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Results of noise and emission analyses

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Executive Summary

The Sourdine II project has proposed and evaluated new, innovative procedures for reducing the impact of aircraft noise on the ground, otherwise known as Noise Abatement Procedures (NAPs). These procedures make use of technologies and tools – both aircraft and ATM - that are considered to be among those that will be available on aircraft around 2015.

This document presents the main parameters that were taken into account in the design of the Sourdine II NAPs. The parameters taken into account for approach procedures include Height, Aerodynamic configuration, Airspeed, Engine setting and Descent angle.

The major part of this document concerns the analyses of noise and emissions produced by these procedures. The Sourdine II procedures were examined in the context of four European airports – Paris Charles de Gaulle, Amsterdam Schiphol, Madrid Barajas and Napoli Capodichino. As well as capacity and safety analyses, the procedures' effects noise were studied individually, and the results of these analyses are available as separate documents for each airport. The purpose of the present document is to provide a general overview of these results, to present an analysis of the effect of the procedures on local air quality, and to extract an over-riding conclusion about the environmental impact of these procedures.

The overall conclusions are that for approach procedures (NAAP), the one that involves a final glide slope of 4 degrees (NAAP 3) produces significantly better results than the others, as would be expected given the increased distance between the aircraft and the ground. This procedure is not, however, expected to be implementable in the short to medium term. Remaining procedures, which show non-negligible improvements in noise-contour size, could provide benefit in the shorter term although, unlike NAAP3, they all have a negative impact on production of CO and unburnt hydrocarbons (HC). They all have a positive impact on Nitrogen Oxide (NO_X) production, however.

For departures, the "Distant" procedure provides the best overall performance, though the "Close-in" procedure should be used in cases where there is a need to reduce noise at distances less than 5.5Nm from brake release. The "Close-in" procedure does however negatively impact areas further away from the airport than 5.5NM. It should be noted, however, that both procedures increase CO and HC emissions by some 20-40%, though their effect on NO_X production is small.

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1 Introduction

This document provides a tie-up of the different noise analyses performed on the four airports studied in Sourdine II (Paris Charles de Gaulle, Amsterdam Schiphol, Madrid Barajas and Napoli Capodichino) as well as an additional analysis of the effects that the Sourdine II approach and departure procedures would have on fuel burn and production of pollutants.

Chapter 2 describes the main parameters taken into account when designing the Sourdine II noise abatement procedures, and their impact on noise exposure. The modelling assumptions, together with the fleet-mixes and other input parameters for the different airport noise studies, are given in chapter 3.

The noise analyses of the four airports are presented on a procedure-by-procedure basis in chapter 4. For each procedure in turn – the four Sourdine II approach procedures, then the “close-in” and “distant” departures – the procedures are described and the noise contours from the different airports are shown, together with a table showing the percentage variation in the size of these contours for each airport. For each group of procedures – approach and departures – bar graphs are also given showing these variations graphically. An analysis of the effect these procedures would have on populations around Madrid Barajas airport is summarised and conclusions are drawn.
Chapter 5 provides an analysis of the effect of the different procedures – again split into two groups: approach and departure – on fuel burn and emissions. This is followed by the general conclusions in chapter.6

2 Main parameters for design of noise abatement procedures

2.1 Approach procedures

This section summarises the main operational parameters - specifically flight parameters affecting the vertical flight profile - that have to be considered when designing noise abatement approach procedures, and their impact on noise.

Considering a noise sensitive zone in the vicinity of an airport and a given traffic flow (number of operations, aircraft types, operating weights), noise abatement in that zone is obtained through a combination of an adapted horizontal flight track and an adapted vertical flight procedure or technique.

For a given aircraft type and weight, the following parameters are considered to be main factors influencing noise impact underneath the approach flight path, affecting source noise and/or sound propagation losses:

- Height or source-observer distance
- Aerodynamic configuration (flap/slat configuration, landing gear position, airbrakes)
- Airspeed
- Engine setting
- Descent angle

Height determines the amount of propagation loss. Aerodynamic configuration and airspeed are the main drivers of airframe noise. Engine setting and airspeed determine the amount of engine noise. The descent angle has indirect impact on noise through the height profile and energy management.

The ranking of parameters in terms of approach-noise sensitivity per parameter is aircraft specific. Whereas, for modern aircraft with modern quiet-engine technology, the airframe noise can be a dominant component, for older generations engines engine noise can still be the dominant factor on approach. The following paragraphs describe the underlying mechanisms.

2.1.1 Height

Maximising height along the approach trajectory ensures maximum source-observer distance. The source-observer distance directly influences the amount of sound energy dissipated during the transmission from source to observer, due to the following propagation phenomena:

- Spherical spreading: Sound spreads out over an increasingly large surface at increasing distance from the source. For a doubling of propagation distance, spherical spreading accounts for a 6dB reduction in terms of sound pressure level (SPL).
- Atmospheric absorption of sound: Sound energy is absorbed when travelling through the atmosphere due to friction. The amount of dissipation per unit of distance travelled depends on air temperature and relative humidity, and on frequency. High frequencies are attenuated more than low frequencies.
- Lateral attenuation: excess attenuation of sound propagated in lateral direction due to ground effect and refraction/scattering.

Other propagation phenomena, of which impact may increase with increasing source-observer distance, are refraction of sound due to temperature and wind gradients, and dissipation due to turbulence.

2.1.2 Aerodynamic configuration

The aerodynamic configuration of the aircraft – relative to the clean configuration used during cruise – is, as far as noise impact is concerned, determined by the following parameters:

- Deflection angle of slats and flaps
- Position of landing gear
- Deflection of airbrakes/spoilers

The following graph shows noise as a function of speed for a number of slat/flap deflection angles and landing gear positions on approach noise for a modern long range four-engine jet aircraft. The engine setting is flight idle. When the landing gear is retracted, the influence of slat/flap angle on noise is significant. A significant increase of 3.5dB between the clean configuration (00/00) and the first intermediate configuration (20/00) is observed. The figure shows that the landing gear becomes the dominant noise source as soon as it is lowered. This case must be considered an example. For other aircraft types the relative contribution of different sources may be different.

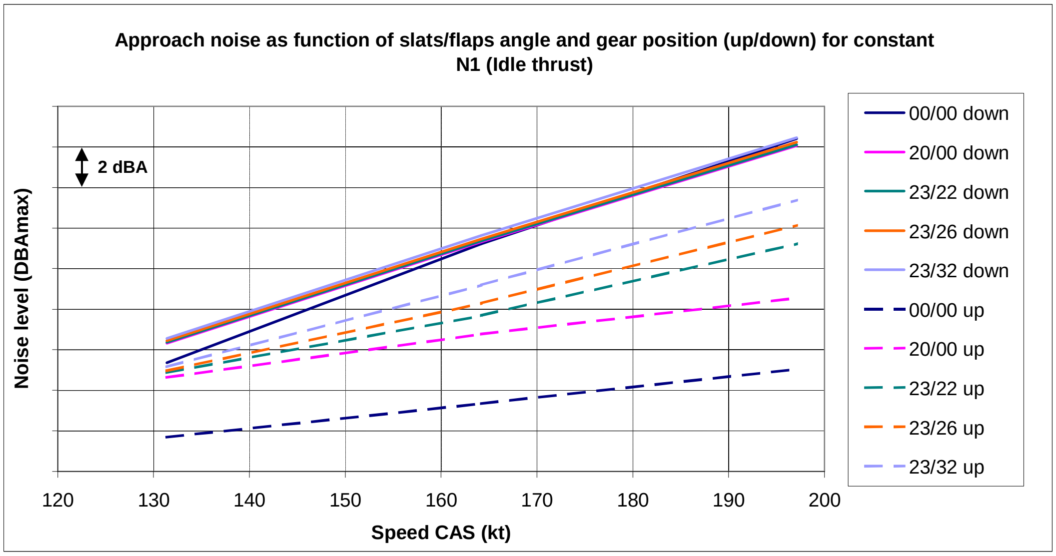

Figure 1. Approach noise as a function of slat/flap angle and gear position

The influence of airbrake extension on airframe noise is considered significant although less data is available to quantify the impact.

2.1.3 Airspeed

The impact of airspeed on approach noise is twofold. The airframe noise level is directly related to airspeed. During approach, airframe noise is an important, if not dominant, noise component as explained. The preceding graph shows the impact of speed on approach noise. The slope of the noise-versus-speed curve depends on the aerodynamic configuration.

Secondly, the airspeed determines the duration of the noise event and thereby the total noise exposure of a given observer position. Sound exposure levels (SEL) account for this duration effect, together with the actual noise levels.

2.1.4 Engine setting

The main variables determining engine noise are N1 and the Mach number since they determine, together with ambient conditions, the engine thermodynamic cycle. The spectral content of sound emitted by the different engine components such as fan, compressor, turbine and jet noise differs

significantly. The spectral content and noise levels therefore vary significantly as function of emission angle.
Approach thrust settings vary between idle thrust and adapted thrust over the stabilised final approach along the glide slope. Thrust levels and associated engine noise levels are therefore considerably lower than during departure. Engine noise levels during the approach can be lower than airframe noise levels.

2.1.5 Descent angle

The selected descent angle for a given approach procedure has indirect, but significant, influence on noise below track, both through the resulting vertical profile and through its impact on energy management.

A steep descent enables a high vertical profile, which increases noise transmission losses between aircraft and observer.

Energy management includes management of thrust and high-lift devices with regard to the amount of speed (kinetic energy) and position along the trajectory.

Although an increased descent angle may lead to reduced thrust in certain conditions, it can lead to decreased braking capability and additional drag requirements in other cases. These situations can cause increased noise, as will be explained.

When an adapted thrust setting is used to maintain a constant speed along an imposed descent angle, a high descent angle requires less thrust than a low angle leading to a reduction in engine noise. Throughout the part of the approach profile where idle thrust (or a fixed setting close to idle thrust) is used, the descent angle does not influence thrust and engine noise.

In other situations, an increased descent angle can decrease the braking capability of the aircraft and lead to a requirement for additional drag. Additional drag by means of early slat/flap, gear or airbrake extension leads to airframe noise. In general a steeper descent results in a longer deceleration distance and requires earlier activation of the high-lift system of an aircraft.

2.2 Departure procedures

This section describes the main flight parameters to be taken into account in the development of noise abatement departure procedures.

During departure, engines are operated at ratings varying from takeoff to climb thrust. As a consequence engine noise is the dominant noise component.

For a given aircraft type and weight, the following parameters are considered to be the main factors of influence, direct or indirect, on noise level perceived at a specific observer position underneath the flight path:

- Height or source-observer distance
- Engine setting and thrust management
- Airspeed
- Takeoff performance (speed and slat/flap setting)

The following paragraphs explain the influence in detail

2.2.1 Height

In the same way as explained in section 2.1.1, height directly influences the amount of noise energy that is lost during the propagation from the source to the receiver.

2.2.2 Engine setting and thrust management

Engine noise is the dominant noise source during departures for existing jet aircraft. The engine setting directly determines the amount of source noise during departure and climb-out. In general an increase of thrust leads to an increase in engine noise.

The thrust management technique applied throughout the departure operation including takeoff ground roll, initial climb, acceleration and continued climb determines the departure climb performance. It has therefore an indirect influence on noise exposure throughout the departure. A high amount of thrust in the initial phase leads to better climb performance in that phase than a reduced amount of thrust and as a consequence to a higher profile and less noise underneath the subsequent part of the departure. The opposite is also true.

As part of thrust management technique the level, position and duration of the thrust cutback including the transition to climb power at the end of the noise reduction zone are principal parameters.

Depending on the aircraft weight and performance constraints at a specific airport (runway length, presence of obstacles) the takeoff thrust rating can vary between derated or flexible takeoff and full takeoff thrust. In real practice the operator applies the level that reduces engine wear and the takeoff thrust setting is therefore considered as fixed.

2.2.2.1 Sequence of acceleration and thrust cutback

The order in which acceleration and slat/flap retraction and thrust cutback take place has a first order impact on the area relative to the brake release point where noise reduction can be accomplished. Two types of noise abatement departure procedure are therefore distinguished.

Procedures for close-in noise reduction include a thrust cutback prior to acceleration and clean-up (slat/flap retraction). Procedures for noise reduction at more distant areas include a thrust cutback after or during the acceleration and clean-up.

2.2.2.2 Cutback thrust level

The level of cutback thrust at a given position along the flight path determines the amount of acoustic energy emitted at that position and therefore the noise level directly underneath.

The standard cutback on wide-body jet aircraft consists of selecting climb thrust. In addition to a Maximum Climb rating, derated climb ratings are normally available and can be selected if conditions allow.

In addition to the standard climb rating, the minimum thrust level that allows regulatory climb performance in case of failure of one engine can be considered a cutback setting. Although not available on current aircraft, aircraft that will enter into service in coming years will feature NADP functions based on this setting, allowing lower cutback levels than the climb rating for a range of operational weights. As a result, lower source noise levels are obtained.

If a deep cutback is applied during a part of the flight path where noise reduction is required, the restoration to maximum climb at the end of that phase can result in an increase of noise. As demonstrated in Sourdine II deliverable D5.3, this can be avoided by applying a gradual restoration of thrust. This function will be available on modern aircraft that enter service in the near future.

2.2.2.3 Cutback thrust height

The minimum height for thrust cutback in current versions of ICAO PANS-OPS is 800ft. Given the drop in perceived noise underneath the flight path associated to the thrust reduction, the cutback height is an important parameter in the optimisation of noise abatement departure procedures.

2.2.3 Airspeed

At a given position along the departure flight path the main influence of airspeed on noise is the influence on duration of the noise event. For a high speed the noise event will be shorter than for a low speed. As a result the airspeed has influence on noise exposure metrics.

Airspeed has an indirect influence on noise through its effect on climb performance. For distant procedures, for which the initial acceleration and clean-up is performed early on, the target speed for this initial acceleration determines both the length of the acceleration phase and climb performance after this acceleration phase. This parameter therefore determines the shape of the noise profile and can be used as an optimisation parameter.

2.2.4 Takeoff speed and flap setting

The takeoff flap setting and associated speed are usually determined in accordance with operational constraints such as aircraft weight, runway length and presence of obstacles underneath the flight path. These settings have an influence on aircraft takeoff and climb performance, including initial climb-out speed, rate of climb and the subsequent acceleration phase, and therefore on noise below track.

3 Inputs and modelling assumptions for airport studies

3.1 Paris CDG

3.1.1 *Fleet mix*

The original fleet mix in use at Paris Charles de Gaulle, the substitutions that had to be made because of the lack of aircraft data available, and the final fleet mix and its distribution across the runways are given in Appendix 0.

3.1.2 *Runways – Route/track description*

The following diagram shows the 2-D Approaches to CDG, including the runways, routes/tracks and specific points (STARs). The tracks presented are the ones actually used for the noise calculations.

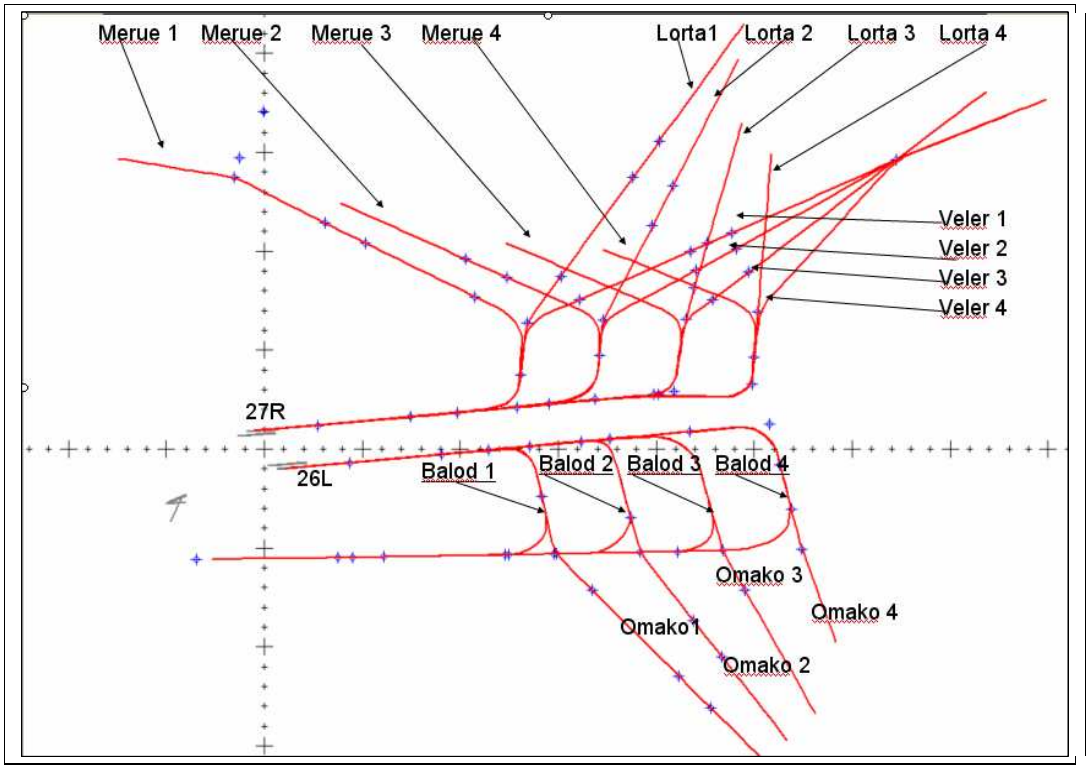

Figure 2. CDG Arrival runways/tracks

The tracks which were used to compute noise levels and contours are point track type.

The TAAM output has been directly used to define and create the tracks but the dispersion related to each leg/star has not been taken into account since it was not considered relevant for the study itself and time consuming in terms of INM run turn around time. As a consequence the same track has been assigned to all the flights that belong to the same leg/star.

Error! Reference source not found. below shows the 2-D departures including the runways, routes/tracksand specific points (SIDs). The tracks presented are the ones actually used for the noise calculations.

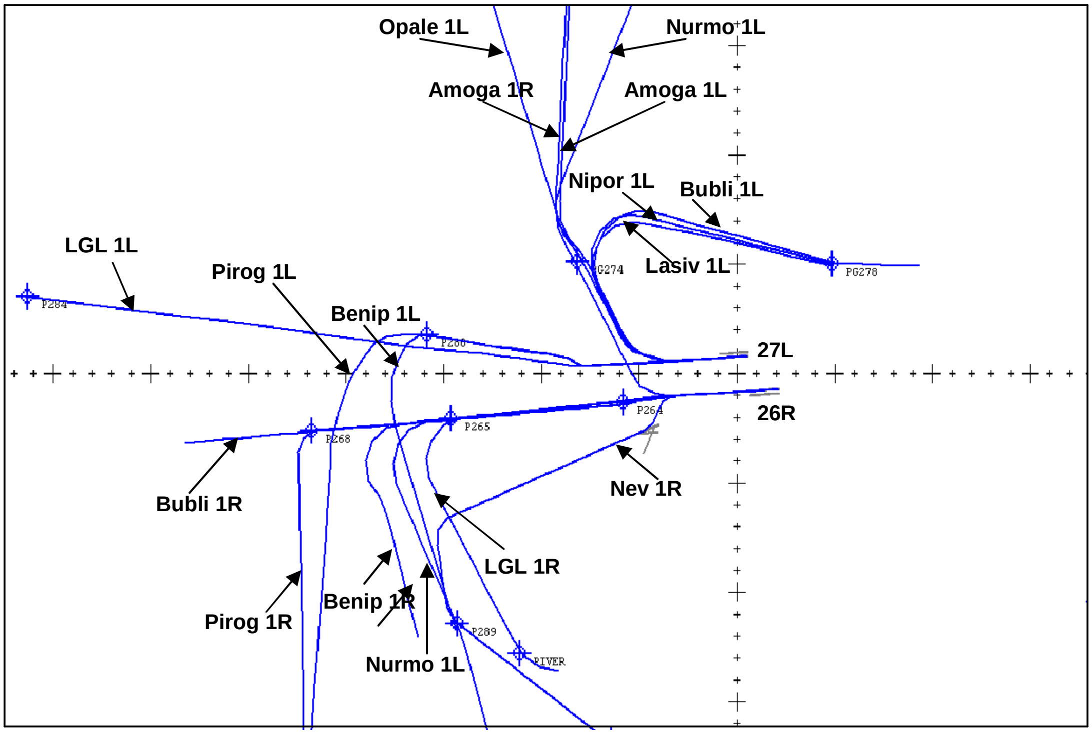

Figure 3. CDG departure runway/tracks

The tracks which were used to compute noise levels and contours are point tracks type.

The tracks have been built by starting from SID instructions since the TAAM output was not available. The same track is associated to the fights that belong to the same SID .

3.1.3 Study/Case parameter description

Noise simulations were carried out for Paris CDG considering the following conditions:

Airport elevation: 390 ft

Atmospheric conditions (temperature, pressure, humidity):

- Temperature (F) = 57.6
- Pressure (in-Hg) = 29.92
- Headwind (kt) = 8

Terrain: No Terrain elevation data have been used

3.2 Amsterdam Schiphol

3.2.1 Fleet mix

The original fleet mix in use at Amsterdam Schiphol, the substitutions that had to be made because of the lack of aircraft data available, and the final fleet mix and its distribution across the runways are given in Appendix 0.

3.2.2 Runways – Route/track description

The following diagram describes the 2-D Approach diagram, showing the runways, routes/tracks andspecific points (STARs). The tracks presented are those actually used for the noise calculations.

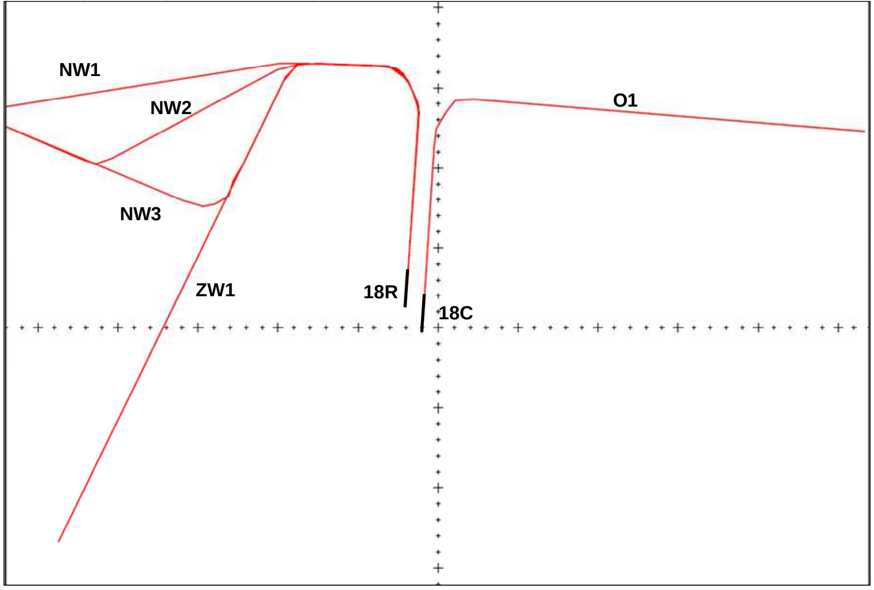

Figure 4. Schiphol arrival runway/tracks.

Figure 5 shows the runways and routes/tracks for all ‘departure’ scenarios. The tracks shown are point tracks.

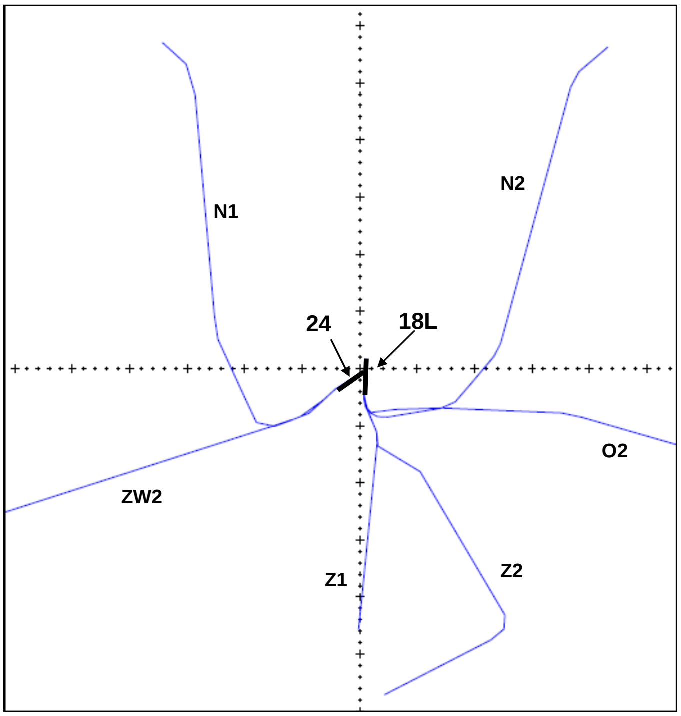

Figure 5. Schiphol departure runway/track.

3.3 Madrid Barajas

3.3.1 Fleet mix

The original fleet mix in use at Madrid Barajas, the substitutions that had to be made because of the lack of aircraft data available, and the final fleet mix and its distribution across the runways are given in Appendix 0.

3.3.2 Runways – Route/track description

The following diagram shows the runway configuration at Madrid Barajas airport together with the frequency of movements on each runway of each pair.

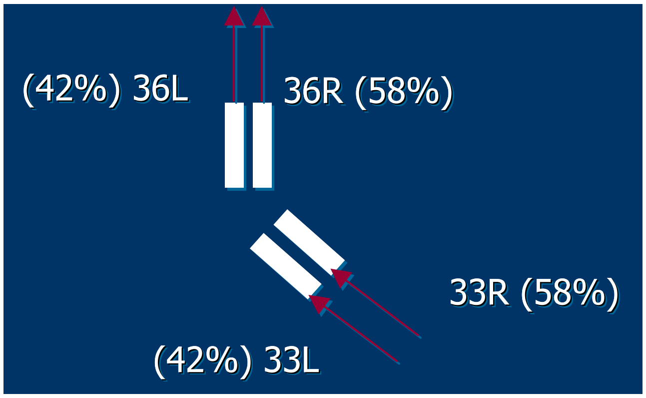

Figure 6. Barajas runway layout and use

The following diagram shows the 2-D Approaches to Madrid Barajas, including the runways, routes/tracks and specific points (STARs). The tracks presented are the ones actually used for the noise calculations.

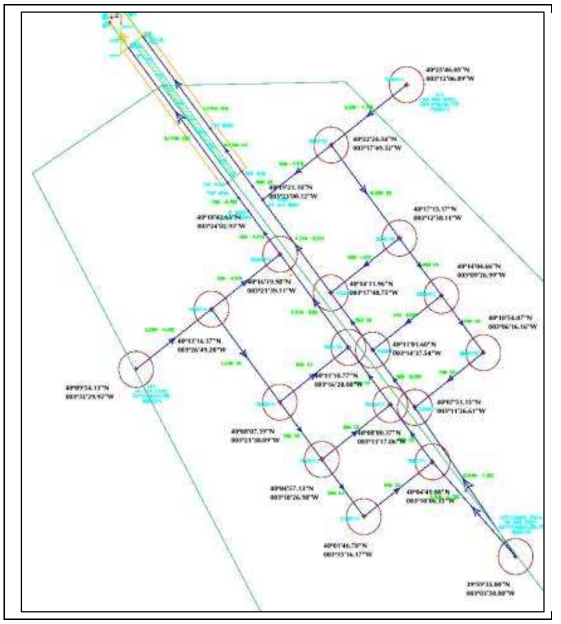

Figure 7. Barajas approach tracks

The following map shows the departure procedures used at Madrid Barajas, overlaid on a map of the surrounding communities.

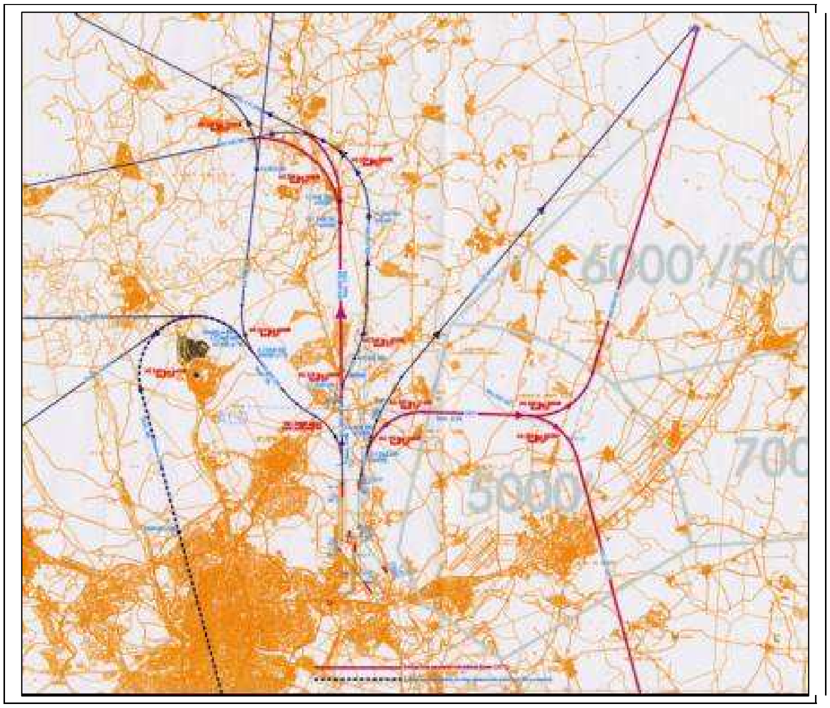

Figure 8. Barajas departure tracks

3.3.3 Study/Case parameters description

Noise simulations were carried out for Madrid Barajas considering the following conditions:

Airport elevation: 2000ft

Atmospheric conditions:

- Temperature: 91.4ºF/33ºC
- Pressure: 29.92 in-Hg
- Humidity: 70%
- Headwind: 8kt

3.4 Napoli Capodichino

3.4.1 Fleet mix

The development of the SII project required working on the fleet mix foreseen to fly to/from Naples Capodichino airport, excluding turboprops and small jets. The following table lists the whole fleet mix foreseen in Naples in 2015, to give a complete picture, but only the aircraft written in black have been considered for the SII noise assessment:

Aircraft Type	Movements Number (24H)	% during Day	% during Evening	% during Night
		07.00-19.00	19.00-23.00	23.00-07.00
A320	72	61%	24%	15%

CL601	43	72%	18%	9%
DO328	37	82%	7%	11%
A319	36	65%	16%	20%
737800	30	71%	17%	12%
737300	30	71%	17%	12%
ATR72	28	72%	16%	12%
EMB145	25	67%	22%	10%

Table 1. Distribution of aircraft types foreseen per time period at Naples in 2015

3.4.2 Runways – Route/track description

Naples airport has only one runway: 06-24. Departures and arrivals from both runway ends are allowed, even if RWY 24 is used preferentially for arrivals because it is ILS equipped. In this study the arrival/departure operations were distributed per runway as following:

	Arrivals	Departures
RWY 24	100%	76%
RWY 06		24%

Table 2. Arrival/departure distribution per runway

The following diagram is a simplistic picture of the initial climb/final approach and departure procedures, SIDs and STARs as used for noise modelling.

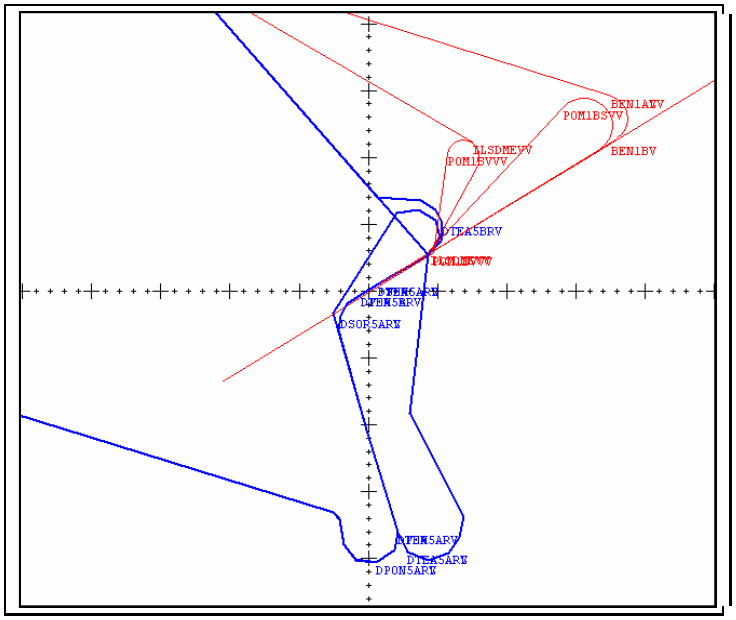

Figure 9. Initial climb/final approach and departure procedures, SIDs and STARs used for the noise assessment around Naples airport

4 Airport noise results

4.1 Introduction

The initial objective of the noise impact assessments at the four airports studied in Sourdine II was to evaluate – using standard airport noise metrics - the actual noise benefit of the selected Sourdine procedures, which would result from applying them to a “real” fleet mix, under airport-specific operational conditions and constraints.

Such an initial objective would have required having traffic simulators which could produce 4-D trajectories for INM, reflecting both the specificities of the studied procedures when applied to different aircraft types (through a sophisticated aircraft performance model) and the airport-specific operational constraints.

Unfortunately, the fast-time simulators (TAAM and Simmod) could not offer such a level of sophistication. Therefore, only the ground tracks produced by theses simulators were used in the airport noise assessments. The flight profiles, required to construct the 4-D trajectories in INM, were provided by Airbus and Boeing for each procedure and each aircraft, under the form of fixed-point profiles. These manufacturer-supplied profiles were applied at the four airport studies, without any modification to account for local specificities. Additonally, the noise assessments have been performed for ISA conditions, with no wind and for airports assumed at sea level (implicitly, through the use of the fixed-point profiles produced by manufacturers for these conditions). Terrain surrounding the airport was assumed flat.

Because of these constraints, differences in the noise results from one airport to another result mainly from differences in the total number of operations (i.e. the size of the airport), and their distribution per aircraft type and route/runway. Additionally, these airport noise results should be considered notional. In particular, results are presented in a relative way: the noise impact of each Sourdine procedure is evaluated against the Baseline/reference noise impact.

4.2 Noise Analyses

The following sections present the synthesis of the noise results obtained for the four airports. These consist of comparisons of the noise contours resulting from the different Sourdine procedures with those resulting from the baseline scenario. The comparisons are made for Lden and Lnight metrics, and for the different noise level thresholds which have been considered.

The purpose is not to rank the procedures (based on their noise benefit), given that the resulting noise reduction (in terms of relative contour area reduction) depends on the noise level thresholds which are considered.

No Lamax contours are supplied, since this is very single-event specific and does not make sense in the light of some of the simplifications which have been made. Additionally, only the noisiest aircraft would be taken into account in the contour calculations, even if there were only one movement.

Noise analyses were performed according to the method described in the Sourdine II report D5.2 “Noise and emission Analysis Methodology”. These analyses made use of INM-7S, a version of the United States (US) Federal Aviation Administration’s (FAA’s) Integrated Noise Model (INM) developed especially for the Sourdine II project and using multi-configuration Noise-Power-Distance (NPD) curves and performance data supplied by Airbus and, through funding from the US National Aeronautics and Space Administration (NASA), by Boeing.

4.3 Approach procedures

Four approach procedures were selected for analysis in the Sourdine II project; these are numbered Procedures II, III, IV and V – the baseline procedure is Procedure I.

These procedures will be more fully described separately. Here we will simply show their comparative height profiles.

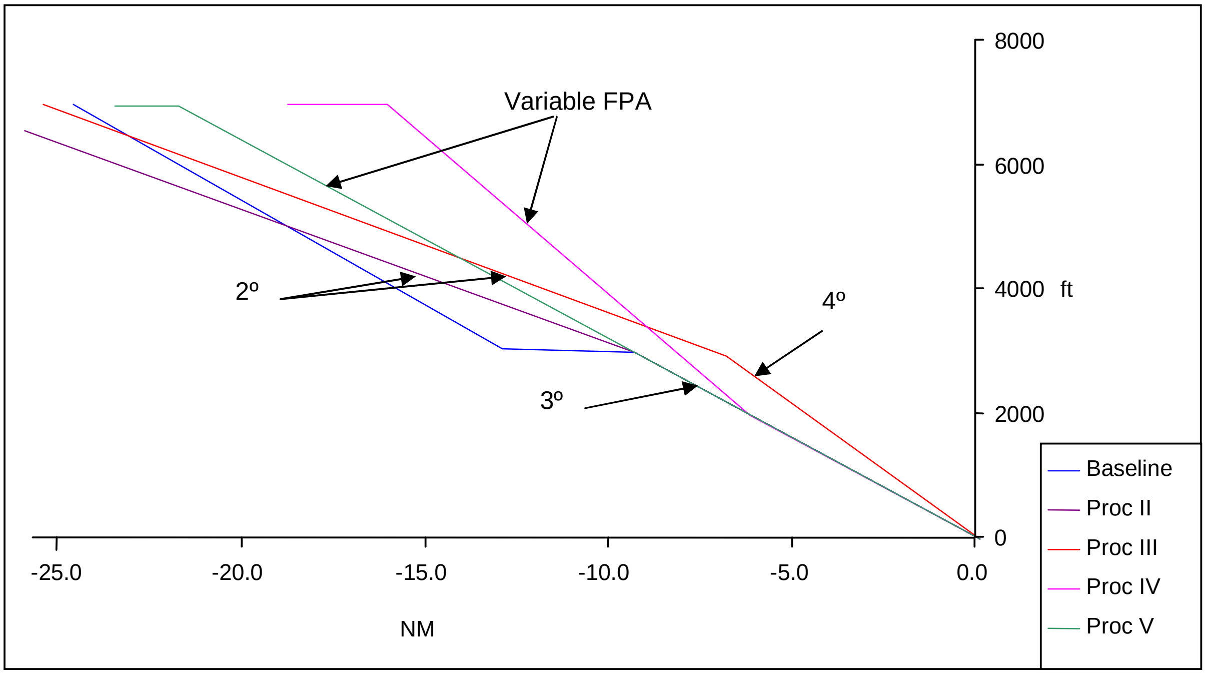

Figure 10. Vertical profiles of arrival procedures

4.3.1 Baseline Procedure

The baseline procedure (Procedure I) has a level deceleration at 3000ft.

Condition	Parameter values
7000 ft (Fixed height)	– Speed 250 KTS CAS – Level flight – Clean configuration – Landing Gear up
	– Idle thrust – Constant CAS descent
3000 ft (Fixed height)	– Level flight – Decelerate to intermediate flap speed (IFS) and change to intermediate configuration
	– Fixed descent angle of 3° – Landing gear down – Decelerate (+) and change to landing configuration (++) – Decelerate to final approach speed (FAS)
Landing configuration and speed reached (Resulting height, minimum 1000ft)	– Adapted Thrust for descent at 3° – Constant speed (FAS) descent to 50ft

Table 3. Procedure I (baseline) definition

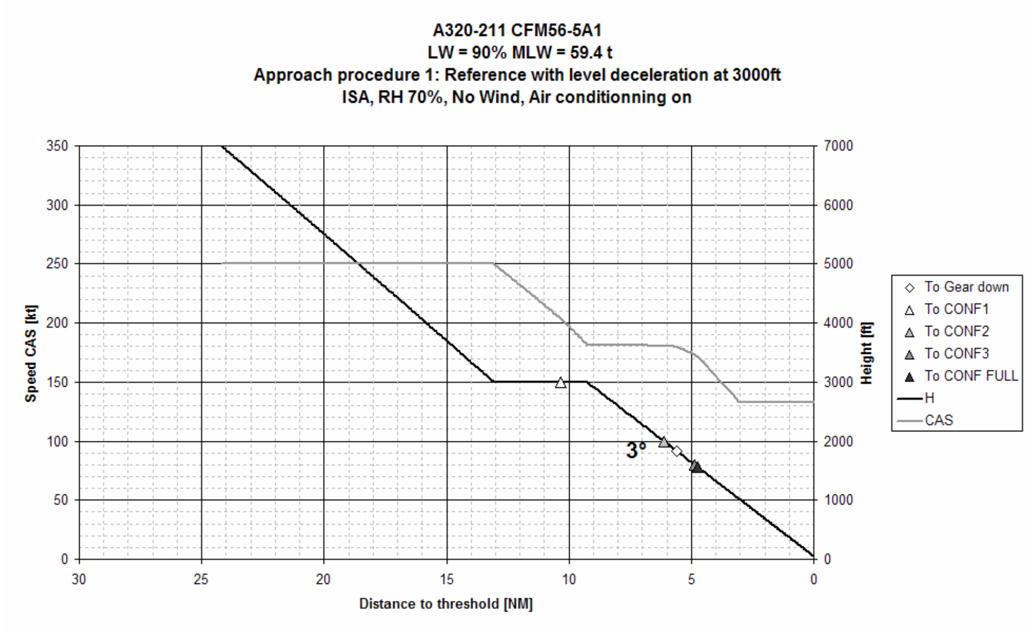

Figure 11. Example of Procedure I (baseline) height and speed profiles for an A320

This procedure is already a very good noise abatement procedure with Idle thrust during the level segment, and with late full flap deployment.

4.3.2 Procedure II

Procedure II is a basic continuous descent approach (CDA) with a 2° initial Flight Path Angle (FPA).

Condition	Parameter values
7000 ft (Fixed height)	– Speed 250 KTS CAS – Level flight – Clean configuration – Landing Gear up
	– Idle thrust – Fixed 2° Flight Path Angle (FPA) – Decelerate to intermediate flap speed (IFS) and change to intermediate configuration
3000 ft (Fixed height)	– Fixed descent angle of 3°. – Landing gear down – Decelerate and change to landing configuration (++) – Decelerate to final approach speed (FAS)
Landing configuration and speed reached (Resulting height, minimum 1000ft)	– Adapted thrust for descent at 3° – Constant speed (FAS) descent to 50ft

Table 4. Procedure II definition

(+) To maximum allowable speed to select landing configuration
(++) Minimum allowable flap deployment

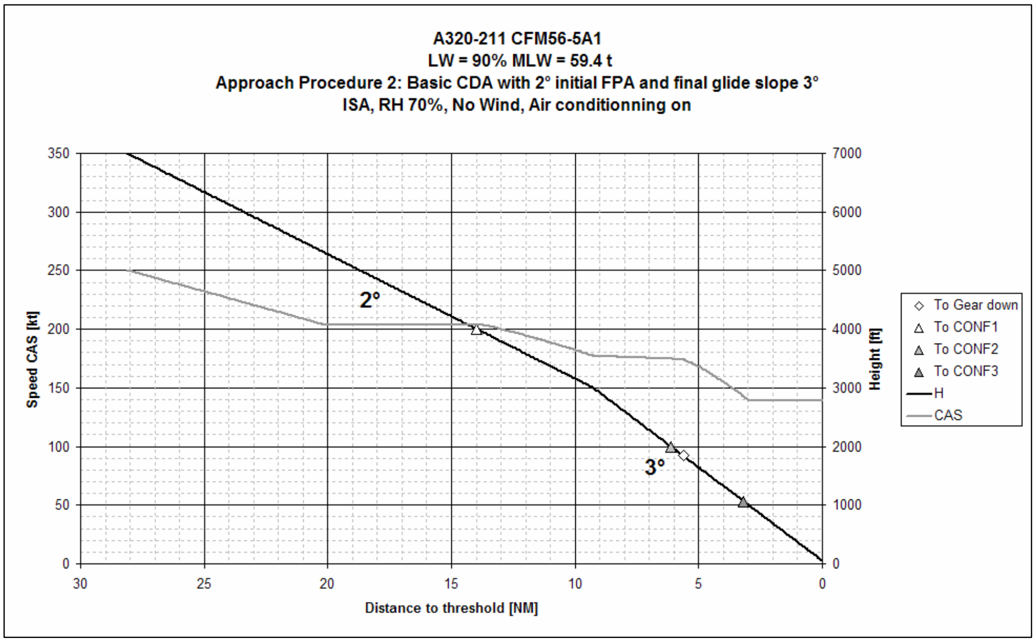

Figure 12. Example of Procedure II height and speed profiles for an A320

Here it can be noticed that the final approach takes place at the minimum allowable flap deployment whereas the baseline procedure defines maximum allowable flap deployment.

4.3.2.1 Noise Contours

The following diagrams show the Lden noise contours for Procedure II, overlaid on those resulting from the Baseline procedure for the four study airports.

4.3.2.1.1 Day-Evening-Night

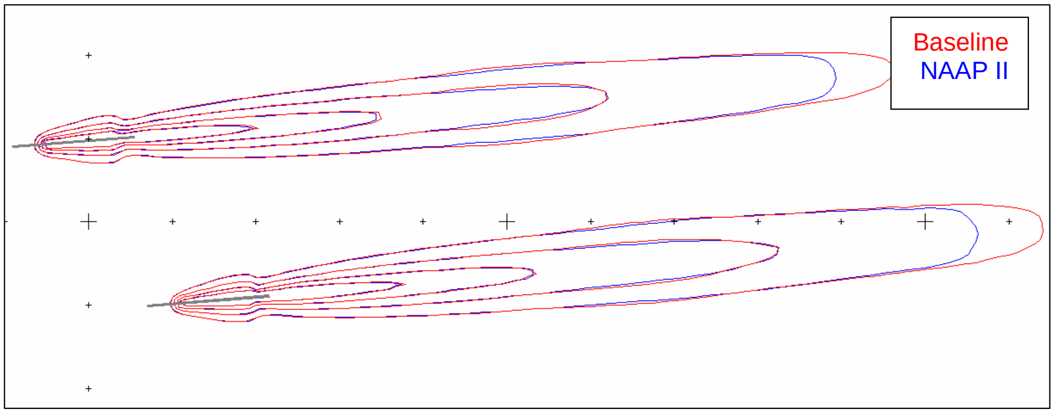

Figure 13. Paris Arrivals Lden Baseline vs Procedure II

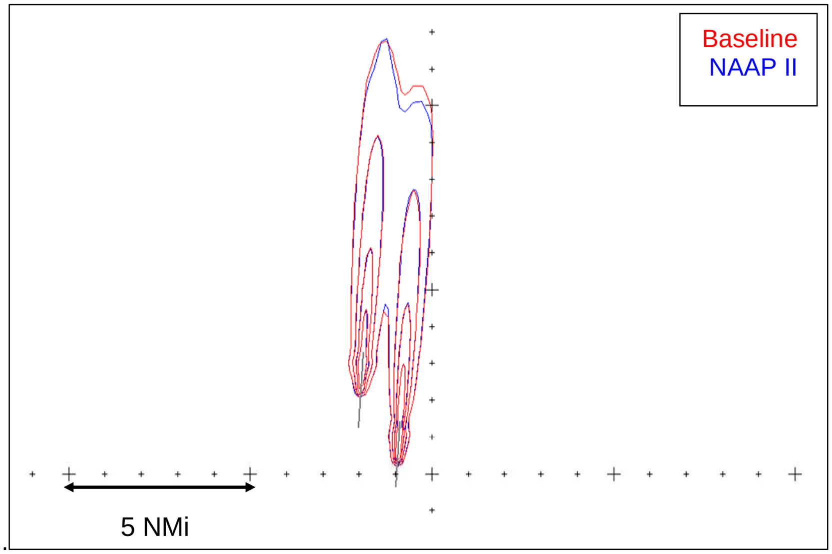

Figure 14. Amsterdam Arrivals Lden Baseline vs Procedure II

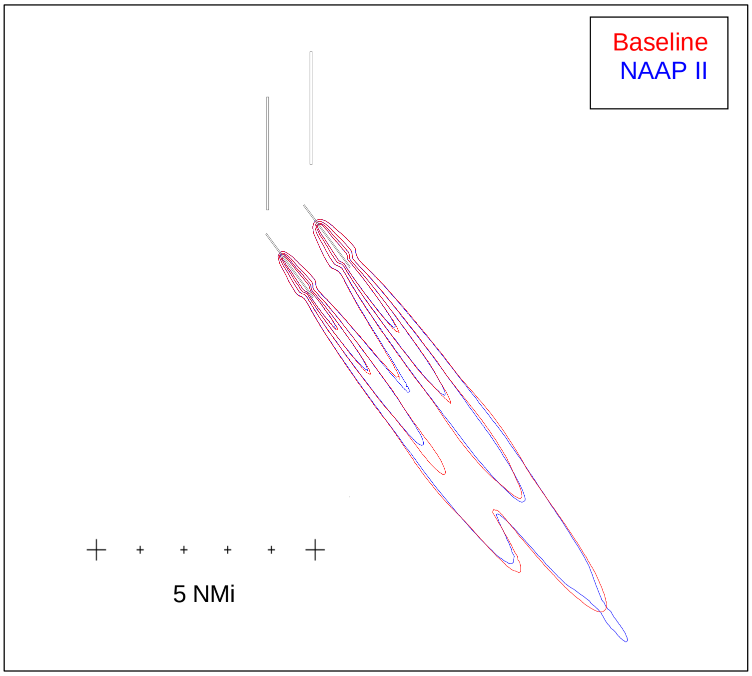

Figure 15. **Madrid Arrivals Lden Baseline vs Procedure II**

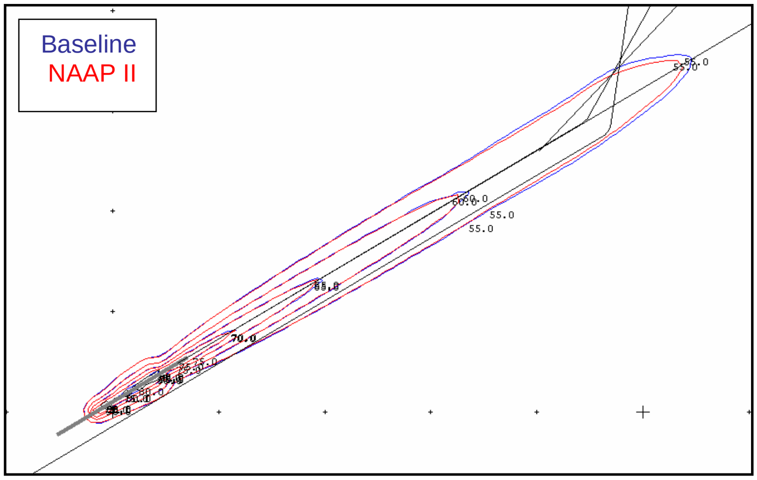

Figure 16. **Napoli Arrivals Lden Baseline vs Procedure II**

	Procedure II Lden contour area change (%)			
Lden Contour level	**CDG**	**Schiphol**	**Barajas**	**Capodichino**
55 Lden	-8.09%	-5%	-4%	-6.6%
60 Lden	-4.15%	-2%	-8%	-3.7%
65 Lden	-2.59%	-1%	-6%	-4.5%
70 Lden	-3.73%	-2%	-7%	-3.9%

Table 5. Percentage variation in Procedure II Lden contour size

4.3.2.1.2 Night only

The following diagrams show the Lnight noise contours for Procedure II overlaid on the Baseline contour, for three of the four study airports.

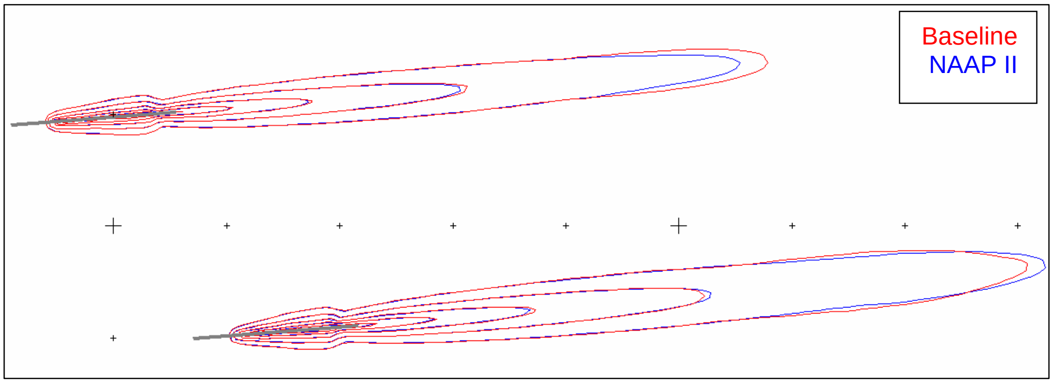

Figure 17. Paris Arrivals Lnight Baseline vs Procedure II

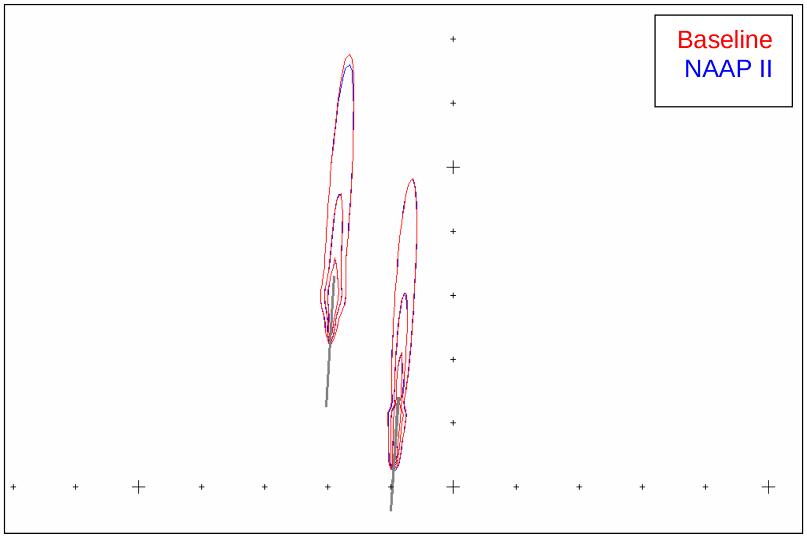

Figure 18. Amsterdam Arrivals Lnight Baseline vs Procedure II

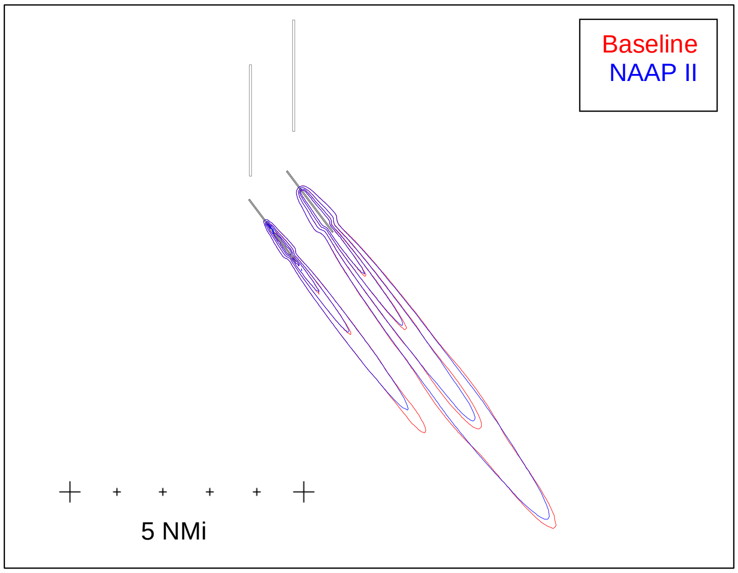

Figure 19. Madrid Arrivals Lnight Baseline vs Procedure II

	Procedure II Lnight contour area change (%)			
Lden Contour level	**CDG**	**Schiphol**	**Barajas**	**Capodichino**
50 Lden	-4.27%	-2%	-7%	
55 Lden	-2.20%	-2%	-10%	
60 Lden	-3.71%	-2%	-6%	
65 Lden	-4.79%		-5%	
70 Lden	-5.24%		-4%	

Table 6. Percentage variation in Procedure II Lnight contour size

4.3.2.2 Procedure II Analysis

In all cases here, it can be seen that the outer procedure II contour (55 dB) is somewhat shorter than the baseline, whereas the other contours are virtually equivalent. Procedure II is higher than the baseline between approx. 17NM and 9NM from the runway threshold, while following the same path after 9NM. This height difference explains the difference in contour length, the noise level being determined to a great extent by altitude. The combination of deployment of flaps/slats for the CDA procedure, earlier than for the baseline but delayed as much as possible, and the lower speed in this area contributes to the noise reduction. The different thrust levels on the final segment, and the cleaner configuration used for the Sourdine procedure do not appear to have significantly altered the size of the other contours although a slight thinning is noticeable between 5 and 3.5 NM at CDG.

In all cases there is a slight reduction in contour area on final approach due to the cleaner configuration.

At Barajas, we see the effect of a too-rapid deceleration of certain types of aircraft during the initial descent, leading to the necessity of increasing thrust before ILS intercept.

The night-time contours do not show the advantage of this procedure as much as the day-time ones since they extend less into the baseline's level segment.

4.3.3 Procedure III

Procedure III is defined as follows:

CDA with 2° initial FPA and increased final glide slope

Condition	Parameter values
7000 ft (Fixed height)	– Speed 250 KTS CAS – Level flight – Clean configuration – Landing Gear up
	– Idle thrust – Fixed 2° Flight Path Angle (FPA) – Delay flap deployment as late as possible – Decelerate and change to intermediate configuration – Decelerate to intermediate flap speed (IFS)
3000 ft (Fixed height)	– Fixed descent angle of 4°. – Landing gear down – Decelerate and change to landing configuration (++) – Decelerate to final approach speed (FAS)
Landing configuration and speed reached (Resulting height, minimum 1000ft)	– Adapted thrust for descent at 4° – Constant speed (FAS) descent to 50ft

Table 7. Procedure III definition

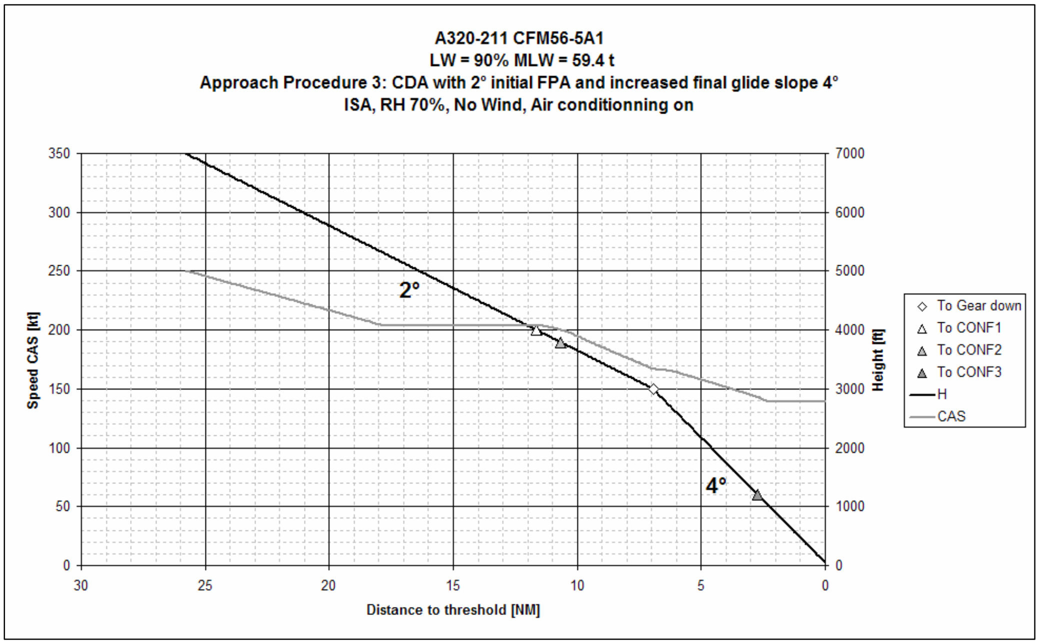

Figure 20. Example of Procedure III height and speed profiles for an A320

In this procedure the final approach again takes place at the minimum allowable flap deployment. The final flight path angle is 4º.

4.3.3.1 Noise Contours

4.3.3.1.1 Day-Evening-Night

The following diagrams show the Lden noise contours for Procedure III, overlayed on those resulting from Baseline for each of the four study airports.

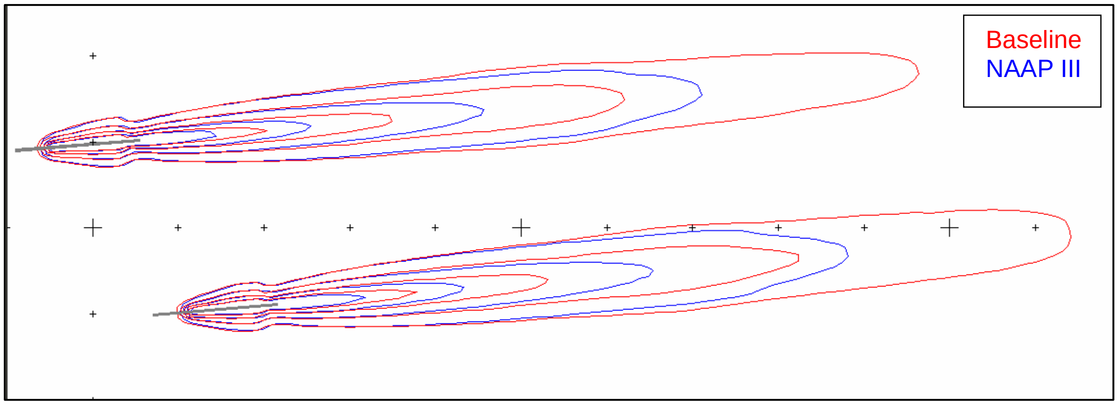

Figure 21. Paris Arrivals Lden Baseline vs Procedure III

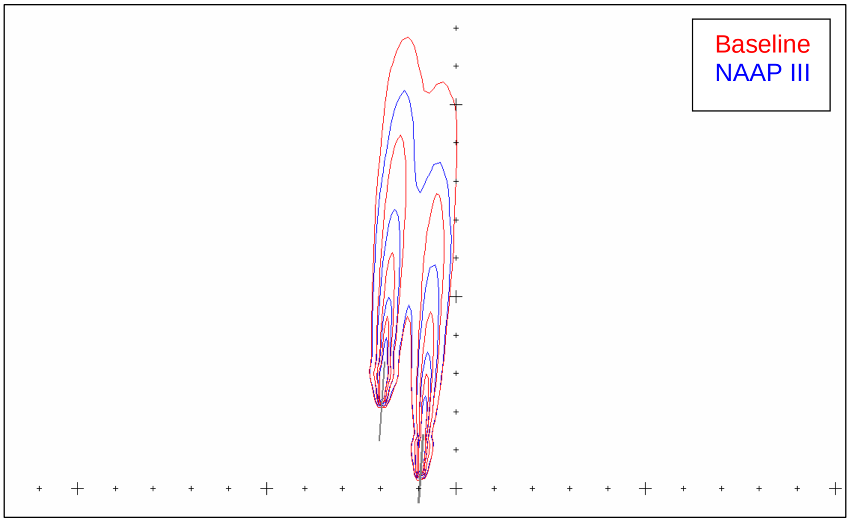

Figure 22. Amsterdam Arrivals Lden Baseline vs Procedure III

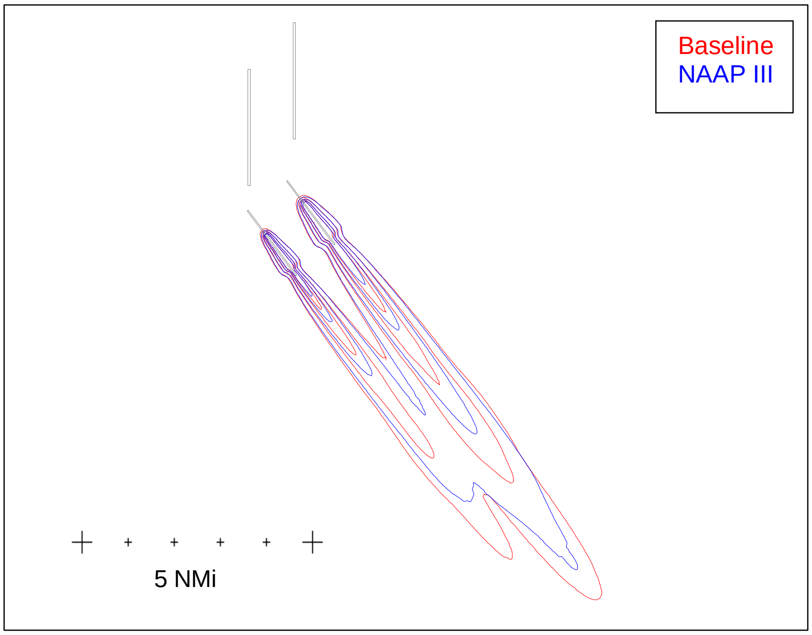

Figure 23. **Madrid Arrivals Lden Baseline vs Procedure III**

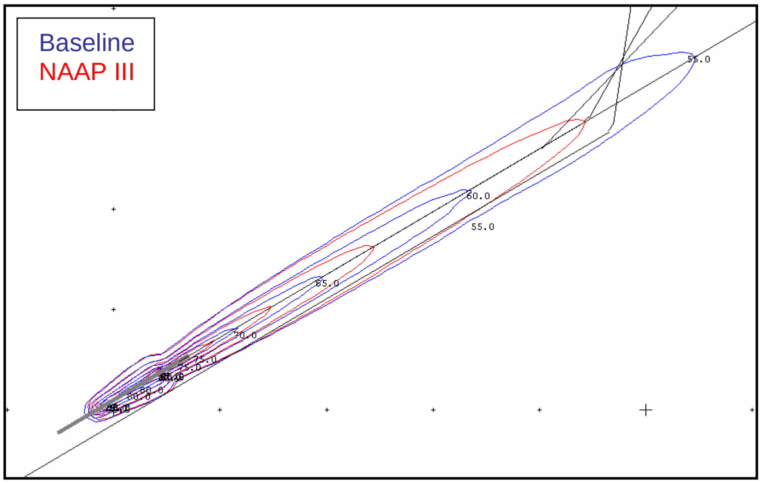

Figure 24. **Napoli Arrivals Lden Baseline vs Procedure III**

	Procedure III Lden contour area change (%)			
Lden Contour level	**CDG**	**Schiphol**	**Barajas**	**Capodichino**
55 Lden	-33.01%	-27%	-21%	-32.3%
60 Lden	-35.59%	-36%	-37%	-33.5%
65 Lden	-32.50%	-35%	-36%	-29.6%
70 Lden	-27.76%	-28%	-28%	-22.3%

Table 8. Percentage variation in Procedure III Lden contour size

4.3.3.1.2 Night only

The following diagrams show the Lnight noise contours for Procedure III overlaid on the Baseline contour, for three of the four study airports.

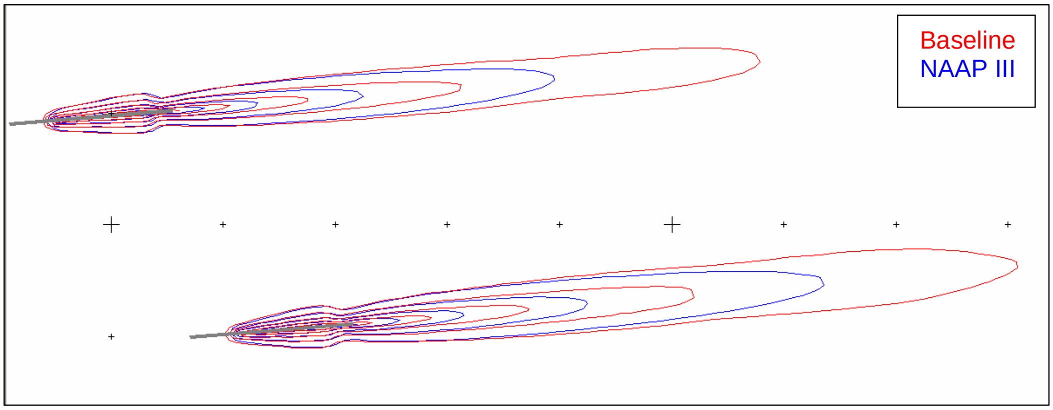

Figure 25. Paris Arrivals Lnight Baseline vs Procedure III

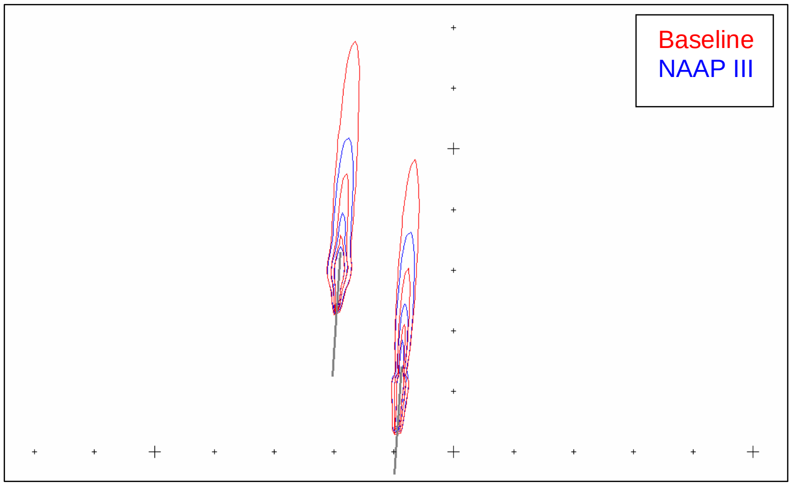

Figure 26. Amsterdam Arrivals Lnight Baseline vs Procedure III

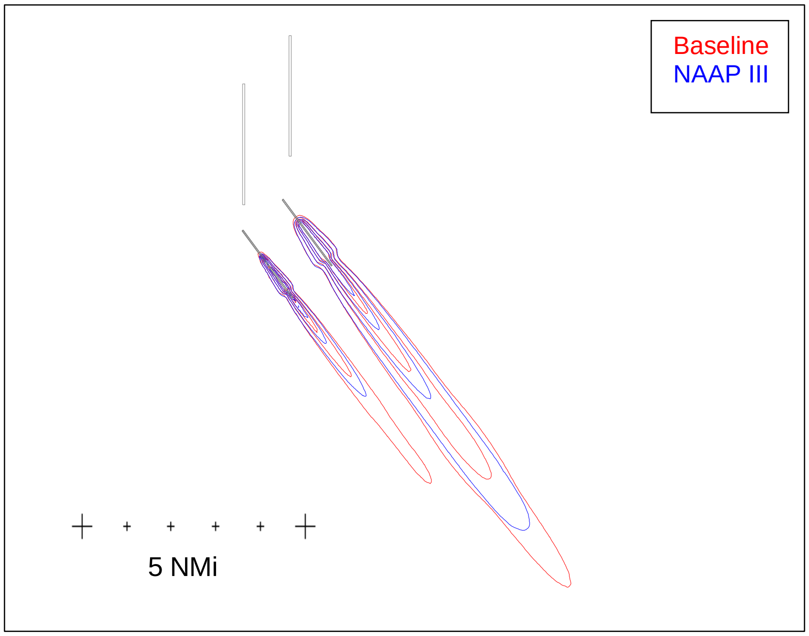

Figure 27. **Madrid Arrivals Lnight Baseline vs Procedure III**

	Procedure III Lnight contour area change (%)			
Lden Contour level	**CDG**	**Schiphol**	**Barajas**	**Capodichino**
50 Lden	-36.83%	-39%	-28%	
55 Lden	-32.49%	-31%	-42%	
60 Lden	-28.11%	-17%	-33%	
65 Lden	-22.16%		-23%	
70 Lden	-13.97%		-15%	

Table 9. Percentage variation in Procedure III Lnight contour size

4.3.3.2 Procedure III Analysis

Procedure III contours are significantly smaller than the baseline for all airports. This is a result of the final descent slope for Procedure III, 4°, whereas the baseline's is 3°. Again, most of this difference is caused by the difference in height of the two profiles (sin4/sin3) which gives a reduction of around 2.5 dB SEL. This difference in noise energy is increased slightly by the differences in thrust settings. At all four airports this gives a reduction in noise contour size of between 20% and 30% at nearly all levels. Similar reductions are seen in the Lnight contours.

4.3.4 Procedure IV

Procedure IV is a CDA with constant speed, variable FPA segment at landing configuration.

Condition	Parameter values
7000 ft (Fixed height)	– Speed 250 KTS CAS – Level flight – Clean configuration – Landing Gear up

	– Idle thrust – Decelerate, landing gear down and change to landing configuration (+), – Decelerate to final approach speed (FAS)
Landing configuration reached (Resulting FPA)	– Descend at constant speed (FAS) to 2000ft – Idle thrust
2000 ft (Fixed height)	– Adapted thrust for descent at 3° – Constant speed (FAS) descent to 50 ft.

Table 10.Procedure IV definition

(+) To maximum allowable speed to select landing configuration?
(++) Minimum allowable flap deployment

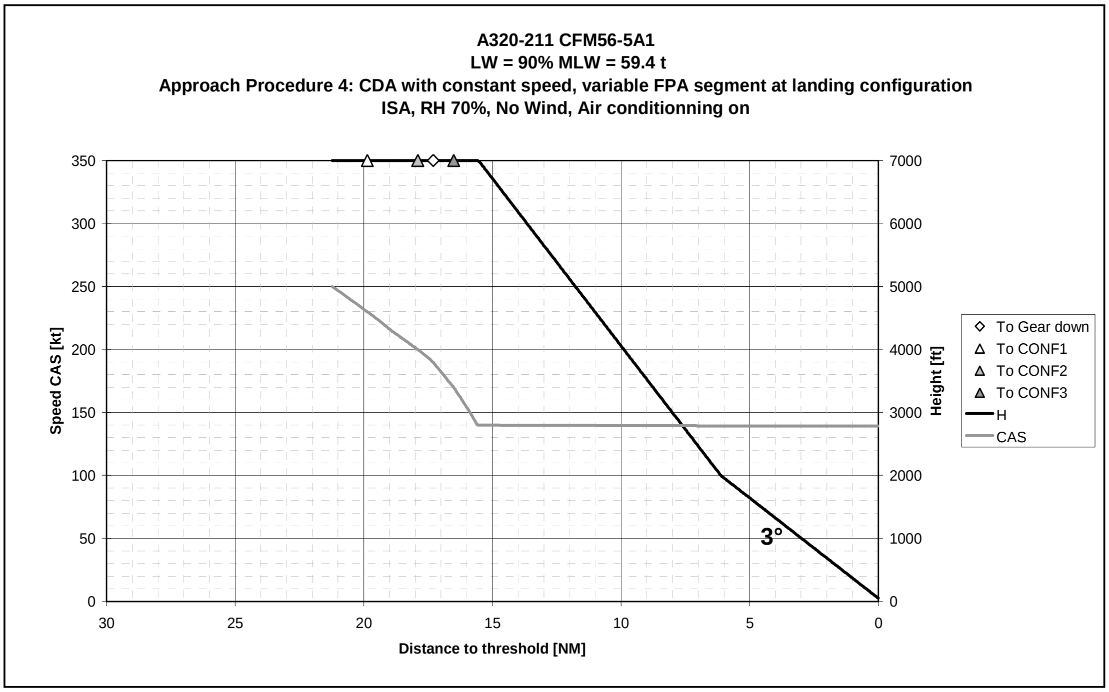

Figure 28. An example of procedure IV height and speed profiles for an A320

Here we have a variable initial glide slope, with ILS interception from above at 2000ft. The aircraft remains at constant speed in landing configuration from the top of descent, at 7000ft.

4.3.4.1 Noise Contours

The following diagrams show the Lden noise contours for Procedure IV, overlaid on those resulting from the Baseline for each of the four study airports.

4.3.4.1.1 *Day-Evening-Night*

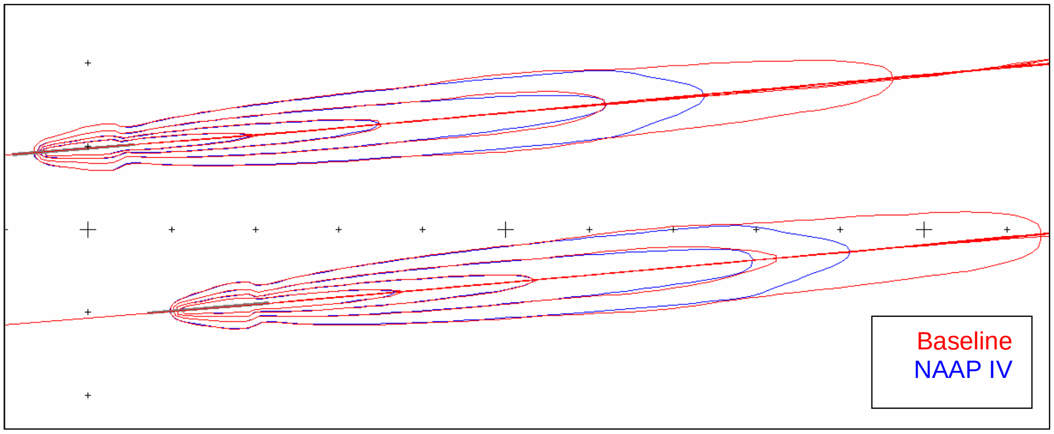

Figure 29. Paris Arrivals Lden: Baseline vs Procedure IV

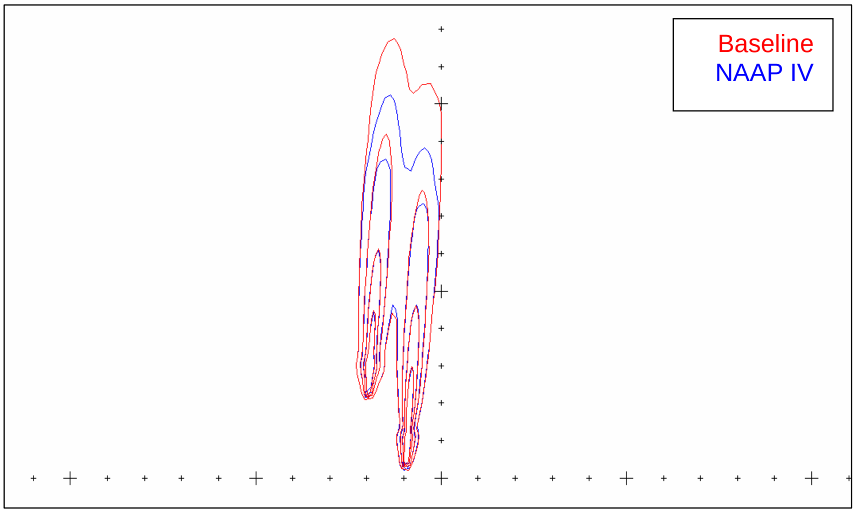

Figure 30. Amsterdam Arrivals Lden Baseline vs Procedure IV

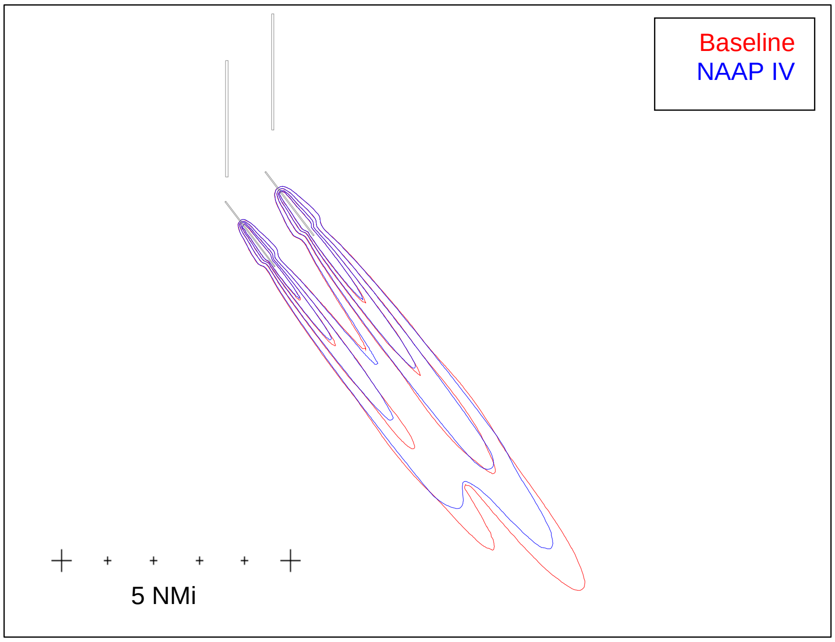

Figure 31. Madrid Arrivals Lden Baseline vs Procedure IV

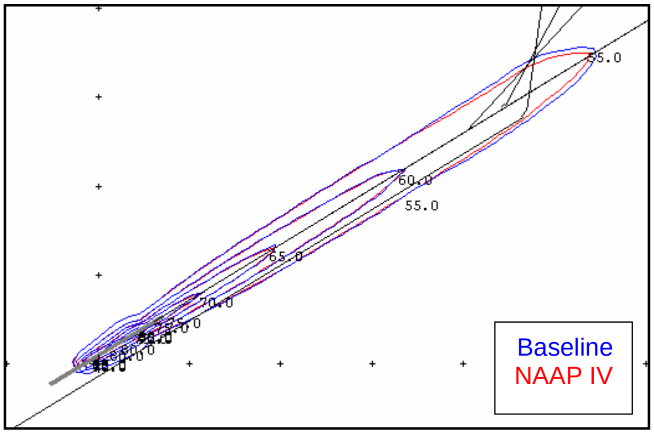

Figure 32. Napoli Arrivals Lden Baseline vs Procedure IV

	Procedure IV Lden contour area change (%)			
Lden Contour level	**CDG**	**Schiphol**	**Barajas**	**Capodichino**
55 Lden	-26.29%	-22%	-15%	-7.6%
60 Lden	-6.59%	-8%	-9%	-3.5%
65 Lden	-3.80%	-2%	-6%	-5.3%
70 Lden	-4.84%	-3%	-7%	-4.3%

Table 11. Percentage variation in Procedure IV Lden contour size

4.3.4.1.2 *Night only*

The following diagrams show the Lnight noise contours for Procedure IV overlaid on the Baseline contour, for three of the four study airports.

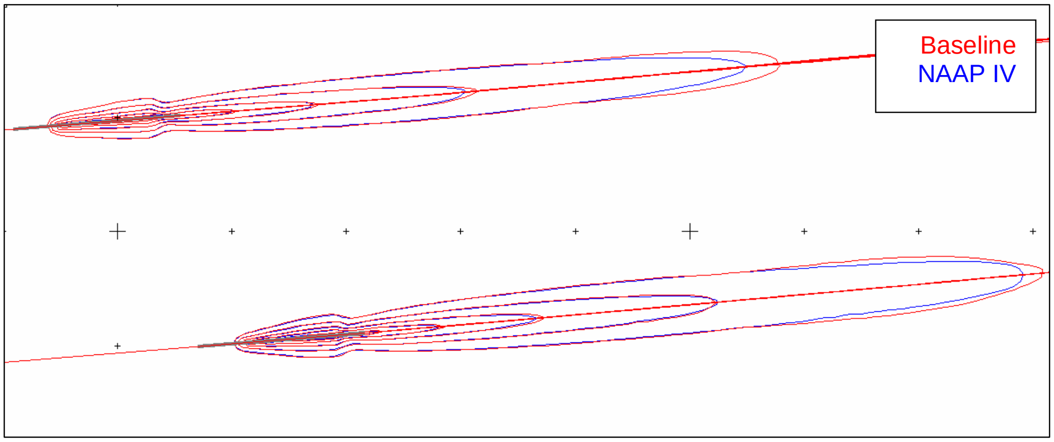

Figure 33. Paris Arrivals Lnight Baseline vs Procedure IV

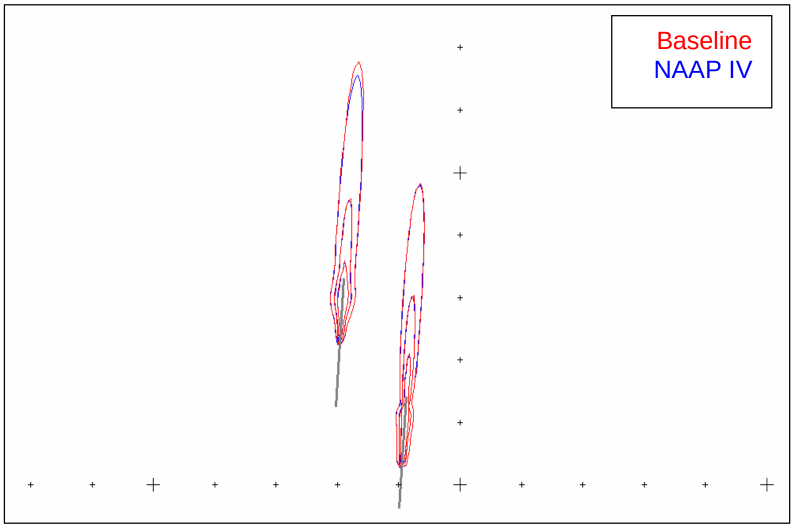

Figure 34. Amsterdam Arrivals Lnight Baseline vs Procedure IV

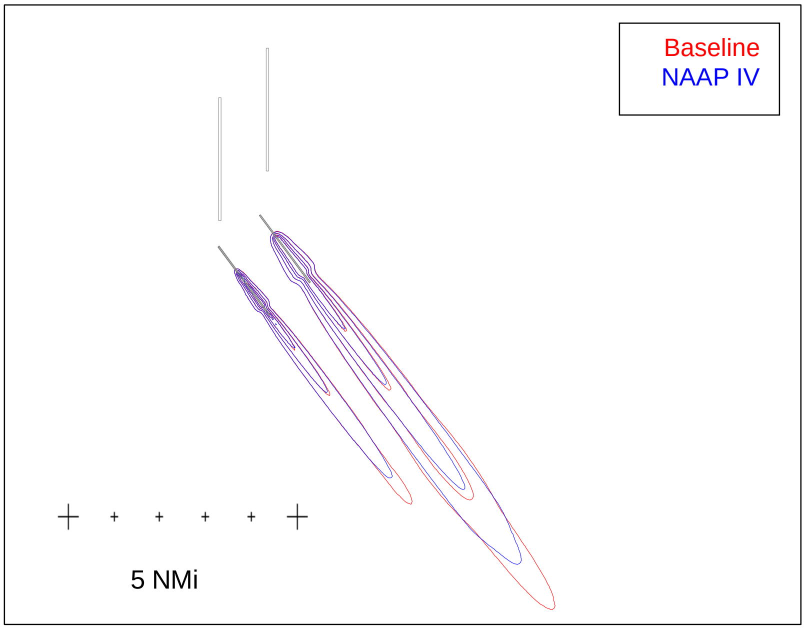

Figure 35. Madrid Arrivals Lnight Baseline vs Procedure IV

	Procedure IV Lnight contour area change (%)			
Lden Contour level	**CDG**	**Schiphol**	**Barajas**	**Capodichino**
50 Lden	-8.04%	-4%	-14%	
55 Lden	-4.24%	-3%	-11%	
60 Lden	-5.52%	-2%	-7%	
65 Lden	-6.16%		-5%	
70 Lden	-7.86%		-4%	

Table 12.Percentage variation in Procedure IV Lnight contour size

4.3.4.2 Procedure IV Analysis

As was already the case with procedure II, only the 55dB contour is affected by procedure IV (with, again, a thinning of the 55dB and 60dB contours noticeable at CDG between 5.5 and 3.5 NM). The sharp initial approach angle increases the height of the aircraft before 10NM and reduces the noise correspondingly. This is, obviously, most easily seen at CDG where the contours are relatively larger and extend further along the approach path.

These effects are also noticeable at night, though to a lesser extent because the relatively smaller overall size of the contours reduces the influence of the increased initial approach angle.

4.3.5 Procedure V

Procedure V has a constant speed, variable FPA segment at intermediate configuration

Condition	Parameter values
7000 ft (Fixed height)	– Speed 250 KTS CAS – Level flight – Clean configuration – Landing Gear up

	– Idle thrust – Decelerate and change to intermediate configuration – Decelerate to intermediate flap speed (IFS)
Intermediate configuration reached (Resulting FPA)	– Descend at constant speed (IFS) to 3000ft – Idle thrust
3000 ft (Fixed height)	– Fixed descent angle of 3°. – Landing gear down – Decelerate and change to landing configuration (++) – Decelerate to final approach speed (FAS)
Landing configuration and speed reached (Resulting height, minimum 1000ft)	– Adapted thrust for descent at 3° – Constant speed (FAS) descent to 50ft

Table 13.Procedure V definition

(+) To maximum allowable speed to select landing configuration
(++) Minimum allowable flap deployment

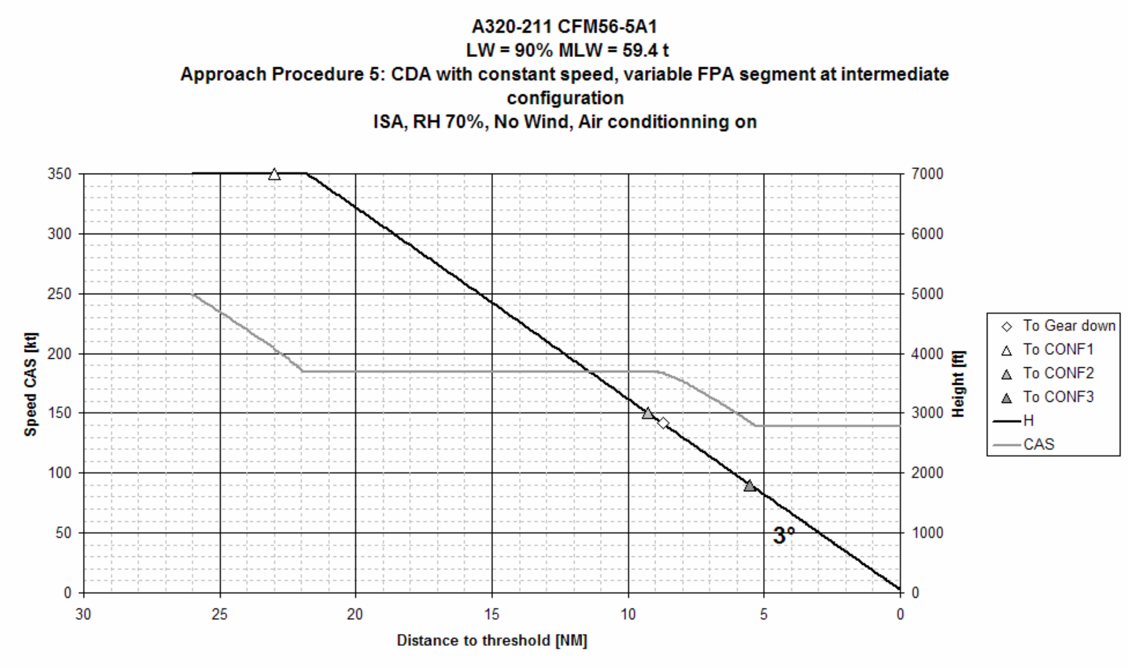

Figure 36. Example of Procedure V height and speed profiles for an A320

Depite the above diagram’s showing a constant 3º glide slope from 7000ft, the initial part, down to 3000ft, of this is variable and depends on the type of aircraft for its actual profile.

4.3.5.1 Noise Contours

The following diagrams show Lden noise contours for Procedure V, overlaid on those resulting from the Baseline procedure for the four study airports.

4.3.5.1.1 Day-Evening-Night

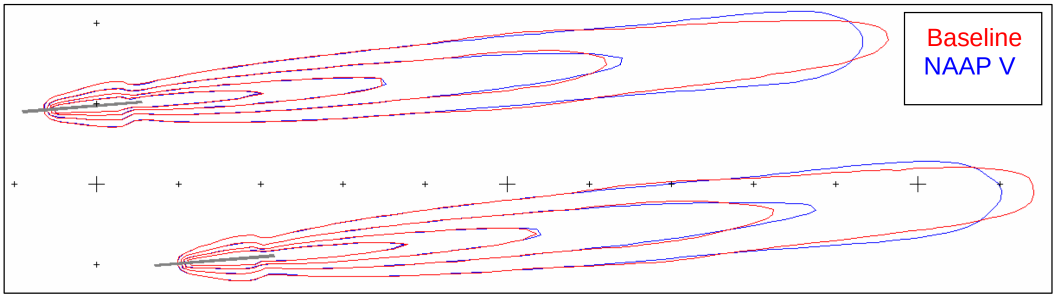

Figure 37. Paris Arrivals Lden Baseline vs Procedure V

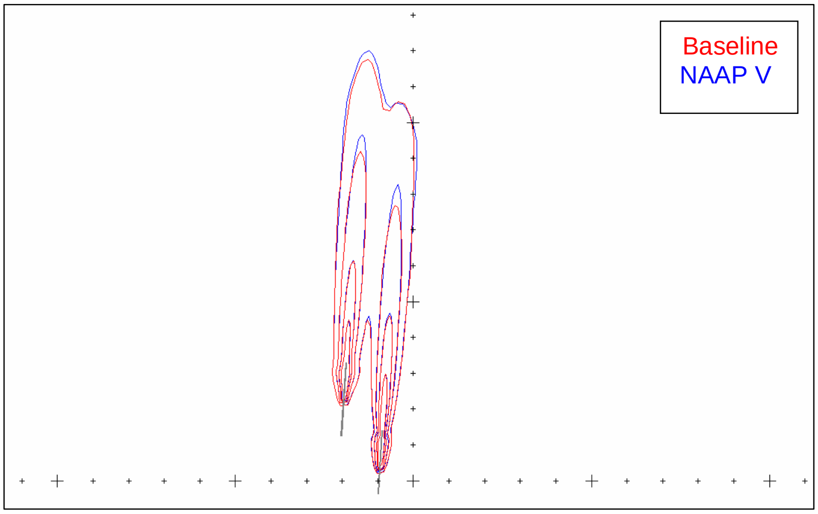

Figure 38. Amsterdam Arrivals Lden Baseline vs Procedure V

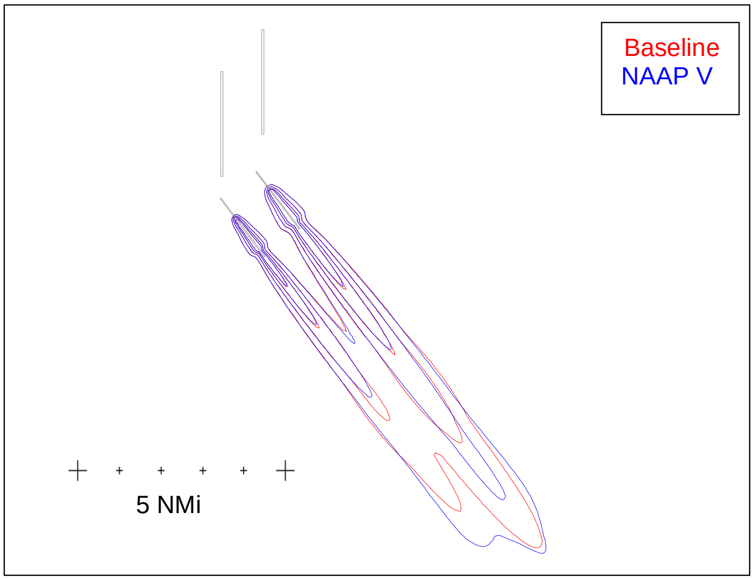

Figure 39. Madrid Arrivals Lden Baseline vs Procedure V

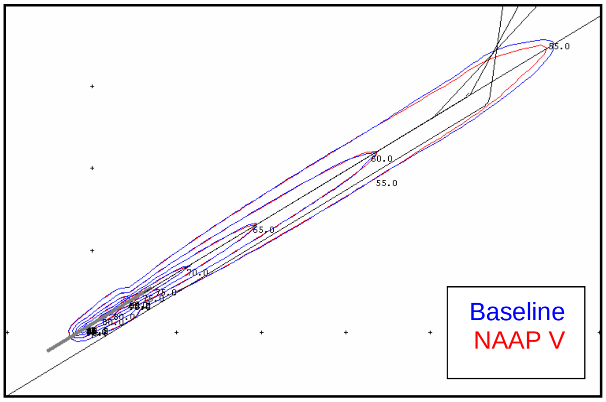

Figure 40. Napoli Arrivals Lden Baseline vs Procedure V

	Procedure V Lden contour area change (%)			
Lden Contour level	**CDG**	**Schiphol**	**Barajas**	**Capodichino**
55 Lden	1.62%	3%	11%	-7.0%
60 Lden	-0.83%	3%	3%	-1.4%
65 Lden	-1.08%	0%	-5%	-3.5%
70 Lden	-2.70%	-2%	-6%	-3.4%

Table 14.Percentage variation in Procedure V Lden contour size

4.3.5.1.2 Night only

The following diagrams show the Lnight noise contours for Procedure V overlaid on the Baseline contour, for three of the four study airports.

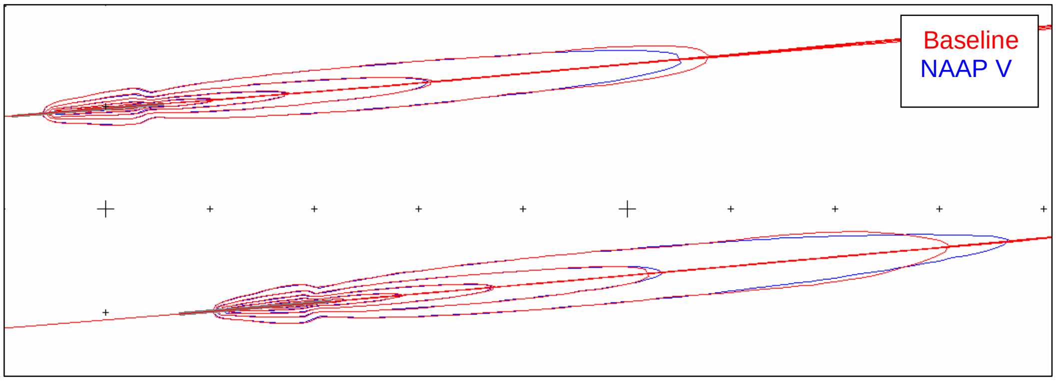

Figure 41. Paris Arrivals Lnight Baseline vs Procedure V

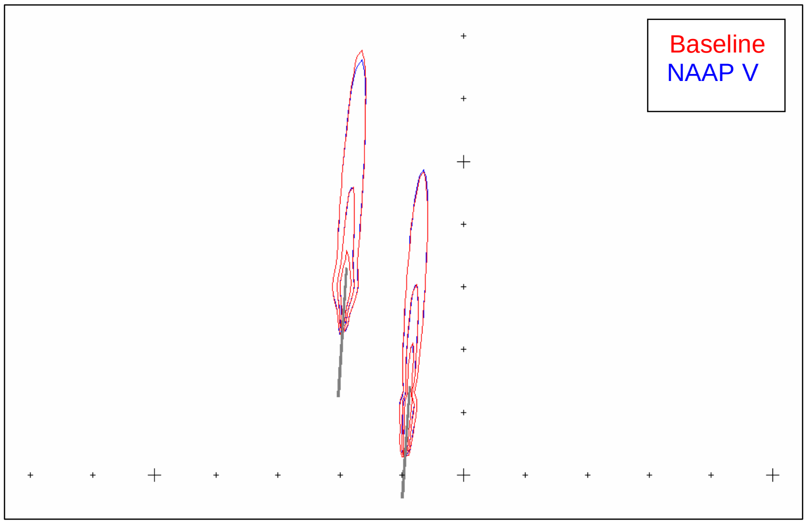

Figure 42. Amsterdam Arrivals Lnight Baseline vs Procedure V

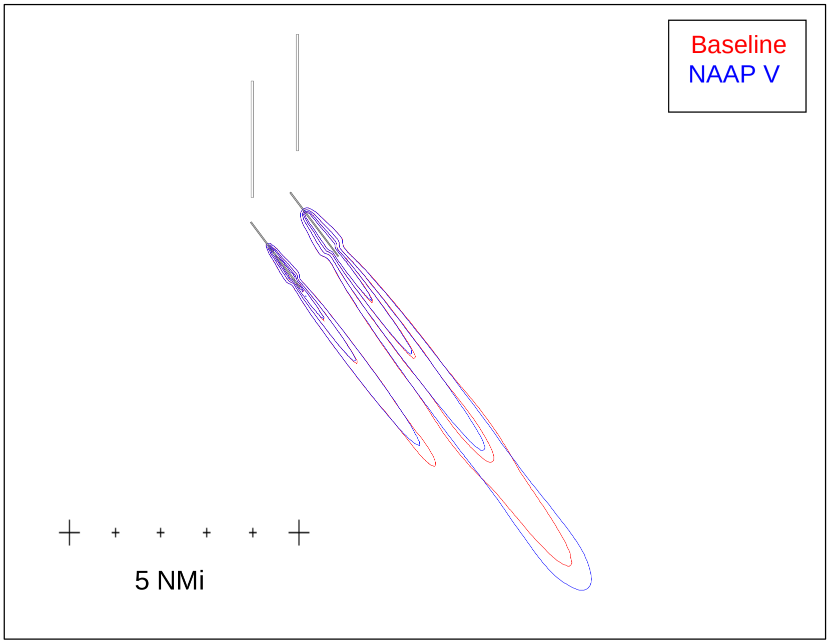

Figure 43. Madrid Arrivals Lnight Baseline vs Procedure V

	Procedure V Lnight contour area change (%)			
Lden Contour level	**CDG**	**Schiphol**	**Barajas**	**Capodichino**
50 Lden	-2.40%	-1%	8%	
55 Lden	-0.99%	-2%	-10%	
60 Lden	-2.81%	-1%	-6%	
65 Lden	-4.10%		-5%	
70 Lden	-6.11%		-4%	

Table 15. Percentage variation in Procedure V Lnight contour size

4.3.5.2 Procedure V Analysis

At CDG the 55dB Lden contour for procedure V is shorter and fatter than that of the baseline, with a slightly greater surface area, whereas the 60dB contour is longer and thinner with a smaller contour area. At Schiphol, both of these contours are 3% larger and at Barajas, the outer contour is 11% greater. These increases are the result of the different aircraft configuration necessary for maintaining speed over the continuous 3º descent in procedure V. The size of the increase is therefore very dependant on the fleet mix used on each runway.?

These differences return to those that we have seen for procedures 2 and 4 as the altitude profiles return to the same as the baseline, after 10NM from the runway threshold.

It should also be noticed that at night, the Barajas 50dB Lnight contour is significantly larger.

4.3.6 Bar-charts

The following charts show the percentage differences in contour area of the different Sourdine II NAAPs compared with the baseline procedure.

4.3.6.1 Lden

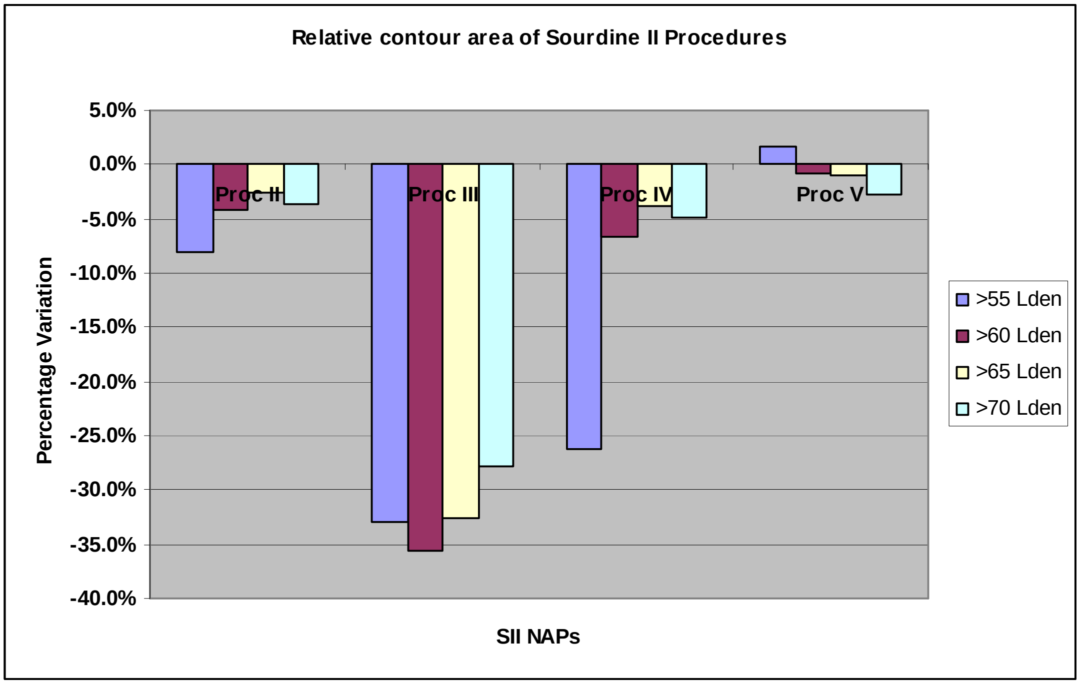

Figure 44. CDG Arrival relative Lden contour area bar chart

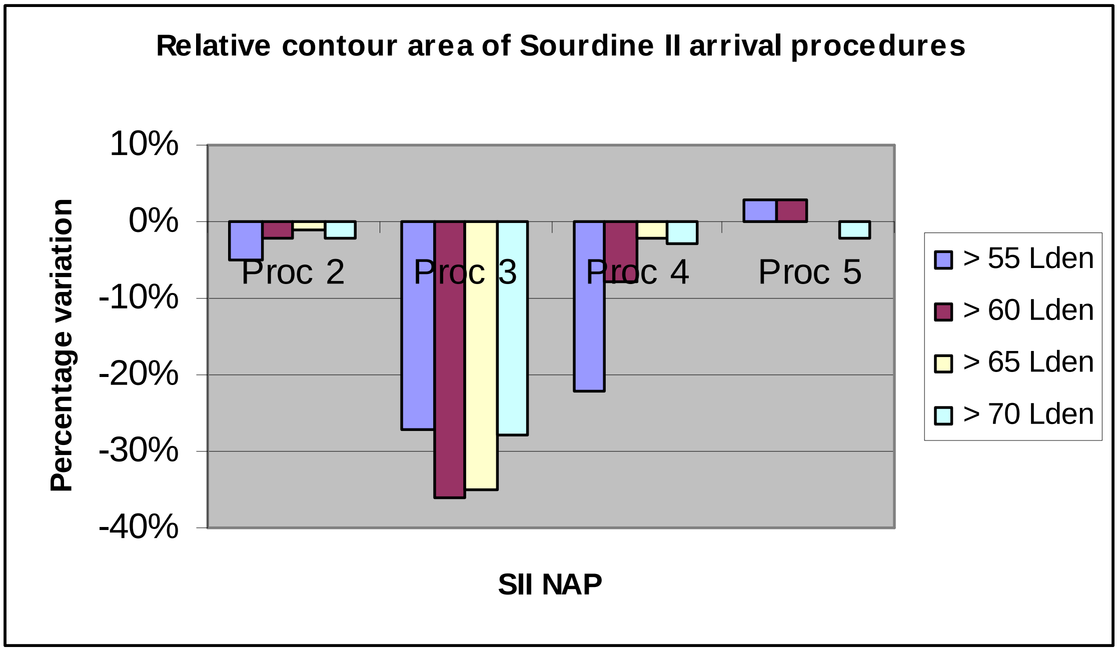

Figure 45. Schiphol relative Lden arrival contour area bar chart

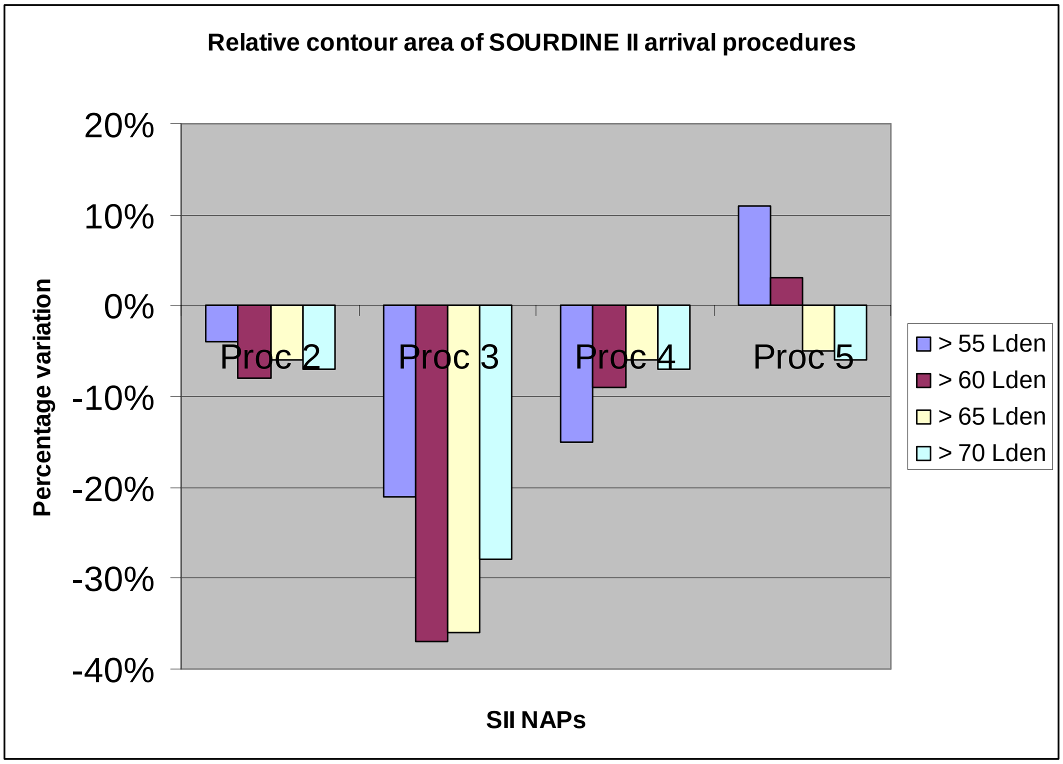

Figure 46. Barajas relative Lden arrival contour area bar chart

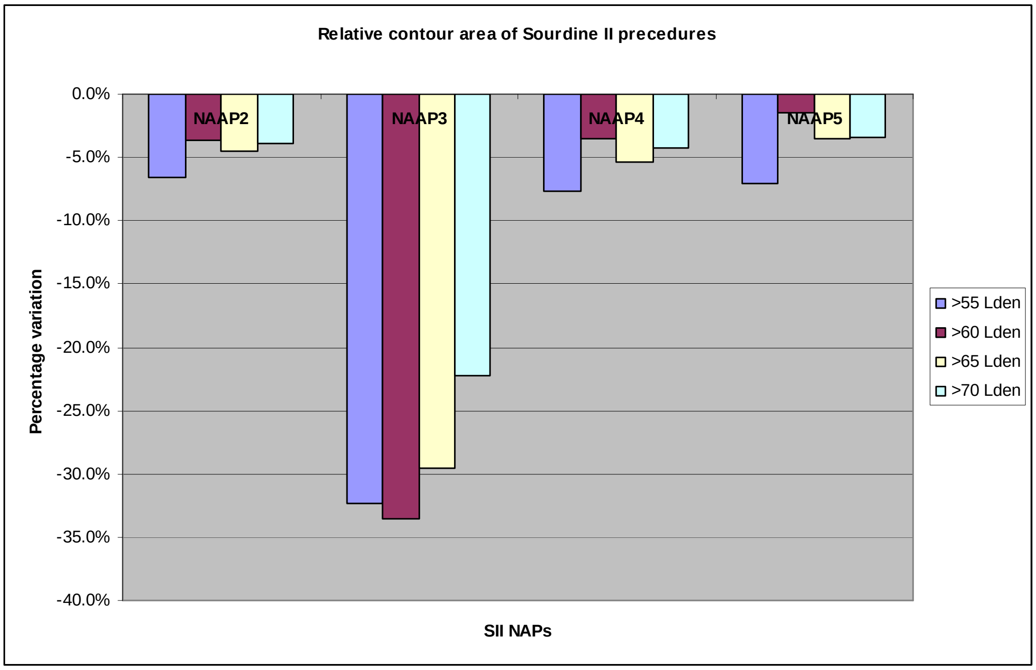

Figure 47. Capodichino relative Lden arrival contour area bar chart

4.3.6.2 Lnight

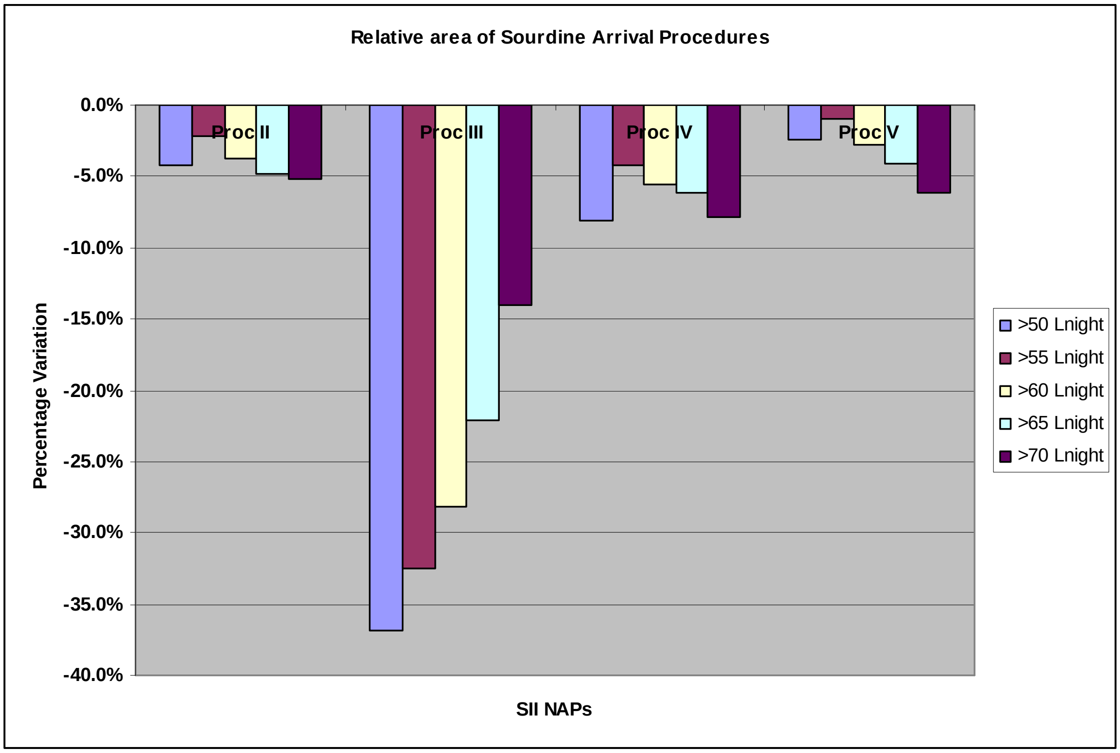

Figure 48. CDG arrival relative Lnight contour area bar chart

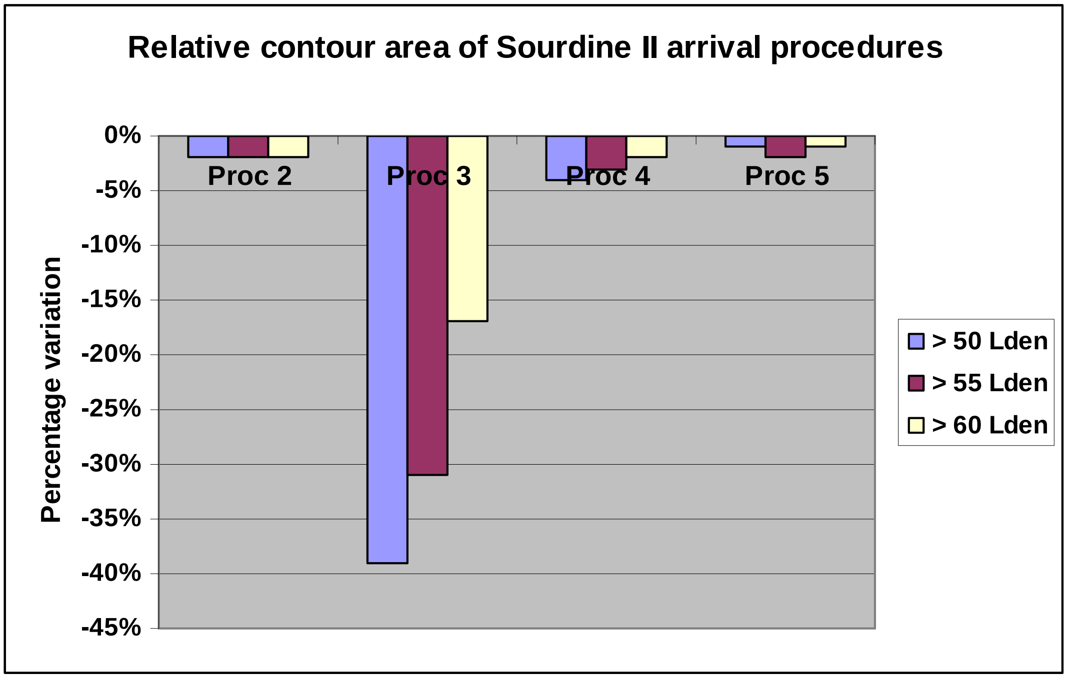

Figure 49. Schiphol arrival relative Lnight contour area bar chart

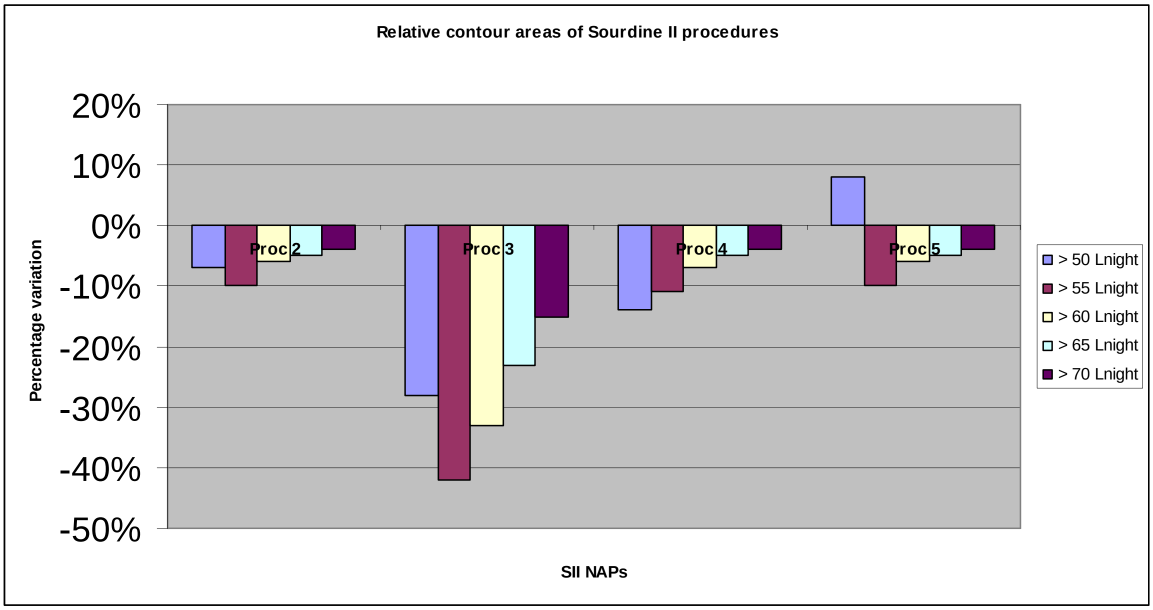

Figure 50. Barajas arrival relative Lnight contour area bar chart

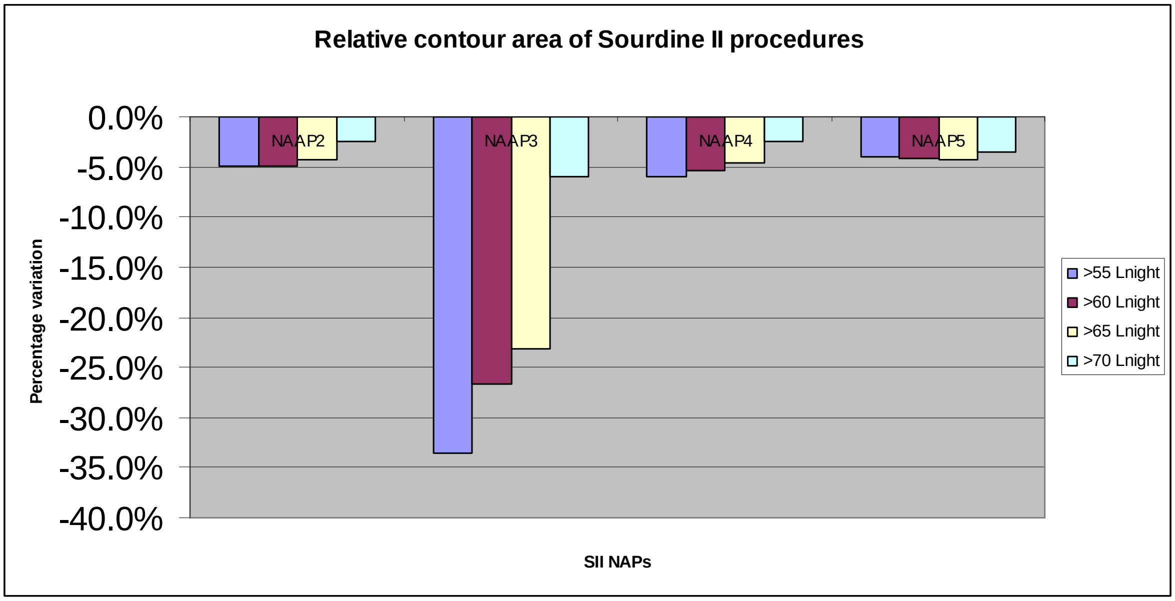

Figure 51. Capodichino arrival relative Lnight contour area bar chart

4.3.7 Comparative Analysis of Sourdine II Arrival Procedures

The noise contours of the Sourdine procedures at each of the four study airports have been compared with those produced by their respective baseline procedures. The analysis of the differences is given in this section. Note that the current reference procedure already represents a noise efficient procedure. A comparison between this procedure and the current practice can be found in deliverable D4-1-1b and the SII final report (D9-1).

4.3.7.1 Lden

The results of the fast time simulation trials indicate that the sizes of the contours are generally a function of the altitude profiles. Since procedure III is continually above the baseline, whereas the other procedures are only higher before 6.5NM (procedure IV) or 10NM (procedures II and V), it is this procedure that gives the best results. For Paris CDG, the traffic volumes are such that the contour for the lowest noise level considered (55 dB) extends to approx. 12 NM from the runway threshold in the baseline, and this contour's size is therefore reduced accordingly at its extremity. Where traffic volumes are less dense, this effect is less noticeable.

On the other hand, it is noticeable that the effects of different configurations and associated speeds have given rise to increased sizes of the largest contours at CDG, Schiphol and Barajas for procedure V. This is not seen at Capodichino due to the relative smallness of the contours.

4.3.7.2 Lnight

The Lnight contours for procedures II, IV and V (figures 4, 8 and 10) show very little difference as they are all in the area where the aircraft follow the same 3º vertical flight path. Slight variations are visible, especially in the 50dB contour due to differences in thrust and configuration, as well as the cumulative duration effect which changes with aircraft speed. In procedure IV at CDG one can just appreciate the end of the height difference where the increased initial glide segment ends at the interception of the ILS glide slope at around 6.5NM.

Procedure III shows a marked reduction in contour size for the Lden index,. Again this is almost all due to the height difference between the two procedures.

4.3.8 *Impacted population:*

Population data was not available for Paris, Amsterdam or Naples, and so this factor was not studied for these airports. For Madrid Barajas, however, a population impact study was performed and the results of these are given below.

The following tables show the changes in population impacted in the communities studied around Madrid Barajas Airport for the baseline and the four Sourdine II NAPs, together with the percentage change for both the Lden and Lnight contours.

It is noticeable that all four procedures showed reductions in impacted population.

Again, as would be expected, procedure III is responsible for the greatest change in impacted population with all 1500 approx. people being removed from the 60dB Lnight contour and major reductions in the other contours. However, procedure IV, and to a lesser extent procedure II produced noticeable reductions in numbers under the 60dB Lnight contour.

4.3.8.1 Lden

Total	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden	62247	60621	59990	60072	61711
>55 Lden	42171	41082	37466	40753	41879
>60 Lden	17381	16744	14789	16548	16828
>65 Lden	9444	8830	1877	8700	8858
>70 Lden	0	0	0	3	1

% Vs Baseline Proc I		Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden		-3%	-4%	-3%	-1%
>55 Lden		-3%	-11%	-3%	-1%
>60 Lden		-4%	-15%	-5%	-3%
>65 Lden		-7%	-80%	-8%	-6%

4.3.8.2 Lnight

Total	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight	18755	18363	16305	18324	18470
>55 Lnight	10293	9834	2810	9767	9961
>60 Lnight	1508	1376	0	1326	1403

% Vs Baseline Proc I		Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight		-2%	-13%	-2%	-2%
>55 Lnight		-4%	-73%	-5%	-3%
>60 Lnight		-9%	-100%	-12%	-7%

4.4 Departure procedures

4.4.1 Baseline

This is the ICAO-A noise abatement procedure.

Altitude (ft)	
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
1500 ft	- Reduce to Climb Thrust - Maintain V2 + 10 kt
3000 ft	- Acceleration to 250 kt, retracting flaps/slats on schedule - Climb to 15000 f

Table 16.Departure baseline definition

4.4.2 Close-in

The Sourdine optimised close-in procedure as defined in the original Sourdine project.

Condition (altitude ft)	Parameter values
0 ft	– TOGA (Take-off Go Around) thrust – Brake release and acceleration to rotation speed (*) – Rotation and lift-off
	– Retraction of undercarriage – Climb out at a speed of V2 + 10-20 KTS IAS (**)
At 800ft	– Reduce thrust to *CUTBACK* or Max Climb, whichever is lowest – Maintain V2 + 10-20 KTS IAS
3000 ft	– If *CUTBACK* thrust was selected: perform *GRADUAL THRUST INCREASE* to Max Climb thrust – Maintain V2 + 10-20 KTS IAS
Upon achieving Max Climb	– Accelerate and retract flaps/slats on schedule to clean configuration – Continue acceleration to 250KTS – Climb to 15000ft

Table 17.Close-in procedure definition

(*) cleanest possible takeoff configuration
(**) V2+10 where possible

The following diagrams show noise contours for SII procedures, overlayed on those resulting from Baseline.

4.4.2.1 Day-Evening-Night

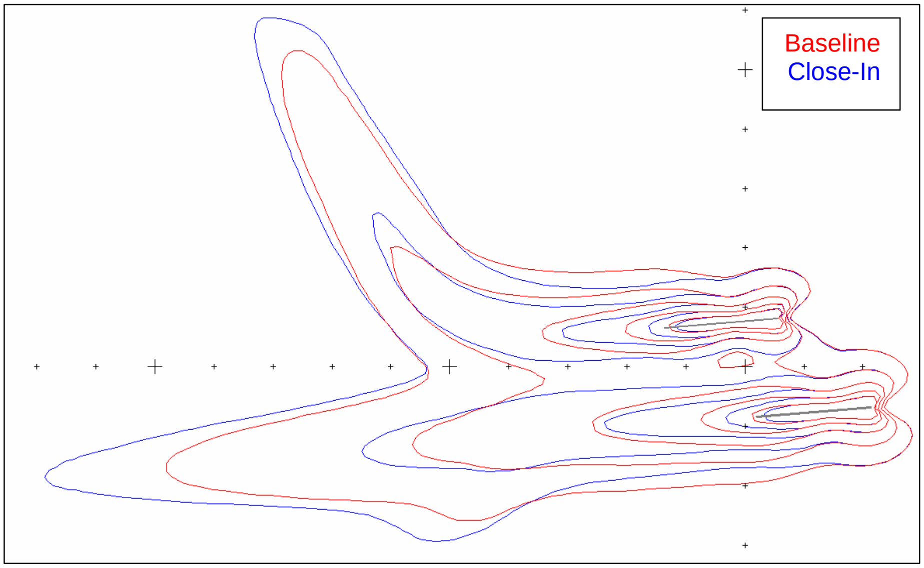

Figure 52. CDG Departure Lden Baseline and Close-in procedure contours

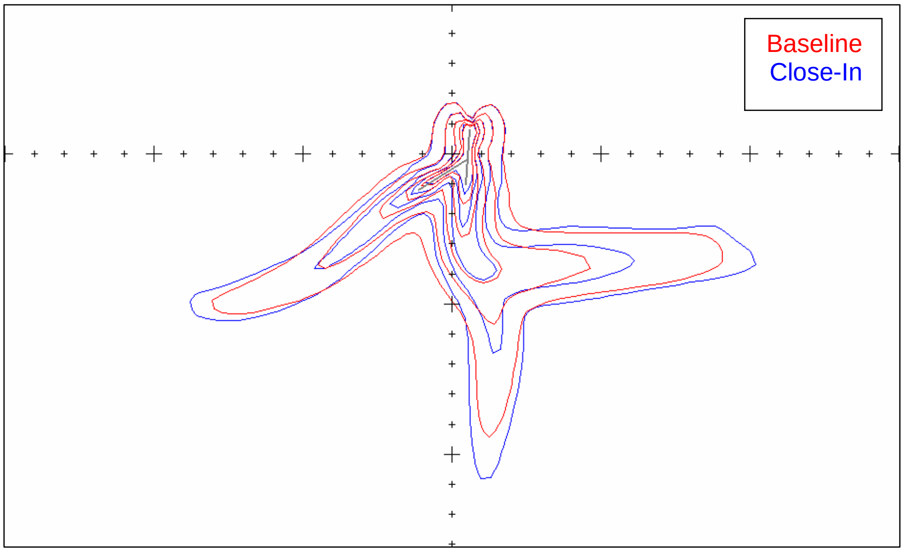

Figure 53. Schiphol Departures Lden Baseline and Close-in procedure contours

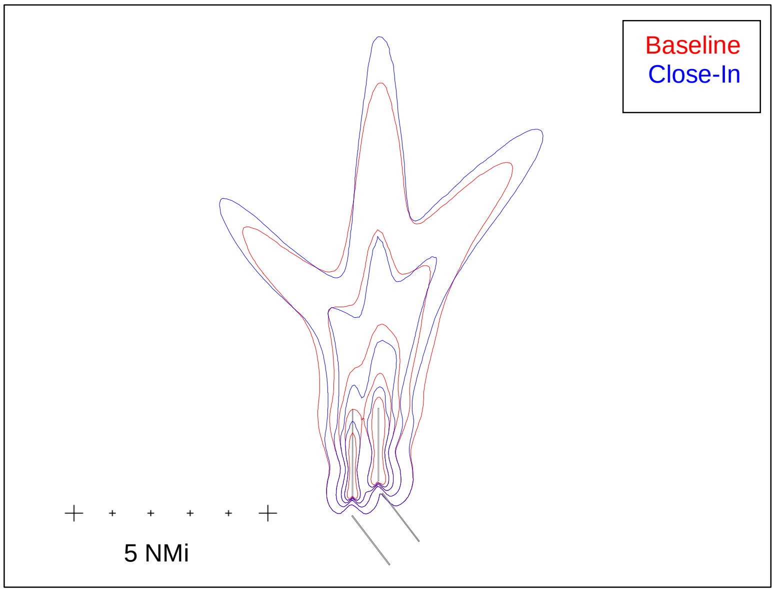

Figure 54. **Barajas Departures Lden Baseline and Close-in procedure contours**

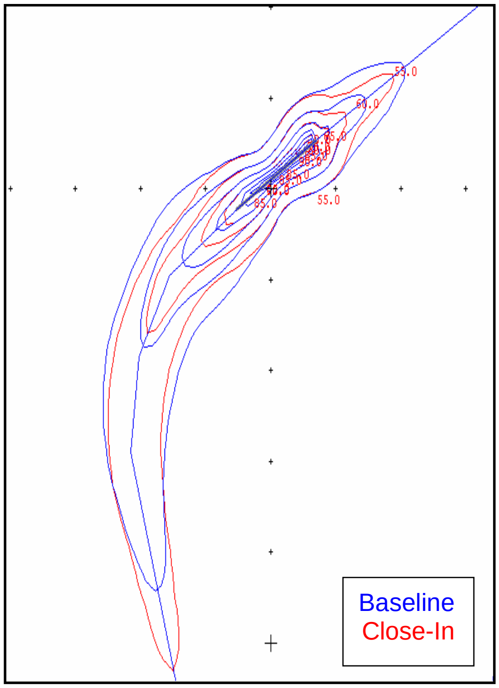

Figure 55. **Capodichino Departures Lden Baseline and Close-in procedure contours**

Close-in Lden Contour level	Baseline	CDG	Schiphol	Barajas	Capodichino
55 Lden	**Reference**	9.90%	9%	9%	
60 Lden		-13.62%	-2%	-12%	
65 Lden		-22.94%	-24%	-21%	
70 Lden		-21.26%	-25%	-24%	
75 Lden		-9.60%	-17%	-12%	

Table 18.Percent Lden Variation of Close-in procedure contour area

4.4.2.2 Night only

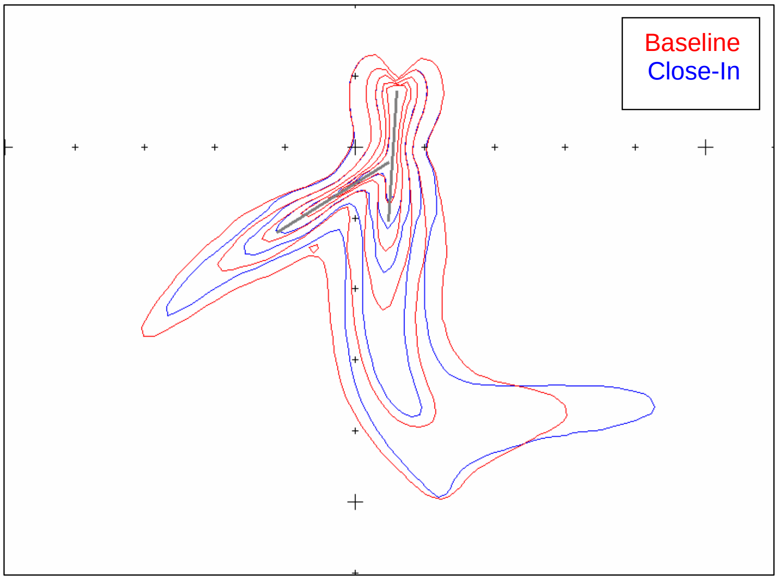

Figure 56. **CDG Departure Lnight Baseline and Close-in procedure contours**

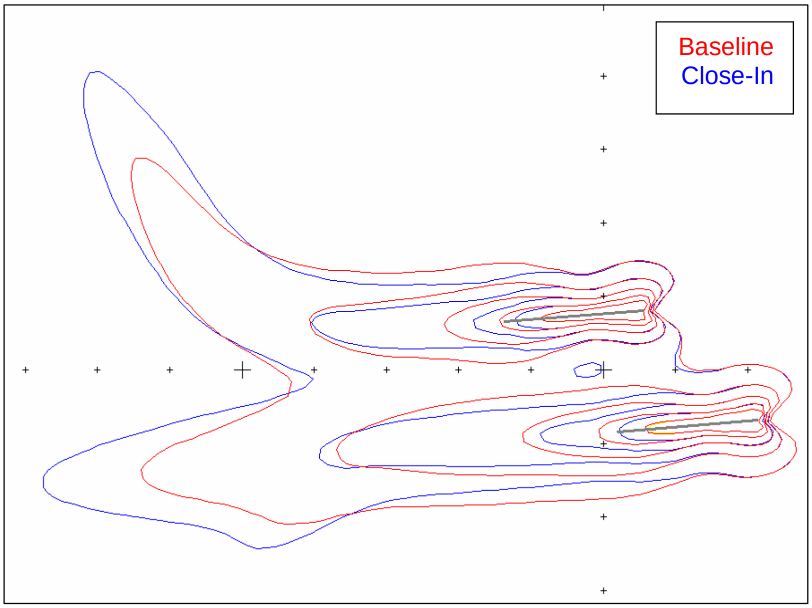

Figure 57. **Schiphol Departures Lnight Baseline and Close-in procedure contours**

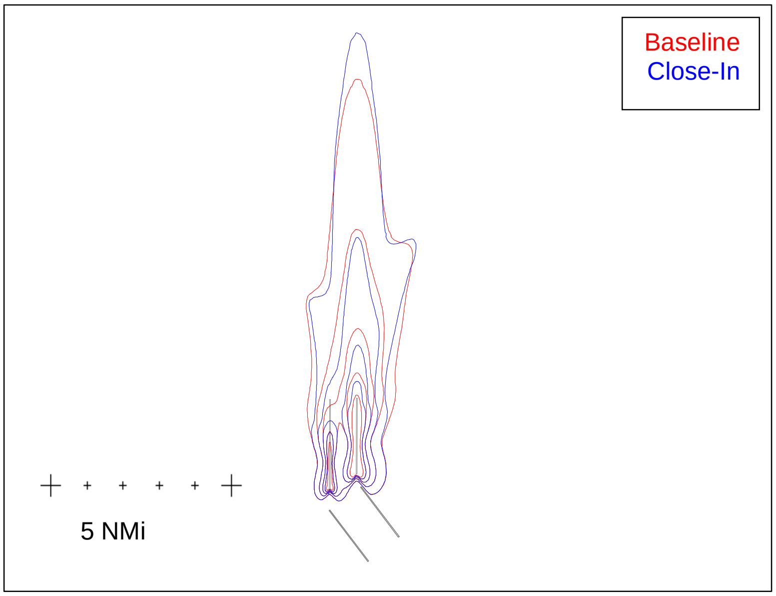

Figure 58. Barajas Departures Lnight Baseline and Close-in procedure contours

Close-in Lnight Contour level	Baseline	CDG	Schiphol	Barajas	Capodichino
50 Lnight	**Reference**	10.21%	-13%	-2%	
55 Lnight		-18.72%	-25%	-20%	
60 Lnight		-22.66%	-23%	-26%	
65 Lnight		-15.06%	-13%	-15%	
70 Lnight		-3.13%	-1%	-8%	

Table 19. Percent Lnight Variation of Close-in procedure contour area

4.4.2.3 Close-in procedure analysis

The Lden contours here clearly show the boundary between noise reduction and noise increase due to this procedure. For example, at CDG the two largest contours (55dB and 60dB) of the close-in procedure are longer - though somewhat thinner due to the decreased propagation from the lower altitude - than those of the baseline, whereas the other, smaller contours are smaller all round. There is a noticeable swap-over point in contour lengths between the 60 and 65 Lden contours at CDG and Schiphol which is seen, due to the smaller sizes of the airports, at the 60 Lden contour at Barajas and between the 55 and 60 Lden contours at Capodichino. This swap-over point occurs at about 5NM from brake-release.

This is the desired result of the close-in procedure.

The differences close in are due to the reduced thrust values of the Sourdine II procedure. whereas the increased lengths of the larger contours for this procedure are due to the lower altitude attained by the aircraft at these points when thrust is restored. In this context it should be noted that the gradual restoration of thrust from cutback to climb thrust contributes to a smooth redistribution of noise energy, from the area to be protected to distant, less sensitive areas.

It should also be noted that the thinning out of the contours has a beneficial effect on their area, even where they are lengthened. Only the 55 Lden contour areas are all considerably increased – by nearly 90% whereas all the others are reduced, sometimes by as much as 25%. At night, only the 50 Lden contour at CDG is larger due to this procedure.

4.4.3 Distant procedure

The Sourdine optimised distant procedure is described below:

Condition (altitude ft)	Parameter values
0 ft	– TOGA (Take-off Go Around) thrust – Brake release and acceleration to rotation speed (*) – Rotation and lift-off
	– Retraction of undercarriage – Climb out at a speed of V2 + 10-20 KTS IAS (**)
At 800ft	– Accelerate to zero-flap speed (Vzf) – Retract flaps/slats on schedule to intermediate configuration
Upon reaching Vzf	– Complete flaps/slats retraction to clean configuration – Reduce thrust to *CUTBACK* thrust or Max Climb, whichever is lowest – Maintain speed
5000 ft	– If *CUTBACK* thrust was selected: perform *GRADUAL THRUST INCREASE* (***) to Max Climb thrust, maintaining constant speed
Upon achieving Max Climb	– Accelerate to 250 KTS IAS – Maintain speed – Climb to 15000 ft

Table 20.Distant procedure definition

(*) cleanest possible takeoff configuration
(**) V2+10 where possible

4.4.3.1 Day-Evening-Night

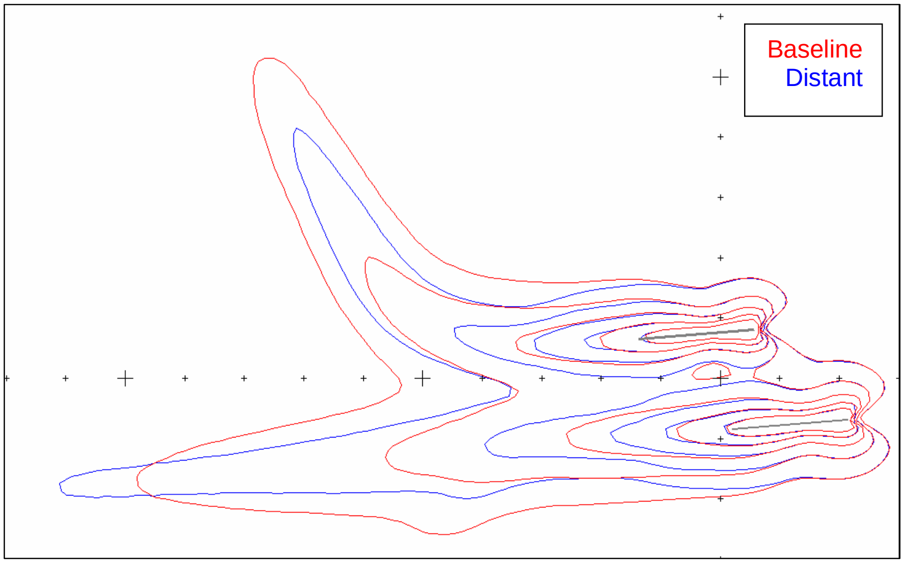

Figure 59. CDG Departure Lden Baseline and distant procedure contours

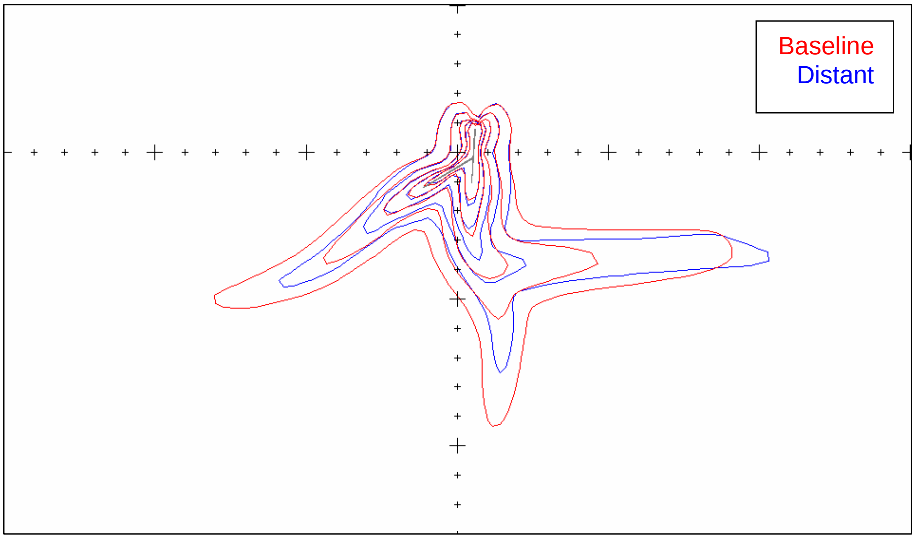

Figure 60. Schiphol Departures Lden Baseline and Distant procedure contours

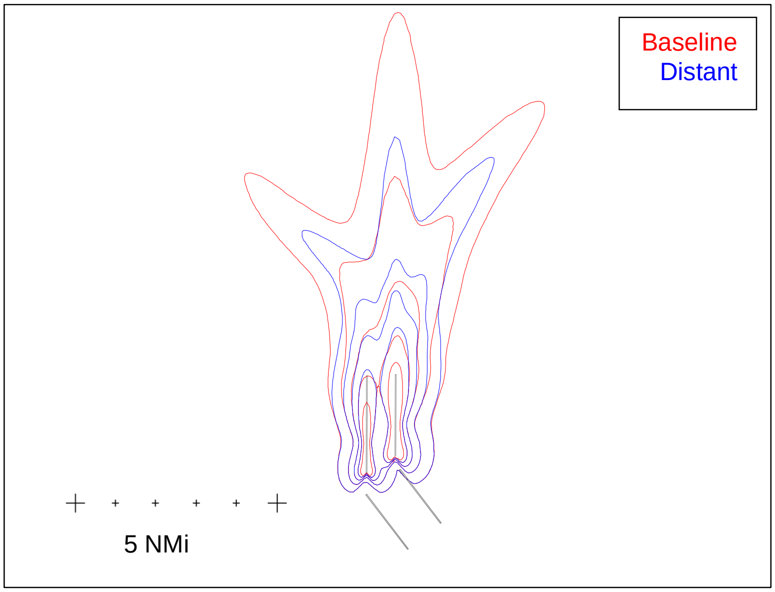

Figure 61. Barajas Departures Lden Baseline and Distant procedure contours

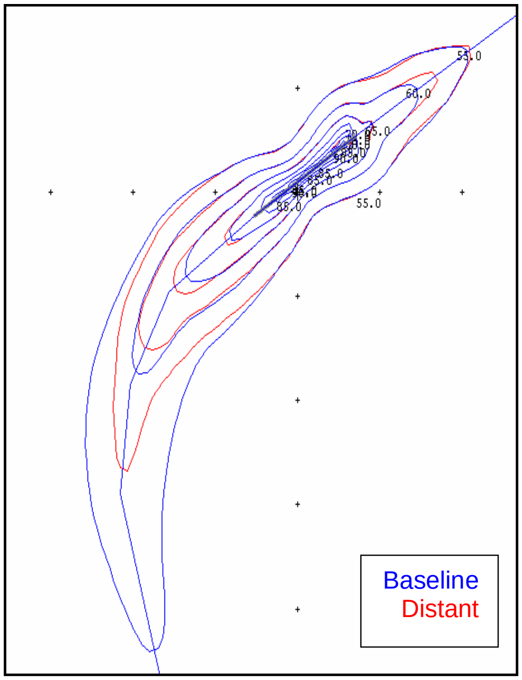

Figure 62. Capodichino Lden Departure Baseline and Distant procedure contours

Distant Lden Contour level	Baseline	CDG	Schiphol	Barajas	Capodichino
55 Lden	**Reference**	-27%	-32%	-42%	
60 Lden		-39%	-40%	-36%	
65 Lden		-15%	-23%	-10%	
70 Lden		3%	-3%	4%	
75 Lden		2%	5%	3%	

Table 21. Percent Lden Variation of Distant procedure contour area

4.4.3.2 Night only

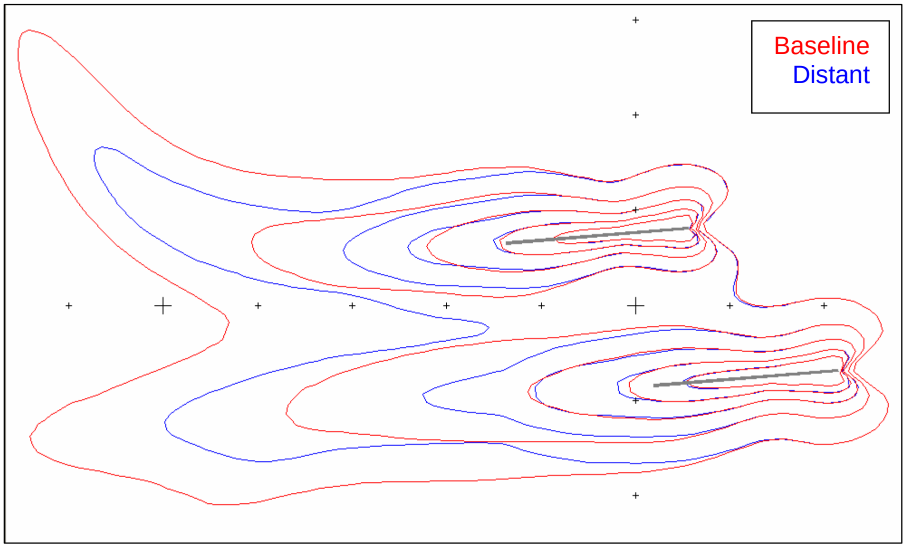

Figure 63. CDG Departure Lnight Baseline and Distant procedure contours

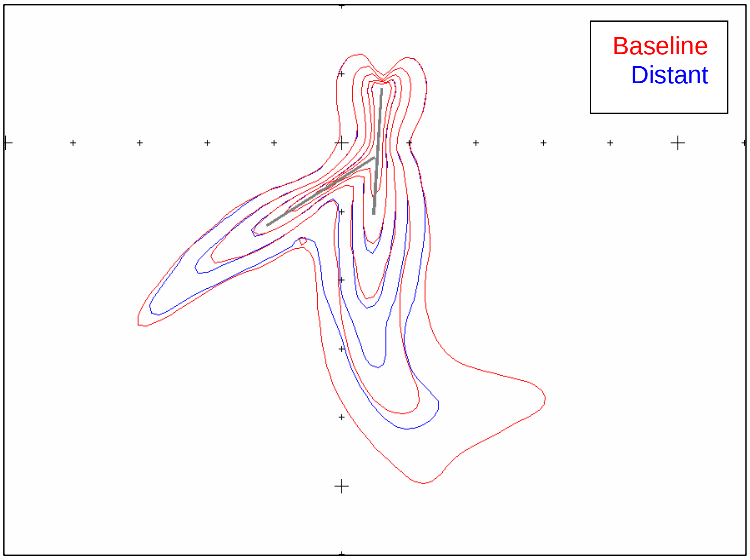

Figure 64. Schiphol Departures Lnight Baseline and Distant procedure contours

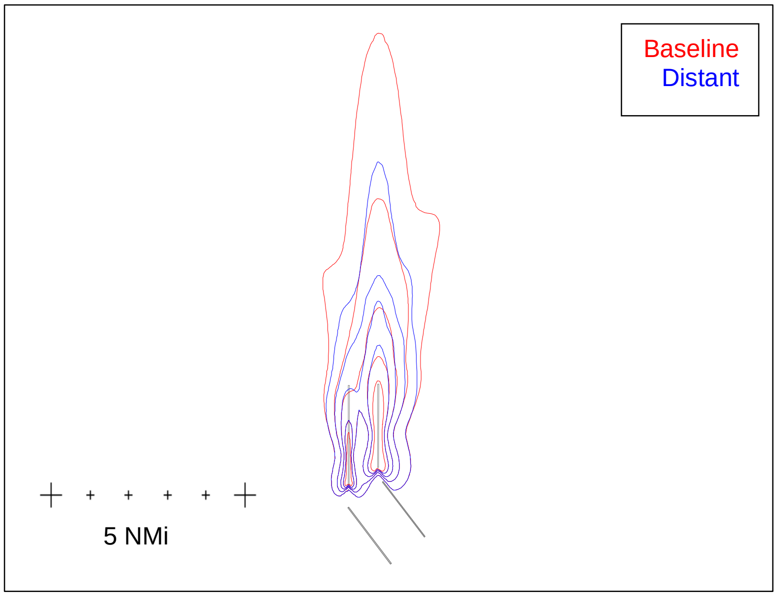

Figure 65. **Barajas Departures Lnight Baseline and Distant procedure contours**

Distant Lnight Contour level	Baseline	CDG	Schiphol	Barajas	Capodichino
50 Lnight	**Reference**	-32%	-31%	-42%	
55 Lnight		-30%	-17%	-27%	
60 Lnight		0%	3%	-1%	
65 Lnight		3%	3%	5%	
70 Lnight		1%	0%	3%	

Table 22.Percent Lnight Variation of Distant procedure contour area

4.4.3.3 Distant procedure analysis

Contrary to close-in procedures, the distant procedures are designed to alleviate noise at areas distant from the airport. It is not surprising then that we see here that the larger contours (e.g. 55-65 Lden at CDG) are significantly smaller for this procedure compared with the baseline whereas the 70 and 75 Lden contours are longer, and very slightly narrower.

In some places, the distant 55dB contour overlaps the baseline 60dB contour – a 5dB reduction in noise levels. In fact, the distant procedure is already quieter than the baseline at 2NM from the end of the runway.

A notable exception here is the extended 55dB contour off the South runway at CDG, and in departures towards the East at Schiphol, which show that different aircraft react differently to the procedure definition; the differences in fleet-mix over the two runways, resulting from the capacity constraints brought to light during simulations, shows this up.

4.4.4 Bar-charts

4.4.4.1 Day-Evening-Night

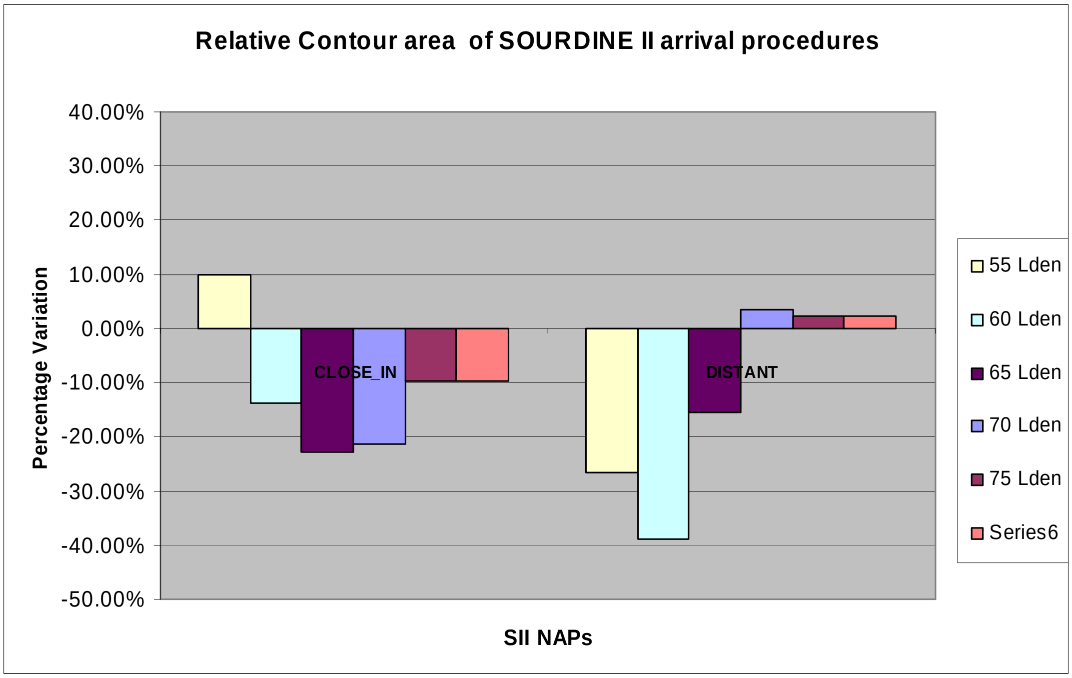

Figure 66. CDG Departures relative Lden contour area bar chart

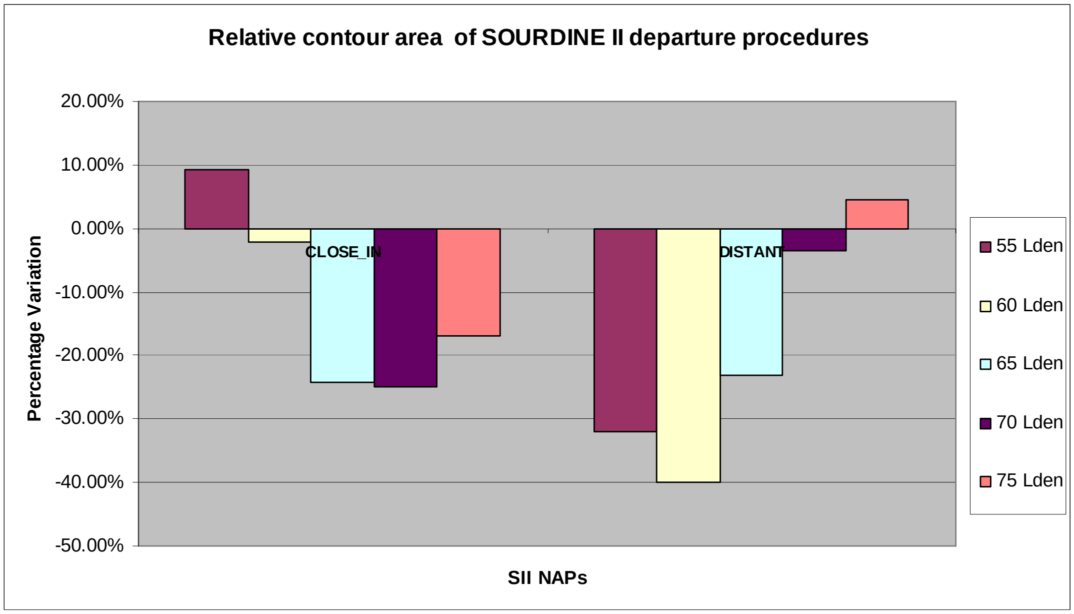

Figure 67. Schiphol departure relative Lden contour area bar chart

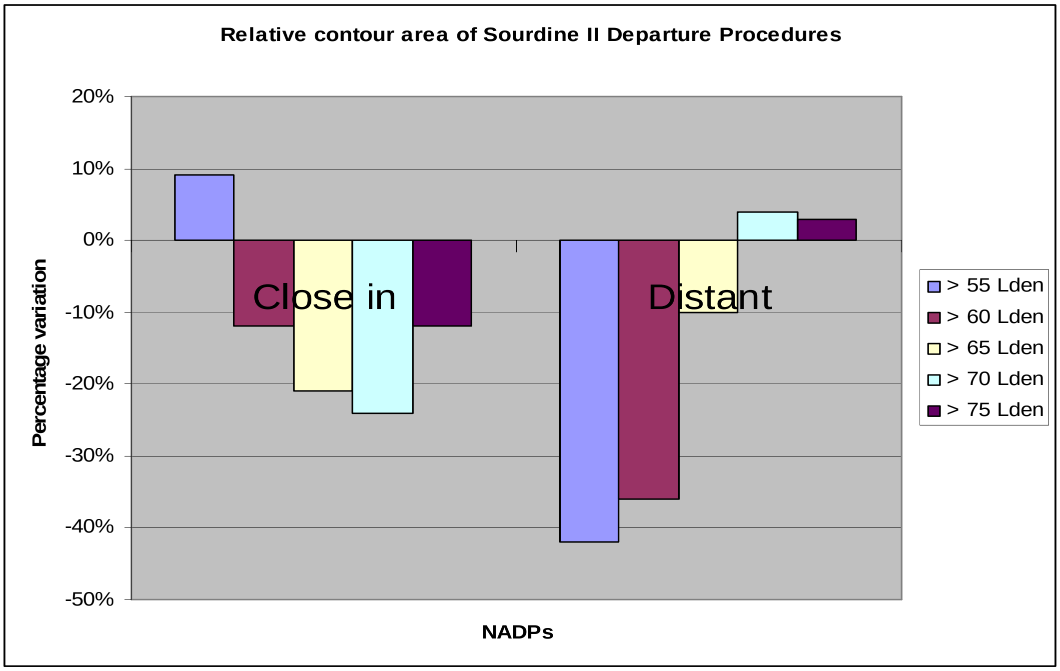

Figure 68. **Barajas departure relative Lden contour area bar chart**

4.4.4.2 Night only

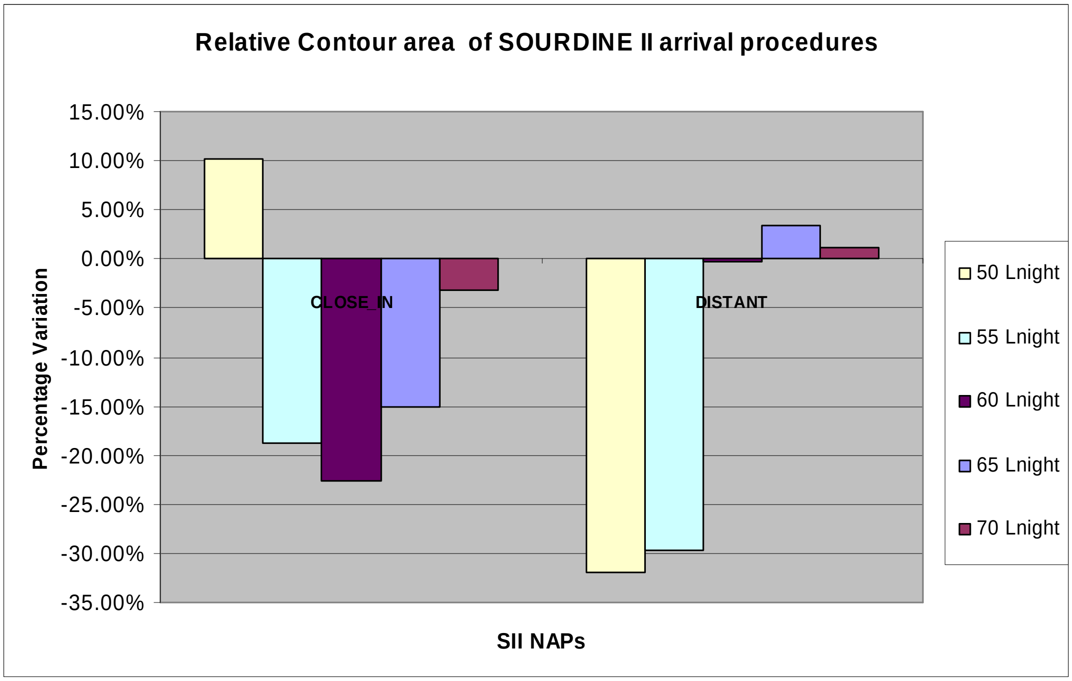

Figure 69. **CDG departure relative Lnight contour area bar chart**

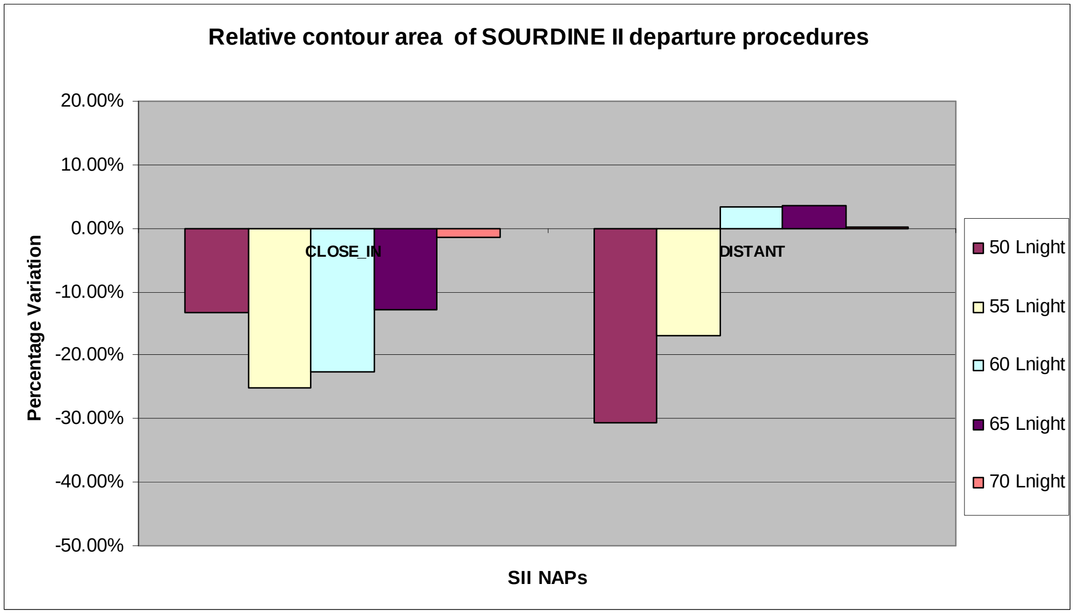

Figure 70. Schiphol departure relative Lnight contour area bar chart

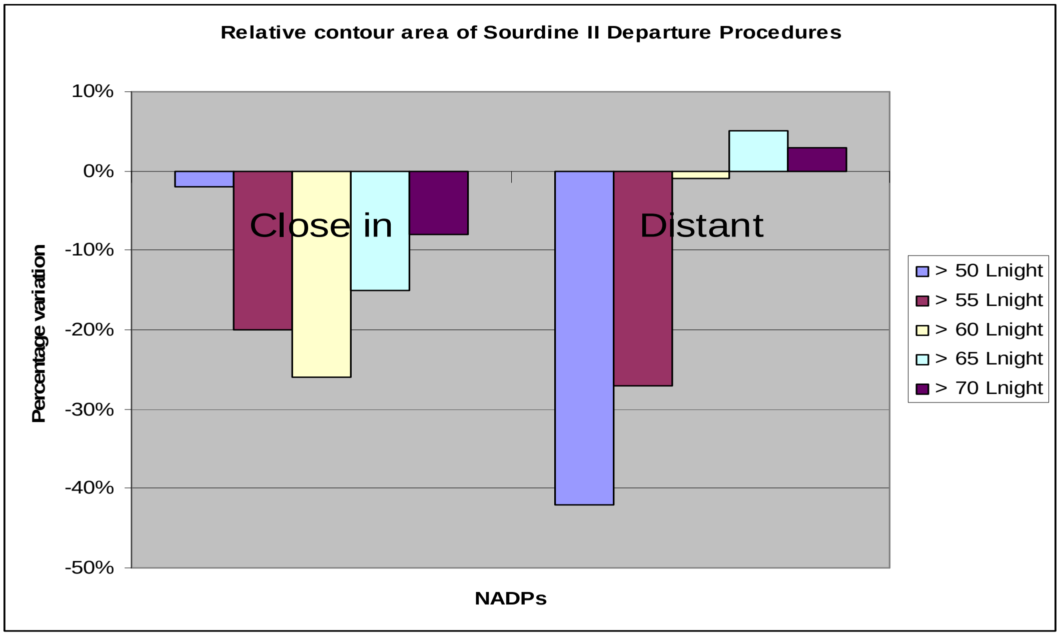

Figure 71. Barajas departure relative Lnight contour area bar chart

4.4.5 Analysis of departure procedures

The two optimised departure procedures analysed here were designed for different effects: one to reduce noise close to the airport, at the expense of increasing noise further away; the other increasing noise close in, but reducing it further out. The comparison of these procedures against a standard close-in procedure (ICAO A) shows that the procedures accomplish their objectives very well.

It should be noted that the crossover point between reference and optimised procedures is, in fact, close to the airport:

- at about 5.5Nm for the optimised close-in procedure, i.e. the optimised close-in procedure produces shorter contours than the baseline at less than 5.5Nm from brake release, but longer ones further out;
- at about 2.5Nm for the distant procedure i.e. the distant procedure starts producing shorter contours after 2.5Nm from brake release, but longer ones closer in.

As far as total contour size is concerned, taking Amsterdam Schiphol as an example,

- for Lden, only the 75Lden contour is negatively impacted by the distant procedure, whereas all the other contours are reduced – the 60Lden contour being reduced by 40%;
- the 65 and 70 Lden contours are greatly improved by the close-in procedure (25%) whereas the same procedure increases the 55Lden contour by 9%;
- for Lnight the close-in procedure improves all contours to 50Lnight by up to 25% (60 & 65 Lnight);
- the distant procedure degrades the 60 & 65 Lnight contours by about 3% but improves the others by up to 31% (50Lnight).

In conclusion, it can be seen that in terms of general impact, the distant procedure has a positive impact on nearly all areas around the airport, unless there is population very close (less than 2.5 Nm from brake release). The Close-in procedure, on the contrary, only benefits the worst hit populations, within 5.5nm of brake release – though benefitting those between 2.5 and 5.5 Nm more than the Distant procedure does – while being disadvantageous to those further out.

4.4.6 Impacted population:

The impact of these procedures on surrounding populations was analysed for the neighbourhoods around Madrid Barajas airport. The tables below show the numbers of people affected by the Baseline, Close-in and Distant contours in the different communities around the airport for Lden and Lnight.

4.4.6.1 Lden

El Molar	Baseline	Close in	Distant
>50 Lden	2607	4275	0

Fuente el Saz	Baseline	Close in	Distant
>50 Lden	4878	4878	4861
>55 Lden	160	3055	0

Monte de la Moraleja	Baseline	Close in	Distant
>50 Lden	37	0	0

Urb. Ciudalcampo	Baseline	Close in	Distant
>50 Lden	201	315	0

Urb. Fuente del Fresno	Baseline	Close in	Distant
>50 Lden	1379	1379	1344
>55 Lden	1246	1198	96

Urb. Prado Norte	Baseline	Close in	Distant
>50 Lden	423	423	423
>55 Lden	423	423	0

Urb. Santo Domingo	Baseline	Close in	Distant
>50 Lden	2443	2465	988
>55 Lden	554	617	0

Total	Baseline	Close in	Distant
>50 Lden	11968	13735	7617
>55 Lden	2382	5293	96

% Vs Baseline	Close in	Distant
>50 Lden	15%	-45%
>55 Lden	122%	-98%

Among the populations studied, none of them were in areas close enough to the airport to benefit from the Close-in procedure.In fact this procedure’s increase in noise further away from the airport more than doubled the number of people in the 55Lden contour. On the other hand, the distant procedure halved the number of people in the 55Lden contour.

4.4.6.2 Lnight

Urb. Prado Norte	Baseline	Close in	Distant
>50 Lnight	318	232	0

Urb. Santo Domingo	Baseline	Close in	Distant
>50 Lnight	226	344	0

Total	Baseline	Close in	Distant
>50 Lnight	545	576	0

% Vs Baseline	Close in	Distant
>50 Lnight	6%	-100%

As can be seen, whereas all of the 545 people subjected to 50Lnight are removed from the contour by using the Distant procedure, their number increases when using the close-in procedure.

5 Local emission results

It is not the role of the present study to perform a complete comparative local air quality study around the four Sourdine II airports. Such studies are very complicated; indeed, the best methodology for performing this sort of study is still the subject of debate. In addition, local air quality studies generally include all sources of pollutants around an airport, not just airborne aircraft. What interests us here is the difference in pollutant production due to the different Sourdine II procedures.

It is generally accepted that local air quality is only affected by emissions produced below 3000ft so analysis has been performed up to (or down from) this level.

Calculation of arrival emissions stops at touchdown since the fuel-flow data available stop at that point. Reverse thrust emissions are not, therefore, taken into account. These would, of course, vary as a function of the landing speed of the aircraft, which is very slightly higher in the Sourdine II procedures than the baseline due to the different landing configurations used.

5.1 Local Emissions from Arrivals

The tables below show emission production, distance travelled and fuel burn, for a mid-sized and a heavy aircraft, over the Sourdine II arrival procedures below 3,000ft. The values are given as a **percentage of those of the same aircraft** flying the Baseline procedure. Four values are given: Fuel Burn, Unburnt Hydrocarbons (HC), CO, NO_X. Fuel-burn and the pollutants produced in quantities directly proportional to it, H_2O, SO_X and CO_2, are not an issue at local level. Lesser pollutants (aromatics etc.) have been omitted for clarity; these are all, however, produced in proportion to unburnt hydrocarbons. There is currently no reliable method of estimating particulate matter production from fuel flow.

It should also be noted that the horizontal distance travelled below 3000ft is different for the different procedures. This difference obviously influences the production of emissions, though not proportionately, as can be seen here.

Procedure	% Distance travelled	% HC	% CO	% NO_X
NAAP2	100.00	116.15	116.13	74.24
NAAP3	75.53	96.91	96.88	36.80
NAAP4	87.23	112.18	112.17	98.48
NAAP5	100.00	118.28	118.26	87.65

Table 23. Local pollutant emissions for a mid-sized aircraft during SII approach procedures as a percentage of that for the baseline procedure

Procedure	% Distance travelled	% HC	% CO	% NO_X
NAAP2	100.00	107.97	107.69	101.18
NAAP3	75.53	109.02	106.83	55.38
NAAP4	87.23	89.91	91.60	131.34
NAAP5	100.00	109.18	109.65	120.74

Table 24. Local pollutant emissions for a heavy aircraft during SII approach procedures as a percentage of that for the baseline procedure

These percentages are reproduced in the bar charts below.

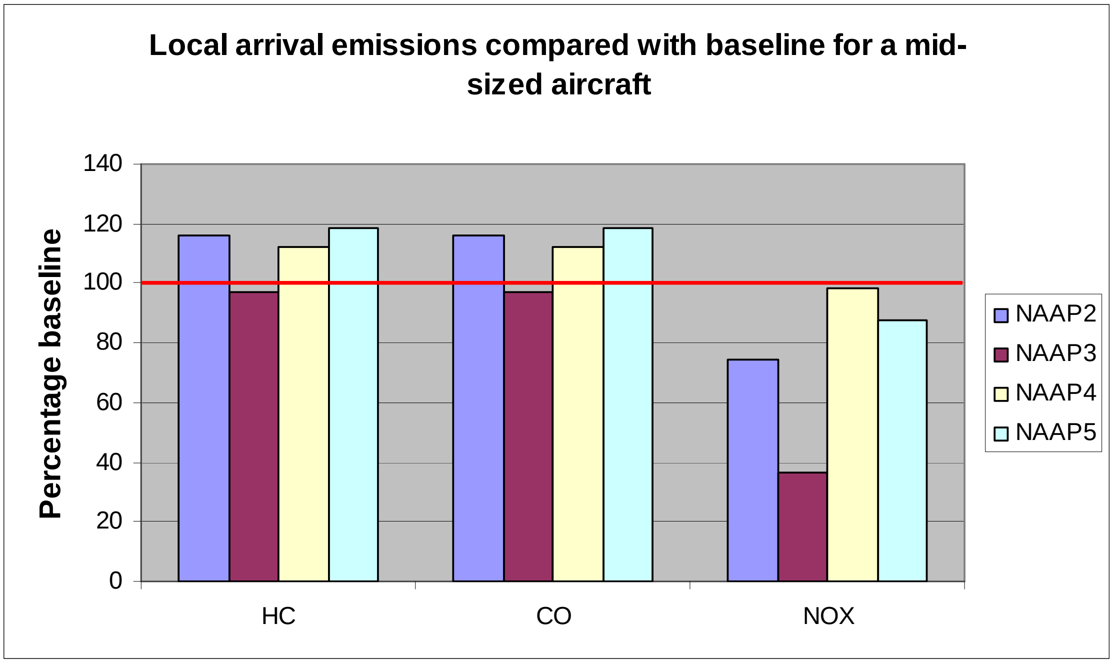

Figure 72. Relative local emissions for a mid-sized aircraft during SII approach procedures

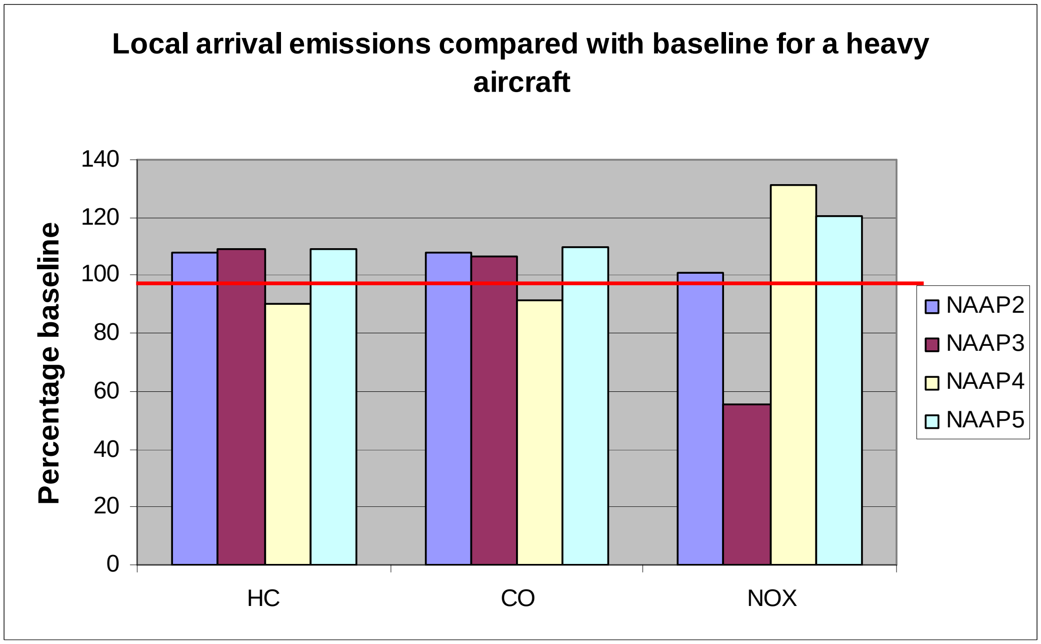

Figure 73. Relative emissions for a heavy aircraft during SII approach procedures

It can clearly be seen that, of the four procedures and three pollutants, the greatest effect, whether for mid-sized or heavy aircraft, is a 40-50% reduction in NO_X using NAAP3. This procedure has little or no effect, however, on production of CO and unburnt hydrocarbons.

NAAP2 shows a 25% reduction in NO_X for a mid-sized aircraft but a 16% increase in CO and HCs for the same aircraft. It has almost no effect of emission production for a heavy aircraft.

NAAP4 gives a reduction of around 10% in CO and HCs for heavy aircraft, but an increase of about the same in these pollutants for a mid-sized aircraft. However, NO_X production, while remaining at baseline levels for a mid-sized plane, increases by over 30% for a heavy one.

In contrast, NAAP5 is generally detrimental in terms of emission production, with increases across the boardby 10-20%, with the exception of a 12% reduction in NO_X for mid-sized aircraft.

The baseline procedure involves relatively high thrust values for the last 1000ft of descent since it requires the aircraft's use of the "FULL" configuration. On the contrary, the Sourdine II approach procedures all define landing at "CONF 3", which requires less thrust to counteract the increased drag. Reduced thrust causes greater production, per kg of fuel burnt, of HC and CO pollutants but this is tempered by the reduction in fuel flow over the same segment. In all, these changes give rise to the different variations in the pollutant levels shown in the above graphs.

Additionally, the timing of the moves to final configuration, and thus the change to a higher thrust level vary considerably between the procedures. Notably, Procedure IV is at final thrust for the entire segment.

Finally, the Baseline and Procedures II and V follow standard 3º final glide slopes and run 9NM below 3000ft. Procedure III, on the other hand, only runs for 7NM under this level, and Procedure IV for 8NM. This different durations obviously affect the respective proportions of polltants produced.

It is noticeable that procedures III and IV show inversed-sign changes for HC and CO between the two types of aircraft. For Procedure IV this is because the heavy aircraft uses a much higher thrust level for the segment, close to the baseline's final thrust level, thereby reducing HC and CO considerably. The mid-sized aircraft's thrust over this segment is much lower than the final baseline thrust, thereby producing more HC and CO. The mid-sized aircraft on Procedure III creates slightly lower quantities of these pollutants due to shortened time below 3000ft. The heavy aircraft has an equally shorter time, however this is more than cancelled out by the very low HC and CO pollution levels at final baseline thrust for this aircraft.

Two factors are responsible for variations in the NOX production of the two aircraft. While their engines produce relatively similar amounts of NOX at low thrust levels, the heavier aircraft produces much more at high thrust. Secondly, the heavy aircraft's baseline procedure involves almost zero net thrust above 2000ft.

5.2 Local Emissions from Departures

Analysis of the departure procedures was performed for the same two aircraft as for the approach procedures. However, in this case two different take-off weights were analysed for each aircraft - 85% Maximum Take-Off Weight (MTOW) and Maximum Take-off Weight. The following tables show the emission of pollutants and distance travelled for the Sourdine II departure procedures up to 3,000ft, for a mid-sized and a heavy aircraft, as a percentage of that of the Baseline procedure for the same aircraft at the same weight. The values show, therefore, for a given aircraft at a given weight, the impact of flying that aircraft over the Sourdine II procedures instead of the baseline procedure.

Mid-sized	Procedure	% Distance travelled	% HC	% CO	% NO_X
85% MTOW	Close-In	120.51	122.43	121.89	102.65
	Distant	153.85	141.22	140.19	103.50

Mid-sized	Procedure	% Distance travelled	% HC	% CO	% NO_X
MTOW	Close-In	143.59	109.17	108.97	101.24
	Distant	153.85	120.95	120.54	104.78

Table 25. Local pollutant emissions for a mid-sized aircraft at two different take-off weights, during SII departure procedures as a percentage of the equivalent baseline

Heavy	Procedure	% Distance travelled	% HC	% CO	% NO_X
85% MTOW	Close-In	155.00	184.72	118.91	105.47
	Distant	185.00	226.93	122.30	103.19

Heavy	Procedure	% Distance travelled	% HC	% CO	% NO_X
MTOW	Close-In	143.33	124.95	106.77	102.24
	Distant	171.67	170.67	114.12	103.64

Table 26. Local pollutant emissions for a heavy aircraft at two different take-off weights, during SII departure procedures, as a percentage of the equivalent baseline

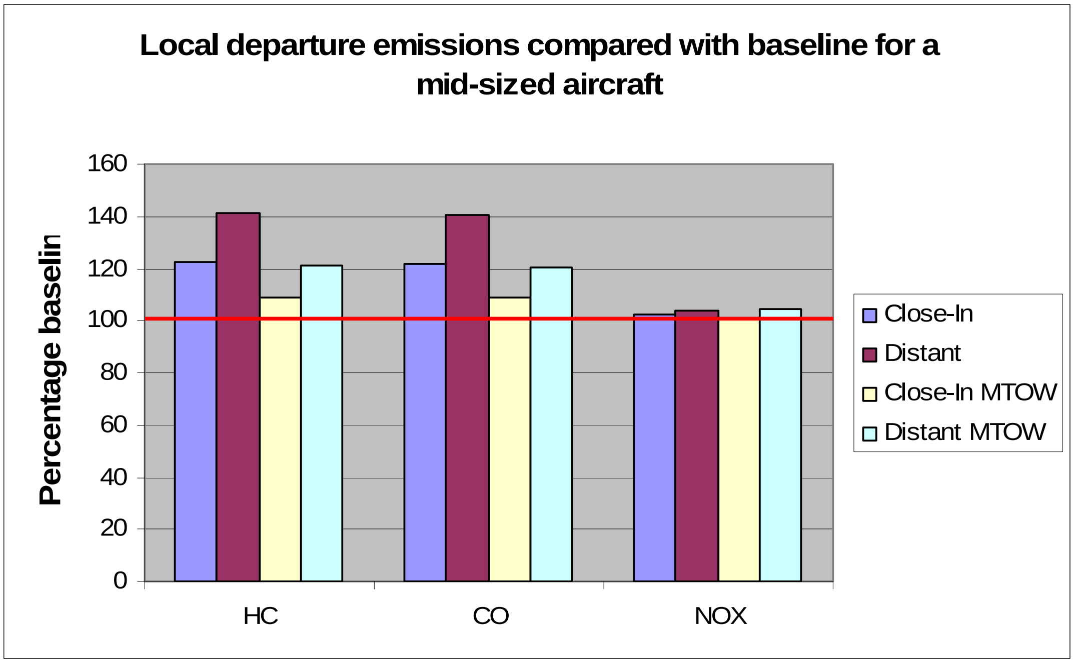

Figure 74. **Relative emissions for a mid-sized aircraft during SII departure procedures**

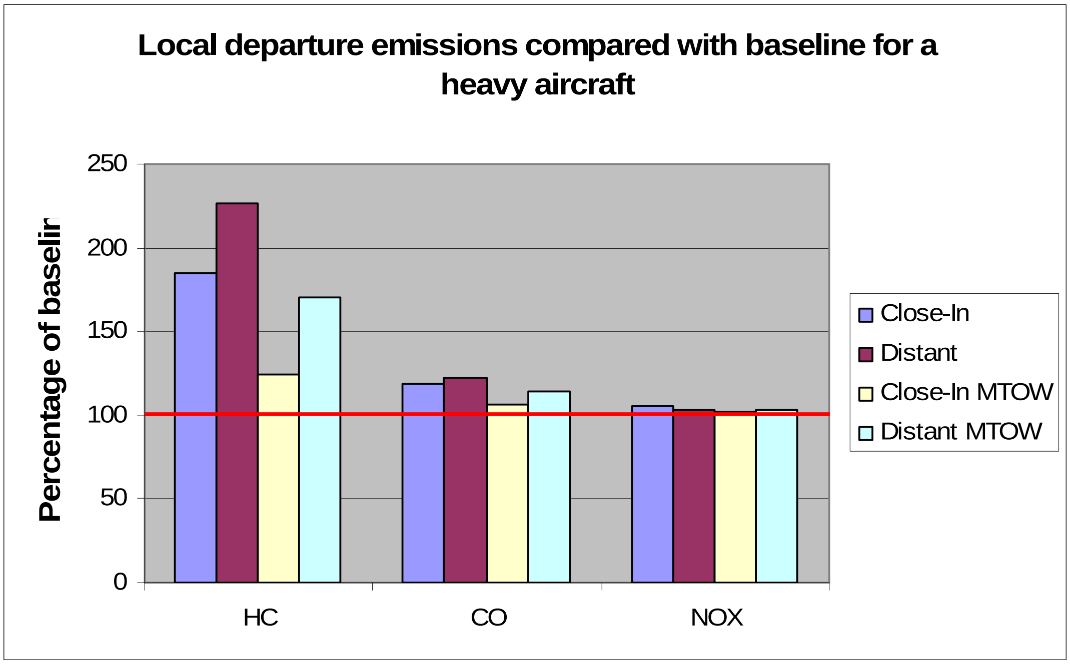

Figure 75. **Relative emissions for a heavy aircraft during SII departure procedures**

Several results are immediately apparent from these charts:

- these procedures generally have a negative effect on emission production;
- neither procedure, whether at MTOW or at 85% MTOW, has any real effect on NO_X production;

- there is an major increase in HC pollution from both procedures, at both weights, for the heavy aircraft and a lesser, though substantial, increase from mid-sized aircraft;
- the Close-in procedure is nearly always better than the Distant one in terms of pollutant emission.

It should be noted that the progressive thrust restoration defined in these procedures is not started until these aircraft are above 3000ft. It has, therefore, no effect on local emissions.

The better position of the Close-in procedure compared with the Distant is due to two factors;

- an aircraft following the Distant procedure travels 20-25% more distance under 3000ft than one following the Close-in procedure;
- the thrust cut-back is greater in the Distant procedure than in the Close-in procedure. This means that HC and CO pollutants, which are a product of under-burn, are produced in greater quantities in the Distant procedure than the Close-in. This result is tempered by the reduced fuel flow at lower thrust, but this reduction is of a shallower gradient than the increase in pollutants due to reduced thrust.

The increase in HC pollution for heavy aircraft is a function of two factors. Firstly, emission calculation is performed using values from the international emission databank. These give very feable values of HC emission - 8 grams per tonne of fuel - for the engines of this aircraft at take-off (100%) and climb-out (85%) thrust settings. Secondly, these values increase to 70g per tonne of fuel at 30% thrust. Now the baseline procedure is always between the take-off and climb-out thrust settings below 3000ft and thus produces very low values of HC. The Sourdine II procedures, on the contrary, involve thrust cutbacks that descend to around 65% (Close-in) or even 50% (Distant) where one unit of fuel used produces between 3 and 5 times as much HC emissions as the baseline. Even when this is reduced due to lower fuel flow, the effect is a major increase in such emissions, aggravated by the increased segment length, as seen in the bar chart.

The mid-sized aircraft has an engine that is much more productive of HC emissions at full thrust – 200grams per tonne – than the heavy aircraft’s. Its HC production at 30% thrust – 700 grams per tonne -, while greater than at full thrust, is proportionately much less than for the heavy aircraft. For this reason the HC emissions for the mid-sized aircraft show much less change due to reduced thrust than for the heavy aircraft.

Despite these results, it must be remembered that local emission nuisance is a function of pollutant concentrations, which cannot be deduced from simple analysis of emission production and distance travelled. Further analysis using emission dispersion models would be needed to estimate these concentrations.

6 Conclusions

The Sourdine II project has proposed six advanced noise abatement procedures, four for approach and landing, and two for departure. These procedures have been analysed in terms of noise and emission production. The noise analysis was performed for four European airports of differing sizes and fleet mixes, whereas emission analysis was performed generically.

Noise analysis was performed using a version of the FAA's Integrated Noise Model, especially improved by the FAA, NASA, Airbus and Boeing in order to take different aircraft configurations into account when calculating noise on approach. Emission analysis was performed with EUROCONTROL's Thrust-Based Emission Calculator, using Airbus-supplied fuel-flow data.

6.1 Arrival procedures

The results of the noise analysis have shown that the sizes of the contours are generally a function of the altitude profiles. Since the altitude of an aircraft flying Procedure III is continually above that of an aircraft flying the baseline whereas, for other procedures, this is only the case before certain points, it is Procedure III that gives the best results. The overall effect of this procedure is a reduction in Lden contour size at large airports. Where traffic volumes are less, this effect is less noticeable. Procedure V, on the other hand, gave rise to increased sizes of the largest Lden contours at larger airports due to the effects of increased thrust and different configurations.

The following table shows the percentage variation in Lden contour size for the four airports.

	CDG			Schiphol			Madrid			Naples		
Lden	55	60	65	55	60	65	55	60	65	55	60	65
NAAP2	-8	-4	-3	-5	-1	-1	-4	-8	-6	-7	-4	-4
NAAP3	-33	-36	-33	-27	-36	-35	-21	-37	-36	-32	-33	-30
NAAP4	-26	-7	-4	-22	-7	-2	-15	-9	-6	-8	-3	-5
NAAP5	2	-1	-1	3	3	0	11	3	-5	-7	-1	-3

Table 27. Percentage variation in Lden contour sizes for the four Sourdine II procedures at the four study airports

The effects of these procedures on Lnight contours were less marked since these contours are smaller and so the areas of influence of the procedures were generally outside the contours, with the exception of Procedure III, because of its increased height.

A population impact study was performed at Madrid-Barajas airport and all four procedures showed reductions in impacted population. Procedure III was responsible for the greatest change in impacted population. However, procedure IV, and to a lesser extent procedure II produced noticeable reductions in numbers under the 60dB Lnight contour.

Not only does procedure III show much reduced noise, it is also shows major reductions in NO_X production – 50-60%. This is also the only procedure that does not show a marked increase in HC and CO production for mid-sized aircraft. The only other notable effects on emission production are a reduction of NO_X by 25% for mid-sized aircraft on procedure II, and an increase in NO_X by 20-30% from heavy aircraft on procedures IV and V.

The noise and emission performance of these arrival procedures can be summarised in the following table. Values given below are the percentage increase (decrease) in: noise at the largest and smallest airports studied for three integrated noise levels; change in population affected by 50Lnight or more at Madrid.

	CDG			Capodichino			Barajas	Mid-sized Aircraft		
Procedure	**55 L_{den}**	**60 L_{den}**	**65 L_{den}**	**55 L_{den}**	**60 L_{den}**	**65 L_{den}**	**Pop >50 L_{night}**	**HC**	**CO**	**NO_X**
								From 3000ft		
NAAP II	-8%	-4%	-3%	-7%	-4%	-5%	-4%	16%	16%	-26%
NAAP III	-33%	-36%	-33%	-32%	-34%	-30%	-73%	-3%	-3%	-63%
NAAP IV	-26%	-7%	-4%	-8%	-4%	-5%	-5%	12%	12%	-2%
NAAP V	2%	-1%	-1%	-7%	-1%	-4%	-3%	18%	18%	-13%

Table 28.Noise and emission performance of Sourdine II noise abatement approach procedures compared with baseline

This graphic clearly shows the advantages to be gained from Procedure III both in terms of noise and emissions. It should be remembered, however, that this is by far the most innovative of the Sourdine II procedures and its implementation, which involves having aircraft land on a 4 degree glide-slope, will not be possible for several years. Procedure IV could be considered the “next best” procedure, although it also will not be implementable in the near future.

6.2 Departure procedures

The Sourdine II departure procedures cannot be compared against each other since, unlike the approach procedures, they have different objectives: reduction of noise close to or (relatively) far away from the airport. The noise analysis has shown that these procedures perform their required tasks.The advantage of the optimised close-in procedure, compared with the baseline close-in procedure, is limited to an area very close to the airport (within 5.5Nm of brake release).

The distant procedure starts having a positive effect after only 2.5Nm, although this positive effect is not necessarily as great as that of the close-in procedure between 2.5 and 5.5Nm.

The distant procedure was found to have a positive impact on nearly all areas around the airport, except for the region less than 2.5 Nm from brake release. The Close-in procedure was found to only benefit the populations within 5.5 Nm of brake release while being very disadvantageous to those further out.

The close-in procedure was found to be disadvantageous to the populations studied, none of which were in areas close enough to the airport to benefit from it. Increased noise further away from the airport more than doubled the number of people in the 55Lden contour. The distant procedure was found to halve the number of people in the 55Lden contour.

Both procedures produce a noticeable increase in HC and CO emission for mid-sized aircraft, though the close-in procedure gives reduced HC emission for heavy aircraft. Neither procedure affects NO_X production.

The noise and emission performance of these departure procedures can be summarised in the following table. Values given are the percentage increase (decrease) in: noise at the largest and smallest airports studied for three integrated noise levels; change in population affected by 50Lnight or more at Madrid.

	CDG			Barajas			Barajas	Mid-sized Aircraft at 85% MTOW		
Procedure	**55 L_{den}**	**60 L_{den}**	**65 L_{den}**	**55 L_{den}**	**60 L_{den}**	**65 L_{den}**	**Pop >50 L_{night}**	**HC**	**CO**	**NO_X**
								To 3000ft		
Close-in	10%	-14%	-23%	9%	-12%	-21%	6%	21%	22%	3%
Distant	-27%	-39%	-15%	-42%	-36%	-10%	-100%	41%	40%	4%

Table 29.Noise and emission performance of Sourdine II noise abatement departure procedures compared with baseline

Fleet Mixes and Substitutions

Paris Charles de Gaulle

- ***Original Fleetmix***

The table below provides the list of “real” arrival aircraft, sorted by number of movements (descending order), with Day-Evening-Night distribution (in percent value).

ARRIVALS: **1101**

Aircraft Type	*Total No. of Movements (24H)*	*% during Day 06:00:00 - 17:59:00*	*% during Evening 18:00:00 - 21:59:00*	*% during Night 22:00:00 - 05:59:00*
A320	186	76%	23%	1%
B735	133	76%	20%	5%
A319	107	75%	18%	7%
B733	93	60%	35%	4%
A321	56	75%	18%	7%
B463	53	68%	23%	9%
E145	40	88%	8%	5%
MD82	35	83%	17%	0%
B772	31	97%	3%	0%
CRJ1	27	74%	22%	4%
B734	20	70%	25%	5%
B763	20	85%	10%	5%
B738	19	63%	21%	16%
F100	18	78%	6%	17%
B744	17	76%	6%	18%
CRJ2	15	87%	13%	0%
B463	14	64%	29%	7%
B737	14	43%	36%	21%
B752	14	93%	7%	0%
A310	13	77%	23%	0%
A343	12	83%	8%	8%
F50	12	83%	0%	17%
F70	11	55%	36%	9%
A30B	10	30%	70%	0%
CRJ7	10	80%	0%	20%
RJ85	10	90%	0%	10%
B742	9	100%	0%	0%
AT45	8	75%	25%	0%
RJ1H	8	75%	25%	0%
AT72	7	29%	71%	0%
A330	6	50%	50%	0%
AT43	6	67%	17%	17%
B762	6	83%	0%	17%

E135	5	80%	20%	0%
MD11	5	80%	20%	0%
A330	4	75%	25%	0%
J328	4	100%	0%	0%
MD88	4	50%	0%	50%
SB20	4	100%	0%	0%
A306	3	100%	0%	0%
DC10	3	100%	0%	0%
MD81	3	100%	0%	0%
B736	2	0%	100%	0%
B743	2	100%	0%	0%
B764	2	100%	0%	0%
CL60	2	100%	0%	0%
F27	2	0%	100%	0%
L101	2	100%	0%	0%
MD83	2	100%	0%	0%
MD90	2	100%	0%	0%
T154	2	100%	0%	0%
T204	2	0%	0%	100%
B721	1	0%	100%	0%
B732	1	0%	100%	0%
B753	1	100%	0%	0%
C130	1	0%	0%	100%
DH8C	1	100%	0%	0%
MD87	1	100%	0%	0%

Table 30. 24-hour distribution of arrival aircraft movements

The table below provides the list of “real” departure aircraft, sorted by number of movements (descending order), with Day-Evening-Night distribution (in percent value).

DEPARTURES: **1145**

Aircraft Type	***Total No. of Movements (24H)***	***% during Day 06:00:00 - 17:59:00***	***% during Evening 18:00:00 - 21:59:00***	***% during Night 22:00:00 - 05:59:00***
A320	194	75%	8%	18%
B735	135	73%	13%	14%
A319	82	78%	9%	13%
B733	82	59%	10%	32%
B463	58	66%	16%	19%
A321	50	64%	30%	6%
B772	46	89%	7%	4%
E145	45	73%	18%	9%
B744	34	62%	38%	0%
B763	30	50%	43%	7%
F100	29	72%	14%	14%
A340	29	90%	10%	0%
MD82	24	71%	13%	17%
B737	23	57%	9%	35%

B742	21	76%	24%	0%
CRJ1	20	72%	26%	2%
A748	19	26%	0%	74%
B734	18	56%	17%	28%
CRJ2	17	86%	14%	0%
A310	17	35%	24%	41%
B738	16	50%	13%	38%
B752	16	63%	19%	19%
A330	15	67%	20%	13%
BA11	14	43%	29%	29%
A30B	13	15%	15%	69%
DH8C	24	88%	12%	0%
SH33	10	0%	0%	100%
B762	8	100%	0%	0%
B773	7	86%	0%	14%
DC10	6	83%	0%	17%
MD81	5	100%	0%	0%
MD83	5	100%	0%	0%
MD11	5	0%	80%	20%
CL60	5	80%	0%	20%
A333	5	100%	0%	0%
B721	4	0%	0%	100%
B764	3	100%	0%	0%
CVLT	2	0%	0%	100%
B733	2	0%	100%	0%
C130	1	0%	0%	100%
B722	1	0%	0%	100%
E120	1	0%	0%	100%
B722	1	100%	0%	0%
L101	1	100%	0%	0%
MD90	1	100%	0%	0%
A306	1	0%	100%	0%

Table 31. 24-hour distribution of departure aircraft movements

- ***Substitutions***

The table below provides the substitution mapping. The original aircraft types are sorted by number of movements (arrivals and departures), in descending order. This table indicates in particular the aircraft which have been discarded, like turbo-props (the second column indicating “None” in this case).

Original aircraft type	*INM70-SII aircraft*
A320	A320-232
B735	737300
A319	A319-111
B733	737300
B463	None
A321	A321-232
E145	None
B772	777200
MD82	A321-232

B744	A340-313
B763	A330-301
CRJ1	None
F100	737300
B734	737300
B737	737800
B738	737800
CRJ2	None
A310	A330-301
B742	A340-313
B752	757RR
A340	A340-313
A330	A330-301
DH8C	None
A30B	A330-301
A748	None
B762	None
BA11	None
A343	A340-313
F50	None
F70	737300
CRJ7	None
MD11	777200
RJ85	None
SH33	None
DC10	A330-301
AT45	None
MD81	A321-232
RJ1H	None
AT72	None
B773	777200
CL60	None
MD83	A321-232
AT43	None
A333	A330-301
B721	None
B764	A330-301
E135	None
A306	A330-301
J328	None
MD88	A321-232
SB20	None
L101	None
MD90	A321-232
B722	777200
B736	737300
B743	A340-313
C130	None
CVLT	None
F27	None
T154	None

T204	None
B732	737300
B753	757RR
E120	None
MD87	A321-232

Table 32. Aircraft substitutions

- ***Resultant Fleet Mix used for Noise Studies***

The following table provides the final fleet-mix per route and runway for Arrivals, which corresponds to the Baseline approach procedure. Indeed, during the fast-time simulations, capacity constraints implied that the aircraft did not always follow the same routes or land on the same runway from one procedure to another. This has been taken into account in the noise studies, even if the tables associated to each procedure are not presented in this report.

The table also provides the number of movements per route/runway for Day, Evening and Night periods with, for each, the distribution (in percent value) per aircraft type.

Runway	*Route/track*	*Aircraft type*	*Day*	*Evening*	*Night*
26L	BALOD1		25	7	7
		737300	**24.00%**	**71.43%**	**42.86%**
		737800	**4.00%**	**14.29%**	**0.00%**
		777200	**12.00%**	**0.00%**	**0.00%**
		A319-111	**16.00%**	**0.00%**	**57.14%**
		A320-232	**28.00%**	**14.29%**	**0.00%**
		A321-232	**8.00%**	**0.00%**	**0.00%**
		A330-301	**8.00%**	**0.00%**	**0.00%**
26L	BALOD2		18	11	4
		737300	**38.89%**	**45.45%**	**0.00%**
		777200	**11.11%**	**0.00%**	**0.00%**
		A319-111	**11.11%**	**9.09%**	**50.00%**
		A320-232	**16.67%**	**36.36%**	**0.00%**
		A321-232	**5.56%**	**0.00%**	**25.00%**
		A330-301	**11.11%**	**9.09%**	**0.00%**
		A340-313	**5.56%**	**0.00%**	**25.00%**
26L	BALOD3		8	7	0
		737300	**37.50%**	**42.86%**	**0.00%**
		A319-111	**25.00%**	**14.29%**	**0.00%**
		A320-232	**0.00%**	**28.57%**	**0.00%**
		A321-232	**25.00%**	**0.00%**	**0.00%**
		A340-313	**12.50%**	**14.29%**	**0.00%**
26L	BALOD4		16	6	2
		737300	**12.50%**	**33.33%**	**50.00%**
		A319-111	**12.50%**	**16.67%**	**50.00%**
		A320-232	**37.50%**	**16.67%**	**0.00%**
		A321-232	**25.00%**	**33.33%**	**0.00%**
		A340-313	**12.50%**	**0.00%**	**0.00%**
26L	OMAKO1		73	24	9
		737300	**38.36%**	**50.00%**	**22.22%**
		737800	**2.74%**	**4.17%**	**22.22%**
		757RR	**2.74%**	**0.00%**	**0.00%**
		777200	**5.48%**	**4.17%**	**0.00%**

		A319-111	15.07%	12.50%	22.22%
		A320-232	17.81%	20.83%	0.00%
		A321-232	12.33%	8.33%	33.33%
		A330-301	2.74%	0.00%	0.00%
		A340-313	2.74%	0.00%	0.00%
26L	OMAKO2		57	11	2
		737300	26.32%	36.36%	100.00%
		737800	3.51%	9.09%	0.00%
		757RR	3.51%	0.00%	0.00%
		777200	3.51%	0.00%	0.00%
		A319-111	22.81%	27.27%	0.00%
		A320-232	21.05%	27.27%	0.00%
		A321-232	12.28%	0.00%	0.00%
		A330-301	3.51%	0.00%	0.00%
		A340-313	3.51%	0.00%	0.00%
26L	OMAKO3		46	14	4
		737300	26.09%	42.86%	25.00%
		737800	6.52%	14.29%	25.00%
		777200	10.87%	0.00%	0.00%
		A319-111	13.04%	21.43%	25.00%
		A320-232	17.39%	0.00%	0.00%
		A321-232	19.57%	7.14%	0.00%
		A330-301	0.00%	14.29%	0.00%
		A340-313	6.52%	0.00%	25.00%
26L	OMAKO4		60	16	2
		737300	26.67%	25.00%	0.00%
		737800	3.33%	18.75%	0.00%
		757RR	3.33%	0.00%	0.00%
		777200	8.33%	0.00%	0.00%
		A319-111	30.00%	31.25%	0.00%
		A320-232	18.33%	12.50%	0.00%
		A321-232	8.33%	12.50%	0.00%
		A340-313	1.67%	0.00%	100.00%
27R	LORTA1		71	16	5
		737300	30.99%	56.25%	40.00%
		737800	1.41%	6.25%	0.00%
		777200	2.82%	0.00%	0.00%
		A319-111	15.49%	25.00%	0.00%
		A320-232	19.72%	6.25%	40.00%
		A321-232	16.90%	6.25%	0.00%
		A330-301	5.63%	0.00%	0.00%
		A340-313	7.04%	0.00%	20.00%
27R	LORTA2		52	14	4
		737300	28.85%	21.43%	0.00%
		737800	3.85%	0.00%	25.00%
		777200	3.85%	0.00%	0.00%
		A319-111	17.31%	21.43%	25.00%
		A320-232	30.77%	50.00%	0.00%
		A321-232	7.69%	0.00%	50.00%
		A330-301	3.85%	7.14%	0.00%
		A340-313	3.85%	0.00%	0.00%

27R	LORTA3		26	11	2
		737300	26.92%	18.18%	50.00%
		737800	7.69%	0.00%	0.00%
		A319-111	23.08%	18.18%	50.00%
		A320-232	11.54%	54.55%	0.00%
		A321-232	23.08%	9.09%	0.00%
		A340-313	7.69%	0.00%	0.00%
27R	LORTA4		36	9	2
		737300	27.78%	44.44%	100.00%
		737800	2.78%	11.11%	0.00%
		757RR	2.78%	11.11%	0.00%
		777200	5.56%	0.00%	0.00%
		A319-111	22.22%	0.00%	0.00%
		A320-232	25.00%	22.22%	0.00%
		A321-232	8.33%	11.11%	0.00%
		A330-301	5.56%	0.00%	0.00%
27R	MERUE1		58	10	2
		737300	25.86%	10.00%	0.00%
		737800	3.45%	0.00%	100.00%
		757RR	3.45%	0.00%	0.00%
		777200	3.45%	0.00%	0.00%
		A319-111	6.90%	50.00%	0.00%
		A320-232	36.21%	20.00%	0.00%
		A321-232	6.90%	10.00%	0.00%
		A330-301	3.45%	0.00%	0.00%
		A340-313	10.34%	10.00%	0.00%
27R	MERUE2		41	13	0
		737300	26.83%	46.15%	0.00%
		737800	4.88%	0.00%	0.00%
		777200	7.32%	0.00%	0.00%
		A319-111	29.27%	15.38%	0.00%
		A320-232	12.20%	23.08%	0.00%
		A321-232	7.32%	7.69%	0.00%
		A330-301	4.88%	7.69%	0.00%
		A340-313	7.32%	0.00%	0.00%
27R	MERUE3		28	4	1
		737300	39.29%	25.00%	0.00%
		757RR	7.14%	0.00%	0.00%
		777200	3.57%	0.00%	100.00%
		A319-111	10.71%	25.00%	0.00%
		A320-232	21.43%	50.00%	0.00%
		A321-232	10.71%	0.00%	0.00%
		A330-301	7.14%	0.00%	0.00%
27R	MERUE4		34	12	1
		737300	17.65%	33.33%	0.00%
		737800	5.88%	0.00%	0.00%
		757RR	5.88%	0.00%	0.00%
		A319-111	20.59%	16.67%	100.00%
		A320-232	20.59%	16.67%	0.00%
		A321-232	11.76%	25.00%	0.00%
		A330-301	11.76%	8.33%	0.00%

		A340-313	**5.88%**	**0.00%**	**0.00%**
27R	VELER1		2	0	0
		777200	**100.00%**	**0.00%**	**0.00%**
27R	VELER2		2	0	0
		A330-301	**100.00%**	**0.00%**	**0.00%**
27R	VELER3		1	1	0
		A320-232	**100.00%**	**100.00%**	**0.00%**
27R	VELER4		7	0	2
		737300	**42.86%**	**0.00%**	**0.00%**
		777200	**28.57%**	**0.00%**	**0.00%**
		A321-232	**14.29%**	**0.00%**	**50.00%**
		A330-301	**14.29%**	**0.00%**	**50.00%**

Table 33. Baseline Arrival fleet mix per route and runway

The following table provides the final fleet-mix per route and runway for all the Departure simulations.

Runway	*Route/track*	*Aircraft type*	*Day*	*Evening*	*Night*
27L	AMOGA1L		32	5	4
		737300	**100.00%**	**100.00%**	**100.00%**
27L	BUBLI1L		4	0	0
		737300	**100.00%**	**0.00%**	**0.00%**
27L	BUBLI1R		70	10	18
		737300	**95.71%**	**100.00%**	**88.89%**
		737800	**4.29%**	**0.00%**	**11.11%**
27L	LGL1L		1	0	0
		777200	**100.00%**	**0.00%**	**0.00%**
27L	LGL1R		35	9	3
		777200	**40.00%**	**44.44%**	**66.67%**
		757RR	**28.57%**	**33.34%**	**33.33%**
		A319-111	**20.00%**	**0.00%**	**0.00%**
		A321-232	**11.43%**	**22.22%**	**0.00%**
27L	MOU1R		26	5	2
		A319-111	**100.00%**	**60.00%**	**0.00%**
		A320-232	**0.00%**	**40.00%**	**100.00%**
27L	NEV1R		19	3	2
		A320-232	**68.42%**	**33.33%**	**50.00%**
		A321-232	**31.58%**	**66.67%**	**50.00%**
27L	NIPOR1L		3	2	0
		A320-232	**66.67%**	**50.00%**	**0.00%**
		A321-232	**33.33%**	**50.00%**	**0.00%**
27L	NURMO1L		29	5	11
		A320-232	**100.00%**	**100.00%**	**100.00%**
27L	OPALE1L		8	2	0
		A320-232	**37.50%**	**0.00%**	**0.00%**
		A330-301	**62.50%**	**100.00%**	**0.00%**
27L	PIROG1R		22	13	4
		A330-301	**0.00%**	**0.00%**	**100.00%**
		A340-313	**100.00%**	**100.00%**	**0.00%**

27L	LASIV1L		2	1	4
		737800	**100.00%**	**100.00%**	**100.00%**
27L	PIROG1L		0	1	0
		A330-301	**0.00%**	**100.00%**	**0.00%**
26R	AMOGA1L		5	1	5
		737300	**100.00%**	**100.00%**	**100.00%**
26R	BENIP1R		8	2	0
		737300	**100.00%**	**100.00%**	**0.00%**
26R	BUBLI1L		36	7	12
		737300	**100.00%**	**100.00%**	**100.00%**
26R	BUBLI1R		27	10	24
		737300	**59.26%**	**90.00%**	**70.83%**
		737800	**40.74%**	**10.00%**	**29.17%**
26R	LGL1L		5	2	1
		737800	**100.00%**	**100.00%**	**100.00%**
26R	LGL1R		54	4	12
		737300	**7.41%**	**25.00%**	**0.00%**
		777200	**57.41%**	**75.00%**	**16.67%**
		757RR	**0.00%**	**0.00%**	**16.67%**
		A319-111	**35.19%**	**0.00%**	**66.67%**
26R	MOU1R		12	4	3
		A319-111	**100.00%**	**100.00%**	**100.00%**
26R	NEV1R		25	5	8
		A320-232	**68.00%**	**0.00%**	**100.00%**
		A321-232	**32.00%**	**100.00%**	**0.00%**
26R	NIPOR1L		51	5	7
		A320-232	**74.51%**	**0.00%**	**71.43%**
		A321-232	**25.49%**	**100.00%**	**28.57%**
26R	NIPOR1R		3	0	3
		A320-232	**100.00%**	**0.00%**	**100.00%**
26R	NURMO1L		67	9	8
		A320-232	**100.00%**	**100.00%**	**100.00%**
26R	OPALE1L		34	8	1
		A330-301	**100.00%**	**100.00%**	**100.00%**
26R	PIROG1R		49	13	0
		A330-301	**14.29%**	**38.46%**	**0.00%**
		A340-313	**85.71%**	**61.54%**	**0.00%**
26R	AMOGA1R		3	0	0
		737300	**100.00%**	**0.00%**	**0.00%**
26R	BENIP1L		2	0	0
		737300	**100.00%**	**0.00%**	**0.00%**

Table 34.Departure fleet mix per route and runway

Amsterdam Schiphol

- ***Original fleet mix***

The table below provides the list of “real” aircraft, used for the ‘Arrivals’ simulations.

Aircraft Type	***Total Nb. of Movements (24H)***	***% during Day 07:00:00 - 18:59:00***	***% during Evening 19:00:00 - 22:59:00***	***% during Night 23:00:00 - 06:59:00***
738	99	56.57%	24.24%	19.19%
733	87	70.11%	24.14%	5.75%
F70	83	55.42%	34.94%	9.64%
100	80	70.00%	27.50%	2.50%
333	66	59.09%	34.85%	6.06%
320	61	73.77%	14.75%	11.48%
319	55	70.91%	20.00%	9.09%
744	51	80.39%	7.84%	11.76%
772	36	83.33%	2.78%	13.89%
AT4	36	58.33%	25.00%	16.67%
734	32	53.13%	37.50%	9.38%
752	32	56.25%	9.38%	34.38%
D32	31	77.42%	9.68%	12.90%
739	30	70.00%	20.00%	10.00%
EM4	26	84.62%	11.54%	3.85%
321	22	81.82%	13.64%	4.55%
343	21	71.43%	14.29%	14.29%
763	21	61.90%	9.52%	28.57%
MD1	13	53.85%	0.00%	46.15%
MD8	12	66.67%	0.00%	33.33%
73G	7	71.43%	0.00%	28.57%
74F	4	75.00%	0.00%	25.00%
74X	2	50.00%	0.00%	50.00%
74E	1	100.00%	0.00%	0.00%
74Y	1	0.00%	0.00%	100.00%

Table 35.Arrivals aircraft movements

The original data on the Departure aircraft movements is not available anymore and therefore all aircraft types were reduced to the categories given in the table below.

Aircraft Type	***Total Nb. of Movements (24H)***	***% during Day 07:00:00 - 18:59:00***	***% during Evening 19:00:00 - 22:59:00***	***% during Night 23:00:00 - 06:59:00***
SMR	721	62.00%	21.78%	16.23%
LR2	129	81.40%	5.43%	13.18%
LR4	40	65.00%	10.00%	25.00%
BSJ	20	45.00%	35.00%	20.00%
MD11	7	28.57%	14.29%	57.14%

Table 36. Departure aircraft movements

- ***Substitutions performed***

- The table below provides the substitution mapping for ‘Arrivals’.
- The original aircraft types are sorted by number of movements, in descending order

- This table indicates in particular the aircraft which have been discarded, like turbo-prop (the second column indicating “None” in that case)

Original aircraft type	***INM70-SII aircraft***
738	B737-800
733	B737-300
F70	A319-111
100	A319-111
333	A330-301
320	A320-211
319	A319-111
744	A340-313
772	B777-200
AT4	None
734	B737-800
752	B757-200
D32	None
739	B737-800
EM4	None
321	A321-211
343	A340-313
763	B757-200
MD1	B777-200
MD8	A320-211
73G	B737-800
74F	A340-313
74X	A340-313
74E	A340-313
74Y	A340-313

Table 37.Substitutions used for arrival aircraft

The table below provides the substitution mapping for ‘Departures’. As the original data are not available anymore, the totals per category have been distributed (roughly following the same ratios as for arrivals) over the corresponding INM70-SII aircraft types.

Original Category	***Representative aircraft type***	***INM70-SII aircraft***
SMR	A320	A319-111
		A320-211
		A321-211
		B737-300
		B737-800
LR2	A330	A330-301
		B757-200
LR4	A340	A340-313
BSJ	F50	None
MD11	MD11	B777-200

Table 38. Substitutions used for departure aircraft

- ***Resulting Fleet mix for the noise studies***

The table below provides the final fleet mix per route and runway for all ‘arrivals’ simulations.

Runway	***Route/track***	***Aircraft type***	***Day***	***Evening***	***Night***
18C	**O1**		**285**	**86**	**26**
		737300	12.98%	15.12%	0.00%
		737800	23.16%	26.74%	34.62%
		777200	4.91%	1.16%	11.54%
		757RR	7.37%	2.33%	15.38%
		A319-111	16.84%	31.40%	15.38%
		A320-211	13.33%	6.98%	3.85%
		A321-211	0.70%	1.16%	0.00%
		A330-301	5.26%	9.30%	7.69%
		A340-313	15.44%	5.81%	11.54%
18R	**NW1**		**17**	**2**	**1**
		737300	5.88%	0.00%	0.00%
		777200	17.65%	0.00%	100.00%
		757RR	5.88%	0.00%	0.00%
		A319-111	41.18%	100.00%	0.00%
		A320-211	17.65%	0.00%	0.00%
		A321-211	5.88%	0.00%	0.00%
		A330-301	5.88%	0.00%	0.00%
18R	**NW2**		**54**	**15**	**0**
		737300	5.56%	26.67%	0.00%
		737800	5.56%	13.33%	0.00%
		777200	9.26%	0.00%	0.00%
		757RR	5.56%	0.00%	0.00%
		A319-111	38.89%	53.33%	0.00%
		A320-211	3.70%	0.00%	0.00%
		A321-211	9.26%	0.00%	0.00%
		A330-301	9.26%	6.67%	0.00%
		A340-313	12.96%	0.00%	0.00%
18R	**NW3**		**96**	**15**	**3**
		737300	8.33%	0.00%	0.00%
		737800	2.08%	0.00%	0.00%
		777200	19.79%	0.00%	66.67%
		757RR	2.08%	0.00%	0.00%
		A319-111	38.54%	46.67%	0.00%
		A320-211	4.17%	0.00%	0.00%
		A321-211	3.13%	13.33%	0.00%
		A330-301	11.46%	33.33%	0.00%
		A340-313	10.42%	6.67%	33.33%
18R	**ZW1**		**130**	**55**	**31**
		737300	11.54%	7.27%	6.45%
		737800	26.92%	30.91%	35.48%
		777200	0.77%	0.00%	0.00%
		757RR	7.69%	5.45%	22.58%
		A319-111	26.15%	32.73%	16.13%
		A320-211	8.46%	5.45%	16.13%
		A321-211	6.15%	0.00%	0.00%

		A330-301	6.92%	16.36%	0.00%
		A340-313	5.38%	1.82%	3.23%

Table 39. Arrivals fleet mix per route and runway

The table below provides the final fleet mix per route and runway for all ‘departures’ simulations.

Runway	***Route/track***	***Aircraft type***	***Day***	***Evening***	***Night***
18L	**N2**		**95**	**35**	**18**
		737300	11.58%	20.00%	11.11%
		737800	15.79%	11.43%	22.22%
		757RR	5.26%	0.00%	5.56%
		A319-111	29.47%	37.14%	33.33%
		A320-211	6.32%	8.57%	5.56%
		A321-211	15.79%	14.29%	5.56%
		A330-301	3.16%	0.00%	0.00%
		A340-313	12.63%	8.57%	16.67%
18L	**O2**		**180**	**61**	**64**
		737300	16.67%	22.95%	21.88%
		737800	28.33%	29.51%	28.13%
		777200	1.11%	0.00%	3.13%
		757RR	7.78%	4.92%	6.25%
		A319-111	21.11%	21.31%	20.31%
		A320-211	15.56%	9.84%	9.38%
		A321-211	2.78%	8.20%	4.69%
		A330-301	3.33%	3.28%	3.13%
		A340-313	3.33%	0.00%	3.13%
18L	**Z1**		**109**	**36**	**44**
		737300	17.43%	16.67%	15.91%
		737800	29.36%	41.67%	34.09%
		757RR	7.34%	2.78%	9.09%
		A319-111	21.10%	19.44%	18.18%
		A320-211	16.51%	16.67%	13.64%
		A321-211	4.59%	2.78%	2.27%

		A330-301	3.67%	0.00%	2.27%
		A340-313	0.00%	0.00%	4.55%
24	**N1**		**106**	**15**	**10**
		737300	11.32%	20.00%	10.00%
		737800	7.55%	6.67%	10.00%
		777200	0.00%	6.67%	10.00%
		757RR	23.58%	0.00%	10.00%
		A319-111	14.15%	40.00%	10.00%
		A320-211	7.55%	6.67%	10.00%
		A321-211	9.43%	13.33%	10.00%
		A330-301	20.75%	0.00%	10.00%
		A340-313	5.66%	6.67%	20.00%
24	**ZW2**		**90**	**22**	**12**
		737300	16.67%	18.18%	8.33%
		737800	24.44%	31.82%	33.33%
		777200	0.00%	0.00%	8.33%
		757RR	13.33%	4.55%	16.67%
		A319-111	20.00%	22.73%	8.33%
		A320-211	14.44%	13.64%	8.33%
		A321-211	2.22%	9.09%	0.00%
		A330-301	6.67%	0.00%	8.33%
		A340-313	2.22%	0.00%	8.33%

Table 40. Departures fleet mix per route and runway

Madrid Barajas

- ***Original fleet mix***

Aircraft Type	Total Nb. of Movements (24H)	**% During the day (7:00 to 18:59)**	**% During the evening (19:00 to 21:59)**	**% During the night (22:00 to 6:59)**
A320	583	68%	15%	16%
B752	181	64%	18%	19%
MD87	136	68%	13%	19%
CRJ2	114	70%	15%	15%
B738	109	68%	13%	19%
F50	76	62%	18%	20%
MD88	65	63%	14%	23%
AT72	49	73%	8%	18%
A321	43	67%	19%	14%
B733	40	78%	13%	10%
B734	36	75%	14%	11%
A343	35	71%	0%	29%
E145	29	69%	3%	28%
A319	26	85%	15%	0%
A346	25	40%	12%	48%
B763	24	92%	4%	4%
A310	20	75%	15%	10%
B762	18	89%	0%	11%
CRJ1	18	72%	0%	28%
B735	14	64%	14%	21%
F100	14	79%	0%	21%
E120	13	15%	46%	38%
MD82	12	75%	8%	17%
DH8C	11	55%	36%	9%
MD83	10	40%	60%	0%
B462	9	33%	22%	44%
DC10	9	56%	44%	0%
A30B	7	43%	57%	0%
B767	6	83%	0%	17%
C525	6	67%	33%	0%
F27	6	67%	33%	0%
SB20	6	33%	0%	67%
A306	4	25%	50%	25%
B736	4	100%	0%	0%
B744	4	100%	0%	0%
CN35	4	50%	0%	50%
EA32	4	100%	0%	0%
G159	4	100%	0%	0%
J328	4	100%	0%	0%
SW4	3	0%	0%	100%
CVLT	2	0%	0%	100%
A342	2	100%	0%	0%
B737	2	100%	0%	0%
B742	2	50%	50%	0%
F70	2	50%	0%	50%
MD90	2	100%	0%	0%

RJ85	2	100%	0%	0%
T154	2	50%	50%	0%
SH36	1	0%	0%	100%
SW3	1	100%	0%	0%

Table 41. Fleet mix for the total of 1799 movements simulated at Barajas

Aircraft Type	Total Nb. of Movements (24H)	**% During the day (7:00 to 18:59)**	**% During the evening (19:00 to 21:59)**	**% During the night (22:00 to 6:59)**
A320	286	69%	16%	14%
B752	102	67%	16%	18%
MD87	67	70%	15%	15%
CRJ2	57	70%	12%	18%
B738	54	69%	15%	17%
F50	39	62%	21%	18%
A343	35	71%	0%	29%
MD88	34	53%	21%	26%
AT72	24	79%	8%	13%
A321	21	81%	10%	10%
B733	20	60%	25%	15%
B734	18	67%	11%	22%
E145	15	93%	7%	0%
A319	14	86%	14%	0%
B763	12	92%	8%	0%
A310	10	80%	0%	20%
B762	9	78%	0%	22%
CRJ1	9	56%	0%	44%
B735	8	75%	13%	13%
F100	8	88%	0%	13%
E120	7	0%	29%	71%
MD82	7	71%	0%	29%
DH8C	6	67%	33%	0%
MD83	6	33%	67%	0%
B462	5	40%	40%	20%
DC10	5	100%	0%	0%
A30B	4	0%	100%	0%
F27	3	33%	67%	0%
SB20	3	33%	0%	67%
SW4	3	0%	0%	100%
A306	2	0%	100%	0%
B736	2	100%	0%	0%
B744	2	100%	0%	0%
CN35	2	100%	0%	0%
CVLT	2	0%	0%	100%
EA32	2	100%	0%	0%
G159	2	100%	0%	0%
J328	2	100%	0%	0%
A342	1	100%	0%	0%
B737	1	100%	0%	0%
B742	1	0%	100%	0%
F70	1	100%	0%	0%
MD90	1	100%	0%	0%
RJ85	1	100%	0%	0%
T154	1	100%	0%	0%

Table 42.Fleet mix for the 914 departures simulated at Barajas

Aircraft Type	Total Nb. of Movements (24H)	**% During the day (7:00 to 18:59)**	**% During the evening (19:00 to 21:59)**	**% During the night (22:00 to 6:59)**
A320	297	67%	14%	18%
B752	79	59%	20%	20%
MD87	69	65%	12%	23%
B738	57	70%	18%	12%
CRJ2	55	67%	11%	22%
F50	37	62%	16%	22%
MD88	31	74%	6%	19%
A343	25	40%	12%	48%
AT72	25	68%	8%	24%
A321	22	55%	27%	18%
B733	20	95%	0%	5%
B734	18	83%	17%	0%
B763	14	43%	0%	57%
A319	12	83%	17%	0%
E145	12	92%	0%	8%
CRJ1	10	70%	30%	0%
B735	9	100%	0%	0%
B762	9	89%	0%	11%
A310	6	50%	17%	33%
DH8C	6	67%	0%	33%
E120	6	33%	67%	0%
F100	6	83%	0%	17%
SW4	6	67%	33%	0%
MD82	5	80%	20%	0%
MD83	5	40%	40%	20%
B742	4	50%	50%	0%
DC10	4	25%	0%	75%
SW3	4	0%	100%	0%
A306	3	100%	0%	0%
A30B	3	100%	0%	0%
CN35	3	33%	0%	67%
A346	2	50%	0%	50%
B744	2	100%	0%	0%
B767	2	100%	0%	0%
F27	2	0%	0%	100%
MD90	2	100%	0%	0%
SB20	2	100%	0%	0%
T154	2	100%	0%	0%
B462	1	100%	0%	0%
B736	1	100%	0%	0%
B737	1	100%	0%	0%
C525	1	0%	0%	100%
CVLT	1	0%	0%	100%
F70	1	100%	0%	0%
J328	1	100%	0%	0%
RJ85	1	100%	0%	0%
SH36	1	0%	100%	0%

Table 43.Fleet mix for the 885 arrivals simulated at Barajas

- ***Substitutions performed***

Original aircraft type	INM70-SII aircraft
B752	B757-200
A320 Engine CFM56	A320-211
MD87	A321-232
A320 Engine V2500	A320-232
CRJ2	NONE
B738	B737-800
F50	NONE
MD88	A321-232
AT72	NONE
B733	B737-300
B734	B737-300
A343	A340-313
E145	NONE
A319	A319-111
A346	A340-313
B763	A330-301
A310	A330-301
CRJ1	NONE
B762	A330-301
A321 Engine CFM56	A321-211
F100	B737-300
B735	B737-300
E120	NONE
MD82	A321-232
DH8C	NONE
MD83	A321-232
DC10	B757-200
B462	NONE
A321 Engine V2500	A321-232
A30B	A330-301
SB20	NONE
F27	NONE
C525	NONE
B767	A330-301
J328	NONE
G159	
EA32	A320-211
CN35	NONE
B744	A340-313
B736	B737-300
A306	A330-301
SW4	NONE
T154	B757-200
RJ85	NONE
MD90	A321-232
F70	B737-300
CVLT	NONE
B742	A340-313
B737	B737-800
A342	A340-313
SW3	NONE

SH36	NONE

Table 44.Aircraft substitutions performed for noise studies at Barajas

- ***Resulting Fleet mix for the noisestudies***

DEPARTURES

Runway	Route/track	Aircraft type	Day	Evening	Night
36L	CNR		47	7	7
		737800D	9%	0%	0%
		757RRD	26%	29%	0%
		A320-211D	19%	43%	29%
		A320-232D	21%	29%	43%
		A321-232D	26%	0%	29%
36L	CNR2		34	7	0
		737300D	21%	0%	0%
		757RRD	9%	29%	0%
		A319-111D	18%	29%	0%
		A320-211D	24%	14%	0%
		A320-232D	9%	29%	0%
		A321-232D	6%	0%	0%
		A330-301D	15%	0%	0%
36L	CNR3		24	4	0
		737800D	17%	25%	0%
		A320-211D	29%	75%	0%
		A320-232D	21%	0%	0%
		A321-211D	8%	0%	0%
		A321-232D	8%	0%	0%
		A340-313D	17%	0%	0%
36L	NAVAS		12	0	0
		A330-301D	42%	0%	0%
		A340-313D	58%	0%	0%
36L	NAVAS2		17	0	0
		A330-301D	35%	0%	0%
		A340-313D	65%	0%	0%
36L	NAVASL		74	30	7
		737300D	5%	13%	29%
		737800D	9%	10%	0%
		757RRD	11%	7%	0%
		A319-111D	14%	7%	0%
		A320-211D	30%	27%	0%
		A320-232D	16%	17%	43%
		A321-211D	3%	7%	0%
		A321-232D	12%	13%	0%
		A330-301D	0%	0%	29%
36L	NAVASW		38	11	2
		737300D	0%	18%	0%
		737800D	3%	0%	0%
		757RRD	5%	0%	0%
		A320-211D	16%	27%	0%
		A320-232D	29%	0%	100%
		A321-232D	42%	55%	0%
		A330-301D	5%	0%	0%

36R	NOCT1		0	0	12
		737300D	0%	0%	8%
		737800D	0%	0%	17%
		757RRD	0%	0%	33%
		A320-211D	0%	0%	17%
		A320-232D	0%	0%	17%
		A321-232D	0%	0%	8%
36R	NOCT2		0	0	26
		737300D	0%	0%	8%
		757RRD	0%	0%	19%
		A320-232D	0%	0%	4%
		A321-232D	0%	0%	8%
		A330-301D	0%	0%	12%
		A330-301D	0%	0%	12%
		A340-313D	0%	0%	38%
36R	NOCT3		0	0	25
		737800D	0%	0%	4%
		757RRD	0%	0%	16%
		A319-111D	0%	0%	12%
		A320-211D	0%	0%	16%
		A320-232D	0%	0%	20%
		A321-211D	0%	0%	8%
		A321-232D	0%	0%	16%
		A330-301D	0%	0%	8%
36R	RBO		249	80	25
		737300D	5%	6%	0%
		737800D	8%	11%	12%
		757RRD	19%	15%	16%
		A319-111D	4%	0%	0%
		A320-211D	23%	40%	8%
		A320-232D	14%	8%	40%
		A321-211D	3%	3%	0%
		A321-232D	17%	13%	24%
		A330-301D	3%	5%	0%
		A340-313D	3%	0%	0%

Table 45.Final fleet mix for the departures simulated at Barajas

Arrivals

Runway	Route/track	Aircraft type	Day	Evening	Night
33L	1		206	51	15
		737300S	7%	14%	13%
		737800S	7%	6%	0%
		757RRS	9%	10%	27%
		A319-111S	3%	4%	0%
		A320-211S	23%	18%	33%
		A320-232S	18%	25%	0%
		A321-211S	0%	4%	0%
		A321-232S	15%	20%	13%
		A330-301S	9%	0%	0%
		A340-313S	8%	0%	13%
33L	2		5	0	0
		A320-211S	40%	0%	0%
		A320-232S	20%	0%	0%
		A321-232S	40%	0%	0%
33L	3		3	0	0

		A320-211S	33%	0%	0%
		A320-232S	33%	0%	0%
		A330-301S	33%	0%	0%
33R	4		0	0	25
		737300S	0%	0%	4%
		757RRS	0%	0%	8%
		A320-211S	0%	0%	24%
		A320-232S	0%	0%	8%
		A321-232S	0%	0%	12%
		A330-301S	0%	0%	16%
		A340-313S	0%	0%	28%
33R	5		247	68	55
		737300S	10%	6%	2%
		737800S	10%	9%	11%
		757RRS	13%	9%	18%
		A319-111S	1%	1%	0%
		A320-211S	27%	24%	31%
		A320-232S	15%	18%	16%
		A321-211S	3%	3%	4%
		A321-232S	16%	25%	13%
		A330-301S	4%	3%	2%
		A340-313S	2%	3%	4%
33R	6		22	5	5
		737300S	9%	0%	0%
		737800S	9%	0%	20%
		757RRS	14%	20%	20%
		A320-211S	27%	20%	20%
		A320-232S	14%	20%	20%
		A321-211S	5%	0%	0%
		A321-232S	18%	40%	20%
		A330-301S	5%	0%	0%
33R	7		6	0	0
		737300S	17%	0%	0%
		737800S	17%	0%	0%
		757RRS	17%	0%	0%
		A320-211S	17%	0%	0%
		A320-232S	17%	0%	0%
		A321-232S	17%	0%	0%

Table 46.Final fleet mix for the arrivals simulated at Barajas