***inter.noise 2000***
***The 29th International Congress and Exhibition on Noise Control Engineering***
***27-30 August 2000, Nice, FRANCE***

**I-INCE Classification:** 5.2

# ENVIRONMENTAL BENEFITS OF CONTINUOUS DESCENT APPROACHES AT SCHIPHOL AIRPORT COMPARED WITH CONVENTIONAL APPROACH PROCEDURES

**F.J.M. Wubben, J.J. Busink**

Air Transport Division, Transport and Environmental Studies, LT-ASD - National Aerospace Laboratory (NLR), Anthony Fokkerweg 2, 1059 CM, Amsterdam, Netherlands

Tel.: (+31) 20 -5113558 / Fax: (+31) 20 -5113210 / Email: bijkerk@nlr.nl

**Keywords:**
AIRCRAFT NOISE, APPROACH PROCEDURES, COMMUNITY NOISE, NOISE FOOTPRINT

**ABSTRACT**
Since a number of years, Continuous Descent Approaches (CDA) are used at Amsterdam Airport Schiphol during night hours and on a single runway. An inquiry among residents of the area surrounding the airport showed that the noise nuisance during nightly hours has been substantially reduced since the introduction of the CDA. Until recently, no operational data was available to demonstrate the reduction of the noise footprint and the fuel consumption. Using operational (FMS) data of actual approaches of both the Boeing 747-400 and the Boeing 737-300/400, an investigation into the environmental benefits of CDA approaches compared to conventional approach procedures is carried out. The results support the inquiry among residents: the noise footprints of the CDA are substantially smaller than the footprints of the conventional approach procedures. Also, fuel consumption is about 30% lower during the last 45 km of the flight.

## 1 - INTRODUCTION
The environmental benefits of the CDA procedure have always seemed quite obvious: a reduced noise nuisance [1] and lower fuel consumption. However, until recently no quantitative operational data were available to support these benefits. The paper demonstrates the benefits of CDA approaches, based on Flight Management System (FMS) data of actual flights. The size of the noise footprint and the total fuel consumption during the last 45 km of the flight was calculated for the following approach procedures:

- Continuous Descent Approach (CDA) starting from flight level 70 (±7000 ft)
- Radar vectored ILS approach with glide slope interception altitude at 2000 ft
- Radar vectored ILS approach with glide slope interception altitude at 3000 ft

Data was gathered for 2 types of aircraft:

- Boeing 747-400
- Boeing 737-300/400

For each combination of aircraft type and approach procedure, the aim was to collect 10 flights. The flights were obtained from KLM after selection with the FANOMOS flight tracking system [2] by inspecting the altitude profile and ground track.

## 2 - APPROACH PROCEDURES
Conventional approach procedures usually consist of three characteristic lateral segments: downwind, base leg and final (see fig. 1). The position of the base leg is not fixed geographically. Depending on the traffic intensity, the location of this segment can shift to or from the airport. This lateral flexibility

also asks for flexibility in the vertical plane. Ideally, the aircraft can descend to touchdown with a glide slope of 3° along an optimized lateral flight path. If traffic control (ATC) decides to extend the downwind segment, this results in an extended arrival route and a horizontal flight segment. During daytime hours, this horizontal segment is maintained at 2000-ft, during night-time at 3000-ft. During this horizontal flight phase the aircraft is in a configuration of high thrust settings of the engines, thus producing a considerable amount of noise and pollution. The advantage of these conventional procedures is the flexibility to accommodate high traffic intensities.

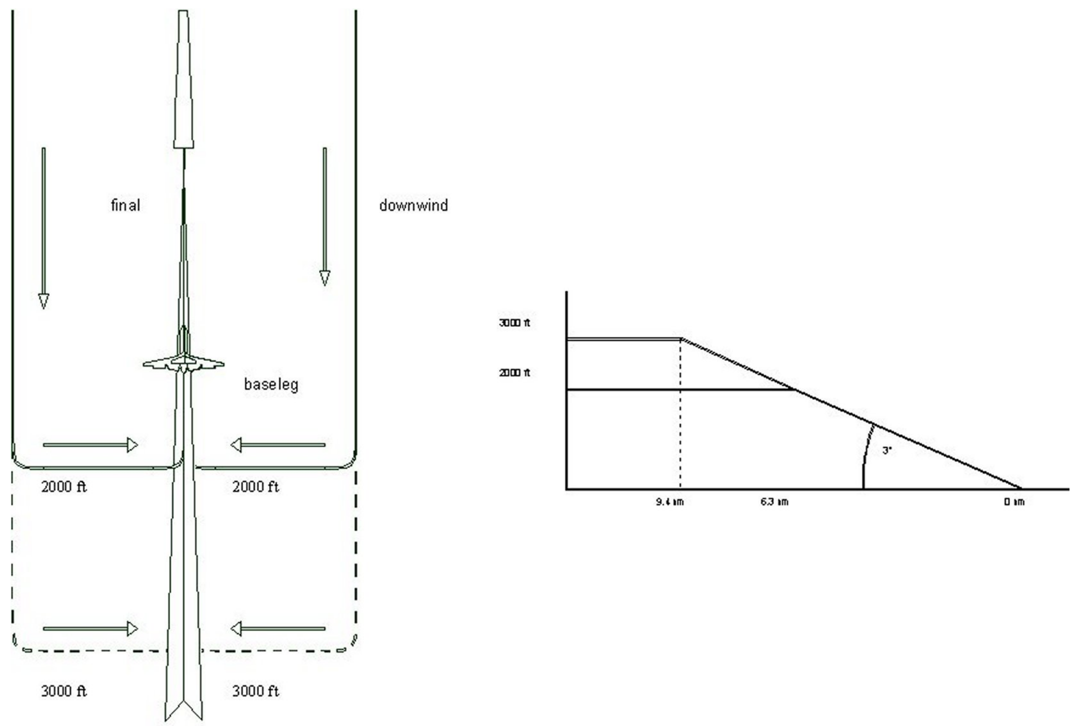


**Figure 1:** Conventional approach procedures.

With the objective to reduce noise of approaching aircraft, the Continuous Descent Approach is being investigated at Schiphol Airport since a number of years. The CDA procedure (Fig. 2) starts from an Initial Approach Fix at approximately 7000-ft. When cleared for the CDA, the aircraft starts its descent in such a way that the ILS (Instrument Landing System) intercept point is reached at 2500-ft (FAP) with idle or near idle power setting (without intervention of traffic control). The disadvantage of the CDA is that the landing interval has to be increased from 1.8 to 4 minutes to guarantee sufficient spacing between aircraft on the final landing segment [3]. The increased landing interval is necessary because of the large dispersion in aircraft approach speeds.

**3 - FLIGHT DATA PROCESSING**

For the $LA_{max}$ noise footprint calculations, ground speed, altitude, thrust and track distance (the distance from the aircraft to the runway threshold) from the FMS were reduced to performance profiles. The fuel consumption was calculated for the final 45 km of the flight (the distance of 45 km was used because within this range, data was available for all flights) using fuel flow and ground speed data. The performance tables were combined with the available noise-power-distance (NPD) tables in order to calculate $LA_{max}$ noise levels in dB(A) at immission points on the ground.
A standard LAmax footprint (65 dB(A)) was calculated using a 3 km runway, straight approach track and calculation range (grid) of 20 x 50 km. The distance between the gridlines is 500 m. The 65 dB(A) footprint area has been chosen because Dutch noise regulations [4] use 65 dB(A) as a threshold value.

**4 - RESULTS**

Table 1 shows the results of both the noise footprint and fuel consumption calculations.

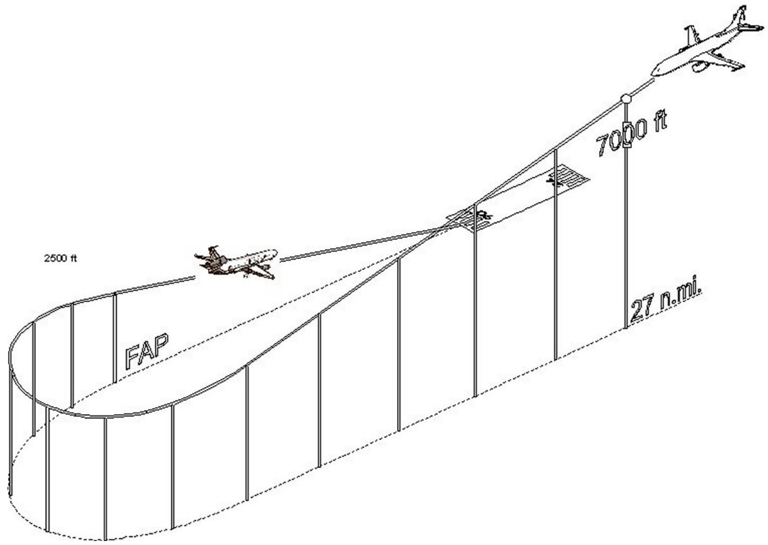


**Figure 2:** CDA approach.

| Aircraft/procedure | | Fuel consumption final 45 km (kg) | 65 dB(A) footprint area ($km^2$) | Length horizontal segment (km) |
|---|---|---|---|---|
| B747 | 2000 ft | 799 | 72 | 15.2 |
| | 3000 ft | 1045 | 74 | 19.5 |
| | CDA | 638 | 43 | – |
| B737 | 2000 ft | 213 | 38 | 18.5 |
| | 3000 ft | 225 | 25 | 12 |
| | CDA | 170 | 17 | – |

**Table 1:** Average results of calculations.

The length of the horizontal segment is the total length of all level-flight segments of the approach. The table clearly shows the advantage of the CDA with a much lower footprint area and lower fuel consumption.
Figure 3 shows that the fuel consumption and footprint area in the last 45 km appear to be directly proportional to the length of the horizontal flight segment. The noise areas for 3000-ft approaches are lower than for 2000-ft approaches at equal horizontal segment length. This is attributed to the higher ILS interception altitude. Also, for equal length of the horizontal segment, the fuel consumption of the 3000-ft approach is structurally higher compared to 2000-ft approaches. This is probably caused by the longer ILS flight path length of the 3000-ft approach resulting in a longer distance with high drag and consequently increases total fuel consumption [5].
Figure 4 clearly shows the environmental benefits of the CDA compared to conventional procedures. In general, fuel consumption is directly proportional to the noise area. The data points of favorable procedures, i.e. low fuel consumption and small noise area, are located in the lower left corner of the graph.

## 5 - CONCLUSIONS

- Comparison of CDA procedures with conventional procedures shows the substantial environmental benefits of the CDA. Differences are mainly due to the presence of a horizontal segment in conventional approaches.

- Conventional 3000-ft approaches in general show larger fuel consumption when compared to 2000-ft approaches with equal length of the horizontal segment. This is mainly caused by the difference in ILS flight path length.

- Noise areas for 3000-ft approaches are in general lower than for 2000-ft approaches at comparable horizontal segment lengths. Despite the longer distance with higher thrust settings along the ILS glide slope, the higher altitude seems to over-compensate for this unfavorable effect.

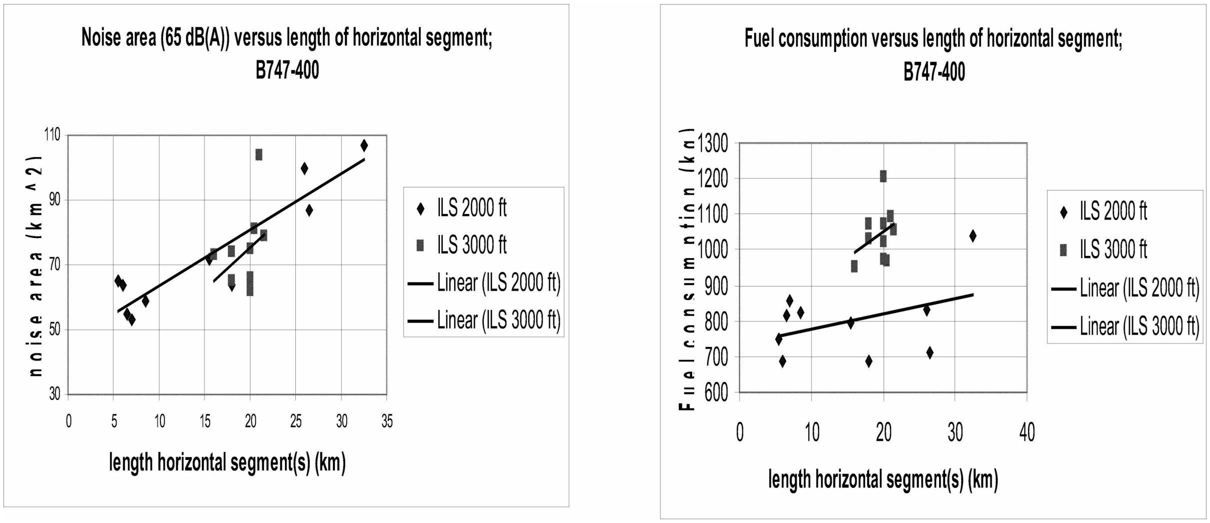


**Figure 3:** Noise area and fuel consumption versus length of horizontal segment.

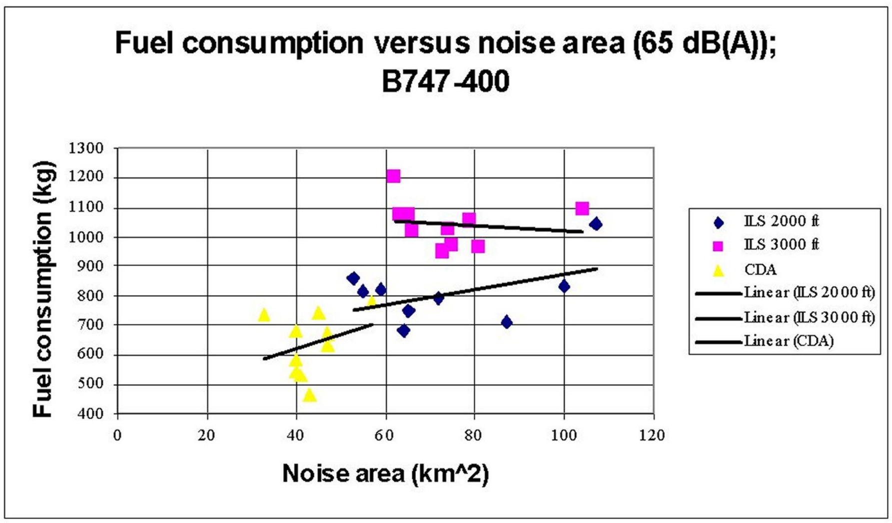


**Figure 4:** Fuel consumption versus noise area.

Although this paper shows the environmental benefits of the CDA, it should be noted that for the introduction of the CDA for day time operations, improved ATC concepts are necessary in order to satisfy, or even increase, the present day approach capacity of conventional procedures.

## ACKNOWLEDGEMENTS

This project was funded by the Dutch Directorate General of civil aviation (RLD). The authors would like to thank Mr. van de Ven of KLM for his help in acquiring the FMS data.

## REFERENCES

1. **S. Paul and al.**, *Establishment of Noise Abatement Solutions*, Final report of EC-project (4th framework) SOURDINE, 1999

2. **H.A. Kreijkamp, H.W. Veerbeek**, *Mid-life update FANOMOS: reference manual 2.0*, NLR report CR-98426, 1998

3. **S.D. Mohleji and al.**, *Curved approaches in the Netherlands: feasibility and benefits*, MITRE Technical report MTR99W99W122, 1999

4. **DG Rijksluchtvaartdienst**, *Procedure for the calculation of aviation noise loads in Kosten-units (in Dutch)*, RLD/BV-01

5. **F.J.M. Wubben, J.J. Busink**, *Environmental benefits of Continuous Descent Approaches*, NLR report CR-2000-080, 2000