanleggen van de verlengde baan inclusief alle benodigde procedures niet voor 2020 zal zijn afgerond. Omdat verwacht wordt dat de baanverlenging tot een reductie van het vliegtuiggeluid zal leiden op Nederlands grondgebied heeft het Nederlandse ministerie van defensie opdracht gegeven voor het uitvoeren van een second opinion om de resultaten van de Duitse analyse te controleren. Dit rapport beschrijft de resultaten van deze second opinion.

Om de geluidbelasting voor de huidige situatie en de situatie met baanverlenging te bepalen is gebruik gemaakt van de volgende gegevens:

- Vliegveldgegevens; hiermee wordt de ligging van de huidige en de verlengde baan beschreven.
- Geluid- en prestatiegegevens van vliegtuigen; hieruit volgt bijvoorbeeld de stuwkracht van een vliegtuig gedurende een vlucht en de geluidproductie van een vliegtuig.
- Vliegroutes; hiermee wordt het grondpad van een vliegbeweging gegeven. Voor dit onderzoek zijn routes gemodelleerd van en naar zowel de huidige als de verlengde baan.
- Verkeersgegevens; hiermee wordt informatie verschaft over het verkeer van en naar een luchthaven gedurende het jaar.

Na de baanverlenging zullen niet alle vliegroutes wijzigen. Een aantal routes zal hetzelfde blijven om de toename van de geluidbelasting boven Duitsland ten gevolge van de baanverlenging te beperken. Daarom zijn alleen de volgende veranderingen van routes meegenomen in dit onderzoek:

- De naderingsroute over Nederland wordt 900 meter naar het oosten verplaatst ten opzichte van de huidige route. Dit geldt zowel voor landingen tot stilstand als voor landingen die deel uitmaken van een doorstart (go-around of touch and go procedure).
- De startroute die wordt gebruikt door vliegtuigen die vanuit stilstand vertrekken in de richting van Nederland wordt 900 meter naar het oosten verplaatst.
- De startroute die wordt gebruikt door vliegtuigen die een doorstart (go-around of touch and go procedure) richting Duitsland uitvoeren wordt 900 meter naar het oosten verplaatst.

De geluidbelasting is berekend voor het jaar 2008, zowel met de huidige baan als ook met de verlengde baan. De berekeningen geven aan dat de geluidbelasting in Nederland lager wordt ten koste van een toename in de geluidbelasting boven Duitsland. De geluidbelasting is uitgedrukt in de vorm van een 35 Ke (Kosten eenheden) contour. De oppervlakte binnen deze contour neemt aan de Nederlandse kant van de grens met 0.5 km^2 (22%) af, terwijl de oppervlakte aan de Duitse zijde met 0.2 km^2 (3%) toeneemt.

Na de baanverlenging zullen de piekniveaus die veroorzaakt worden door een aantal van de vliegbewegingen van en naar de basis toenemen in de Duitse dorpen Teveren en Geilenkirchen. In Teveren nemen de piekniveaus veroorzaakt door starts en landingen over Nederland toe met 10.5 tot 22.2 dB(A). In Geilenkirchen resulteren starts in oostelijke richting die een onderdeel zijn van een touch and go of go-around procedure in een toename met 2.2 tot 2.5 dB(A). Verder toont deze studie aan dat de piekniveaus veroorzaakt door starts uit stilstand over Nederland in Schinveld en Brunssum met 0.8 tot 2.9 dB(A) afnemen. Voor naderingsprocedures over Nederland varieert het effect van de baanverlenging per locatie. Het effect op de berekende piekniveaus in Schinveld en Brunssum varieert van een afname met 3.3 dB(A) tot een toename met 1.5 dB(A).

Als de huidige baan verlengd wordt, zal dit gevolgen hebben voor de ruimtelijke ordening in de omgeving van de vliegbasis. Uit het onderzoek naar deze effecten blijkt dat de verlengde baan en taxibaan een rivier met beschermde status, een natuurgebied, een pijpleiding, twee hoofdwegen, een aantal kleine wegen en fietspaden en een sportveld kruisen.

Alvorens de baanverlenging kan worden uitgevoerd zal een uitgebreide planningsprocedure doorlopen moeten worden voorafgegaan door een procedure om het ruimtelijke ordeningsbeleid aan te passen. Afhankelijk van het aantal beroepsprocedures zal dit tussen de twee en zeven jaar duren. Voordat de formele procedures gestart kunnen worden moet eerst een voorstel en alle ondersteunende documentatie worden ingediend. Verder dient te worden opgemerkt dat in het gebied van de baanverlenging een hoogteverschil van 15 meter bestaat.

De kosten van de baanverlenging worden op 45 tot 90 miljoen euro geschat en de verwachting is dat de aanleg van de baan inclusief alle voorafgaande procedures niet voor 2020 afgerond zal zijn.

Het verlengen van de baan beïnvloedt de ligging van verschillende obstakelvlakken. De inner horizontal en conical vlakken worden met 900 meter naar het oosten verlengd. Verder worden het take-off climb vlak voor starts over Duitsland en het naderingsvlak voor landingen over Nederland 900 meter naar het oosten verschoven. Het is mogelijk dat deze nieuwe obstakelvlakken nieuwe objecten bevatten. Deze objecten zullen als nieuwe obstakels onderzocht moeten worden.

De locatie van het take-off climb vlak voor starts naar het westen en de locatie van het naderingsvlak voor landingen vanuit het oosten zullen niet veranderen na de baanverlenging. Ook de obstakelvrije zone voor naderingen vanuit het oosten verandert niet. Omdat er geen ILS beschikbaar is voor naderingen vanuit het westen is de obstakelvrije zone voor deze naderingen niet onderzocht.

Summary (English)

This report investigates the effects of an extension of the current runway of the NATO airbase in Geilenkirchen with 900 metres to the east. The goal of this extension is to allow aircraft flying to and from the base to make use of different routes which in turn should lead to a reduction of the noise load near the villages of Schinveld and Brunssum. The runway extension will not only influence the noise load around the airbase, but also has an effect on the spatial planning and on the obstacle limitation surfaces.

At the request of the German government an analysis was carried out in order to investigate these effects. This analysis shows that the noise impact near the airbase will increase on German territory and that the construction of the extended runway and all required procedures will not be finished before 2020. Since the runway extension is expected to lead to a reduction of the noise impact in the Netherlands, the Dutch ministry of defence requested a second opinion in order to verify the results of the German analysis. This report presents the results of this second opinion.

In order to calculate the noise load for the current situation and with the extended runway the following data is used:

- Airport data; this describes the location of both the current and the extended runway.
- Aircraft noise and performance data; this defines for instance thrust settings of an aircraft during flight and the noise production of an aircraft.
- Flight routes; this defines the ground path of a flight movement. Routes are modelled for flights to and from the current and the extended runway.
- Traffic data; this provides information about the traffic during the year.

Not all flight routes will change after the runway extension. Several routes remain unchanged in order to limit the increase of the noise load above German territory. Therefore only the following changes in flight routes are taken into account in this research:

- The landing route over the Netherlands is moved 900 metres to the east compared to the current landing route. This holds for full-stop, go-around and touch and go landing procedures.
- The take-off route that is flown by aircraft that start from standstill from the extended runway over the Netherlands is moved 900 metres eastward from the current take-off point.
- A take-off over Germany from the extended runway that is part of a touch and go or go-around procedure, starts 900 metres eastward from the current starting point.

Using the input data the noise load is calculated for the year 2008 with the current runway and for the year 2008 with the extended runway. The calculations indicate that the noise load on Dutch territory is reduced at the expense of an increase in the noise load on German territory. The noise load is expressed using the 35 Ke (Kosten unit) contour. The contour area on the Dutch side of the border becomes 0.5 km^2 (22%) smaller, while the contour area on the German side of the border becomes 0.2 km^2 (3%) larger after the runway extension.

After the runway extension the peak noise levels due to some of the flight movements in the German cities of Teveren and Geilenkirchen will increase. In Teveren the peak noise levels caused by take-offs and approaches over the Netherlands increase with 10.5 to 22.2 dB(A). In Geilenkirchen the peak noise levels produced by take-off procedures (climb outs) that are part of (are preceded by) a touch and go or go-around from the west increase with 2.2 to 2.5 dB(A). Furthermore this study shows that the calculated peak noise levels in Schinveld and Brunssum caused by aircraft starting from standstill become 0.8 to 2.9 dB(A) lower. For landing procedures over the Netherlands, the effect of the runway extension on the calculated peak noise levels in Schinveld and Brunssum varies between a 3.3 dB(A) decrease and a 1.5 dB(A) increase.

If the current runway is to be extended, this will also have an impact on the spatial planning nearby the airbase. These effects have been studied, which showed that the extended runway and the taxiway will cross an environmentally protected river, a nature reserve, a pipeline, two major roads, a few minor roads and cycle paths and a sports field.

The runway extension will require an extensive planning procedure, preceded by a procedure to change spatial planning policy. Depending on the amount of appeal procedures, procedures will take between two and seven years and before the start of the formal procedures the extension proposal and all supporting documentation have to be provided. Furthermore it should be noted that a height difference of up to 15 metres exists at the location of the runway extension. The costs of the runway extension are estimated to be 45 to 90 million Euros. The construction of the extended runway including the preceding procedures is not expected to be completed before 2020.

Lengthening the runway will influence the location of several obstacle limitation surfaces. The inner horizontal and conical surfaces are extended 900 metres eastward. Furthermore, the take-off climb surface for departures over Germany and the approach surface for arrivals over the Netherlands are shifted 900 metres eastward. It is possible that new objects will be included in one or more of the shifted surfaces. These objects will have to be assessed as new obstacles.

The location of the take-off climb surface for departures to the west and the approach surface for arrivals from the east will not change after the runway extension and also the obstacle free zone for approaches from the east remains the same after the runway extension. Because there is no ILS operation for approaches from the west the obstacle free zone for these approaches is omitted.

Contents

Abbreviations

ATRA	Air Traffic Regulation Act
AWACS	Airborne early Warning And Control System
BauGB	Baugesetzbuch
BMVg	Bundesministerium der Verteitigung
BSB	Bauschutzbereich
dB(A)	decibel, with A-weighted frequency filter
DTHR	Displaced Threshold
EIA	Environmental Impact Assessment
FANOMOS	Flight Track and Aircraft Noise Monitoring System
FluglärmG	Gesetz zum Schutz gegen Fluglärm
ILS	Instrument Landing System
Ke	Kosten unit
LBAG	Luftfahrt Bundesambt
LBO	Landesbauordnung
LLärmV	Landeplatz-Lärmschutz-Verordenung
LPLG	Landesplanunggesetz
LROG	Landesraumordnungsgesetz
LuftSiG	Luftsicherheitsgesetz
LuftVG	Luftverkehrsgesetz
LuftVO	Luftverkehrs-Ordnung
LuftVZO	Luftverkehrs-Zulassungs-Ornung
MP	Measurement Post
NATO	North Atlantic Treaty Organization
NLR	National Aerospace Laboratory
NPD	Noise Power Distance
OFZ	Obstacle Free Zone
OLS	Obstacle Limitation Surface
PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
RWY	Runway
ROG	Raumordnungsgesetz
STHR	Shifted Threshold
THR	Threshold

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1 Introduction

Since 1982 radar aircraft are stationed at the NATO airbase in Geilenkirchen. These so-called Airborne early Warning And Control System (AWACS) aircraft are used to monitor the airspace. The airbase is situated in Germany, just outside the border of the Netherlands. Due to the location of the base, almost 50% of all aircraft take-off and landing procedures take place over the south of the Netherlands and since most of the aircraft that fly to and from the base have a high noise production compared to modern civil aircraft, the presence of the base results in nuisance in villages near the base.

In 2009 Landrum & Brown wrote a report that discussed several options to reduce the annoyance caused by aircraft flying to and from Geilenkirchen (Ref. [1]). One of these options is the extension of the current runway with 900 metres to the east. The goal of this extension is to reduce the noise impact on the Dutch side of the border.

After the publication of the Landrum & Brown report, the German government requested a separate analysis on the effects of the runway extension. The German analysis indicates that the noise impact near the airbase will increase on German territory and that the construction of the extended runway and all required procedures will not be finished before 2020. Since the runway extension is expected to lead to a reduction of the noise impact in the Netherlands, the Dutch government requested a second opinion in order to verify the results of the German analysis. This report gives the results of this second opinion and presents the effect of the runway extension on noise, spatial planning and obstacle limitation surfaces.

An aspect of the runway extension that will not be discussed in the remainder of this report is the effect of the extension on the approach lights. These are the lights that are placed in front of a runway in order to provide guidance for approaching aircraft. Due to the fact that the landing point of approaches from the west is shifted to the east, the approach lights have to be modified. A complicating factor is that it is not possible to place conventional approach lights on the runway. However, it is possible also to install approach lights in case of a so-called displaced threshold without blocking the runway in front of the displaced threshold. Since the runway will be extended in eastern direction, the current conventional approach lights on the east side of the current runway have to be modified to prevent them to become a physical obstacle for aircraft that take-off from the shifted take-off point. The approach lights can not be placed in front of the runway since the landing point of approaches from the east will not be shifted. Similar to the situation on the western runway end, this means that the approach lights have to be installed in such a way that they do not block the runway for departing aircraft.

An example of a runway with a displaced threshold is the Zwanenburgbaan (18C-36C) on Amsterdam Airport Schiphol. This runway has a threshold that is displaced with 450 metres. Despite this displacement this runway has all required lights to be operational in low visibility conditions.

1.1 Document structure

Chapter 2 gives a description of the noise assessment that analyses the changes in the noise load and peak noise levels due to the extension of the runway. This chapter describes the used method and the results of the noise assessment. In chapter 3 the effects of the runway extension on the spatial planning are discussed and in chapter 4 the changes in the obstacle limitation surfaces are described. Finally chapter 5 will present the conclusions from the preceding chapters.

2 Noise assessment

An extension of the runway of Geilenkirchen airbase offers the possibility to modify the existing flight routes in such a way that the impact on the local communities is reduced. This chapter will discuss the effect of changing the flight routes on the noise load and on the peak noise levels nearby the airbase.

2.1 Description of the noise load assessment

The calculation of the noise load is carried out according to the Dutch regulations to calculate the noise load (Ref. [2]). These regulations prescribe that the noise load produced by aircraft flying to and from the base is calculated using the so-called Kosten unit (Ke). The noise zone on the Dutch side of the border near the base is defined with this metric, more in particular with the 35 Ke contour. In Germany a different noise metric is used to express the yearly noise load. However, it should be noted that the chosen metric is not expected to have a large influence on the outcome of this study, since the goal of this noise assessment is to show how the noise load changes due to the runway extension. The calculated effects are expected to be comparable for a noise load expressed in Ke and in for instance Lden.

For the calculations several input parameters are required, including:

- Airport data; this describes the location of the runway(s) of an airport.
- Aircraft noise and performance data; this defines for instance thrust settings of an aircraft during flight and the noise production of an aircraft.
- Flight routes; this defines the ground path of a flight movement.
- Traffic data; this provides information about the traffic during the year.

In the remainder of this paragraph these parameters will be discussed.

2.1.1 Airport data

For the calculation of aircraft noise the location of the runways must be known. The airport data defines the starting and end point of all considered runways. In this study calculations are performed with the existing runway and with a runway that is extended with 900 metres to the east. Figure 10 (on page 38) shows the location of the current and the extended runway.

2.1.2 Aircraft noise and performance data

The aircraft performance data is used to model the aircraft performance. For several procedures so-called performance profiles are defined. These profiles define parameters such as altitude, speed and thrust as a function of the travelled distance. The noise data is provided in so-called noise-power-distance (NPD) tables. These tables are used to determine the noise level as a function of the thrust of the aircraft and the distance between the aircraft and the observer.

Both the noise and performance data is not affected by the lengthening of the runway and therefore the same data is used as for the calculation of the yearly noise load on the Dutch side of the border.

2.1.3 Flight routes

In order to determine where aircraft noise is heard, the flight route or ground path of the aircraft has to be defined. Flight routes can be determined using radar, however for this research the use of radar data is not possible for two reasons:

1. There is not enough information available for flights over Germany.
2. No radar data is available for aircraft flying to and from the extended runway since this runway does not exist.

For these reasons modelled flight routes are used to model the ground paths of aircraft flying to and from the current and extended runway. A modelled route consists of a nominal or average route and information about the distribution of flights around this nominal route; the so-called route dispersion.

The modelled routes are based on radar data of aircraft flying to and from Geilenkirchen. In two cases more than one route is defined in order to give a more realistic representation of the actual flight routes to and from the runway. This is for instance the case for landing routes over Germany. In total 11 routes are defined for this study:

- A take-off route over the Netherlands from the current runway.
- A take-off route over the Netherlands from the extended runway. This route is extended 900 metres to the east compared to the current take-off route over the Netherlands.
- A landing route over the Netherlands to the current runway.
- A landing route over the Netherlands to the extended runway. The landing point of this route has moved 900 metres eastward compared to the landing route to the current runway.
- Two take-off routes over Germany from the current runway.

- One changed take-off route over Germany from the extended runway. Only one take-off route from the extended runway is required. Training flight departures (climb outs) from the extended runway that are part of (are preceded by) a touch and go or go-around (from the west) are moved 900 metres eastwards compared to the current situation, so only the route of aircraft that use this procedure is modified. Training flight departures always follow the southern departure route (see Figure 4 for the location of this take-off route). Departures from standstill start at the same location on the current and on the extended runway. Therefore these flight movements do not require a different route after extending the runway.
- Four landing routes over Germany to the current runway. Since the landing point of the current runway is the same as for the extended runway; these routes are the same for both runways. Since the landing procedure from the east is not changed, the take-off procedures (climb outs) over the Netherlands that are part of (are preceded by) a touch and go or go-around (from the east) are the same as for the current runway.

Figure 1 shows radar tracks of several approaches to the airbase from the east. The figure also gives a rough indication of the location of the runway and the location of the city of Geilenkirchen.

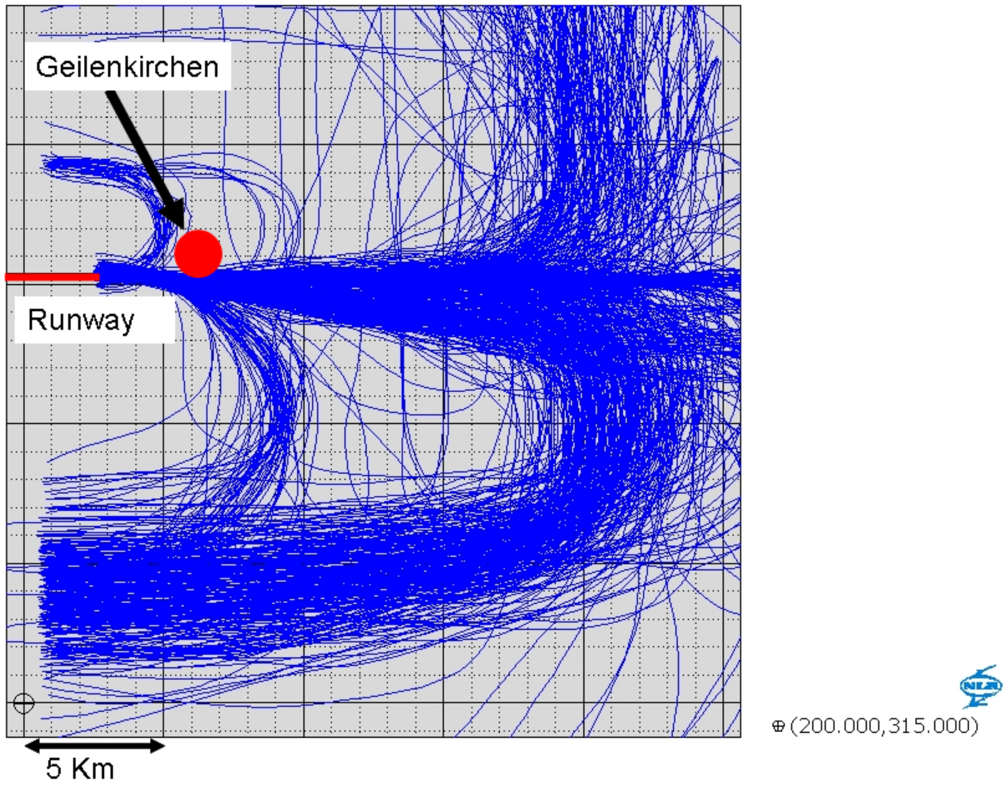

Figure 1: Radar tracks of landing aircraft from the east

Four landing routes over Germany are modelled using the radar data shown in Figure 1:

- A route for flight movements from the north with a turn close to the runway.
- A route for flight movements from the south with a turn close to the runway.
- Two routes for flight movements that approach from the east without making a turn in the vicinity of the runway. Since some of the landing aircraft fly straight to the runway while other landing aircraft approach under an angle, two routes are used.

Most of the flight movements on a route without a turn nearby the runway initially come from the north or south before they make a turn to the west. These turns are made at such a distance from the runway that these turns do not affect the location of the 35 Ke contours. Therefore these turns are not modelled. Figure 2 shows the modelled landing routes that were derived from the radar data.

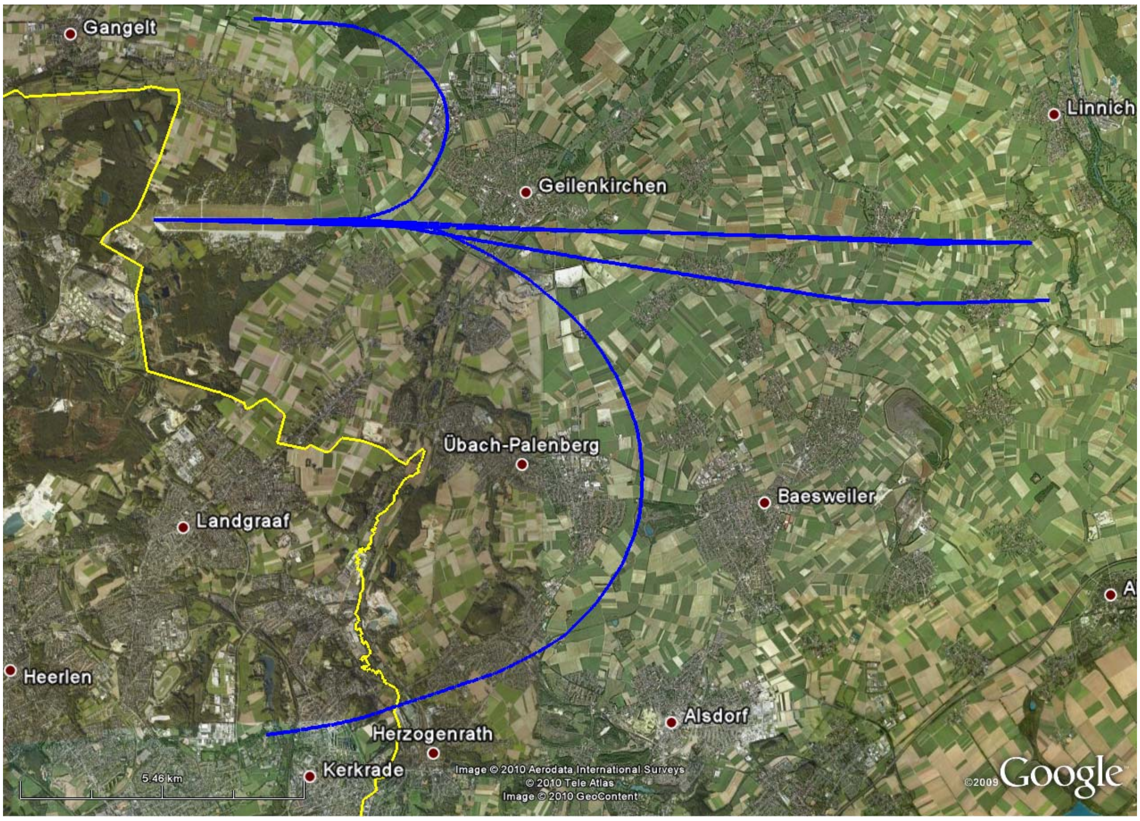

Figure 2: Modelled landing routes to Geilenkirchen from the east

The other take-off and landing routes are determined in a similar way as the landing routes from the east. Modelled routes to and from the extended runway are based on the routes to and from the current runway, taking the location of villages nearby the airbase into account. The routes to and from the extended runway over the Netherlands for instance are modelled in such a way that they do not overfly the villages of Schinveld and Brunssum. This can be seen in Figure 3. This figure shows the take-off (blue line) and landing (red line) routes over the

Netherlands. Both routes are located in between the villages of Schinveld and Brunssum and do not turn north or south before passing the villages to make sure that the villages are not over flown.

Figure 3: Modelled take-off and landing routes over the Netherlands to/from extended runway

Figure 4 shows the take-off routes in eastern direction from the current and the extended runway. The blue lines represent the current flight routes, while the black line shows the take-off route to the south that is moved 900 metres eastward. As discussed before, the touch and go and go-around take-off route will change after the runway extension. Aircraft that use the route straight-out to the east will continue to take-off from the same point, leaving this route unchanged.

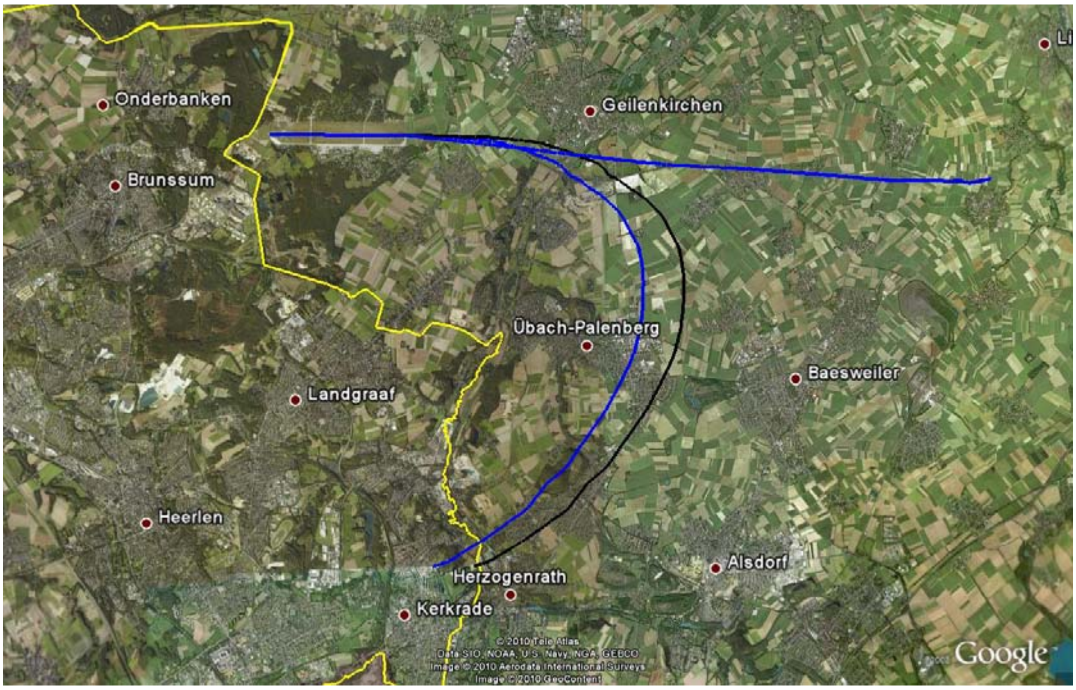

Figure 4: Take-off routes over Germany from the current and extended runway

It is assumed that the modified route is shifted 900 metres eastward (see Figure 4). In practice it might be possible that pilots can turn to the south earlier in order to avoid flying nearby the city of Geilenkirchen. Since this is not taken into account, the calculation with this route is a worst case-scenario.

2.1.4 Traffic data

To perform a noise load calculation, traffic information is required. The traffic information includes for each flight during a year:

- The aircraft types that are used;
- The time when flight movements took place;
- The routes the aircraft followed;
- The flight procedure used;
- To or from what runway the aircraft flew.

The aircraft type has to be known since different aircraft types have a different noise production (see paragraph 2.1.2). The time when a flight movement takes place is required for the calculation of the Ke noise load, as the noise impact of flights that take place between 18:00 o'clock and 08:00 o'clock is calculated with a penalty factor. The value of this penalty factor differs depending on the time. In practice the use of a penalty factor means that a flight movement that takes place between 18:00 o'clock and 08:00 o'clock has a larger contribution to the total noise load compared to a similar flight movement that takes place outside this time frame. The information about the runway and route is relevant since this determines where the aircraft noise is heard (see respectively paragraph 2.1.1 and 2.1.3).

To calculate the noise load, the number of flight movements for each combination aircraft type, route, flight procedure and runway that occurs during a year has to be known. Appendix A provides an overview of the number of flight movements over the Netherlands and Germany per procedure and gives an indication of the division of flight movements over the flight routes.

Each year the National Aerospace Laboratory (NLR) calculates the yearly noise load on the Dutch side of the border. For this purpose the airbase provides the required traffic information of flight movements over Dutch territory. For this study the traffic on the Dutch side of the border for the year 2008 is used.

Since the noise load on the German side of the border is not calculated by the NLR, no detailed traffic information is available for aircraft flying to and from Germany. The only data on the traffic on the German side of the border available is the daily number of take-offs, landings and touch and go or go-around procedures to the east. This information is provided by the airbase. This means that the fleet mix and the flight times are unknown.

Since no detailed information about the traffic on the German side of the border is known, the following assumptions had to be made in order to generate traffic data for aircraft flying over Germany:

- Since training flights fly circuit routes, it is known that every training landing over the Netherlands results in a take-off over Germany and vice versa. It is assumed that the flight time is limited so that the penalty factor is equal for both training flights over the Netherlands and over Germany.
- It is assumed that the fleet mix and the distribution of flight movements over the day are equal for operational flights over the Netherlands and Germany. This means that the average penalty factor is equal for operational flights over the Netherlands and Germany.
- It is assumed that the yearly number of take-off and landing procedures is equal. Since the available data indicate a small difference between the total number of take-off and landing procedures; the values of take-off and landing procedures over Germany is corrected. The number of take-off and landing procedures is set equal to the average of both numbers.
- As shown in Figure 1, different landing routes exist. The division of traffic over the different routes is based on the number of aircraft that used each of the different routes during the year 2008. The number of movements per route is analysed separately for operational and training flights. Appendix A provides an overview of the division of flight movements per route.
- For operational flights, it is assumed that the fleet mix and the division of flight movements over the day are equal for each route.

For each flight movement the route must be specified. The division of flight movements over the different routes is done using the following principals:

- A landing on the extended runway over the Netherlands lands 900 metres eastward from the current landing point and therefore it makes use of a modified route. This holds for full-stop, go-around and touch and go landing procedures.
- A take-off from standstill from the extended runway over the Netherlands takes off 900 metres eastward from the current take-off point and therefore it makes use of a modified route.

- A take-off over the Netherlands from the extended runway that is part of a touch and go or go-around procedure uses the current flight route.
- A landing on the extended runway over Germany has the same landing point as a landing on the current runway and therefore uses the same route as a landing to the current runway. This holds for full-stop, go-around and touch and go landing procedures.
- A take-off from standstill from the extended runway over Germany has the same starting point as a take-off from the current runway and therefore uses the same route as a take-off from the current runway.
- A take-off over Germany from the extended runway that is part of a touch and go or go-around procedure, starts 900 metres eastward from the current starting point. Therefore these procedures will make use of an adapted flight route.

2.2 Description of the peak noise level assessment

The extension of the runway leads to modifications in some flight routes. This will not only affect the yearly noise load, but also the peak noise levels caused by individual flight movements. In order to calculate the peak noise levels the same type of input data is used as for the noise load calculations (see paragraph 2.1).

The main differences between a noise load calculation and a peak noise level calculation in this study are:

- The noise load is expressed with the unit Ke, while the peak noise levels are expressed using the dB(A) noise level.
- The noise load is calculated on a grid, while the peak noise levels are determined in a limited number of points.
- In order to calculate the noise load the noise production of all flight movements over a year is summed, while the peak noise levels are calculated for single flight movements.

The peak noise levels are calculated in nine points: three points in Schinveld, two points in Brunssum, two points in Teveren and two points in Geilenkirchen. All five points on Dutch territory correspond with the locations of measurement posts of the local noise monitoring network; namely measurement posts 172, 175, 184, 185 and 187 (see Ref. [3] for the locations of these measurement posts). In Germany the following locations are used:

- Teveren north (the crossing of Bocketzgracht and Kirchstraße).
- Teveren centre (Schmiedgasse).
- Geilenkirchen south (the crossing of Am Mausberg and Am Sonnenhügel).
- Geilenkirchen centre (Herzog-Wilhelm-Straße, near number 73).

Figure 5 shows the location of the analysed points. The locations of the measurement posts are denoted as MP followed by the number of the measurement post.

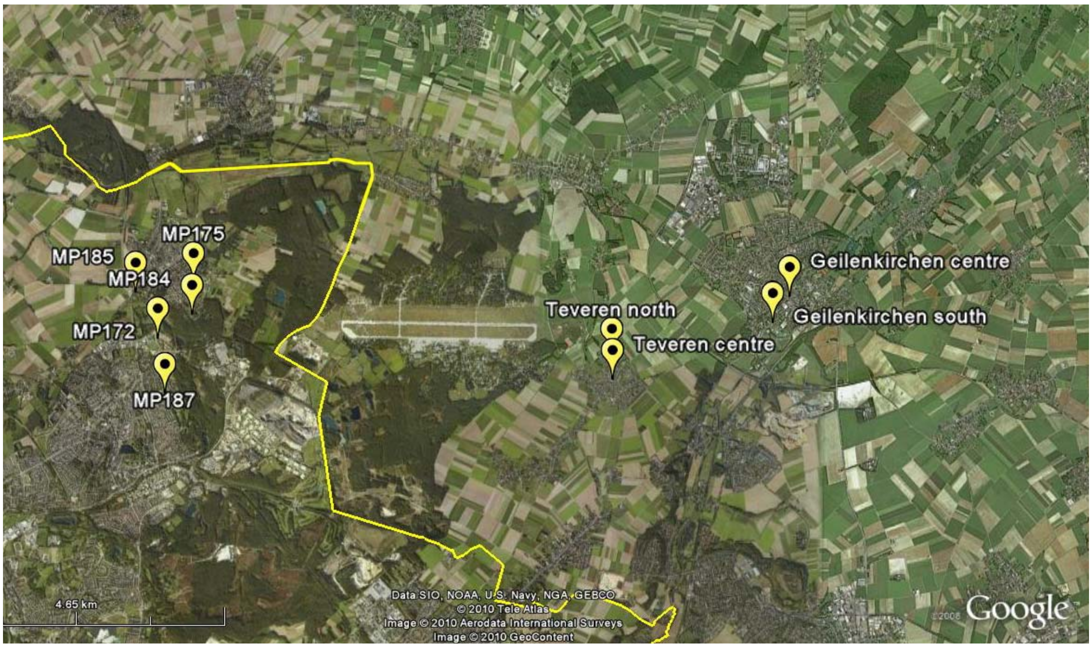

Figure 5: Locations of peak noise level analyses

In order to show the effect of the modified flight routes on the peak noise levels, the peak noise levels have been analysed for the following cases:

- A take-off from standstill over the Netherlands from the current and the extended runway.
- A full-stop landing over the Netherlands to the current landing point and to the landing point 900 metres eastward.
- A take-off over Germany that is part of a touch and go or go-around procedure from the current and the extended runway.

This means that the peak noise levels are calculated for six cases. The calculations are done for flight movements with an AWACS E3TF over the modelled take-off and landing routes over the Netherlands shown in Figure 3 and the modelled landing route over Germany shown in Figure 4. The AWACS E3TF is the type of aircraft that is most used at Geilenkirchen airbase. It should be noted that the calculated peak noise levels are determined in a few points for one specific aircraft type. Each peak noise level is calculated using one specific route and flying one specific procedure.

The peak noise levels give an indication of the effect of the extended runway on the peak noise levels in the considered points. In practice the actual peak noise levels will vary per flight and therefore the calculated noise levels will not by definition be equal to the actual noise levels. This is caused by the fact that in practice the flight route of each flight movement is different, that the weather conditions change over time and also by the fact that the noise calculations do not take shielding due to objects on the ground into account. Shielding has the largest effect on sound levels produced by a noise source close to the ground, which means that especially the peak noise levels in Teveren centre, caused by arrivals and departures over the Netherlands might be overestimated. This can be explained by the fact that the noise source (the aircraft) is on the ground in the vicinity of Teveren and the fact that there are several objects (houses) in between the aircraft and the point in the centre of Teveren.

2.3 Noise calculation results

Combining all input data described in the previous paragraph, the noise impact of aircraft flying to and from the airbase can be calculated. Both the yearly noise load around Geilenkirchen airbase and the peak noise levels at several locations near the airbase are determined for both the current situation and the situation with an extended runway. The results of these calculations are presented in paragraphs 2.3.1 and 2.3.2.

2.3.1 Noise load results

The noise load is calculated in order to show the noise produced by all aircraft movements to and from Geilenkirchen airbase during the year. These calculations take traffic over the Netherlands and over Germany into account. As discussed in paragraph 2.1, the noise load is expressed using the 35 Ke contour. Figure 6 shows both the contour for the current situation and for the expected noise load after the runway extension.

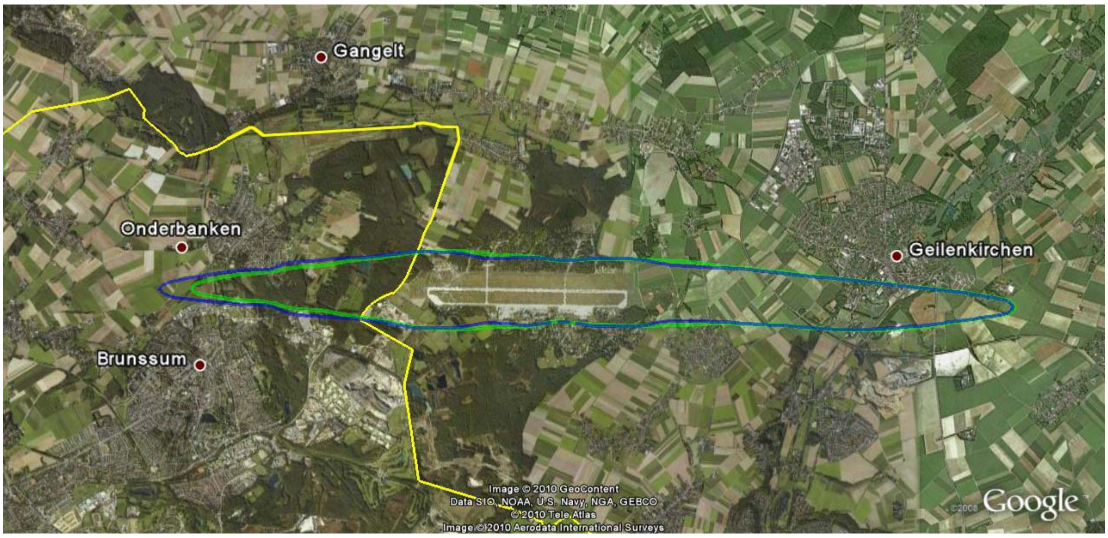

Figure 6: Comparison of 35 Ke contours for the current and with the extended runway

The blue contour represents the noise load of the year 2008 with the current runway. The green contour what the noise load would have been when the extended runway would have been used in 2008. The main conclusions from this figure are:

- The noise load nearby Schinveld and Brunssum is reduced and therefore the 35 Ke contour is smaller than the contour for the 2008 situation with the current runway.
- The noise load increases at approximately 900 metres east of the western end of the runway. This increase is caused by the fact that approaches from the west land 900 metres more to the east which results in a slightly wider contour.
- The noise load nearby the location where the runway is extended increases. This can be explained by the fact that aircraft taking off in western direction start 900 more to the east and by the fact that landing aircraft from the west touch down at a point 900 metres east of the current landing point.
- The runway extension only has a limited effect on the contour near the city of Geilenkirchen. The contour is slightly larger in this area. The fact that the effect is limited in this area can be explained by the fact that the runway extension only has an effect on approximately 8% of the total number of flight movements over German territory, namely the take-offs out of a touch and go or go-around (see Appendix A for an overview of the number of flight movements and the division of flight movements over the different routes).

The changes in the noise load will affect the area of the contour. Table 1 summarizes the contour area for the situation with the current runway and with the extended runway. The contour area is given for the contour on Dutch territory, on German territory and for the total contour.

Table 1: Area of 35 Ke contour with and without runway extension (in km^2)

	Current runway	Extended runway	Absolute difference (km^2)	Relative difference
Netherlands	2.3	1.8	-0.5	- 22%
Germany	7.9	8.1	+0.2	+ 3%
Total	10.2	9.9	-0.3	- 3%

The table shows that the total contour area is reduced with 0.3 km^2 (3%) after the runway extension. This decrease is caused by the 0.5 km^2 (22%) reduction in contour area on the Dutch side of the border. The area of the contour on German territory increases with 0.2 km^2 (3%) after the runway extension. This increase is caused by a wider contour at the location of the runway extension and by the fact that the contour is extended slightly to the east. The latter change is small compared to the first which means that the effect on the noise load near the city of Geilenkirchen is limited compared to the effect on the noise load in Teveren.

2.3.2 Peak noise level results

As discussed before the extension of the runway results in modified flight routes. This will not only affect the yearly noise load, but also the peak noise levels caused by individual flight movements. The table below shows the results of the analysis of the peak noise levels. The peak noise levels are expressed in dB(A). The following procedures have been analysed:

- A take-off from standstill over the Netherlands.
- A full-stop landing procedure over the Netherlands.
- A take-off over Germany that is part of a touch and go or go-around procedure.

All peak noise levels are calculated for the situation with the current and with the extended runway at the points shown in Figure 5. The results are summarized in Table 2.

Table 2: Peak noise levels in dB(A)

	172	187	175	184	185	TN	TC	GS	GC
TO-SS-CR-NL	90.8	81.8	89.4	91.2	89.3	67.1	64.6	46.7	45.4
TO-SS-ER-NL	87.9	81.0	87.5	89.6	86.7	83.9	75.1	51.4	49.7
Difference	**-2.9**	**-0.8**	**-1.9**	**-1.6**	**-2.6**	**16.8**	**10.5**	**4.7**	**4.3**
LA-SS-CR-NL	101.6	71.8	89.0	106.8	95.0	57.1	53.5	29.9	28.6
LA-SS-ER-NL	99.8	73.3	89.3	103.5	94.1	79.3	68.1	35.5	33.4
Difference	**-1.8**	**1.5**	**0.3**	**-3.3**	**-0.9**	**22.2**	**14.6**	**5.6**	**4.8**
TO-TG/GA-CR-GER	53.2	52.7	56.9	57.3	50.8	95.5	90.1	90.2	86.9
TO-TG/GA-ER-GER	47.8	47.7	50.7	50.9	46.0	94.0	87.9	92.4	89.4
Difference	**-5.4**	**-5.0**	**-6.2**	**-6.4**	**-4.8**	**-1.5**	**-2.2**	**2.2**	**2.5**

Explanation:

TO	=	Take-off	TG/GA	=	Touch and go or go-around
SS	=	Standstill	GER	=	(over) Germany
CR	=	Current runway	TN	=	Teveren north
NL	=	(over the) Netherlands	TC	=	Teveren centre
ER	=	Extended runway	GS	=	Geilenkirchen south
LA	=	Landing	GC	=	Geilenkirchen centre

The differences between the calculated peak noise levels for the different procedures are caused by differences in altitude, thrust and flight route. During a take-off both the thrust and the altitude will be higher compared to a landing procedure. For instance three kilometres west of the runway threshold, the altitude of a landing aircraft will be approximately 150 metres, while an aircraft that takes off flies at an altitude of approximately 500 metres at the same point.

Differences in altitude have two effects on the calculated noise level at a given observer location on the ground. First of all, the distance between the observer location on the ground and the noise source increases when the altitude increases, which leads to a decrease of the noise level on the ground. Secondly, an increase in altitude leads to an increase of the incidence angle of the noise when the observer location is not straight under the aircraft. A higher incidence angle results in a higher noise level at the observer location, while the increase in distance results in a decrease of the noise level at the observer location. The effect of an increase in incidence angle can be larger than the effect of the increasing distance. This is the case for aircraft that fly at relatively low altitude (landing aircraft) in combination with an observer location at a relatively large distance from the noise source.

From the table the following conclusions can be drawn:

- If an aircraft takes off in western direction from the extended runway this results in a reduction of the peak noise levels in Schinveld and Brunssum with 0.8 dB(A) to 2.9 dB(A). The smallest reduction is found in the point that is located at the largest distance from the nominal flight route.
- A take-off in western direction from the extended runway starts 900 metres eastward compared to a take-off from the current runway (i.e. closer to the cities of Teveren and Geilenkirchen). This will affect the noise levels near the extended part of the runway. Since the distance to Geilenkirchen is still relatively large, a take-off procedure in western direction does not lead to noise levels of more than 52 dB(A) in Geilenkirchen. Teveren is located closer to the runway and in the north and centre of Teveren the peak noise levels increase with respectively 16.8 and 10.5 dB(A).
- If an approach over the Netherlands touches down 900 metres east from the current landing point, this results in a maximum reduction of 3.3 dB(A) in the considered points in the Netherlands. This is the case in point 184, which is the point that is closest to the flight route. However, a landing on the extended runway does not lead to a reduction of the peak noise levels in all considered points on Dutch territory. The highest increase in peak noise levels (1.5 dB(A)) is calculated for point 187. This is the point at the largest distance from the flight route. This phenomenon can be explained by the fact that the higher altitude of the aircraft leads to a higher incidence angle, which in turn results in a higher noise level on the ground, despite the larger distance between this location an the aircraft.

- Due to the fact that the touch down point has moved 900 metres eastward the ground-roll after a landing from the west will be shifted 900 metres eastward. This results in higher noise levels in the city of Teveren. In the north and centre of Teveren the peak noise levels go up with respectively 22.2 and 14.6 dB(A). This procedure does not result in noise levels higher than 36 dB(A) in Geilenkirchen.
- Comparing the peak noise levels of departures over Germany that are part of a go-around or touch and go procedure from the extended runway with the peak noise levels of these procedures from the current runway shows lower peak noise levels in the considered locations in Teveren, but higher peak noise levels in both locations in Geilenkirchen. The lower noise levels in Teveren can be explained by the fact that the altitude of an aircraft is still low near Teveren. Due to the fact that the take-off point moves 900 metres eastward the altitude decreases further which in turn results in lower peak noise levels at some distance of the flight route. Near Geilenkirchen the altitude of departing aircraft is higher which means that the effect of the increased altitude on the incidence angle is smaller. At both locations in Geilenkirchen the peak noise levels increase due to the fact that the flight route passes closer to these points and due to the fact that the aircraft fly lower, which reduces the distance between the aircraft and the considered points on the ground.

The analysis of peak noise levels is done using three flight procedures for nine locations. This gives an indication of the effect of the runway extension on the peak noise levels in Schinveld, Brunssum, Teveren and Geilenkirchen. The take-off procedures over Germany that are part of a go-around or touch and go are the only procedures over Germany that change due to the runway extension. These movements only comprise 8% of the total number of movements over German territory which means that the peak noise levels caused by the other 92% of the movements will not change after the runway extension.

3 Spatial planning

As discussed before, it has been suggested to extend the runway of the Geilenkirchen airbase 900 metres in eastern direction. However, the German study on the runway extension has argued that such a runway extension would be impossible in practice. Considering the airbase's location, so the argument ran, the required planning procedures would take so long that whenever the extended runway would be finished, the existing AWACS fleet would be obsolete. This chapter verifies whether these difficulties of a runway extension as stated in the German analysis are reasonable.

In this chapter, both the current situation and the required procedures to extend the runway are examined closer. Based on the German analysis, the following questions will be answered:

- Does the extended runway cross an area of outstanding natural beauty and will this require compensation?
- Is there a pipeline in the runway extension area?
- Are there two roads crossing the runway extension area?
- Is there a sports field situated in the area?
- Does a legally protected small river cross the area?
- What is the area's height topography?
- Does a runway extension require a procedure to designate the area as new airbase?
- What is the estimated time required by the runway extension procedures?
- What are the estimated costs of the runway extension, including ground works but excluding land purchase and compensation?
- How long will the completion of the runway extension probably take?

In order to answer those questions, this chapter starts with a short introduction of the German spatial planning system. This introduction provides a rough outline which will be used as the background for further analyses. Following this introduction, the chapter outlines the current situation 'on the ground'. After that, a number of recent runway extensions in Germany is described. Combining those sources, it will be possible to answer most of the questions formulated in the above. Throughout this chapter several German terms will be used. Appendix B provides a list with a number of these terms and gives an English and a Dutch synonym or explanation of these German terms.

3.1 The German spatial planning system

To understand and evaluate the steps that need to be taken to allow a runway extension, one should consider the necessary procedures, especially with regard to spatial and environmental planning. Furthermore, to understand those spatial and environmental planning procedures, one should keep in mind the general legislative and administrative framework of a country. This section will first deal with these institutional backgrounds in general, focusing on German spatial planning law. Second, specific attention is paid to the characteristics of airport planning within the general institutional framework of German spatial planning.

3.1.1 Spatial planning in Germany: the institutional context[1)]

The German governmental system in general does resemble the Belgian or Austrian system more than the Dutch. The major difference with the Dutch 'unitary' system is the federal administrative structure, in which legislative power is distributed between national and regional governments, both having their own autonomous jurisdiction.

In general, three main levels of government can be distinguished in Germany: the federal (*Bund*) level, the state (*Länder*) level and the local (*Kreis*) level. Besides, five out of the sixteen states are subdivided in districts called *Regierungsbezirke*; Nordrhein Westfalen, in which Geilenkirchen and the NATO Airbase are situated, is among these five. The districts are mainly administrative bodies that take care of the execution of state policies. Below the level of the districts is the local government. Larger cities often have a *Kreis* of their own (*Kreisfreie Stadt*), smaller towns are often part of regional administrative bodies (*Landkreise* or *Kreise*) consisting of several municipalities (*Kreisangehörige Gemeinden*). These regional *Kreise* execute the tasks that cannot be carried out by the municipalities, like road construction, transport policy and waste disposal.

Bund		
Bundesländer		Stadtstaaten (Berlin, Hamburg, Bremen)
Regierungsbezirke		
(Land)kreise	Kreisfreie Stadt	
Kreisangehörige Gemeinden		

Figure 7: German administrative structure

Although the governmental system in general is quite different from the Dutch system, the (spatial) planning systems show remarkable similarities. With regard to spatial planning and policies, the federal level issues a regulatory framework, which is aimed to ensure consistency in planning legislation. The *Bund* is responsible for the policy framework and content of

1) Part of the information in this section is derived from Ref. [4], Ref. [6] and Ref. [7].

spatial planning covering the whole of Germany. In addition, the *Bund* coordinates the spatial effects of (federal) sector policy and spatial policies by the *Länder*.

The German planning system mostly operates at the state (*Länder* and *Stadstaaten*) and lower levels. These states can act rather independently from the *Bund*. Regional and local governments develop policy independently, respecting the boundaries set by the respective higher level policies. State planning comprises both strategic comprehensive planning and sector planning affecting spatial policy (e.g. traffic planning). The responsibilities of the states include the preparation and supervision of regional spatial planning and development, supervising and coordinating local land use planning, urban development and renewal, agricultural development, environment and nature conservation and transport and road construction.

The districts supervise and coordinate the execution of state and federal policies. Depending on the situation, state tasks and responsibilities might be assigned to these *Bezirke*. Like in the Dutch planning system, the local level is the most important level for spatial planning, in the sense that local governments alone may issue plans that are legally binding on private individuals[2)]: the local land use plan (*Bebauungsplan*[3]). This is the most detailed plan, containing detailed prescriptions of land use, building heights, et cetera. Besides this legally binding plan, municipalities may adopt indicative zoning plans (*Flächennutzungsplan*). Evidently, any land use plan has to be in accordance with the zoning plan. Both, in turn, have to be in accordance with higher level sector plans and spatial development plans.

Building permits are issued in accordance with the local land use plan. However, it is not the municipality that decides upon approval or rejection of a requested building permission. This is the sole competence of the regional bodies (*Kreisfreie Stadt* or *Landkreise*). The spatial planning act determines that for certain activities that require a building permit, an Environmental Impact Assessment (EIA) is obligatory. In that case, a building permit can only be granted if the necessary other permits are issued. The German spatial planning system is summarized in Figure 8.

[2)] All other plans mentioned are binding to public authorities only.
[3)] In Dutch: *bestemmingsplan*.

Governmental level		Role/function in planning system	Legal instruments and policy domains	Formal title in German	Equivalent in Dutch law
Federal (*Bund*)	National government	Regulatory frameworks, coordination and integration	Spatial planning act Federal building law Sector plans Federal nature protection act	Raumordnungsgesetz (ROG) Baugesetzbuch (BauGB) Fachpläne, Fachgesetz Bundesnaturschutzgesetz	Wet ruimtelijke ordening Bouwbesluit Sectorale plannen (Nota mobiliteit, milieubeleidsplan, etc.) Natuurbeschermingswet
State (*Länder*) or *Stadstaaten*	Sixteen state governments	Comprehensive spatial planning, programs and framework Urban development and building	State planning act (in agreement with ROG) State spatial planning State building regulations Environment, nature conservation; Traffic, road development; agricultural policies Nature protection act	Landesplanungsgesetz (LPLG) Landesraumordnungsgesetz (LROG) Regionalplan, Landesplanung, Landesentwicklungsplan Landesbauordnung (LBO) Fachplanung Landschaftsgesetz	- Provinciale structuurvisie [4)] - - -
District administrations (*Regierungsbezirke*)	Administrative bodies, part of state goverment	Coordination and supervision of federal and state legislation and regulations	Depending on situation regional state planning can be assigned to district administrations		Structuurvisie
Regional bodies (*Landkreise, Kreisfreie Stadt)*	Regional bodies of municipalities	Both local authority and lower-authority of the state. Coordination and supervision of local policies	Issuing of building permission (based on Bebauungsplan) Public transport, road construction		Regionale structuurvisie
Municipalities (*kreiseangehörige Gemeinde, Kreisfreie Stadt*)	Local government	Local land use planning and development plans	Preparatory land use plan or zoning plan, binding public authorities Legally binding building plan or *Flächennutzungsplan*	Flächennutzungsplan Bebauungsplan	Bestemmingsplan, projectbesluit

Figure 8: Characteristic elements of the German spatial planning system

[4)] According to the (old) Dutch law: Wet op de Ruimtelijke Ordening 1965: Streekplan.

3.1.2 Spatial planning in Germany: airport planning[5)]

Having outlined the German spatial planning system in general, we now turn towards the specific case of spatial planning for airport and airbase development. Within the framework of the general planning system sketched in the above, airbase planning is part of the sector plans which need to be implemented in general spatial plans. In describing the normal way of airport planning, we distinguish between the legal conditions and context and the actual process required for the drafting and approval of these plans.

Conditions and (legal) context

The Federal Ministry of Transport, Building and Urban Development[6)] is responsible for the execution and application of the federal Air Traffic Regulation Act (*Luftverkehrsgesetz, LuftVG*). The Air Traffic Regulation Act (ATRA) consists of five parts, the first part of which is of specific relevance to airport planning: *Luftverkehr*. This part of the ATRA includes requirements for airplanes and personnel, airline companies, airports, airport coordination and traffic regulations. Table 3 shows a shortlist of acts that are relevant to airport planning and ordinances that can be applied by the department based on the *LuftVG*. By means of ordinances, the departments elaborate and specify the content of the federal acts.

Table 3: Shortlist of acts and ordinances relevant to airport planning[7)]

Acts	
Luftverkehrsgesetz (LuftVG)	Air traffic regulation act
Gesetz über das Luftfahrt Bundesamt (LBAG)	Act on the federal air traffic office
Gesetz zum Schutz gegen Fluglärm (FluglärmG)	Air traffic noise protection act
Luftsicherheitsgesetz (LuftSiG)	Air traffic security act
Ordinances	
Luftverkehrs-Ordnung (LuftVO)	Air traffic ordinance
Luftverkehrs-Zulassungs-Ordnung (LuftVZO)	Air traffic admission ordinance
Landeplatz-Lärmschutz-Verordnung (LLärmV)	Air traffic noise ordinance
Bauschutzbereich (BSB)	Restricted building area

The Luftverkehrs-Ordnung is designated to set out regulations and conditions with respect to air traffic rules, conditions to airplanes and personnel et cetera. Regarding airport planning,

[5)] Parts of this section are derived from Ref. [5].

[6)] Ministerium für Verkehr, Bau und Stadentwicklung. In practice, a sector department is assigned to do this on behalf of the Ministerium: the Unterabteilung Luft- und Raumfahrt.

[7)] Derived from Ref. [5].

the Luftverkehrs-Zulassungs-Ordnung (based on the LuftVG) is of specific interest. In this ordinance, the rules and regulations to the planning, development and use of airports are described. In fact, this ordinance for a large part determines the regulatory framework for airport planning.

Application and execution of the regulatory framework as set out in the various acts and ordinances is largely done by the *Länder*. According to the Air traffic regulation act the *Länder* take care of licensing regarding the realization of airports and corresponding building conditions (especially the maximum height of buildings in the surrounding of the airport). This implies that every airport plan has to be approved by the state.

Of course, several other governmental institutions are involved in airport planning and operation. Amongst others, the following institutions are of specific relevance to this project. The *Luftfahrt Bundesamt*[8)] is responsible for flight safety regulations, while the Department of the Interior (Bundesministerium des Innern) is focused on interior safety in general. The Federal Department of Defence[9)] is responsible for everything related to the defence of the country, including the military forces and obligations following from international alliances such as NATO.

Requirements for airbase modification

Paragraph 8 of the *Luftverkehrsgesetz* states that an airport or airbase may be neither constructed nor changed unless a so-called *Planfeststellungsverfahren* has been completed. The *Planfeststellungsverfahren* is a planning procedure which includes, among other things, possibilities for public consultation, an environmental impact assessment and detailed specifications of the works to be executed. There are some exceptions to this general rule, allowing changes to airports with only a permit request procedure (*Genehmingungsverfahren*) or without any procedure at all. However, none of those exceptions pertains to the Geilenkirchen case, as one of the requirements is that the plan does not interfere with the rights of others – which a runway extension clearly does.

Thus, summarising the above, a *Planfeststellungsverfahren* is required. The start of this procedure should be requested by the airport authorities and needs to be substantiated by ample documentation. One of the requirements is that the request can be shown to be compliant with current spatial planning policies in the area. If it is not, a *Raumordnungsverfahren*, a procedure to change spatial planning policy, is required to adapt the spatial planning policies to the desired situations.

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8) Related to the Federal Ministry of Transport, Building and Urban Development.

9) Bundesministerium der Verteidigung (BMVg).

Conclusion: required procedures for the Geilenkirchen runway extension

First, it is clear that the Geilenkirchen runway extension cannot be treated as a minor modification, requiring a *Genehmingungsverfahren* only. Leaving other reasons aside, it is clear that the runway extension does interfere with land currently owned by others. Thus, a full *Planfeststellungsverfahren*, to be completed by the Nordrhein-Westfalen state government, is required in order to allow the runway extension.

Second, one of the requirements for a successful *Planfeststellungsverfahren* is that the intended modification is compliant with current spatial planning policy. Most probably, the Geilenkirchen runway extension is not, as a nature reserve is situated beyond the current runway. This means that, most presumably, a *Raumordnungsverfahren* will be required as well. Like the *Planfeststellungsverfahren*, this is also the responsibility of the state government. Besides, one can reasonably expect such a procedure to be rather difficult, as both public opposition to and residents' fear of increased aircraft noise levels may be substantial.

3.2 Current situation

Having shown in the above that the Geilenkirchen runway extension would require both a *Planfeststellungsverfahren* and a *Raumordnungsverfahren*, we now turn to a short outline of the current situation in the vicinity of the airbase. The NATO airbase is situated a few kilometres west of Geilenkirchen, close to the village of Neuteveren. Figure 9 shows the current situation in the vicinity of the airbase.

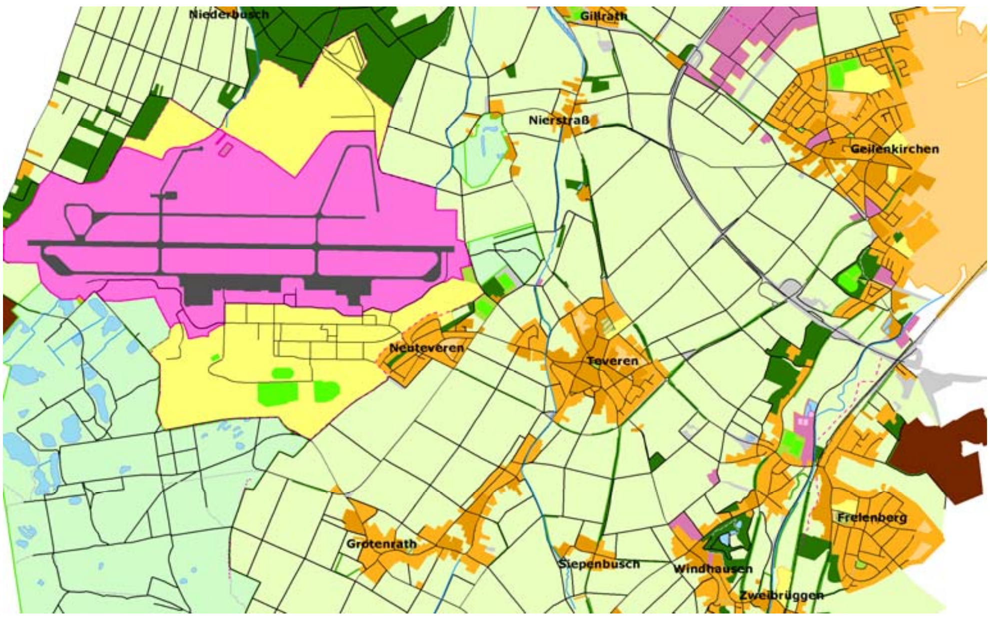

Figure 9: The Geilenkirchen NATO-airbase

In Figure 10, the projected runway extension – 900 metres eastwards – is included. North of the airbase is a forest and to the east of it most of the lands are in agricultural use. To the south-west as well as to the east there are areas of outstanding natural beauty.

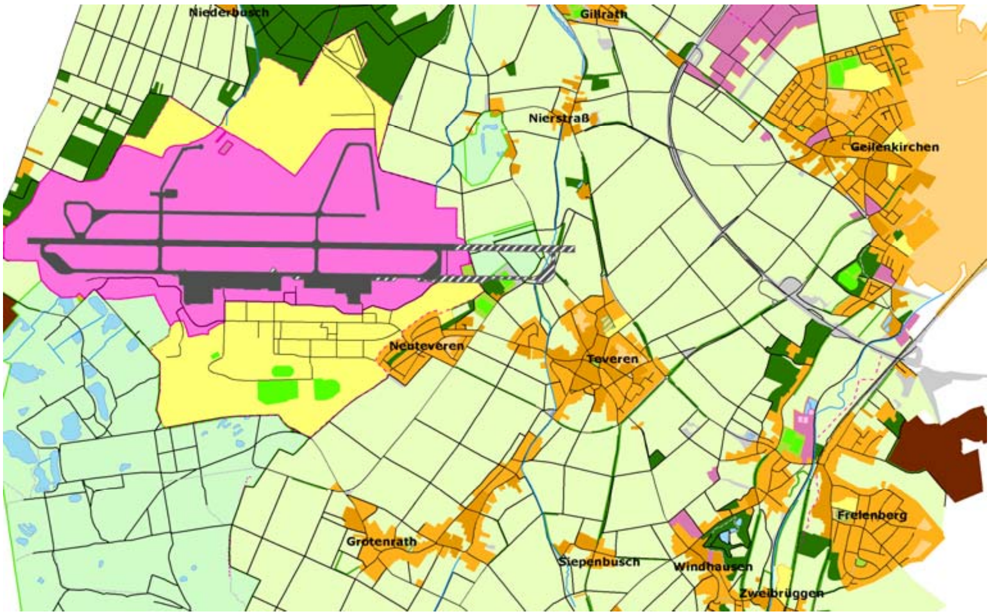

Figure 10: The Geilenkirchen NATO-airbase with projected runway extension

The extended runway would cross a small river, called the *Rodebach* in German (*Roode Beek* in Dutch, *Red Brook* in English). There is a joint Dutch-German protection plan for the *Rodebach*, part of this plan is to keep the brook and its surroundings attractive for tourism. In December 2008, the Koeln *Bezirk* adopted an ordinance in which the *Rodebach* area was designated as a *Naturschutzgebiet*[10)].

[10)] See *Amtsblatt für den Regierungsbezirk Köln*, 189:2, January 12, 2009, p. 23 ff.

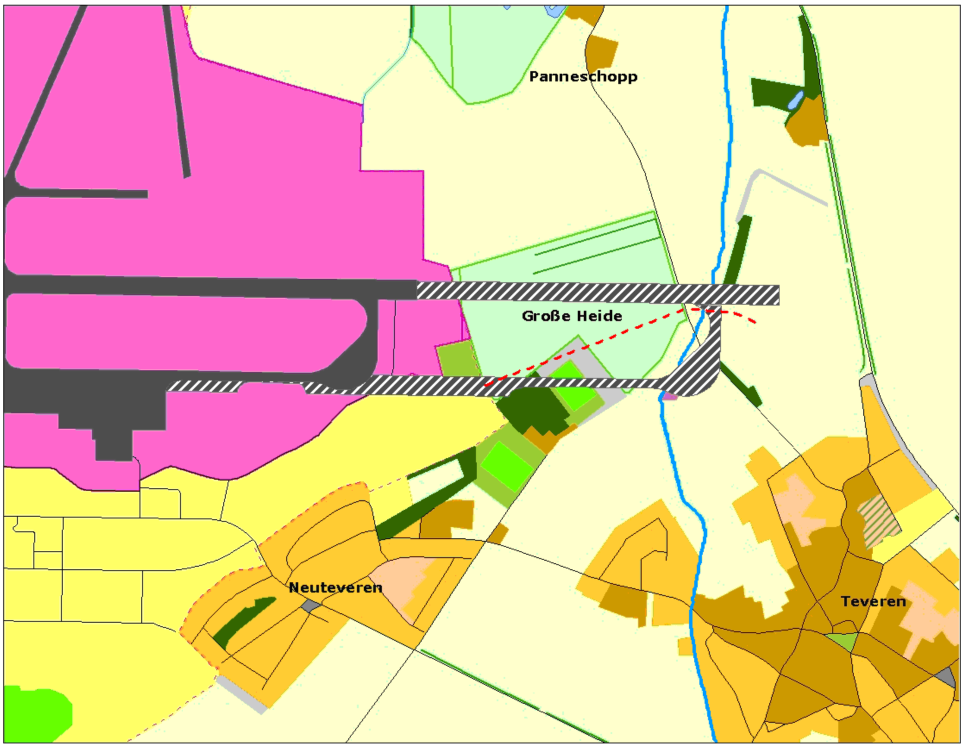

Figure 11: Detail: the extended runway crossing the Red Brook and the Grosse Heide

The extended runway would cross an area of outstanding natural beauty as well: the so-called *Grosse Heide* (shown in light green east of the runway in Figure 11). The *Grosse Heide* is a nature reserve protected by the German *Naturschutzgesetz* (Nature protection act). One of the basic rules of the *Naturschutzgesetz* is the so-called *Eingriffsregelung* (intervention regulation)[11)]. Based on the *Eingriffsregelung*, any intervention which affects some protected area of natural beauty requires compensation. Compensation in this case means that the natural values which have been lost will somehow be added elsewhere in the area. Only in exceptional cases compensation outside the area is allowed.

Figure 11 also shows the location of a pipeline that is located near the airbase. The pipeline is shown with the dotted red line in the south of the *Grosse Heide*. It should be noted that the location of the pipeline is sketched in the figure and that the location of the pipeline is only known in the area of the runway extension. In practice the pipeline does not end below the extended taxiway or near the end of the extended runway but it continues to the west and to the east despite the fact that this is not shown in Figure 11. From the figure it can be concluded that this pipeline is located in the runway extension area.

[11)] See for Nordrhein-Westfalen http://www.lanuv.nrw.de/natur/eingriff/grundlagen.htm.

Also a sports field (shown in bright green) is located somewhat south of the main runway. This sports field would be crossed by the taxiway access to the runway. The extended runway would cross at least one major road (see Figure 12). Besides that, several smaller roads are crossed by the runway. If the airbase itself would need to be extended considerably beyond the end of the runway (around 150 metres), it would cross a second major road.

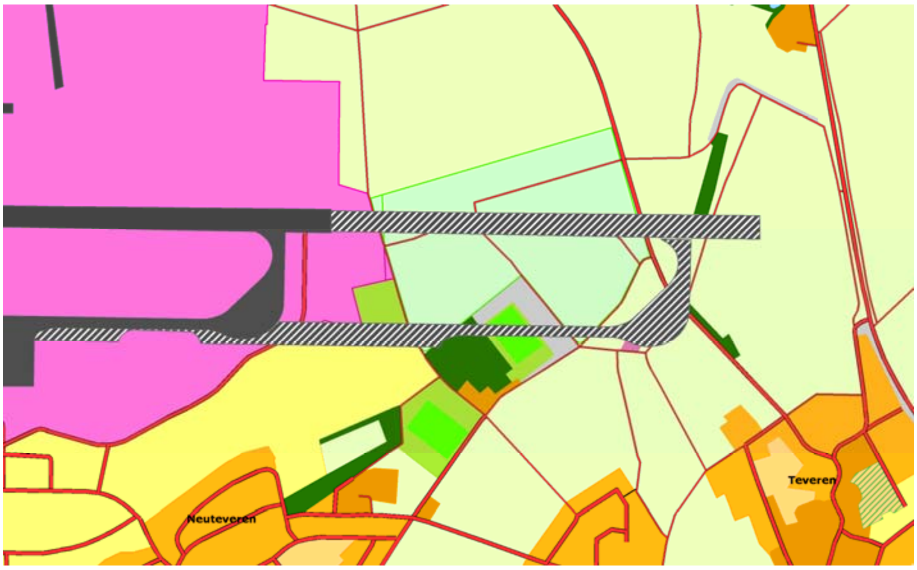

Figure 12: Detail: the extended runway crossing existing roads

Figure 13 shows the height topography of the current airbase (without the runway extension). The map shows that an extension of the runway with about 900 metres would cross a small valley (the *Rodebach* valley). The side view (Figure 14)[12)] and the 3D-view (Figure 15) show that the height differences in the area of the runway extension amount to up to 15 metres, mainly in the final 200 metres of the runway extension. Figure 15 shows the heights from about 50 metres left to approximately 50 metres right of the runway.

Figure 13: Height topography in the vicinity of the airbase

[12)] In Figure 14, different 'slices' across the runway are shown. The dark blue, thick lines are closest to the centre of the runway.

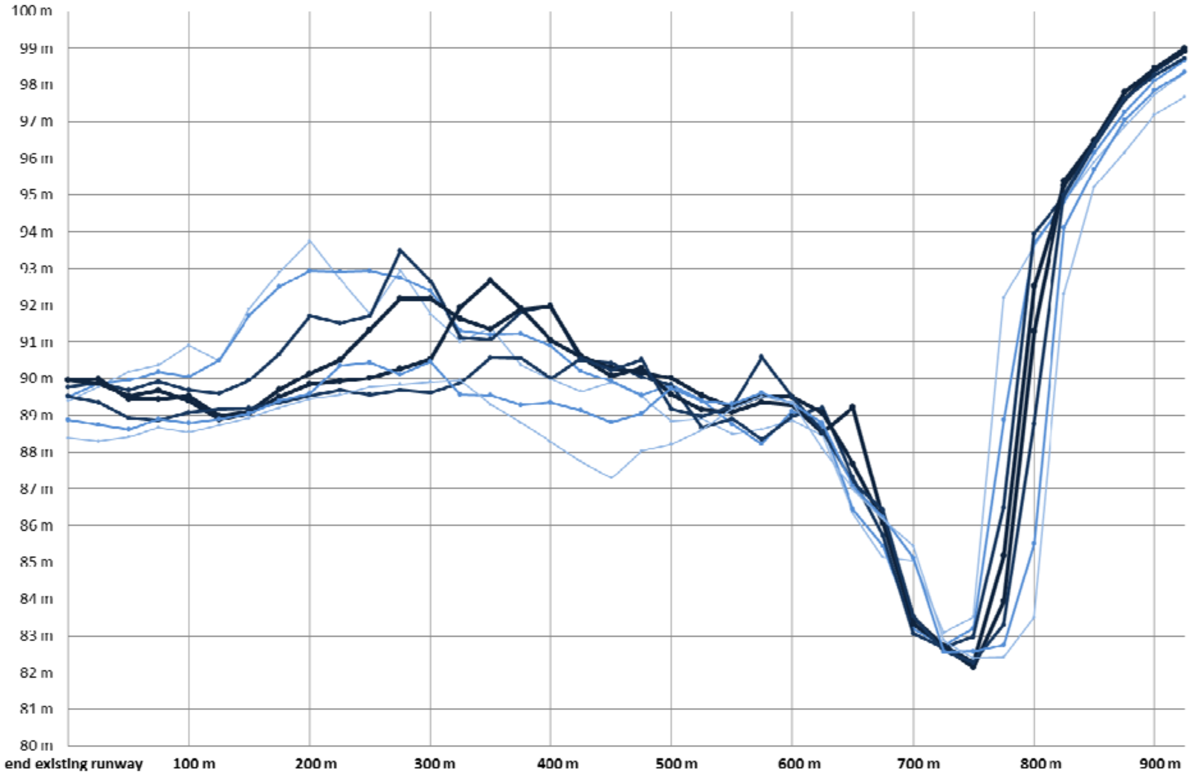

Figure 14: Height differences in the area of the runway extension: side view

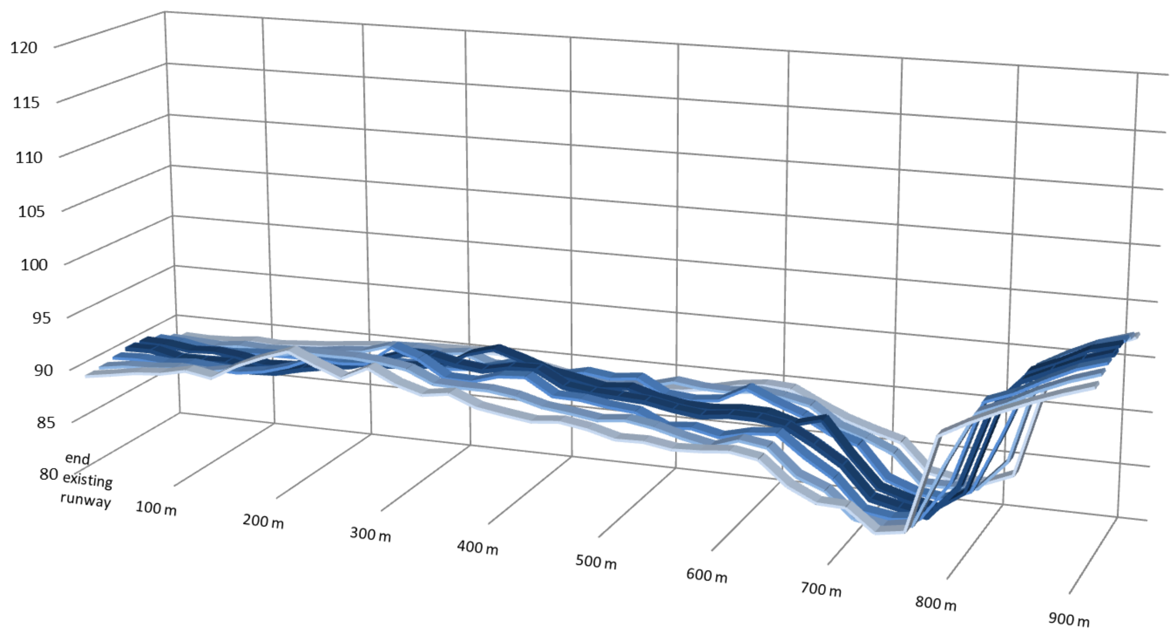

Figure 15: Height differences in the area of the runway extension: 3D view

3.3 Case studies

In order to improve the understanding of the required procedures for a runway extension in practice, a few recent runway extensions have been investigated. Below, five airports are described which have either recently completed a runway extension or which are in the process of extending a runway: Braunschweig, Hamburg-Finkenwerder, Frankfurt-Hahn, Münster-Osnabrück and Schwarze Heide. Of these five, the Braunschweig and Hamburg-Finkenwerder cases are most similar to the Geilenkirchen runway extension.

Braunschweig

The Braunschweig-Wolfsburg airport is a regional airport near Hannover. It has one paved runway and two grass airstrips besides. The paved runway currently measures 1,680 metres and will be extended by 620 metres to a length of 2,300 metres. The cost of the runway extension is estimated at around €38 million, which amounts to about €61,000 per meter.

In December 2003, the airport requested an environmental impact assessment, in order to start a *Raumordnungsverfahren.* For the completion of the *Raumordnungsverfahren*, several documents were submitted in 2005 and 2006, including a prognosis of future air traffic, an investigation of noise nuisance due to the extension and an EIA[13)]. On January 15th 2007, the Niedersächsen government approved the *Planfeststellungsbeschluss* for the runway extension[14)]. Immediately, appeal procedures started at the Lünebeck court. All appeals were rejected by May, 2009, after which the construction of the extended runway started in January 2010[15)].

Summarising, the runway extension procedures for the Braunschweig-Wolfsburg regional airport took more than six years, starting in 2003 with the first request for an environmental impact assessment and continuing into 2010 after the rejection of all appeals in December, 2009. Currently, the runway is still under construction, and there has been some delay in wood clearing due to public protests.

Hamburg–Finkenwerder[16)]

The Hamburg-Finkenwerder airport is used mainly by the adjacent Airbus factory, in which a substantial part of new Airbus planes is constructed. When Airbus planned to use the Hamburg site for the construction of the new Airbus A380, it was clear that the current runway was insufficient for the takeoff and landing of these large planes. Therefore, a runway

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13) LaReg, *Ausbau des Forschungsflughafens Braunschweig-Wolfsburg; Umweltverträglichkeitsstudie,* July 2006.
14) Niedersächsische Landesbehörde für Straßenbau und Verkehr, *Planfestsetellungsbeschluss Verlängerung der Start- und Landebahn des Flughafens Braunschweig-Wolfsburg*, January 15th, 2007.
15) Source: Wikipedia.
16) See http://www.ndr.de/wirtschaft/dossiers/airbus/chronologie/airbus44.html.

extension was required. Before the extension, the runway measured 2,320 metres and afterwards, it was 3,273 metres in length.

The extension was completed in several phases. Partly, the costs of the runway extension are known: the cost of an extension over 589 metres was estimated at about €38 million. The *Planfeststellungsverfahren* for the runway extension started in 1998. First, the runway was extended to 2,684 metres. As the planned extension was to cross the *Mühlenberger Loch,* a nature reserve, a special procedure for allowing construction works inside an area of outstanding natural beauty was required. Against the decision to allow the runway extension, many appeal procedures were started, which took the airport authorities over three years to complete.

Besides, some of the land owners refused to sell their land, which was required for the runway extension. This led to new appeal procedures and other legal quarrels, while at the same time a *Planfeststellungsverfahren* was started for another extension up to the final 3,273 metres. By January 2007, the full runway extension was completed.

Summarising, the runway extension in Hamburg took about ten years. However, it was completed in two phases, the procedures for the second phase started during the construction of the first phase. The first phase took around seven years to complete. For the extension of the runway of Geilenkirchen airbase it is not feasible to extend the runway in two phases since current runway is located close to an area of outstanding natural beauty. This implies that it is not possible to start with the first part of the runway extension without completing the *Planfeststellungsverfahren*.

Frankfurt-Hahn

The main runway of the Frankfurt-Hahn airport has been extended from a length of 3,040 metres to 3,800 metres. The extension was completed in 2006. It cost about €37.5 million, which amounts to €49.000 per meter.

The first investigations into a possible runway extension were completed in 1998. The *Raumordnungsverfahren* started in 2002 and the *Planfeststellungsverfahren* in 2003. The procedures were finished by the *Planfeststellungsbeschluss* of the Nordrhein-Westfalen government in December 2004. The construction of the runway extension started in January 2005 and was completed about a year later. However, because of appeal procedures the use of the full 3,800 metres runway was not allowed legally until September, 2007[17)].

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17) See http://www.hahn-airport.de/default.aspx?menu=press_archive&cc=en&dataid=509820.

Münster-Osnabrück

The runway of the Münster-Osnabrück airport is being extended from 2,170 metres to 3,000 metres. The estimated cost of the extension by 830 metres is about €60 million. A further extension to 3,600 metres costs another estimated €60 million. Thus, the costs per meter amount to about €72,000 - €100,000. The *Planfeststellungsbeschluss* was decided in 2005, the procedures having taken almost ten years[18)]. The full runway extension has not been finished yet.

Schwarze Heide

The *Verkehrslandeplatz Schwarze Heide* is a minor airstrip near Bottrop in the Northern Ruhr area. Currently, the runway measures 900 metres, because of which the airstrip is only suitable for light airplanes and gliders. A procedure for the runway extension was started early in 2006, taking about 2.5 years to complete. In November 2008, a plan was approved for the extension of the runway to a length of 1,500 metres, the cost of which was estimated at about €6,5 million (approximately €11.000 per meter). The construction works started in February 2010, and are expected to be completed by mid-2010.

In this case the required time for procedures and construction was lower compared to the other cases. Also the costs of the runway extension per meter were lower compared to the other cases. This can be explained by the fact that *Schwarze Heide* is a small airstrip, while the other cases were larger airports. Therefore this case is considered to be the least representative for the Geilenkirchen runway extension.

3.4 Conclusion

Summarising the above, this paragraph will provide the answers to the questions described in the beginning of this chapter.

- Does the extended runway cross an area of outstanding natural beauty and will this require compensation?
  The extended runway crosses the Naturschutzgebiet 'Grosse Heide'. Compensation for the loss of environmental qualities will be required.
- Is there a pipeline in the area?
  A pipeline is located in the runway extension area.
- Are there two roads crossing the runway extension area?
  Two major roads do cross the extended runway. Also a few minor roads and cycle paths do.

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18) *Ministerialblatt Nordrhein-Westfalen*, 2005:31, p. 761 – 776.

- Is there a sports field situated in the area?
  The taxiway giving access to the extended main runway would cross a sports field.
- Does a legally protected small river cross the area?
  The extended runway would cross the Rodebach, a small river which was designated as a Naturschutzgebiet in 2008.
- What is the area's height topography?
  The height differences in the area of the extended runway amount to up to 15 metres, especially in the final 200 metres.
- Does a runway extension require a procedure to designate the area as new airbase?
  Any airport modification will require a Planfeststellungsverfahren. Exceptions are made for minor modifications, which require a Genehmingungsverfahren only. However, one of the requirements for using the easier procedure is that the modification does not affect land owned by others. For the Geilenkirchen runway extension, this means that a Planfeststellungsverfahren, including a preceding Raumordnungsverfahren to adapt the spatial planning policies in the region, will be required.
- What is the estimated time required by the runway extension procedures?
  Depending on the amount of appeal procedures, procedures will take between two and seven years starting from the first proposal and running up to the final completion of the appeal procedures. It must be kept in mind, however, that the extension proposal and all supporting documentation have to be provided before the start of the formal procedures. In the case of Frankfurt-Hahn, the complete file amounted to about 2,000 pages. Appeals may be taken to the highest level, the federal court of justice, before being decided beyond dispute. This process may take up to four years out of the full two to seven years. As the number of appeals in the Geilenkirchen case can be expected to be substantial, it is reasonable to expect the required time for the completion of all procedures to be at least five years.
- What are the estimated costs of the runway extension, including ground works but excluding land purchase and compensation?
  To a large extent, the cost of a runway extension depends on local characteristics such as soil quality and on the projected use of the runway. Cost estimates from other runway extensions vary from €11,000 per meter to about €100,000 per meter. The €11,000 per meter estimate, however, is derived from the Schwarze Heide runway extension, which can only accommodate aircraft up to 7,000 kg. At €50,000 per meter, the costs of the 900 metres runway extension would amount to €45 million. Depending on local circumstances, however, the true costs of the runway extension may be twice as high.
- How long will the completion of the runway extension probably take?
  The actual construction of the extended runway could probably be completed in about one or two years. However, the preceding procedures will take about four times as long.

This means that the runway extension will take at least five years to complete, provided that all required documents have been drafted. This not being the case, the extension will probably take two more years. Besides, given the impact of the runway extension on the Grosse Heide and Rodebach natural areas, as well as the increased noise nuisance in Germany, the procedures cannot be expected to be completed without legal appeals. Therefore, it is highly improbable that the runway extension will be completed before 2020.

4 Analysis of the obstacle limitation surfaces

The effective utilization of an aerodrome may be considerably influenced by natural features and man-made constructions inside and outside its boundary. These may result in limitations on the distances available for take-off and landing and on the range of meteorological conditions in which take-off and landing can be undertaken. For these reasons certain areas of the local airspace must be regarded as integral parts of the aerodrome environment. The degree of freedom from obstacles in these areas is as important to the safe and efficient use of the aerodrome as are the more obvious physical requirements of the runways and their associated strips[19)]. The influence of any object in the vicinity of the runway can be assessed by the use of set of obstacle limitation surfaces (OLS) defined by ICAO in Annex 14 *Aerodromes*.

The NATO has decided to use the same criteria for obstacle limitation surfaces for military airports as the criteria that are used for civil airports (see Ref. [10]). These are the criteria defined in ICAO Annex 14. Therefore, the following assessment is based on the obstacle limitation surfaces as defined in ICAO Annex 14, despite the fact that Geilenkirchen is not a civil airport for which ICAO regulations are mandatory.

The lay out of the current runway can be found in reference [8]. This runway is 3,048 metres long and 45 metres wide. After the extension the length of the runway will equal 3,948 metres, while the width of the runway does not change. A more detailed description of the runway is provided in Appendix C.

Throughout this chapter the terms runway (RWY) and threshold (THR) will often be used. In order to clarify in what direction a runway is used, the report distinguishes between RWY09 and RWY27. The number behind RWY indicates in what direction a runway is used:

- RWY09 means that the runway is used in eastern direction (landing over the Netherlands and take-off over Germany).
- RWY27 means that the runway is used in western direction (landing over Germany and take-off over the Netherlands).

For the current runway the term threshold refers to the starting point of the usable runway (this is not the same as the landing point where aircraft touch down). It should be noted that a non-usable strip of concrete is located at both ends of the runway. These parts of the runway are not considered in the analyses of the OLS.

[19)] *Ministerialblatt Nordrhein-Westfalen*, 2005:31, p. 761 – 776.

All landing aircraft make use of a so-called displaced threshold (DTHR). This means that the aircraft will not use the full runway length for landing. In the case of Geilenkirchen airbase the DTHR is located 150 metres from the THR on both sides of the runway. A sketch of the location of the thresholds and displaced thresholds of the current runway is shown in the upper part of Figure 16.

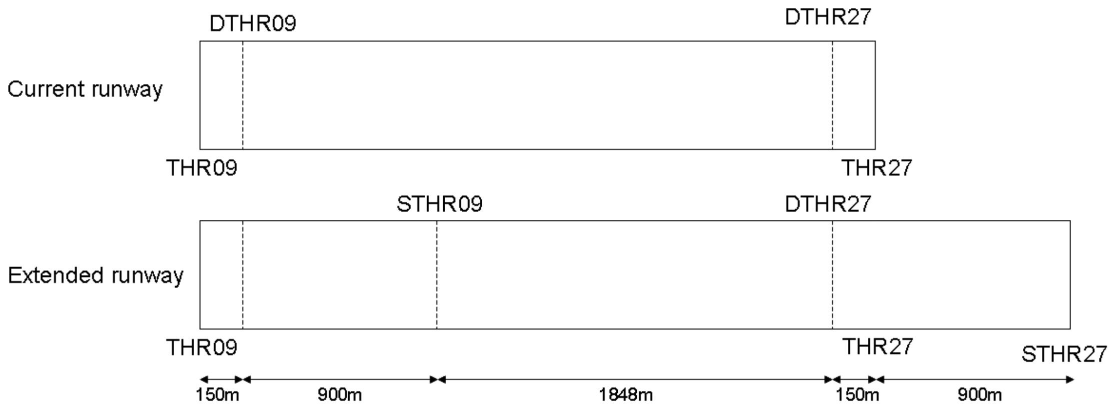

Figure 16: Sketch of different thresholds for current and extended runway.

The runway will be extended eastward which means that the point where the usable runway ends in the east is shifted 900 metres to the east. This implies that THR27 is shifted 900 metres to the east. This new threshold will be denoted with STHR27 (see the lower part of Figure 16).

After the runway extension, the landing point of RWY09 will be located 900 metres east from the current landing point. This means that the location of DTHR09 will be shifted 900 metres eastward. This new threshold will be denoted as shifted threshold 09 (STHR09). It should be noted that STHR09 is a shifted displaced threshold, while STHR27 is a shifted threshold.

The remainder of this chapter will discuss the effect of a runway extension on the obstacle limitation surfaces at the Geilenkirchen airbase. First, a description of the OLS according to Annex 14 is provided. After that, the changes in OLS due to the runway extension will be discussed. The location of the OLS partly depends on the take-off and landing procedures. Paragraph 2.1.4 gives a description of these procedures for both the current and the extended runway.

4.1 Introduction to ICAO Annex 14 obstacle limitation surfaces

The significance of any existing or proposed object within the aerodrome boundary or in the vicinity of the aerodrome is assessed by the use of two separate sets of criteria defining airspace requirements. The first of these comprises the obstacle limitation surfaces particular to a runway and its intended use detailed in Chapter 4 or ICAO Annex 14 - *Aerodromes*. The broad purpose of these surfaces is to define the volume of airspace that should ideally be kept free from obstacles in order to minimize the dangers presented by obstacles to an aircraft, either during an entirely visual approach or during the visual segment of an instrument approach. The second set of criteria comprises the surfaces described in Ref. [9]; the *Procedures for Air Navigation Services - Aircraft Operations* (PANS-OPS).

The PANS-OPS surfaces are intended to be used by procedure designers for the construction of instrument flight procedures and for specifying minimum safe altitudes for each segment of the procedure. [20)]. In this report, only the Annex 14 surfaces are tackled, while the PANS-OPS surfaces are out of the scope of the current analysis. The PANS-OPS surfaces could be assessed in the future, once the instrument flight procedures - approaches and departures - are designed for the new, extended runway, and relevant navigation aids, such as ILS, are repositioned.

This report does not contain the detailed description of Annex 14 OLS; for which reader is referred to Annex 14, volume I, Chapter 4. Nevertheless, the figures below present a general overview of the shape and construction of these surfaces for a better understanding of the names of different surfaces used in this document. The approach and take-off climb surfaces shown in Figure 17 are located 60 metres from the THR.

It should be noted that these figures are based on a situation without displaced thresholds. In Figure 17 the approach surfaces are located 60 metres from the THR. In case of a DTHR, these surfaces will be placed 60 metres from the DTHR. The location of the take-off climb surface only depends on the physical end of the runway and will therefore not change if a DTHR is used.

[20)] *Ministerialblatt Nordrhein-Westfalen*, 2005:31, p. 761 – 776.

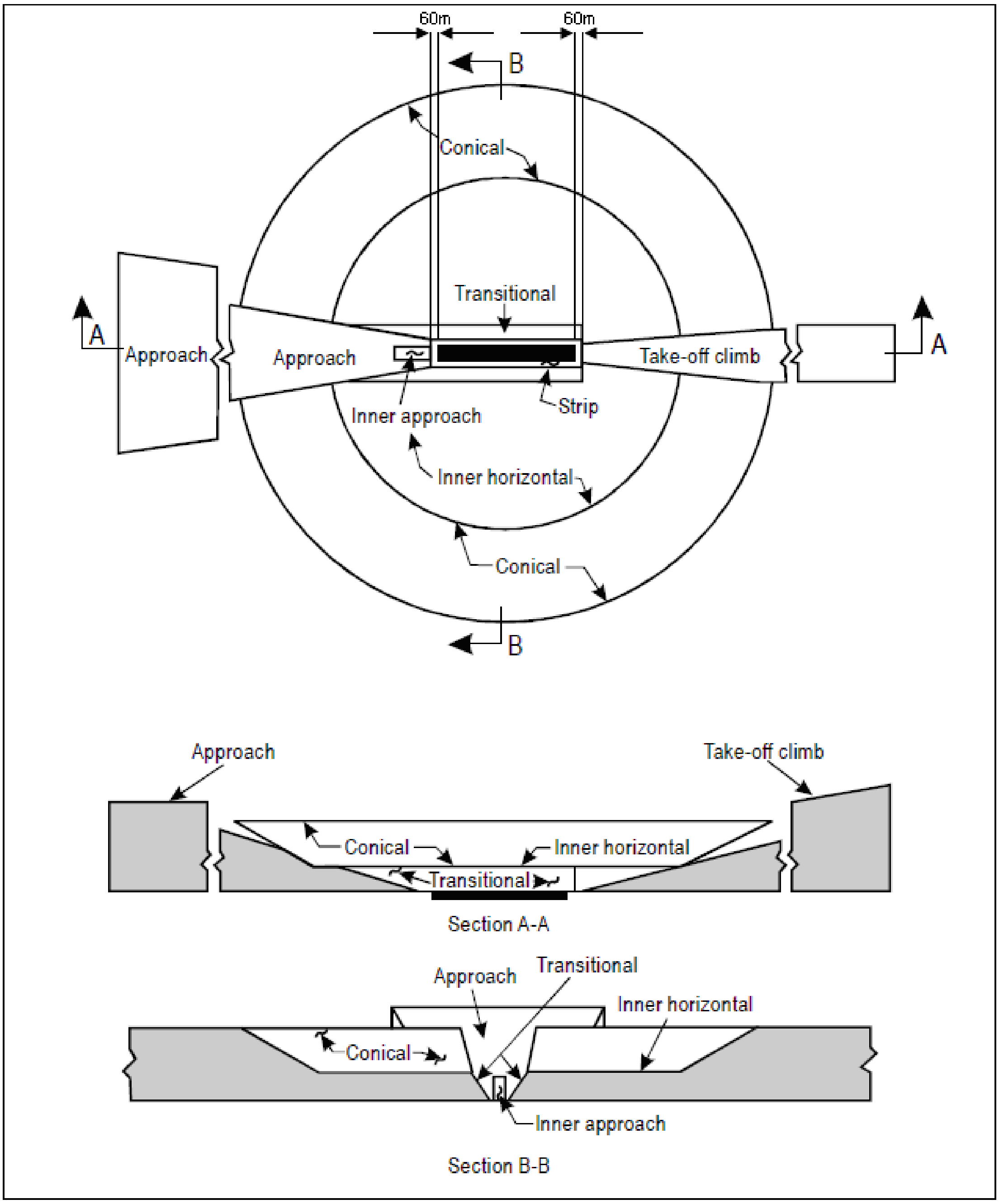

Figure 17: Obstacle limitation surfaces according to ICAO Annex 14

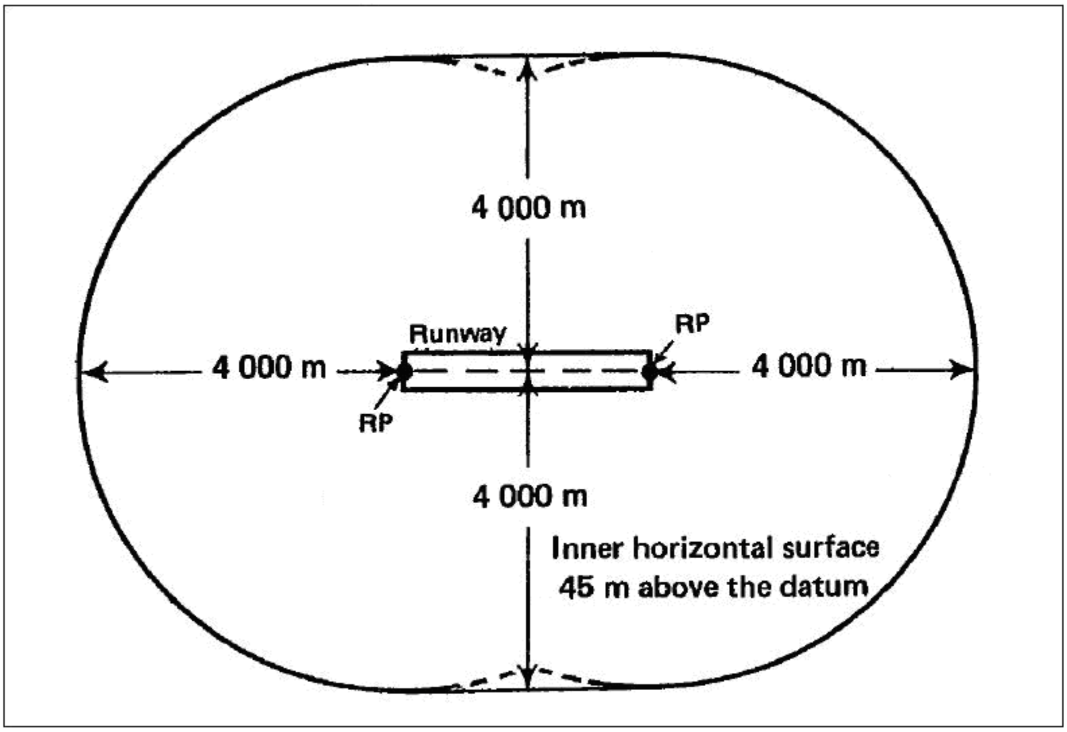

Figure 18: Inner horizontal surface for a single runway

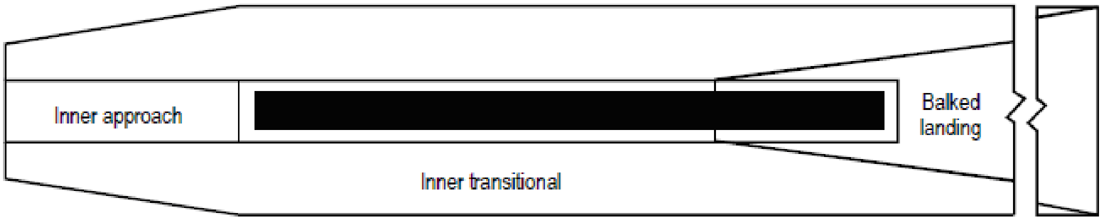

Figure 19: Obstacle free zone surfaces - inner approach, inner transitional and balked landing obstacle limitation surfaces according to ICAO Annex 14

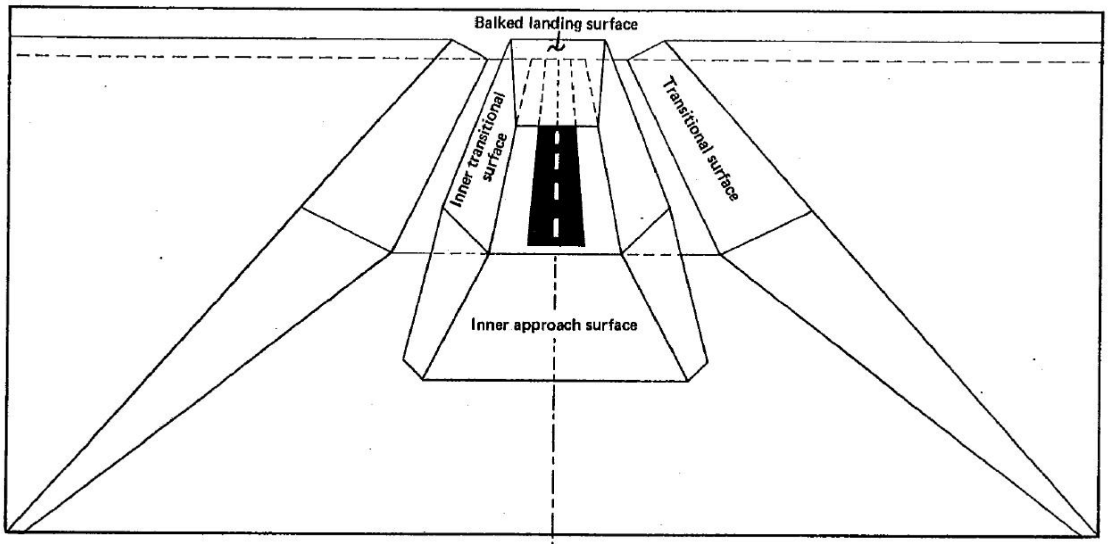

Figure 20: Obstacle free zone surfaces - 3D view

Obstacle limitation surfaces define the airspace around the aerodrome to be maintained free from obstacles to permit the intended aeroplane operations at the aerodrome to be conducted safely and to prevent the aerodrome from becoming unusable by the growth of obstacles around the aerodromes. [21)]

It has to be noted that these surfaces are related to the physical characteristics of the runway and the location of (displaced) thresholds. Therefore, changing the position of a threshold will change the position of a related surface. In case of the Geilenkirchen airbase, the runway is planned to be extended on one side (repositioning THR27). As a consequence, the locations of all the limiting surfaces related to the position of this threshold will change. At the same time, the physical end of the runway at the THR09 remains unchanged and the surfaces related to this part of the runway, such as the take-off climb surface (see Figure 17) originating at the side of THR09, will also remain unchanged. Nevertheless, due to the introduction of the shifted threshold 09 (STHR09), the approach operations to RWY09 will be shifted to the east, and the approach surface (see Figure 17) will be shifted accordingly.

4.2 Changes to OLS due to runway extension

In the present section the comparison between the current and future OLS will be presented. The impact of the runway extension on the obstacle limitation surfaces range and eventual penetration of these surfaces will also be analyzed.

4.2.1 OLS RWY09

Figure 21 presents the current shape of OLS for RWY09. The yellow line represents the inner horizontal surface (inner oval) and conical surface (outer oval). The orange line represents the take-off climb surface from RWY09, while the purple line depicts the approach and transitional surfaces. Later in this chapter the OLS will also be projected on a map to indicate where the OLS are located relative to the airbase and the villages in the vicinity of the airbase (see Figure 27).

[21)] *Ministerialblatt Nordrhein-Westfalen*, 2005:31, p. 761 – 776.

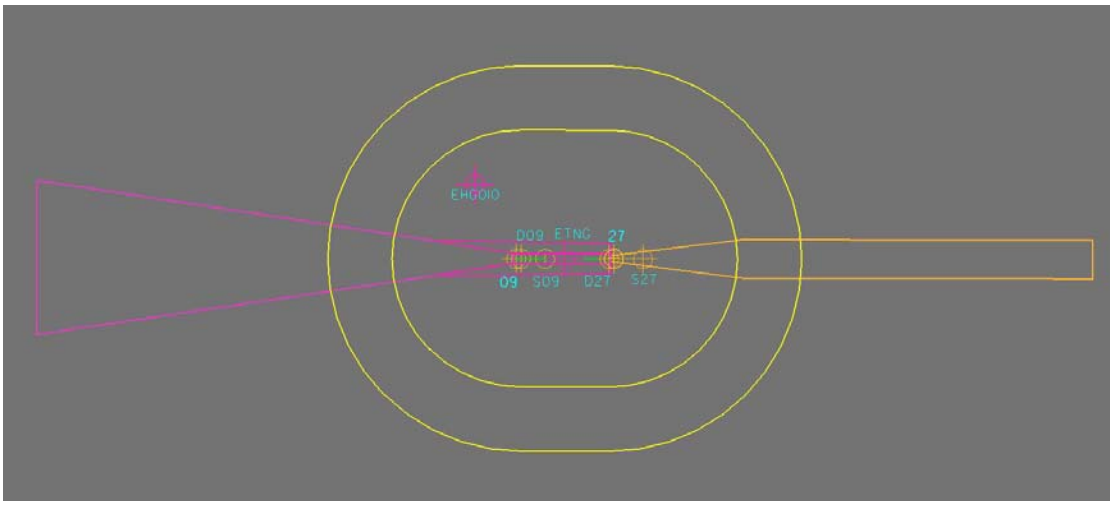

Figure 21: Current OLS RWY09

The following figure shows the current and future layout of OLS for runway 09. This is the amended version of Figure 21, where only current OLS is shown.

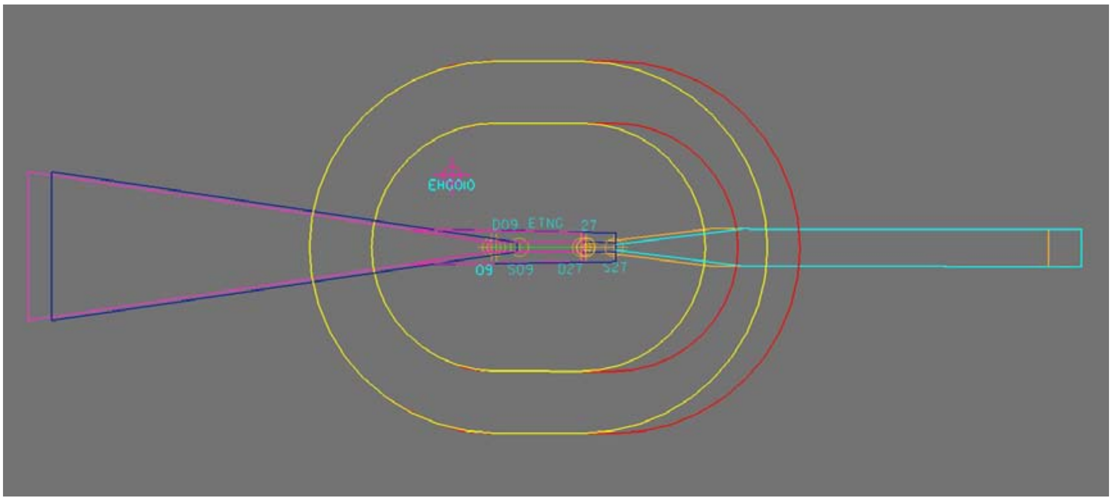

Figure 22: Current and future OLS for RWY09

The new inner horizontal and conical surfaces (red lines) are extended, together with the take-off climb surface (light blue) that is shifted by 900 metres towards east. The yellow and orange lines depict the current surfaces in the same order as on the Figure 21. The dark blue line presents the future approach surface that is also shifted 900 metres in comparison to the current one, marked with the purple line. It has to be noted that the shift of the future take-off climb surface is independent of the operational use of the runway, as this surface is related to the physical end of the runway, which in this case is shifted to the east. This means that the surface also is shifted to the east in case all take-off procedures start at the current threshold.

4.2.2 OLS RWY27

The following figures represent the same set of obstacle limitation surfaces as in the previous section, but for RWY27.

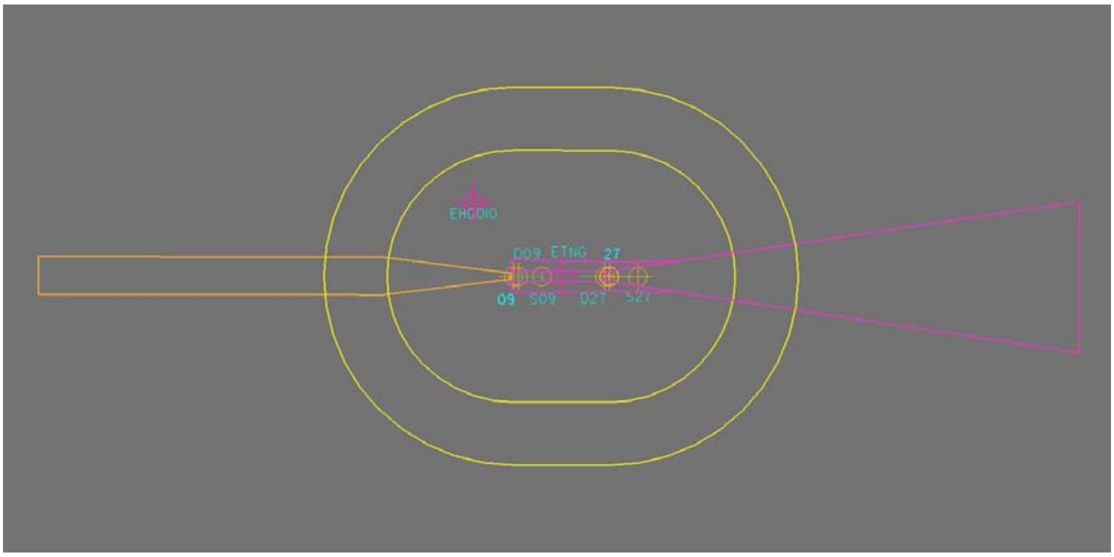

Figure 23: Current OLS RWY27

The yellow lines in the figure above represent the inner horizontal surface (inner oval) and conical surface (outer oval). The orange line represents the take-off climb surface while the purple line defines approach and transitional surfaces.

The following figure represents the effects of the runway extension on the OLS. It should be noted that approaches from the east fly to the current DTHR27 and not the new STHR27. Two sets of obstacle limitation surfaces are presented; namely the current and future OLS for runway 27.

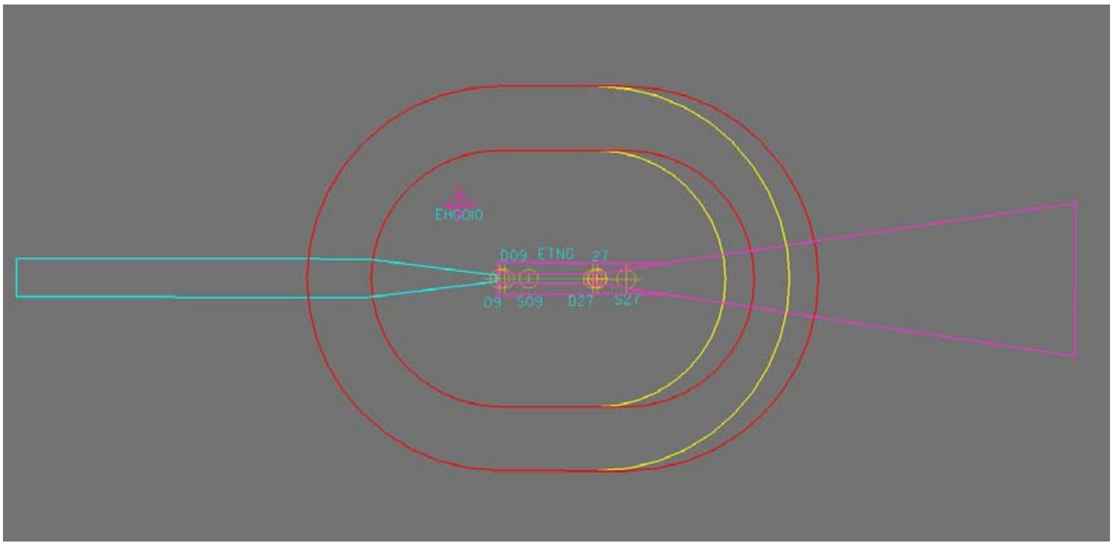

Figure 24: Current and future OLS for RWY27

With red lines the future inner horizontal and conical surfaces are depicted. They are extended 900 metres to the east with regard to the current surfaces that are depicted with yellow lines. The current approach surface will overlap precisely with the future approach surface (purple line). This is the result of the fact the approach operations to RWY27 will be conducted to the current location of the DTHR27. The take-off climb surface (light blue line) for RWY27 remains unchanged despite the runway extension. As mentioned earlier; the location and dimensions of this are dependent of the physical location of the runway end THR09 and the location of THR09 does not change.

4.2.3 Obstacle free zone

The current section briefly discusses the ICAO Annex 14 obstacle free zone (OFZ). This zone is the airspace above the inner approach surface, the inner transitional surface and the balked landing surface and that portion of the strip bounded by these surfaces (see Figure 19 and Figure 20). Analyses show that the OFZ does not change after the runway extension. Therefore this section will only give a short overview of the effects of the runway extension the OFZ. For a more detailed description, the reader is referred to Appendix D.

The OFZ is provided for precision approaches. It is assumed that after the runway extension, the instrument landing system (ILS) will be installed as it is now. This means that no ILS is available for approaches from the west so that no precision approaches can be conducted from the west. Only for approaches from the east an ILS is available and therefore only the obstacle free zone for RWY27 is investigated.

The landing point of future approach operations from the east will not change after the runway extension and therefore the current obstacle free zone will overlap exactly with the future obstacle free zone. This means that there will not be any objects that penetrate the new OFZ after the runway extension.

4.2.4 Consequences of changes in obstacle limitation surfaces

On the western side of the Geilenkirchen airbase runway, where no extension is foreseen, the approach surface for RWY09 will be shifted to the east. Because of the shifted approach surface the limiting effect of this surface on the maximum obstacle height will be less restrictive than the limiting effect of the current approach surface. Since the surface will be shifted, it will cover a different area compared to the current situation. The area between the blue and purple lines in Figure 22 will be included in the future surface, while it is not included in the current surface. Therefore it is possible that new objects will be included in the future surface. These objects will have to be assessed as new obstacles.

On the eastern side of the runway, where the extension will take place, most of the surfaces will be extended by 900 metres, analogically to the runway extension. Therefore, an obstacle assessment will have to be performed in these areas. The new surfaces will not only be extended (inner horizontal and conical) but also shifted (take-off climb). Shifted surfaces will originate in a different location and therefore they will be below the current surfaces. This issue is explained in the sketch below.

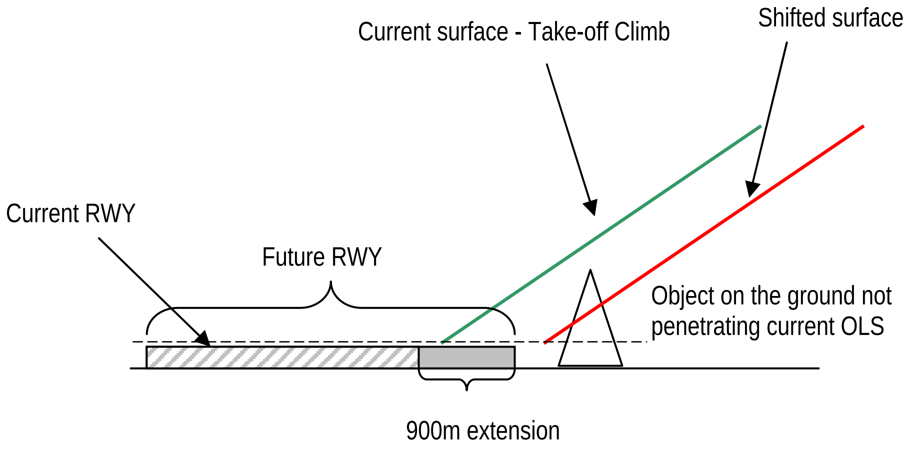

Figure 25: Current obstacle limitation surface vs. shifted surface (profile view; example)

It is possible that objects that are currently under the obstacle limitation surfaces, such as the take-off climb surface shown with the green line in the sketch above, will be penetrating the shifted future surface (red line in the sketch above). Also extended surfaces can lead to a situation where objects that are currently outside the OLS boundaries may be included in the contours of future OLS and may have some influence on the surfaces as well (see Figure 26). Therefore, the assessment of new surfaces will have to be performed.

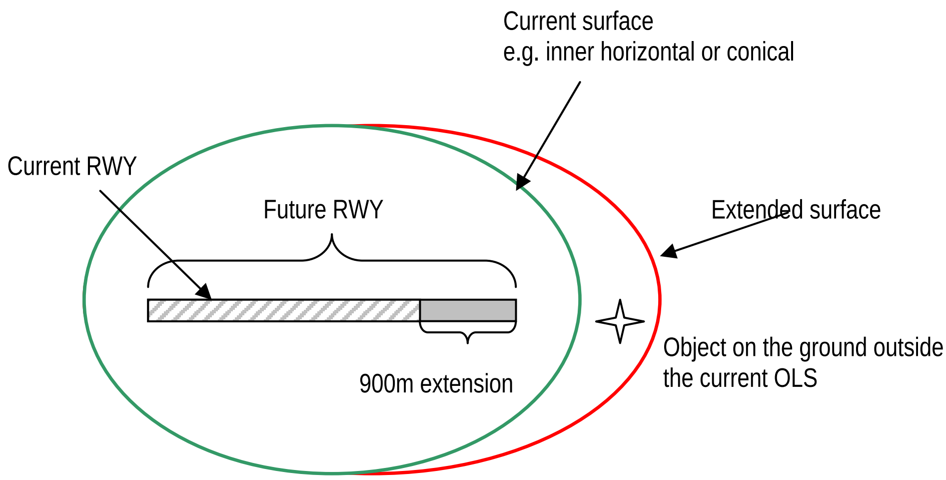

Figure 26: Current obstacle limitation surface vs. extended surface (top view; example)

Figure 27 shows the current and future OLS sets for RWY09, with a Google Earth map as a reference.

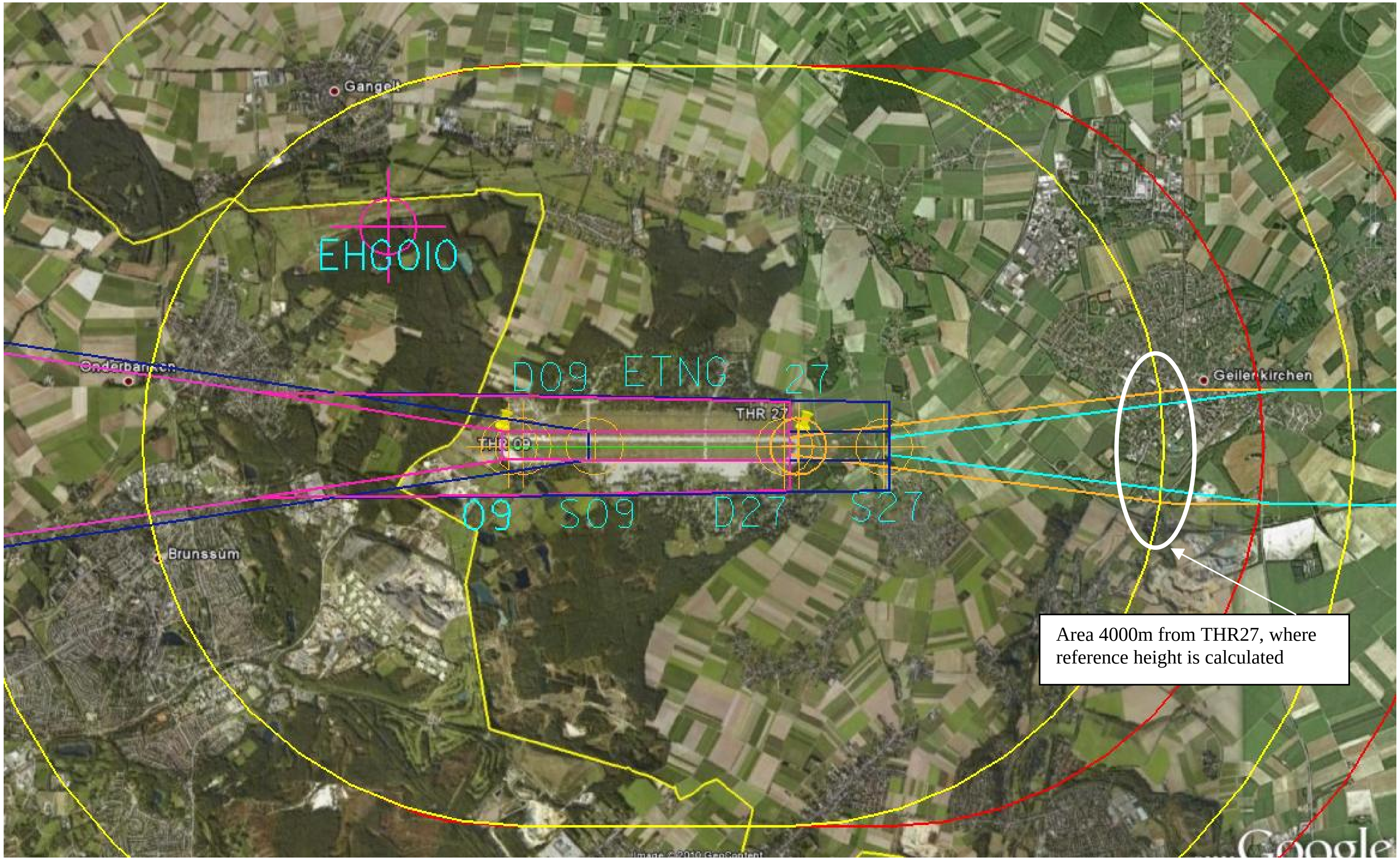

Figure 27: OLS surfaces (current and new) for RWY09. Note: for easier reference, the colours defining each surface are the same as in Figure 22

To clarify the effect of the runway extension on the obstacles heights limitations, some calculations are done. One point is used as a point of reference to show the differences in heights between current and future surfaces. For this purpose the heights of the take-off climb surfaces are determined in a point in the city of Geilenkirchen. This point is located at a distance of 4000 metres east from the current THR27 of the take-off climb surfaces in this common position. In Figure 27 this point is exactly at the intersection of the mentioned surfaces with the boundary of the current inner horizontal surface, i.e. with the inner yellow oval line.

The take-off climb surface for RWY09 is analyzed (see Figure 22 and Figure 27 for the location of the analysed surfaces). According to Annex 14, the take-off climb surface originates 60 metres from THR27 (departure end of the runway) [22). The length of the surface is equal to 15000 metres along the extended runway centre line and its slope is 2%.

The origin of the future take-off climb surface is shifted by 900 metres to the east in comparison to the current take-off climb surface. The new surface begins 60 metres from STHR27. The height of the current surface at the origin point of the future surface is equal to 18m:

900m * 2% = 18.0 m

For example, the height of current and future surfaces has been calculated at a distance of 4000 metres from the current THR27 (see Figure 27). This is the point where the current (orange line) and future (light blue line) take-off climb surfaces intersect with the current inner horizontal surface (inner, yellow line). The height of the current take-off climb surface at the point of intersection with the current inner horizontal surfaces is equal to:

3940m (from the origin of the surface) * 2% (slope) = 78.8m above the THR27 elevation.

Since the height of the future take-off climb surface at the point of intersection with the current inner horizontal will be 18 metres lower, the future take-off climb surface will have a height of 60.8 metres above the THR27 elevation. As a consequence, any object that is currently 18 metres or less below the present surface will penetrate the future take-off climb surface from RWY09.

[22)] *Ministerialblatt Nordrhein-Westfalen*, 2005:31, p. 761 – 776.

5 Conclusions

If the runway of the NATO airbase in Geilenkirchen is extended 900 metres eastward, the current flight routes will be modified in order to change the noise load and peak noise levels produced by aircraft flying to and from the base. Besides the changed flight routes; the runway extension also has an impact on the obstacle limitation surfaces and the spatial planning nearby the base. The conclusions with regard to these aspects will be discussed in the first three paragraphs of this chapter. After that the conclusions will be compared to the conclusions of the German analysis.

5.1 Impact of runway extension on noise load and peak noise levels

In chapter 2 both the yearly noise load produced by all flight movements over the year and the peak noise levels of individual flight movements are analysed. Based on these analyses the following conclusions can be drawn:

- The runway extension has the largest effect on the noise load on Dutch territory. The area of the noise contour on Dutch territory decreases with 0.5 km^2 (22%) due to the runway extension. The noise contour becomes smaller between Schinveld and Brunssum.
- The runway extension leads to a higher noise load in Germany. The 35 Ke contour area on German territory increases with 0.2 km^2 (3%) after the runway extension. The increased area is caused by a wider contour at the new landing point for approaches from the west, by a wider contour at the location of the runway extension and by the fact that the contour is shifted slightly to the east. The latter change is small compared to the first two.
- The peak noise levels in Schinveld and Brunssum are reduced when the starting point of take-off procedures over the Netherlands is moved 900 metres eastward. The investigated points in these villages show a reduction of 0.8 to 2.9 dB(A). Since the starting point has moved 900 metres eastward, the noise levels in Teveren caused by a take-off in western direction increase with 10.5 to 16.8 dB(A) at the investigated locations. The peak noise levels in Geilenkirchen are relatively low for both the current situation and the situation with the extended runway.
- The largest decrease in peak noise levels near the landing route over the Netherlands equals 3.3 dB(A) at the investigated locations in the Netherlands. This decrease is caused by the fact that aircraft fly at a higher altitude between Schinveld and Brunssum if the landing point is moved 900 metres to the east. On a larger distance from the landing route, the peak noise levels increase due to the fact that the higher altitude results in a larger incidence angle. The highest calculated increase equals 1.5 dB(A). The increase in the peak noise levels generated by a landing over the

Netherlands equals 14.6 to 22.2 dB(A) in the investigated locations in Teveren. The peak noise levels in Geilenkirchen are relatively low for both the current situation and the situation with the extended runway.

- The analysis of a take-off over Germany that is part of a touch and go or go-around procedure shows that the runway extension results in an increase in peak noise levels of 2.2 to 2.5 dB(A) in the considered locations in Geilenkirchen. The peak noise levels in Teveren are reduced with 1.6 to 2.2 dB(A) due to the lower incidence angle of the noise.

5.2 Impact of runway extension on spatial planning

The runway extension will have several effects on the spatial planning in the vicinity of the airbase. The most important conclusions with regard to these effects are:

- The extended runway crosses the *Naturschutzgebiet* (nature reserve) '*Grosse Heide*'. Compensation for the loss of environmental qualities will be required.
- A pipeline is located in the runway extension area.
- Two major roads do cross the extended runway; besides, a few minor roads and cycle paths do.
- The taxiway giving access to the extended main runway would cross a sports field.
- The extended runway would cross the *Rodebach*, a small river which was designated as a Naturschutzgebiet in 2008.
- The height differences in the area of the extended runway amount to up to 15 metres, especially in the final 200 metres.
- Any airport modification will require a *Planfeststellungsverfahren*. Exceptions are made for minor modifications, which require a *Genehmingungsverfahren* only. However, one of the requirements for using the easier procedure is that the modification does not affect land owned by others. For the Geilenkirchen runway extension, this means that a *Planfeststellungsverfahren*, including a preceding *Raumordnungsverfahren* to adapt the spatial planning policies in the region, will be required.
- Depending on the amount of appeal procedures, procedures will take between two and seven years. It must be kept in mind, however, that the extension proposal and all supporting documentation is to be provided before the start of the formal procedures. In the case of Frankfurt-Hahn, the complete file amounted to about 2,000 pages. Appeals may be taken to the highest level, the federal court of justice, before being decided beyond dispute. This process may take up to four years.
- To a large extent, the cost of a runway extension depends on local characteristics such as soil quality and on the projected use of the runway. Cost estimates from other runway extensions vary from €11,000 per meter for the extension of a small airstrip

to about €100,000 per meter. The €11,000 per meter estimate, however, is derived from the Schwarze Heide runway extension, which can only accommodate aircraft up to 7,000 kg. At €50,000 per meter, the costs of the 900 metres runway extension would amount to €45 million, wile at €100,000 per meter the runway extension will cost €90 million.

- The actual construction of the extended runway could probably be completed in about one or two years. However, the preceding procedures will take about four times as long. This means that the runway extension will take at least five years to complete, provided that all required documents have been drafted. This not being the case, the extension will probably take two more years. Besides, given the impact of the runway extension on the Grosse Heide and Rodebach natural areas, as well as the increased noise nuisance in Germany, the procedures cannot be expected to be completed without legal appeals. Therefore, it is highly improbable that the runway extension will be completed before 2020.

5.3 Impact of runway extension on obstacle limitation surfaces

Lengthening the runway will influence the location of the obstacle limitation surfaces in the following ways:

- The inner horizontal and conical surfaces are extended 900 metres eastward.
- The take-off climb surface for departures to the east and the approach surface for arrivals from the west are shifted 900 metres eastward.
- The location of the take-off climb surface for departures to the west and the approach surface for arrivals from the east will not change after the runway extension.
- Because there is no ILS operation for approaches from the west the obstacle free zone for these approaches is omitted. The obstacle free zone for approaches from the east remains the same after the runway extension.

It is possible that new objects will be included one or more of the shifted surfaces. These objects will have to be assessed as new obstacles.

5.4 Comparison with results of the German analysis

The goal of this study was to verify the results of a German analysis on the effects of the runway extension. Some important conclusions of the German analysis were that the noise impact near the airbase will increase on German territory and that the construction of the extended runway and all required procedures will not be finished before 2020.

The conclusions described in the paragraphs 5.1 to 5.3 confirm that these conclusions are valid. Also most other conclusions of the German analysis are confirmed by this study.

Only the following conclusion of the German analysis is not agreed with: "*The runway extension provides only marginal noise mitigation on Dutch territory*". This study shows that the area of the noise contour on Dutch territory decreases with 0.5 km^2, which is 22% of the total area of the contour of the 2008 situation with the current runway. At some locations the peak noise levels become lower. The peak noise levels of individual flights decrease with at most 3.3 dB(A) in the investigated points. However, this decrease is smaller at other locations and for other procedures and in some cases even an increase in peak noise level is calculated.

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References

[1] Landrum and Brown, Final Comprehensive study NATO Air Base Geilenkirchen

[2] *Voorschrift voor de berekening van de geluidsbelasting in Kosteneenheden (Ke) van het vliegverkeer*, RLD release RLD/BV-01, March 1998 (only available in Dutch).

[3] http://www.geluidsnet.nl/project/brunssum_onderbanken, cited 24th of June 2010.

[4] P. Newman and A. Thornley, *Urban planning in Europe, International competition, national systems & planning projects*, Routledge, 1996.

[5] H. Mensen, Planung, anlage und betrieb von Flugplätzen, Springer, 2007.

[6] European Communities, *Regional development studies: the EU compendium of spatial planning systems and policies, European Union, Regional Policy and cohesion*, 1997.

[7] European Communities, *Regional development studies: the EU compendium of spatial planning systems and policies, Germany, European Union, Regional Policy and cohesion*, 1999.

[8] EAD - Eurocontrol managed European AIS Database, cited 11th of June 2010.

[9] ICAO Doc 8168 Procedures for Air Navigation Services - Aircraft Operations, vol. II Construction of Visual and Instrument Flight Procedures.

[10] Letter of the state secretary of Defence, *maximaal toelaatbare hoogte van objecten in de omgeving van luchtvaartterreinen en radars*, DRMV/2006021602, 27th of October 2006 (only available in Dutch).

Appendix A Number of flight movements

This appendix provides an overview of the number of flight movements per flight procedure based on the traffic in 2008. Also the division of flight movements over the different flight routes is discussed. The following flight procedures are considered:

- Take-off from standstill.
- Landing to standstill.
- Take-off that is part of a touch and go or go-around procedure.
- Landing that is part of a touch and go or go-around procedure.

The number of flight movements over the Netherlands and over Germany is given for each of these procedures. It should be noted that the table contains the number of flight movements that is corrected with a penalty factor. This factor makes sure that a flight movement that takes place between 18:00 o'clock and 08:00 o'clock has a larger contribution to the total noise load compared to a similar flight movement that takes place outside this time frame. This means that the total number of flight movements in this table is larger than the actual number of flight movements that took place during 2008.

Table 4: Number of flight movements per route

Route	Absolute value	Percentage
TO-SS-NL	1490	21.0%
LA-SS-NL	496	7.0%
TO- TG/GA -NL	1192	16.8%
LA- TG/GA -NL	302	4.3%
TO-SS- GER	465	6.5%
LA-SS- GER	1662	23.4%
TO- TG/GA - GER	302	4.3%
LA- TG/GA -GER	1192	16.8%
Total	**7101**	**100.0%**

Explanation:

TO = Take-off
SS = Standstill
NL = (over the) Netherlands
LA = Landing
TG/GA = Touch and go or go-around
GER = (over) Germany

As can be seen in Figure 2 and Figure 4, multiple routes exist for take-off and landing procedures over Germany. All approach procedures from the east are divided over the four landing routes (see Figure 2) as follows:

- Most northern route: 1.8%.
- Most northern of the middle routes: 76.4%.
- Most southern of the middle routes: 17.4%.
- Most southern route: 4.3%.

The departure procedures to the east are divided over the two take-off routes (see Figure 4) as follows:

- Most northern route: 48.2%.
- Most southern route: 51.8%.

Figure 4 shows that the most southern take-off route is shifted 900 metres eastward after the runway extension. This modified route is used by take-offs over Germany that are part of a touch and go or go-around procedure. Take-off procedures from standstill will continue to use the current route after the runway extension. The division of flight movements over the current and extended route will be as follows after the runway extension:

- Current route: 24.0%.
- Extended route: 76.0%.

Appendix B List with expressions German - English - Dutch

German	English	Dutch
Baugesetzbuch	Construction law	Bouwbesluit
Bauschutzbereich	Restricted building area	Bouwbeperkingsgebied
Bebauungsplan	Construction plan	Bestemmingsplan / bouwplan
Eingriffsregelung	Intervention regulation	Ingreep-regeling
Fachplan	Sector plan	Sectoraal plan
Flächennutzungsplan	Land use plan	Bestemmingsplan
Genehmigung	Permission	Vergunningverlening
Genehmigungsverfahren	Permit procedure	Vergunningverleningsprocedure
Gesetz zum Schutz gegen Fluglärm	Air traffic noise protection act	Luchtvaartwet
Landesbauordnung	State construction law	-
Landesplanungsgesetz	State planning law	-
Landschaftsgesetz	State landscape act	-
Luftverkehrsgesetz	Air traffic regulation/act	Wet Luchtvaart
Luftverkehrsordnung	Air traffic ordinance	Besluit luchtverkeer
Naturschutzgebiet	Area of outstanding natural beauty	Natuurgebied
Naturschutzgesetz	Nature protection act	Natuurbeschermingswet
Planfeststellungsverfahren	Plan approval procedure	Planvaststellingsprocedure
Raumordnungsgesetz	Spatial planning act	Wet ruimtelijke ordening
Raumordnungsverfahren	Spatial planning procedure	Ruimtelijke ordeningsprocedure
Regionalplan, Landesentwicklungsplan	Regional spatial plan	Structuurvisie, streekplan

Appendix C Runway description

The current runway 09/27 is 3,048 metres long and 45 metres wide. The coordinates of the current thresholds (THR) and displaced thresholds (DTHR) are:

THR09: 50°57’39.7692”N 006°01’12.2802”E
DTHR09: 50°57’39.6918”N 006°01’19.9068”E
THR27: 50°57’38.1678”N 006°03’48.4800”E
DTHR27: 50°57’38.2458”N 006°03’40.8840”E

In the case of the current runway the threshold is the starting point of the physical runway.

The new runway 09/27 will be 3,948 metres long and 45 metres wide; i.e. 900 metres longer than the current runway. For easier reference, the new thresholds will be called shifted thresholds (STHR). The coordinates of THR09 will remain unchanged. However, the STHR 09 will be located 900 metres east from the current DTHR09 since the landing point is shifted 900 metres eastward. This will have an effect on the landing operations for the RWY09. STHR27 is the new physical runway end. The coordinates of the new STHR09 and STHR27 will be as follows:

STHR09: 50°57’39.2240”N 006°02’06.1007”E (shifted 900 metres eastward from the current DTHR09).

STHR27: 50°57’37.6831”N 006°04’34.6623”E (900 metres eastward from the current THR27 along the extended runway centre line).

Appendix D Detailed analysis of the obstacle free zone

The ICAO Annex 14 obstacle free zone (OFZ) was discussed briefly in paragraph 4.2.3. This appendix gives a more detailed overview of the OFZ. This zone is the airspace above the inner approach surface, the inner transitional surface and the balked landing surface and that portion of the strip bounded by these surfaces (see Figure 19 and Figure 20). The OFZ should not be penetrated by any fixed obstacle other than a low-mass and frangibly mounted one required for air navigation purposes. The OFZ is provided on a precision approach. It is assumed that after the runway 09/27 is extended, the instrument landing system (ILS) will be installed as it is now. This means that only an ILS is available for approaches from the east. Therefore only the obstacle free zone for RWY27 is presented herein. Because there is no ILS operation for RWY09 and it is assumed there will be no ILS approach for this direction in the future, the OFZ for RWY09 is omitted.

The following figure presents the comparison between the current and future OFZ for RWY27. The shifted threshold 27 is marked on the figure as threshold 27D for easier distinction. The current physical thresholds are marked as 09 and 27.

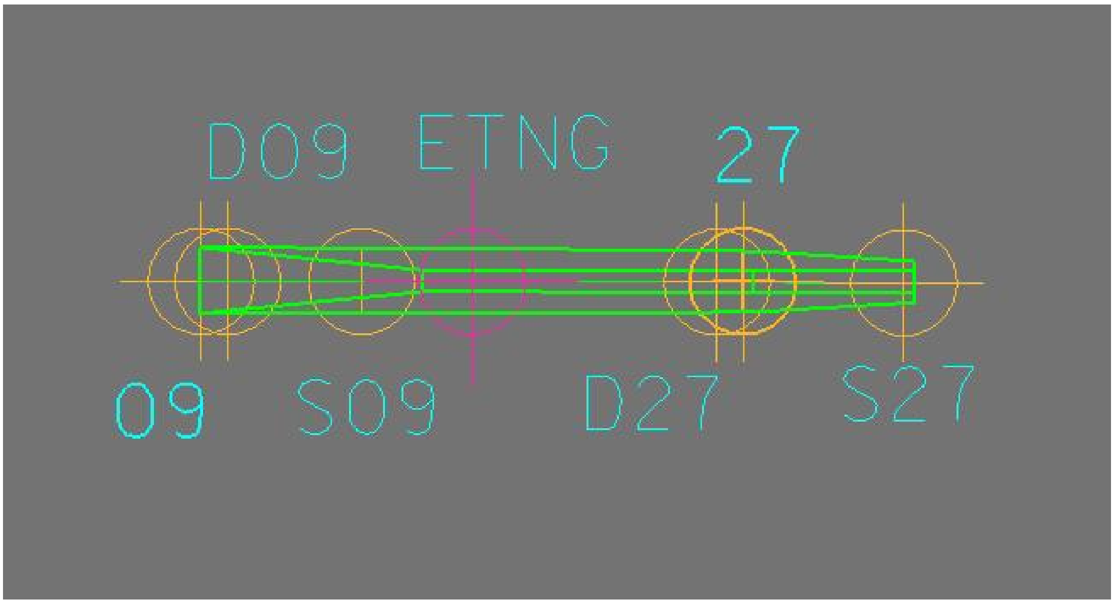

Figure 28: Current and future OFZ of RWY27

Figure 28 shows two sets of obstacle free zones with its surfaces for runway 27. The landing point of future approach operations will not change after the runway extension. Therefore the current obstacle free zone will overlap exactly with the future obstacle free zone. Therefore no difference between the current and future obstacle free zone is visible in the figure.

Figure 19 shows the location of the obstacle free zone surfaces: the inner approach surface, the inner transitional surface and the balked landing surface. These surfaces are shown in Figure 28 for Geilenkirchen airbase. The inner rectangular surface on the right hand side of the picture represents the inner approach surface. This surface is related to the approach threshold, which is the current threshold in this case. On the northern and southern side of the runway, the inner transitional surface can be seen. On the left hand side of the picture, the balked landing surface is shown (see Figure 19). This surface is located at a specified distance after the approach threshold. Since the latter will not be shifted, the whole set of surfaces will remain unchanged as well.

Figure 29 presents the same set of obstacle free zone with the reference terrain from Google Earth for easier understanding of the location of the OFZ.

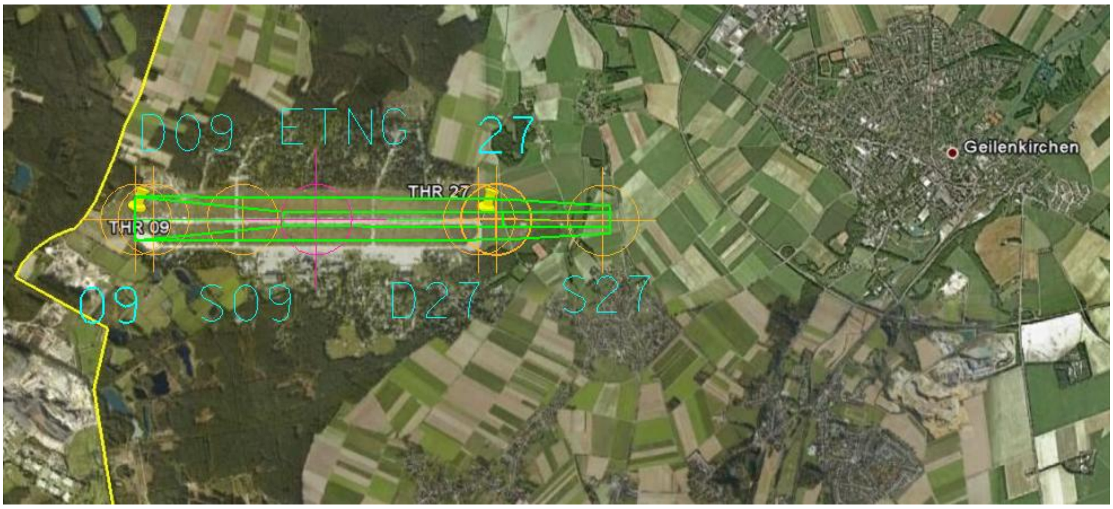

Figure 29: Obstacle free zone with Google Earth background