



## Executive summary

# Measures to Reduce AWACS Noise Impact



### Problem area

Since 1982 radar aircraft are based in Geilenkirchen. The NATO airbase is situated in Germany, just outside the border of the Netherlands. Due to its location, aircraft fly relatively low over the south of the Netherlands and cause nuisance in Dutch villages near the base. This article discusses mitigation measures that have been evaluated over last recent years aiming to reduce the nuisance.

### Description of work

The following 4 mitigation measures are evaluated:

1. Reduction of flight movements
2. Use of more silent (not AWACS) aircraft
3. Use of other flight procedures
4. Lengthening the runway

Results are given by yearly noise load or recorded noise levels.

### Results and conclusions

The reduction of flight movements and the use of more silent (not AWACS) aircraft will lead to a

lower yearly noise load. The individual noisy passage however remains.

The use of other flight procedures seems limited. Test flights were carried out to determine silent procedures. There were many difficulties in order to get to well supported conclusions for the evaluation of the individual procedures. Rough orders of magnitude are given of the effect of different procedures on noise levels. The test flights were also part of the regular training scheme. Within the training scheme all aspects of different procedures are being trained so that it is not always possible to fly the most silent procedure. Therefore the effect on the yearly noise load becomes negligible.

Another suggested mitigation measure is lengthening the runway. This measure will reduce the noise levels of the individual passages and the yearly noise load. With this measure some areas get more noise and some less, but the overall

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nuisance in the area is expected to be reduced. The effect of the on the noise levels and yearly noise load is still to be studied.

**Applicability**

The evaluation of the mitigation measures gives more insight of the impact of the different mitigation measures. Although the statistical basis of some evaluations is limited; the rough order of magnitude may help to decide if a mitigation measure is worth implementing. This type of research can support the decision making and policy process.



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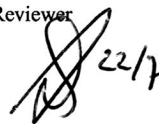

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## MEASURES TO REDUCE AWACS NOISE IMPACT

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### **Abstract**

For many years AWACS flights from the NATO airbase Geilenkirchen in Germany result in nuisance in Dutch cities and villages near the base. In order to reduce the noise impact several measures have been taken. This paper will discuss a number of mitigation measures that have been investigated in order to reduce the noise impact of AWACS flight movements, such as: a reduction of the number of flight movements, the use of more silent aircraft, the use of other flight procedures and lengthening the runway.

**Keywords:** AWACS, noise, annoyance, noise abatement

## 1 Introduction

Since 1982 radar aircraft are based in Geilenkirchen. The NATO air base is situated in Germany, just across the border of the Netherlands. Due to its location, aircraft fly relatively low over the south of the Netherlands and cause nuisance in villages like Schinveld and Brunssum (see Figure 1, right).

Radar aircraft are called AWACS. AWACS is the acronym for Airborne early Warning And Control System. Figure 1 (left) gives an impression of an AWACS with its characteristic dish at its back. It has equipment on board to scan areas where it flies. The information withdrawn by AWACS aircraft supports NATO's defence- and safety missions. The AWACS aircraft based in Geilenkirchen are of the type E-3A. This is a modified Boeing 707 which is an older generation aircraft. The AWACS falls in chapter 2 of the ICAO (International Civil Aviation Organisation) annex 16 [1] certification method. The difference between Chapter 2 aircraft and the newer generation aircraft is that today's engines generate up to 10 dB(A) [2] less noise while operating in the same circumstances. Passages of AWACS aircraft lead to recorded noise levels in Schinveld and Brunssum that can exceed 100 dB(A). Therefore replacing the engines seems the most promising measure to take. In the past this has been considered, however due to economical reasons the replacement has been rejected.

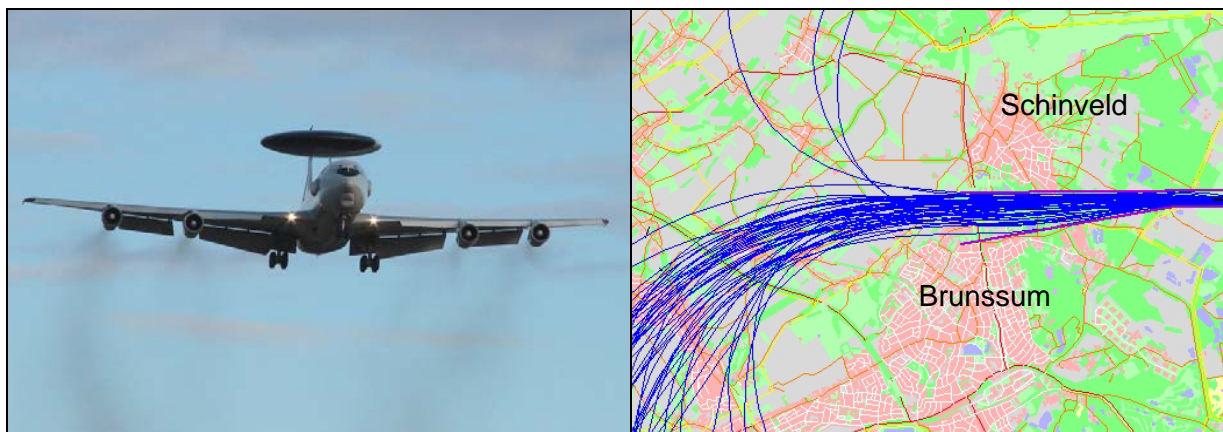


Figure 1 – Left: an AWACS type E-3A – Right: Radar tracks

The Dutch ministry of housing, spatial planning and environment monitors whether the NATO operates within the noise zone that was defined in 1983 [3]. Every year noise calculations are made to verify whether the noise zone is not exceeded. If the zone is exceeded the cause is being investigated and measures can be taken. In the last years no crossings were determined in the urban areas of Schinveld and Brunssum. Which is explained by a substantial drop of movements since 1983, but the nuisance remains.

The operations of the air base Geilenkirchen are under NATO command. International treaties underlie NATO's tasks and the Netherlands only has a limited voting right to change these treaties. The USA and Germany are the biggest contributors to the costs and therefore have more influence on the airbase policies. Despite this limited influence, the Dutch minister of housing, spatial planning and environment together with the Dutch state secretary of defence and the authority of the NATO base intend to reduce the nuisance. For this reason several mitigation measures were suggested, such as:

1. Reduction of the number of flight movements
2. The use of more silent (not AWACS) aircraft
3. The use of other flight procedures
4. Lengthening the runway

This article discusses the above measures in more detail. It evaluates the measures and shows the effect of the measures on the calculated yearly noise load or on recorded noise levels. The first two measures are typical for Geilenkirchen and are depending on its operational fleet. The last two however are the ones which are more special. For the use of other flight procedures a unique data set is available: noise data at several locations together with radar data of the same aircraft flying different procedures on the same day, thus having similar weather conditions. Furthermore it is unique to mitigate by changing the landing and starting points of the runway. In the end of the article conclusions are drawn.

## 2 Mitigation Measures

### 2.1 Reduction of flight movements

In a letter [4] addressed to the Dutch parliament the state secretary of defence offered to move 120 AWACS training flight movements and 40 cargo flights (meaning 80 cargo flight movements) from Geilenkirchen to Dutch military air bases. Less flight movements must lead to a reduction of the noise load. The effect on the yearly noise load having a reduction of

flight movements has been studied with a scenario that will be referred to as scenario 1 in this article. The input of the yearly noise load calculation for 2008 is used as reference. In scenario 1 the 2883 flight movements that took place in 2008 are changed to 2723 flight movements (160 movements less). This means 40 movements less as offered by the state secretary of defence. However cargo flights will typically depart and land on the same day. Assuming throughout the day no big weather changes will occur, Dutch residence only benefit of one movement (during take-off or landing). Therefore only 40 cargo flight movements are considered. The reduction is established by removing 120 AWACS aircraft and 40 Ilyushin-76 aircraft flight movements. The Ilyushin-76 typically is used for cargo flights and is an older generation aircraft that has relatively noisy engines.

The airbase also will lower the number of flight by caring out training flights in a simulator. The actual reduction due to the use of the simulator is hard to estimate and depends on the training scheme. Scenario 1 therefore only includes the offer of the state secretary.

The yearly aircraft noise zone on the Dutch side of Geilenkirchen is defined in 35 Ke (Kosten), this is a typical Dutch metric. Doubling the number of flight movements will change the 35 Ke to 41 Ke. The reduction of the number of flight movements leads to a reduction of the contour area of 8% of the 35 Ke noise contour (see Figure 2 and Table 1) compared to the 2008 scenario and a reduction of 45% compared to the noise zone.

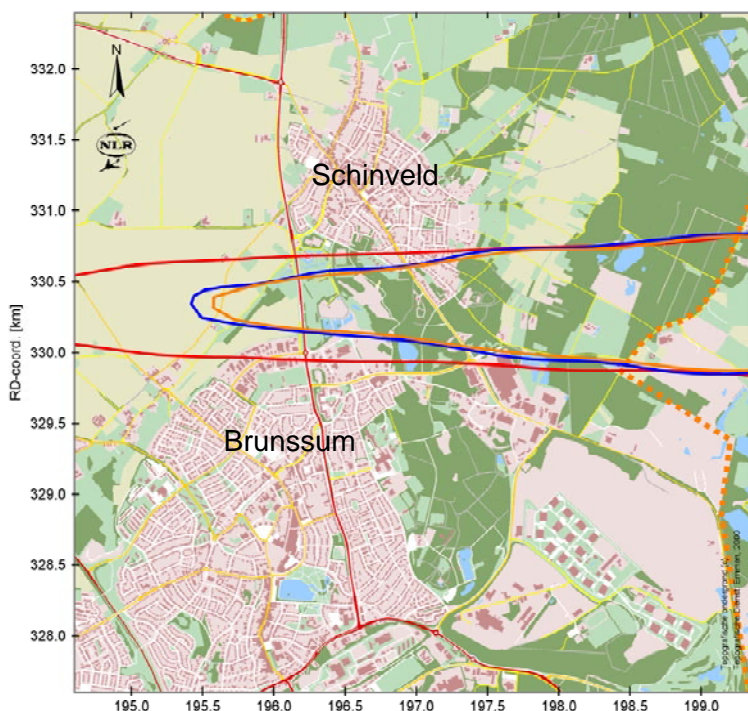


Figure 2 – 35 Ke contours

Inner contour (orange) = scenario: 1, centre contour (blue) = 2008, outer contour (red) = zone

Table 1 – 35 Ke contour decreases against 2008 in %.

	Ke [km <sup>2</sup> ]	Against Scenario 2008 [%]	Against Scenario Noise zone [%]
Scenario 1	1.93	- 8	- 45
Scenario 2	1.78	- 15	- 49
Scenario 2008	2.10	0	- 40
Noise zone (1983)	3.52	+ 68	0

## 2.2 The use of more silent (not AWACS) aircraft

Besides the AWACS and the Ilyushin-76, other aircraft like the TCA and the K35E fly to and from Geilenkirchen. The TCA also belongs to the Boeing 707 family but does not have a dish at its back. It is used for training and cargo flights. The K35E is a tanker mainly used for cargo flights and belongs to the same generation of aircraft as the AWACS. NATO considers replacing the Ilyushin-76, the K35E and the TCA with newer, more silent aircraft. The scenario that is used to calculate the impact of this measure is referred to as scenario 2 in this paper.

In scenario 2, 415 TCA and 33 K35E in 2008 are replaced by more silent aircraft (namely Airbus 320). The K35E aircraft are replaced by more silent tanker aircraft. The TCA is also used to train AWACS pilots (this is possible as they both belong to the Boeing 707 family), which means that replacing the TCA results in an increase of the number of AWACS flight movements. It is assumed that the number of training flights remains the same, therefore it is estimated the AWACS movements will increase by 200. This means that 415-200=215 AWACS flights are being replaced.

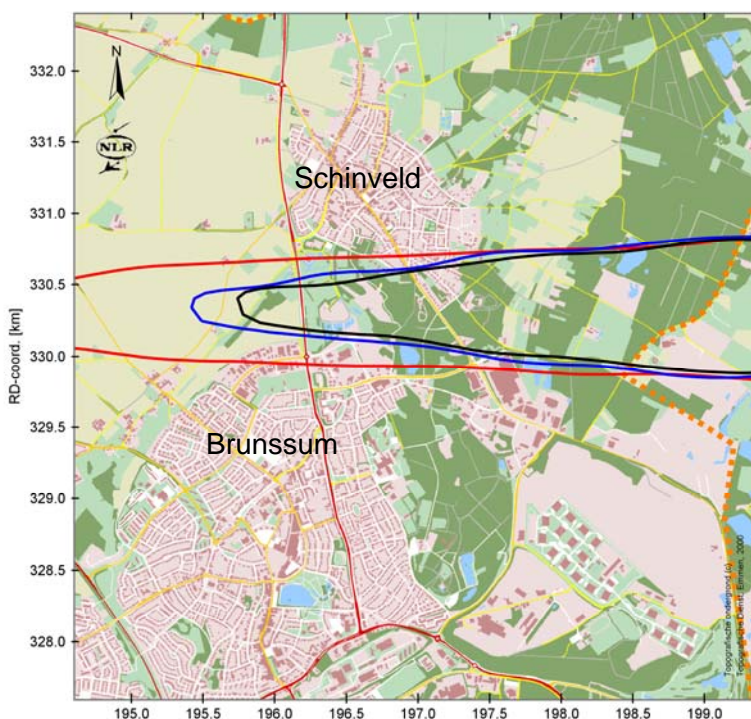


Figure 3 – 35 Ke contours

Inner contour (black) = scenario: 2, centre contour (blue) = 2008, outer contour (red) = zone





For the 35 Ke noise contour (see Figure 3), this mitigation measure leads to a reduction of 15% of the contour area (see Table 1) compared to the 2008 scenario and 49% compared to the noise zone. Scenario 2 has a larger impact on the noise load than scenario 1, even though the number of flight movements in scenario 1 is less. This is explained by the noise load dominance of the AWACS. In scenario 2, more Boeing 707 family aircraft are replaced.

### 2.3 The use of other flight procedures

The nuisance caused by aircraft noise is related to the noise production of the aircraft. The noise impact on the ground of an aircraft is mainly influenced by the position of the aircraft and its thrust. Second order parameters like flight path angle, climb speed, flap settings, speed and wind speed also have an effect on the noise exposure perceived on the ground. To reduce the noise impact, aircraft should preferably fly silent procedures. All variables affecting the noise exposure are related to each other. To determine the silent AWACS approach beforehand all aspects have to be considered.

The horizontal projection (ground path) is not considered while evaluating the use of other flight procedures. If the AWACS flies more towards Schinveld, the noise level in Schinveld increases while it decreases in Brunssum. This phenomenon has nothing to do with the flight procedure. In order to limit the horizontal spread a measure is already in place. Between the authorities of the airbase, the Dutch ministry of housing, spatial planning and environment, the state secretary of defence, the county of Limburg and the people living in the vicinity of Geilenkirchen it is agreed that aircraft should fly in a funnel between Schinveld and Brunssum. The aim of this measure is to ensure that aircraft do not overfly Schinveld and Brunssum. The air traffic controller can overrule this agreement if this is necessary for safety reasons. Each quarter of a year it is reported how many departures flew outside the funnel. The funnel measure is in place for several years now and no extra benefits are expected from further optimisations of this funnel.

On the 8<sup>th</sup> of November 2008 and the 4<sup>th</sup> of September 2009 test flights were flown in order to determine silent take-off and landing procedures. During these tests Geluidsnet<sup>1</sup> has recorded the noise levels each second at several locations throughout the area while the aircraft passed. The noise data was made available to the NLR and was analysed together with radar data in [6] and [7]. In Figure 4 and Figure 5 profiles are shown for respectively the departures and approaches. The x-axis gives the RD-X coordinates (following the Dutch coordinate system) having the scale in metres where left is west and right is east. In this way the figure becomes a sort of window, looking in a northern direction. The altitude on the y-axis is given in metres relative to mean sea level. The figures also show the location of the runway and some measurement locations. This indicates the geographical differences between the profiles, measurement locations and the runway.

Figure 6 shows the noise events for the departures at a location in Schinveld. For each event peak levels are set at  $t=0$  seconds. In this way the noise events become comparable. The noise has been corrected in order to eliminate the influence of differences between the ground paths of the different flight movements. All flight movements were projected on a reference ground path and the noise levels were corrected for differences in distance and absorption. For approach flights this correction could not be made due to the lack of position data of the flight track between Schinveld and Brunssum. Besides different ground paths, more aspects will cause differences between the measured noise levels of the different test flights:

1. Most of the departures and approaches were touch and go and go-around procedures. This means the aircraft did not come to standstill and that the aircraft did

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<sup>1</sup> The real-time results of Geluidsnet monitoring network system can be viewed on [www.geluidsnet.nl](http://www.geluidsnet.nl)



in some cases not touch the runway. This will influence the aircraft performance during the remainder of the take-off procedure.

2. There is a lack of detailed information of the aircraft settings during the test flights (such as thrust and flap settings). Correlating different aspects of the flight procedure with the noise results therefore became unfeasible.
3. The number of test flight is too small to determine statistically reliable trends.

The results of the test flights were combined to determine the most silent procedures and after that the effect of parameters like distance and thrust were studied. In the areas of Schinveld and Brunssum the differences between the peak levels of the most noisy departure and the least noisy departure was 6 dB(A) as can be seen in Figure 6. Since the most silent departure was a go-around that flew approximately 200ft above the runway, the possible noise reduction of a take-off procedure from the runway will be smaller. Doing an expert judgement, it is expected that the difference between the most silent and the most loud departure procedure will be in the order of 3 to 4 dB(A) if all procedures would be carried out from standstill.

For the approaches benefits expressed in decibels could not be derived from the test flights due to the lack of position (radar) data of the aircraft between Schinveld and Brunssum. Therefore no accurate correction could be made for differences in the flight paths of the different test flights. The correction however has been done using a flight path extension to the runway. This way the most silent approach of the test flights was determined. Figure 7 shows the corrected peak levels of all approaches per monitor position (mp). The approach that flies at the highest altitude (see Figure 5, flight 18) results in the most silent flight procedure.

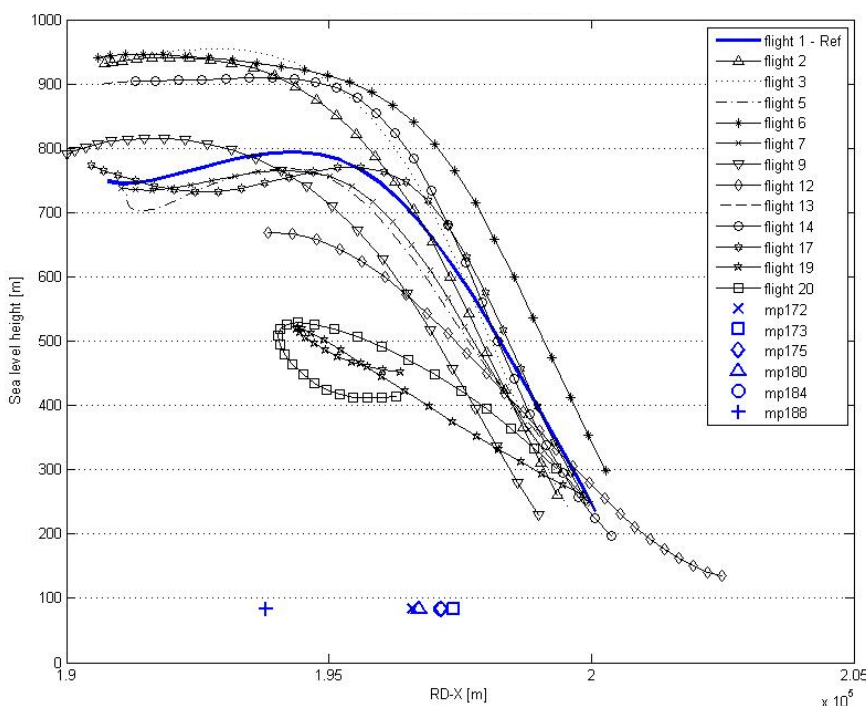


Figure 4 – Height profiles: departures 8 November 2008

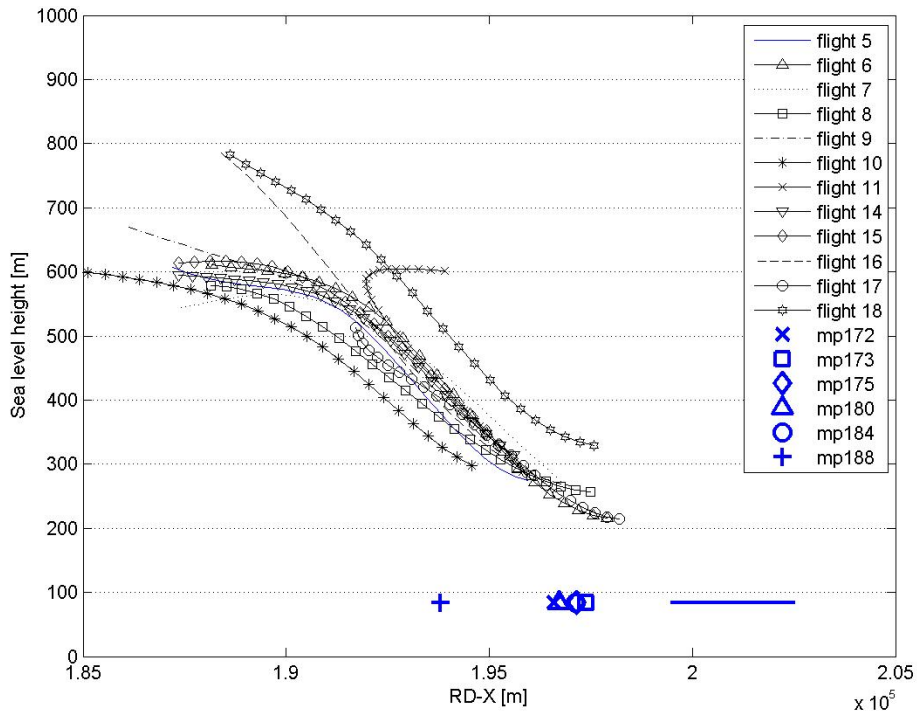


Figure 5 – Height profiles: approaches 4 September 2009

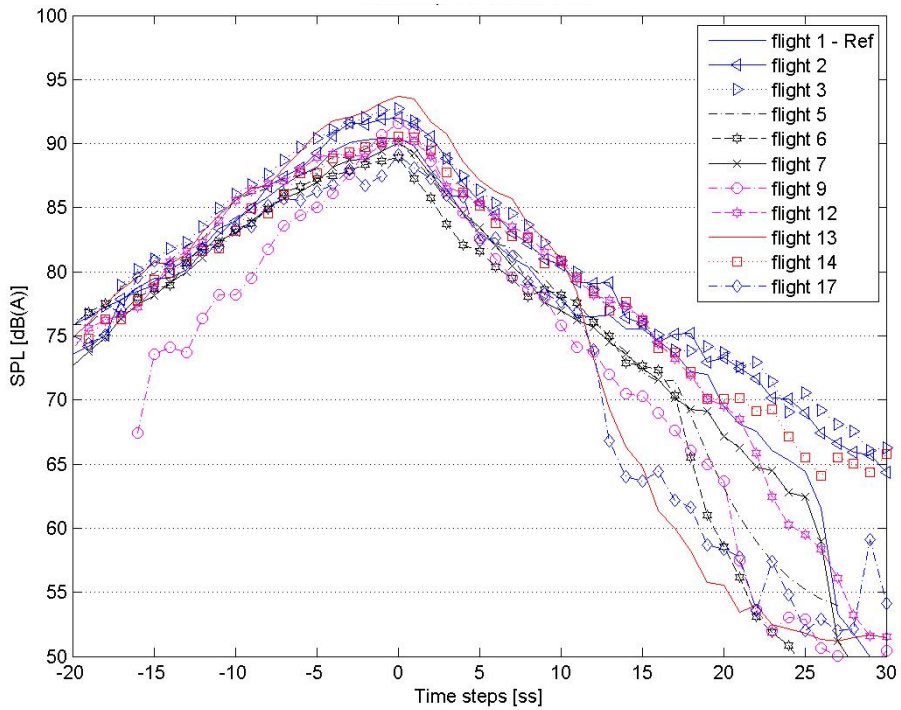


Figure 6 – Corrected sound pressure level in dB(A): departures 8 November 2008



For both departure and approach test flights a high altitude results in low noise levels (for instance departure flight 6 and approach flight 18). For the silent approach it was logged that the thrust was relatively low in comparison with the other test flights. In general the noise level on the ground became lower when the altitude increased. However, for approaches this was not always the case. A possible explanation for this phenomena might be the fact that shielding by objects on the ground is more likely to occur for landing procedures since the altitude of an AWACS is lower during an approach than during a departure (see Figure 4 and Figure 5). This is especially the case in urban environments. This means that for some locations the noise level becomes lower when the aircraft flies closer to the ground due to shielding of ground objects.

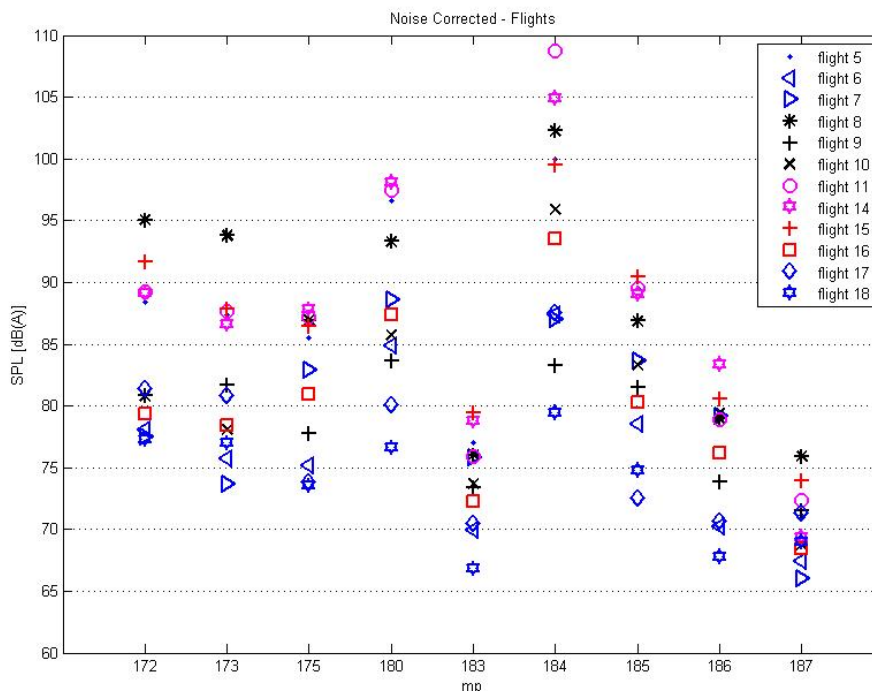


Figure 7 – Corrected peak levels in dB(A): approaches 4 September 2009

## 2.4 Lengthen the runway

This measure has been suggested by Landrum and Brown [8]. The idea behind it is to create the possibility for aircraft to turn north or south before reaching the urban areas of Schinveld and Brunssum. If the runway is lengthened 900 metres in east direction, the lift-off happens earlier and a turn can be made within the safety regulations before the cities are reached.

As an aircraft turns north- or southward, it will overfly less dense populated areas, which will therefore result in a reduction of the overall nuisance. This will lead to a change of the noise landscape. At locations north east of Schinveld and south east of Brunssum the noise load will increase since the AWACS overflies these areas, whereas at the west side of these villages the noise load will become lower.

For the approaches such turns do not seem to be a save procedure to fly. The runway lengthening is too limited for that. The approach route between Schinveld and Brunssum will therefore not change. But if the landing point is moved 900 meter eastward the aircraft will fly higher above Dutch territory during their approach. If a landing procedure is flown with a descent angle of 3 degrees, this means the altitude of the aircraft increases approximately 50

metres between the villages. It is expected that this measure will lead to a reduction of the noise levels in Schinveld and Brunssum of approximately 3 dB(A) for approaches. This assumption is based on the data two measurement locations in Schinveld located roughly 900 meters apart in the direction of the approach routes [7]. The effect of lengthening the runway on the yearly noise load will be investigated in a future study. A simple assumption to shift the contours 900 metres can not be done since the shape of the current contours will change due to the turn before the urban areas.

### 3 Conclusions

The Dutch minister of housing, spatial planning and environment together with the Dutch state secretary of defence and the authority of the NATO base intend to reduce the nuisance near the base. The question is how large the noise reduction will be and this reduction is experience. Having less AWACS movements or replacing noisy none-AWACS aircraft leads to a lower yearly noise load. This means that throughout the year current noise levels (sometimes more than 100 dB(A)) will still occur but will appear less often.

Test flights with AWACS aircraft showed that the difference between the most noisy and most silent departure procedure was 6 dB(A). This figure was determined out of 13 flights, thus having a very weak statistical basis. Thereby, the most silent departure did not touch the runway as it was a go-around procedure that flew about 200ft above the runway. The test flights were part of the training scheme of AWACS pilots. Within the training scheme all aspects of different procedures are being trained so not all training flights can make use of silent procedures. Therefore the effect on the yearly noise load will be small.

The suggested mitigation measure by Landrum and Brown to lengthen the runway will reduce the noise levels of individual flight movements and the yearly noise load. For approaches it is expected that the noise levels can be reduced by approximately 3 dB(A) in the urban areas of Schinveld and Brunssum. If departure flights turn north or south before the urban areas are reached, this will change the noise landscape. Some areas get more noise and others less. However it seems that the overall nuisance in the area is to be reduced since the aircraft will overfly less dense populated areas. The effect of this measure on the yearly noise load still has to be studied.

### References

- [1] ICAO, Annex 16 to the Convention of International Civil Aviation, *Environmental Protection Volume 1 - aircraft noise*, Fourth Edition July 2005.
- [2] Cfm international, DFM56 Engine For Low Noise NATO AWACS Operations, October 1985.
- [3] C.S. Beers, *The noise load around airbase Geilenkirchen – zone calculation*, NLR TR88003 (confidential), 1988.
- [4] Letter by the state secretary of defence to the chairman of the Dutch house of parliament, 18 February 2009, 31 700XI Nr 72 (written in Dutch).
- [5] Bergmans, D.H.T., Lania, H.A., *Contourberekeningen Geilenkirchen – Ondersteunend aan de motie Neppérus en Samson*, NLR-CR-2009-319 (only available in Dutch).
- [6] Hogenhuis, R.H., Bergmans, D.H.T., *Stillere AWACS vliegprocedures? – Een analyse van 20 vluchten*, NLR-CR-2009-002 (only available in Dutch).



- [7] Bergmans, D.H.T., *Stillere AWACS vliegprocedures? – Een analyse van 12 landingen*, NLR-CR-2010-122 (only available in Dutch).
- [8] Landrum and Brown, Final Comprehensive study NATO Air Base Geilenkirchen.