EUROPEAN COMMUNITY

COMPETITIVE AND SUSTAINABLE
GROWTH PROGRAMME

# SOURDINE II

## D4-1-4b
## Paris CDG Noise Results

| | |
|---|---|
| Project acronym: | SOURDINE II |
| Project full title: | “Study of Optimisation procedURes for Decreasing the Impact of NoisE II” |
| Project number: | GRD2-2000-30105 |
| Contract number: | G4RD-CT-2000-00394 |
| Start date: | 12 November 2001 |
| Duration: | 45 months |

*Sourdine Consortium:*

| | | |
|---|---|---|
| NLR | *Stichting Nationaal Lucht- en Ruimtevaartlaboratorium* | *NL* |
| AENA | *Entidad Pública Empresarial Aeropuertos Españoles y Navegación Aérea* | *ESP* |
| AIRBUS F | *Airbus France SAS* | *F* |
| EUROCONTROL | *European Organisation for the safety of Air Navigation* | *INT* |
| ISDEFE | *Ingenieria de Sistemas para la Defensa de España S.A.* | *ESP* |
| INECO | *Ingenieria y Economia del Transporte* | *ESP* |
| SICTA | *Sistemi Innovativi per il Controllo del Traffico Aereo* | *IT* |

## Document Change Log

| Release | Author | Affected Sections / Comments | Document Nature | Date |
|---|---|---|---|---|
| 0.1 | EEC | All, Creation | Confidential | 25/8/05 |
| 0.2 | EEC | Overall comments | Confidential | 17/2/06 |
| 0.3 | EEC | Conclusions | Confidential | 10/5/06 |
| 1.0 | EEC | Final | Public | 18/5/06 |

## Document Distribution

| Partner | Distribution list |
|---|---|
| AENA | Pablo Sánchez Escalonilla<br>Alfredo Gomez de Segura |
| EUROCONTROL Experimental Centre | Peter Hullah<br>Laurent Cavadini |
| NLR | Ruud den Boer<br>Collin Beers |
| SICTA | Mariacarmela Supino |

## Review and Approval of the Document

| Organisation Responsible for Review | Reference of comment documents | Date |
|---|---|---|
| SICTA | E-mail | 17/03 2006 |
| | | |
| **Organisation Responsible for Approval** | **Name of person approving the document** | **Date** |
| Project Manager | Ruud den Boer | 10/05 2006 |
| Work Package Leader | Pablo Sánchez Escalonilla | 10/05 2006 |
| EC Official | Morten Jensen | 12/05 2006 |

| Document Information | |
|---|---|
| Document title | D4-1-4b CDG Noise Results |
| Version | V03 |
| Date | 10/05 2006 |
| Classification | Confidential |
| Work Package | WP4 |
| Document identification | SII_WP4_D4-1-4b_CDG-Noise-Results |

| Contributing Partners | Authors |
|---|---|
| - | - |

| Contact Information |
|---|
| EUROCONTROL Experimental Centre |
| FAO. Peter H.C. Hullah |
| Centre de Bois des Bordes, BP15, |
| 91222 BRETIGNY SUR ORGE CEDEX |
| France |
| Tel.: +33 1 69 88 75 49 |
| Fax: +33 1 69 88 78 90 |
| e-mail: Peter.Hullah@eurocontrol.int |

# Summary

The Sourdine II project defined four advanced and innovative approach procedures, and two departure procedures to be analysed for their ability to reduce the noise burden on people around the airports at which they would be implemented.

This analysis was performed for four European airports – Paris Charles de Gaulle, Amsterdam Schiphol, Madrid Barajas and Napoli Capodichino. This document describes the Noise analysis performed for the first of these.

Analysis was performed using a modified version of the US FAA’s Integrated Noise Model, specially developed by the FAA to cover the needs of the Sourdine II project, with special data supplied both by Airbus and, with funding from NASA, Boeing. This Sourdine II-specific noise modelling system is fully described in [D5-2]. It has to be noted that the special data supplied by Boeing and Airbus could not, however, cover the entire fleet at CDG and various substitutions had to be made to enable representative noise analysis.

Noise results were analysed in a relative way: the noise contours resulting from each Sourdine II procedure were compared with those associated to a baseline procedure.

The results show that the Sourdine II arrival procedure which features an increased final glide path angle (procedure III) provides the greatest benefit.

The two departure procedures studied have different aims, one to reduce noise close to the airport and one further away. The results of the noise analysis show that the “close-in” procedure is beneficial within 4.5NM (on average) of brake release, whereas the “distant” procedure starts to provide benefit from 3.5NM from brake release.

# Table of Contents

# 1. Introduction

## 1.1. Purpose

The procedures selected by the Sourdine II project have been analysed in several different manners. This has included fast-time simulation for capacity assessment, real-time simulation for controller and pilot evaluation, CBA, safety assessment, and noise and emission impact assessment, as well as expert panels.

This report provides the results of the noise assessments for Paris Charles de Gaulle airport as performed by EEC.

## 1.2. Background

SOURDINE II is a Research, Technology development and Demonstration (RTD) project aimed at providing solutions to the following issues:

- Airport approach and departure procedures that are aimed at reducing the environmental (noise and emissions) impact around airports require a co-ordinated solution by all involved parties. A European and international standardisation and harmonisation of such procedures is required in order for them to become operationally acceptable and only then can such new procedures be easily introduced on a larger scale and at a level of safety acceptable to the community.
- Provide an accepted implementation plan by all involved stakeholders to be able to migrate from the current situation to advanced environmentally friendly approach and departure procedures. This avoids the need to develop specific local solutions to a European problem.
- Produce air traffic controller and pilot tools to guarantee a high level of safety for the new advanced procedures

## 1.3. Glossary

| **Term** | **Description** |
|---|---|
| *CBA* | Cost Benefit Analysis |
| *CDA* | Continuous Descent Approach |
| *FAS* | Final Approach Speed |
| *FIR* | Flight Information Region |
| *FL* | Flight Level |
| *FTS* | Fast time simulations |
| *INM* | Integrated Noise Model |
| $L_{DEN}$ | Day-Evening-Night Level (dBA) |
| $L_{night}$ | Night-time $L_{eq}$ (dBA) |
| *NLR* | Nationaal Lucht- en Ruimtevaartlaboratorium<br>National Aerospace Laboratory |
| *NM* | Nautical Mile |
| *RNAV* | Area Navigation |
| *RTD* | Research, Technology development and Demonstration |
| *RTS* | Real time simulations |
| *SES* | Single Event Simulations |

| **Term** | **Description** |
|---|---|
| *SID* | Standard Instrument Departure |
| *SOURDINE* | Study of optimisation procedures for decreasing the impact of noise |

## 1.4. References

| **Short Reference** | **Author / Organisation, Title, Edition, Date and Reference** |
|---|---|
| [D2-1] | Sourdine II, D2-1: Validation Methodology Report, version 0.9 |
| [D3-1-2] | Sourdine II, D3-1-2: Detailed Definition of New Noise Abatement Procedures |
| [D5-2] | Sourdine II, D5-2: Airport Noise and Emission Modelling Methodology |

# 2. Description of the analysis

## 2.1. Paris Charles de Gaulle Airport

Paris Charles de Gaulle airport (CDG), which opened in the early 1970s, is the largest European airport in terms of number of movements with 1600 movements per day, and second largest in terms of number of passengers. Airport capacity is currently suibject to a ministerial decree capping it at 55 million passengers p.a.

CDG is situated some 20km North-East of Paris at the extremity of the capital's conurbation, with densely populated areas to the West and small country villages to the East, although approaches from the East pass very close to the major city of Meaux.

Operations at CDG make use of two independent parallel pairs of runways running East-West. The Northern pair are labelled 09-27 L&R and the Southern pair 08-26 L&R. Landing use the exterior runways (27R and 26L or 08R and 09L) to enable go-arounds away from the airport, whereas departures use the interior runways (27L and 26R or 08L and 09R).

## 2.2. Noise Modelling Method

The United States (US) Federal Aviation Administration (FAA's) Integrated Noise Model (INM) is a de facto standard for noise modelling worldwide. In its current version, version 6.1, it takes no account of aircraft configuration changes (flaps, slats and landing gear), which have a major impact on the noise produced by aircraft on approach. A new version of INM was therefore produced by the FAA especially for the Sourdine II project, with data supplied by Airbus and by Boeing with financing from the US National Aeronautics and Space Administration (NASA). Details of this new version are given in the Sourdine II document "D5.2 Noise and Emission Modelling Methodology".

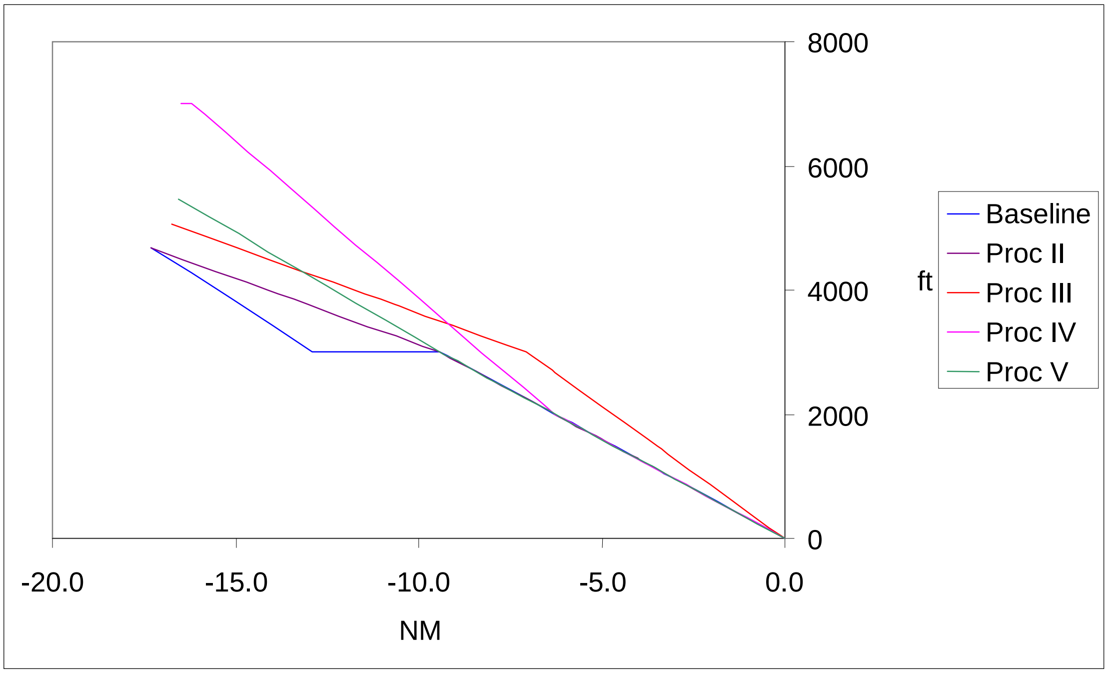
Input data used for modelling aircraft noise in this study come from Sourdine II procedure flight profiles specially supplied by Airbus and Boeing for height, speed, thrust and configuration information, and from the paths used for the capacity simulations for the ground track.

Simulations were run using a Westerly configuration only – arrivals on 27R and 26L, departures on 27L and 26R. The routes used are shown in Section 3.4.

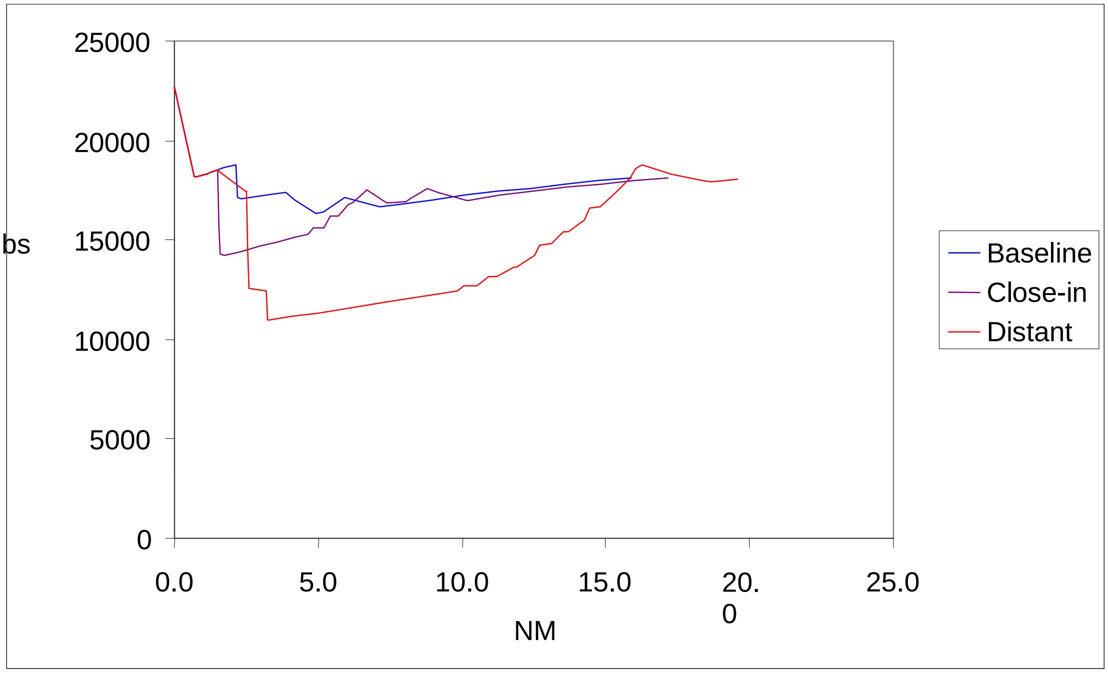
## 2.3. Procedures Modelled

Noise modelling was performed for five arrival procedures - a baseline (Procedure I) and four Sourdine II procedures (Procedures II, III, IV and V) – and three departure procedures – Baseline, Close-in and Distant. The reader is referred to Sourdine II WP3 [D3-1-2] for a full description of these procedures. Here we give a brief graphical illustration of them to facilitate understanding of the analyses and their results.

The approach procedures are best graphically illustrated by their altitude profiles in the following diagram:



The departure procedures are better distinguished by their thrust profiles as follows:



# 3. Input data and modelling assumptions

## 3.1. Original fleet mix

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 1: 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 2: 24-hour distribution of departure aircraft movements**

## 3.2. Performed 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 3: Aircraft substitutions**

## 3.3. Resulting Fleet mix for the 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 4: 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 5: Departure fleet mix per route and runway**

## 3.4. Runways – Route/track description

Figure 1 describes the 2-D approaches showing the runways, routes/tracks, specific points (STARs). The tracks presented are the ones actually used for the noise calculations.

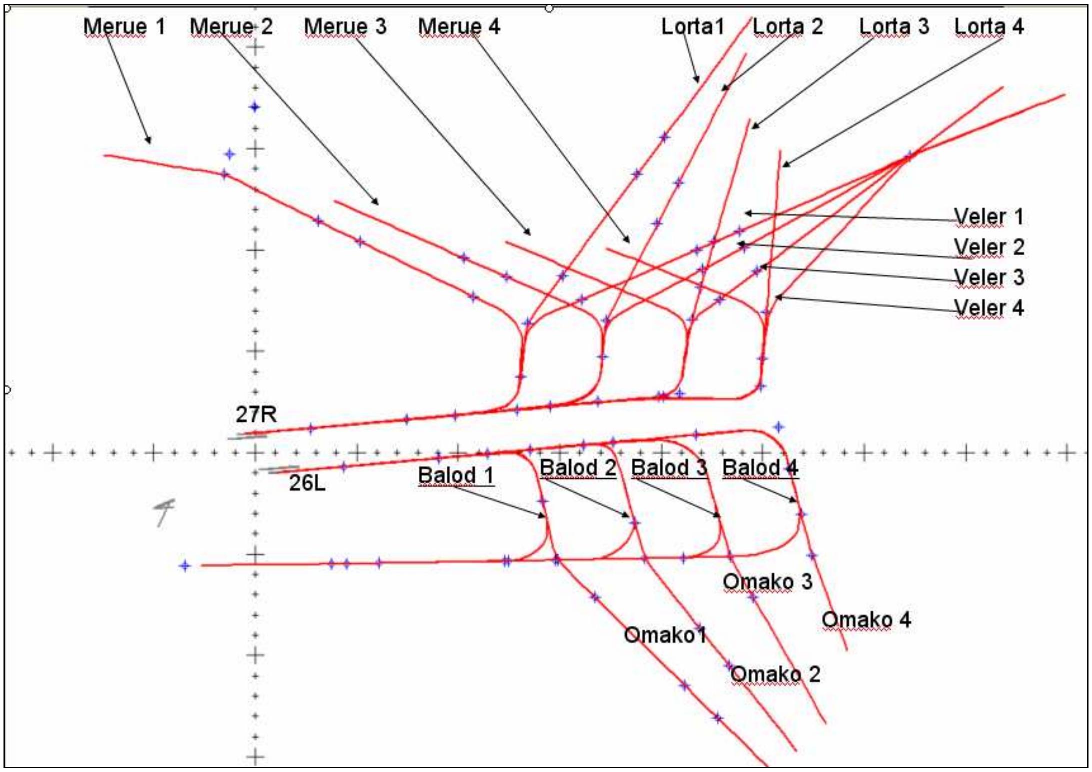


**Figure 1: Arrival runway/track description**

The tracks which were used to compute noise levels and contours are point tracks 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 fights that belong to the same leg/star.

Figure 2 is the 2-D Approach diagram showing the runways, routes/tracks, specific points (SIDs). The tracks presented are the ones actually used for the noise calculations.

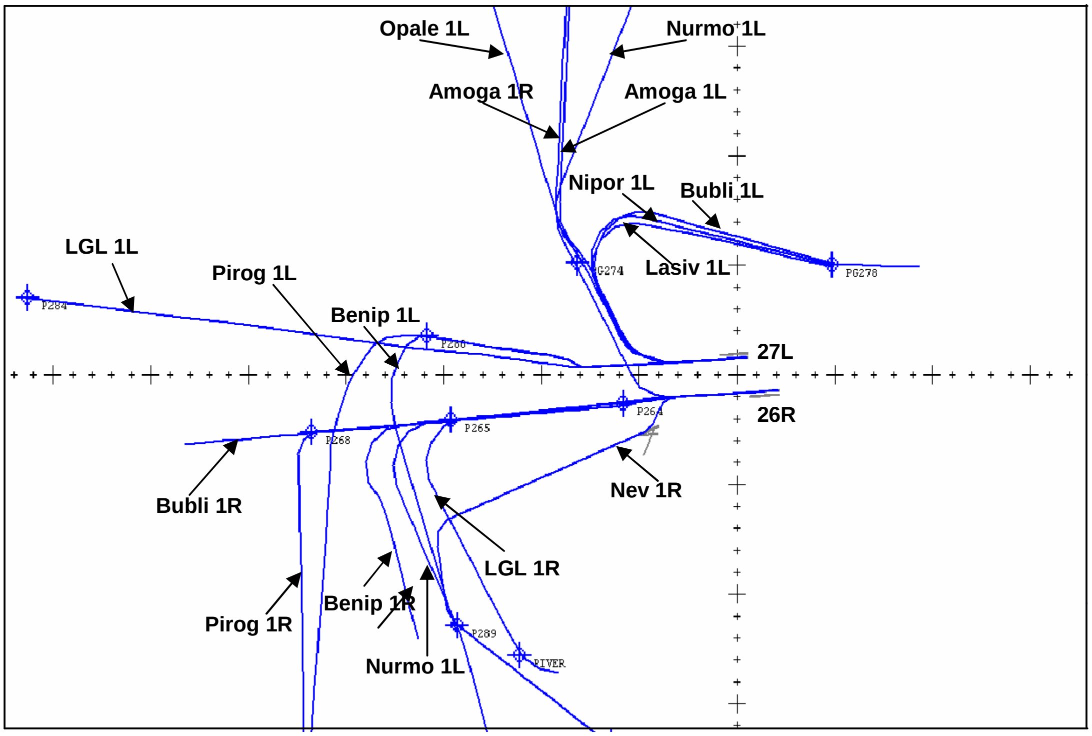


Figure 2: Departures' runways/tracks description

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

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

## 3.5. Study/Case parameter description

Airport elevation:0 ft MSL

Atmospheric conditions (temperature, pressure, humidity):

- Temperature (F) = 59
- Pressure (in-Hg) = 29.92
- Headwind (kt) = 0 kt

Terrain: No terrain elevation data have been used

# 4. Noise results

Noise results are presented in a relative way: SII procedures are evaluated against the Baseline Procedures. Results are provided for Lden and Lnight.

Noise levels are given from 55 dB for Lden, 50 dB for Lnight, and incremented by 5dB. The highest noise level threshold to be accounted for in the results is determined by airport (and metric) specificities, and is determined by the surface of the corresponding contour - there is no point in presenting contour area variations (in percent) for very small areas – but in any case, the highest threshold levels do not exceed 75 dB for Lden, and 70 dB for Lnight.

## 4.1. Noise Contours

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

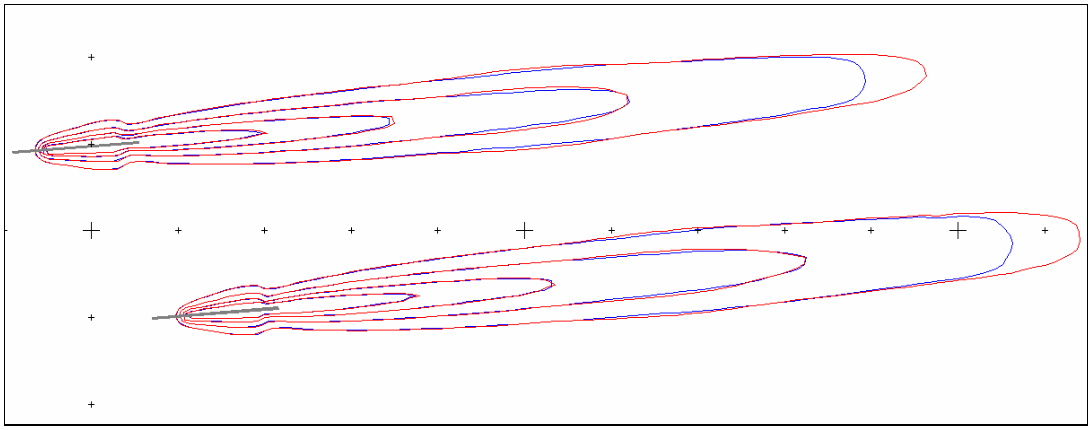


**Figure 3: Arrivals Lden Baseline procedure (red) and Procedure II (blue) contours overlapping**

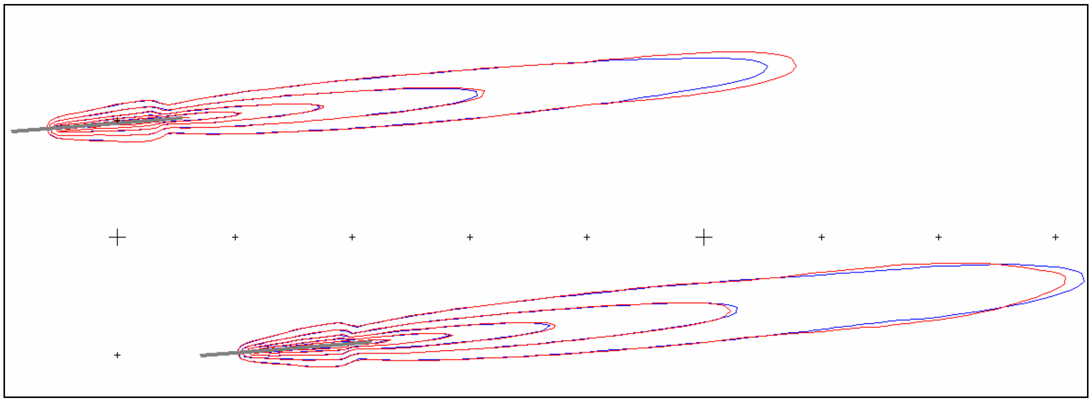


**Figure 4: Arrivals Lnight Baseline procedure (red) and Procedure II (blue) contours overlapping**

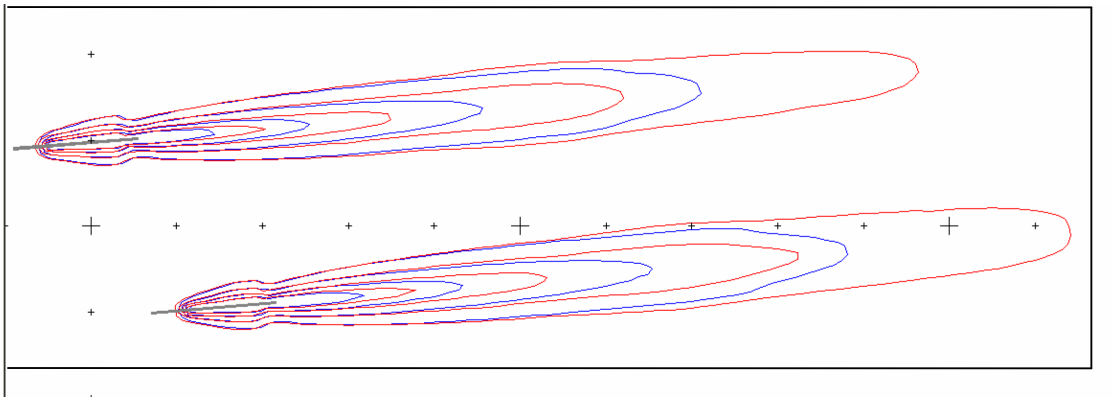


Figure 5: Arrivals Lden Baseline procedure (red) and Procedure III (blue) contours overlapping

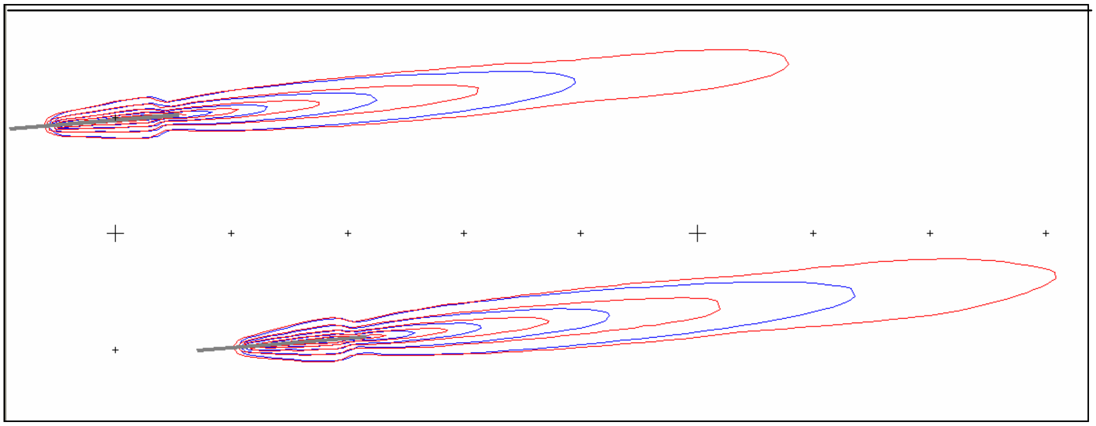


Figure 6: Arrivals Lnight Baseline procedure (red) and Procedure III (blue) contours overlapping

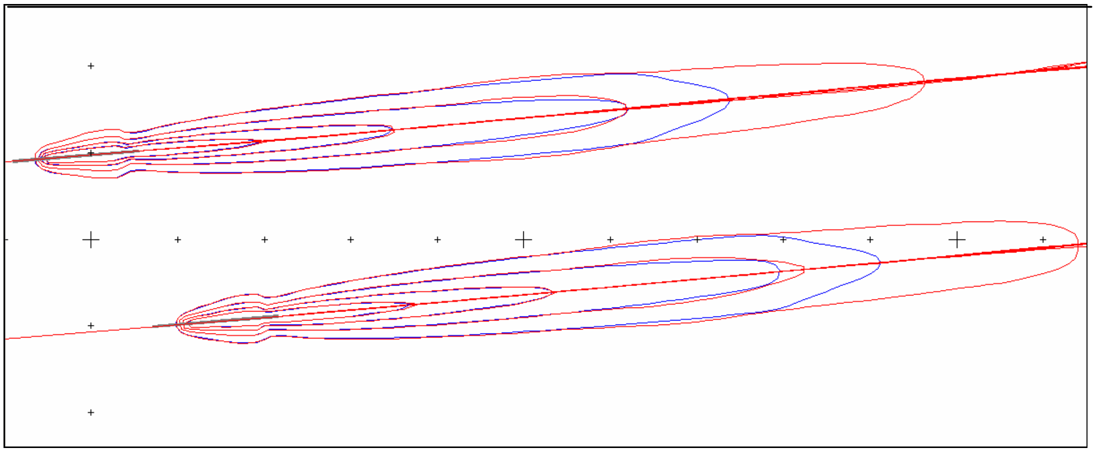


Figure 7: Arrivals Lden Baseline procedure (red) and Procedure IV (blue) contours overlapping

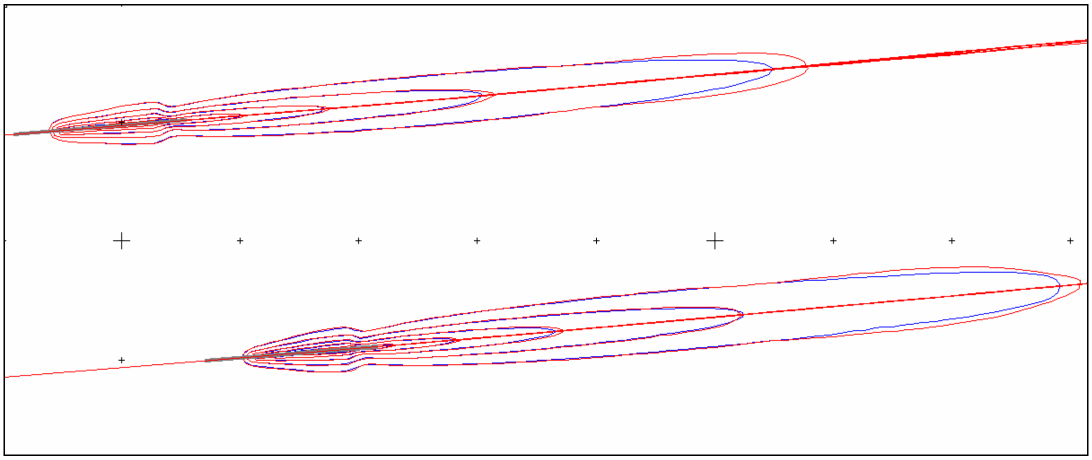


Figure 8: Arrivals Lnight Baseline procedure (red) and Procedure IV (blue) contours overlapping

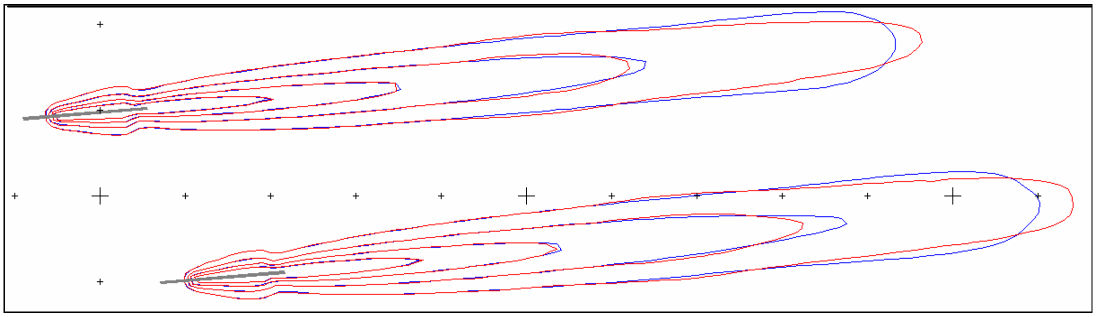


Figure 9: Arrivals Lden Baseline procedure (red) and Procedure V (blue) contours overlapping

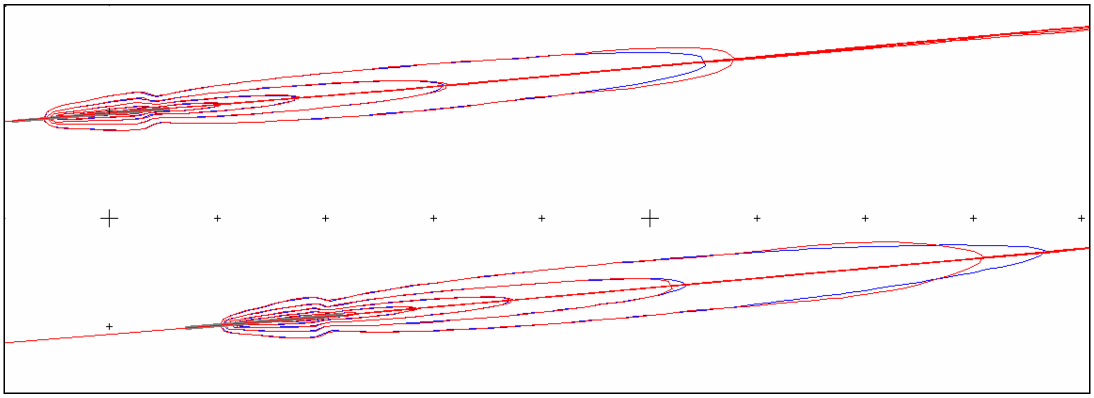


Figure 10: Arrivals Lnight Baseline procedure (red) and Procedure V (blue) contours overlapping

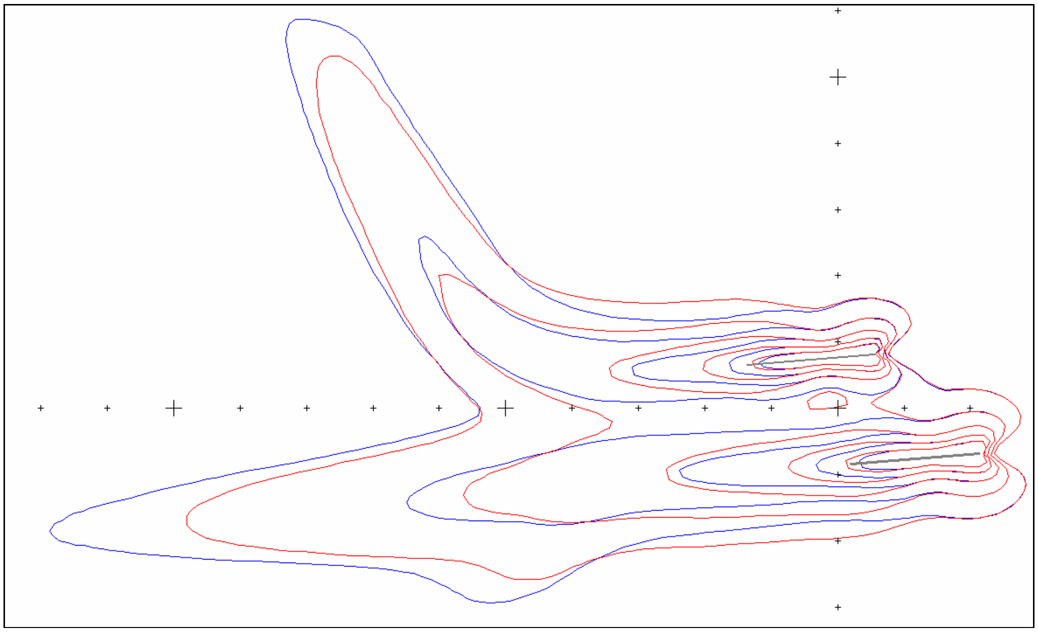


Figure 11: Departure Lden Baseline procedure (red) and close_in (blue) contours overlapping

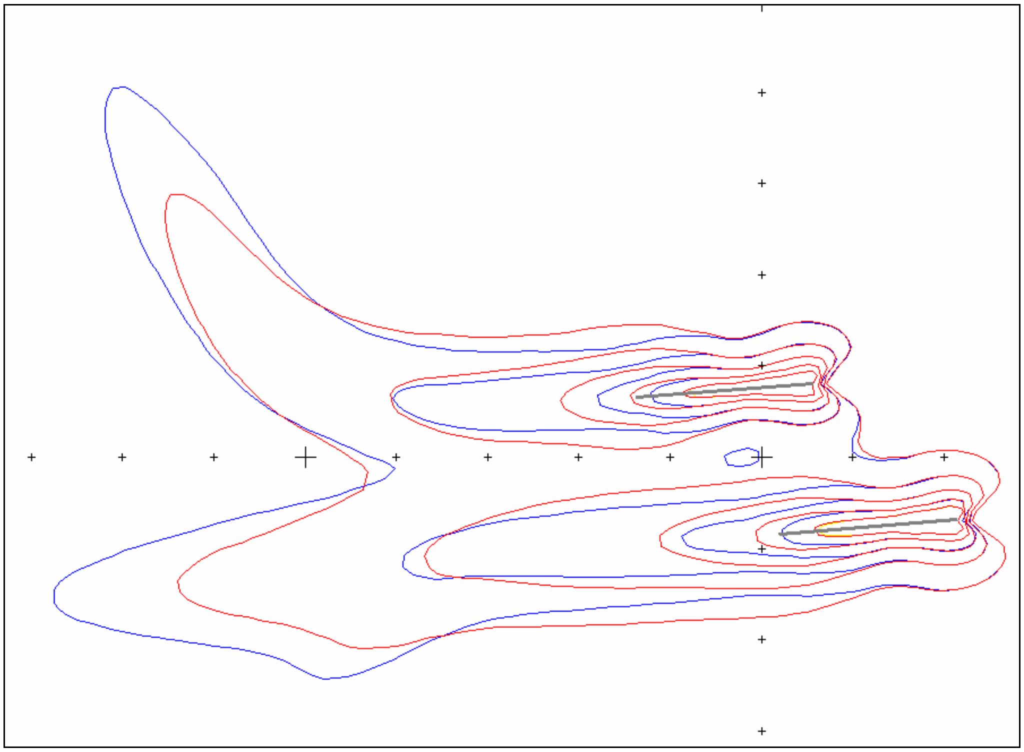


Figure 12: Departure Lnight Baseline procedure (red) and close_in (blue) contours overlapping

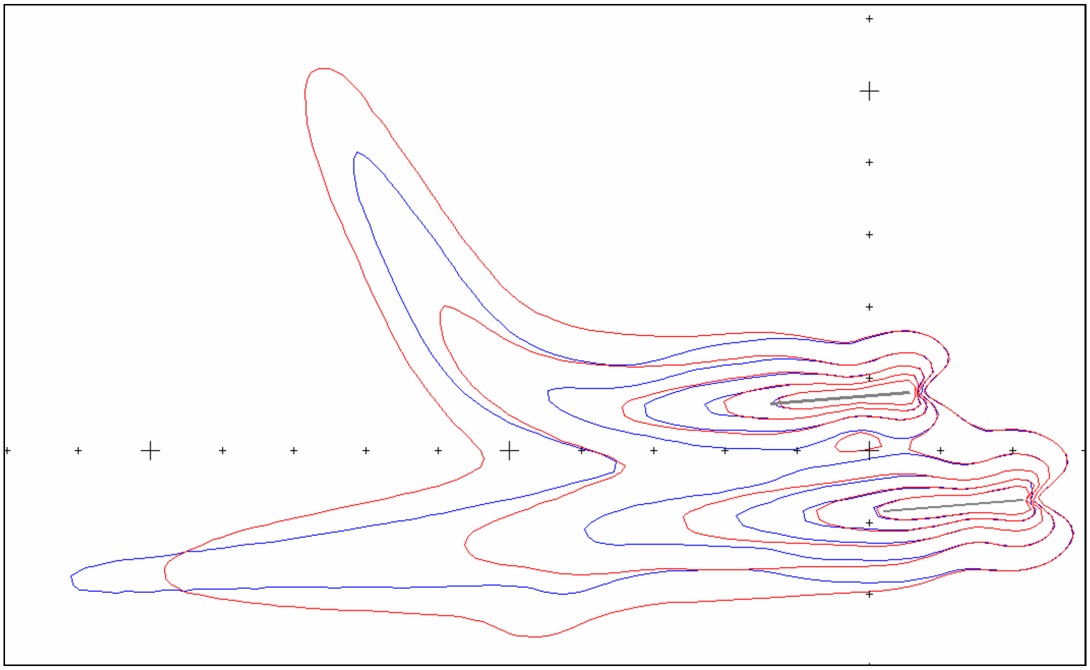


Figure 13: Departure Lden Baseline procedure (red) and distant (blue) contours overlapping

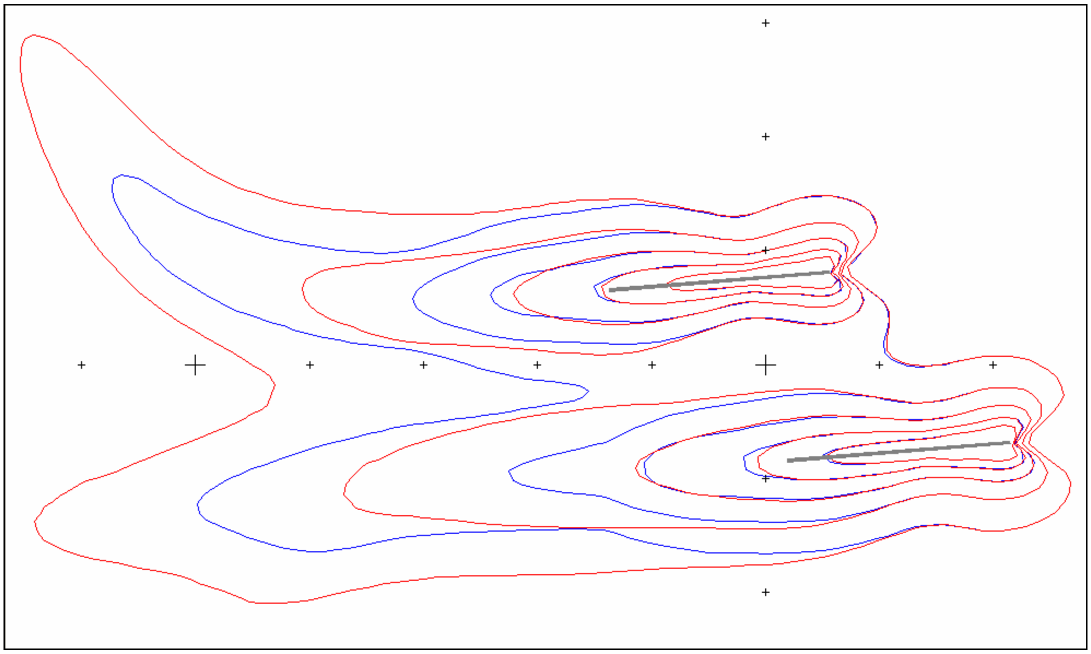


Figure 14: Departure Lnight Baseline procedure (red) and distant (blue) contours overlapping

## 4.2. Contour area tables

The table below provides the arrival Lden absolute values Contour areas expressed in $Km^2$

| Contour Area IN SQ. KM | | | | | |
|---|---|---|---|---|---|
| **Lden Contour level** | **Baseline** | **ProcII** | **ProcIII** | **ProcIV** | **ProcV** |
| **55 Lden** | 52.265 | 48.038 | 35.012 | 38.525 | 53.11 |
| **60 Lden** | 20.548 | 19.695 | 13.235 | 19.193 | 20.377 |
| **65 Lden** | 6.679 | 6.506 | 4.508 | 6.425 | 6.607 |
| **70 Lden** | 2.334 | 2.247 | 1.686 | 2.221 | 2.271 |

**Table 11: Arrival Lden Contour Area**

The table below provides the arrival Lden variation in percent values of the contour areas of each procedure vs Baseline procedure.

| Contour area change (%) | | | | | |
|---|---|---|---|---|---|
| **Lden Contour level** | **Baseline** | **ProcII** | **ProcIII** | **ProcIV** | **ProcV** |
| **55 Lden** | **Reference** | -8.09% | -33.01% | -26.29% | 1.62% |
| **60 Lden** | | -4.15% | -35.59% | -6.59% | -0.83% |
| **65 Lden** | | -2.59% | -32.50% | -3.80% | -1.08% |
| **70 Lden** | | -3.73% | -27.76% | -4.84% | -2.70% |

**Table 12: Arrival Lden Percent Variation of each procedure contour area vs baseline procedures**

The table below provides the arrival Lnight absolute values contour areas expressed in $Km^2$

| Contour Area IN SQ. KM | | | | | |
|---|---|---|---|---|---|
| **Lnight Contour level** | **Baseline** | **ProcII** | **ProcIII** | **ProcIV** | **ProcV** |
| **50 Lnight** | 17.96 | 17.194 | 11.345 | 16.516 | 17.529 |
| **55 Lnight** | 5.731 | 5.605 | 3.869 | 5.488 | 5.674 |
| **60 Lnight** | 1.992 | 1.918 | 1.432 | 1.882 | 1.936 |
| **65 Lnight** | 0.731 | 0.696 | 0.569 | 0.686 | 0.701 |
| **70 Lnight** | 0.229 | 0.217 | 0.197 | 0.211 | 0.215 |

**Table 13: Arrivals' Lnight Contour Area**

The table below provides the arrival Lnight variation in percent values of the contour areas of each procedure vs Baseline procedure.

| Contour area change (%) | | | | | |
|---|---|---|---|---|---|
| **Lnight Contour level** | **Baseline** | **ProcII** | **ProcIII** | **ProcIV** | **ProcV** |
| **50 Lnight** | **Reference** | -4.27% | -36.83% | -8.04% | -2.40% |
| **55 Lnight** | | -2.20% | -32.49% | -4.24% | -0.99% |
| **60 Lnight** | | -3.71% | -28.11% | -5.52% | -2.81% |
| **65 Lnight** | | -4.79% | -22.16% | -6.16% | -4.10% |
| **70 Lnight** | | -5.24% | -13.97% | -7.86% | -6.11% |

**Table 14: Arrival Lnight Percent Variation of each procedure contour area vs baseline procedures**

The table below provides the departure Lden absolute values Contour areas expressed in Km$^2$

| Contour Area IN SQ. KM | | | |
|---|---|---|---|
| **Lden Contour level** | **Baseline** | **Close_in** | **Distant** |
| **55 Lden** | 135.462 | 148.873 | 99.352 |
| **60 Lden** | 64.029 | 55.308 | 39.162 |
| **65 Lden** | 22.114 | 17.041 | 18.700 |
| **70 Lden** | 8.768 | 6.904 | 9.064 |
| **75 Lden** | 3.626 | 3.278 | 3.713 |

**Table 15: Departure Lden Contour Area**

The table below provides the departure Lden variation in percent values of the contour areas of each procedure vs Baseline procedure.

| **Lden Contour level** | **Baseline** | **Close_in** | **Distant** |
|---|---|---|---|
| **55 Lden** | **Reference** | 9.90% | -26.66% |
| **60 Lden** | | -13.62% | -38.84% |
| **65 Lden** | | -22.94% | -15.44% |
| **70 Lden** | | -21.26% | 3.38% |
| **75 Lden** | | -9.60% | 2.40% |

**Table 16: Departure Lden Percent Variation of each procedure contour area vs baseline procedures**

The table below provides the departure Lnight absolute value Contour areas expressed in $Km^2$

| Contour Area IN SQ. KM | | | |
|---|---|---|---|
| **Lnight Contour level** | **Baseline** | **Close_in** | **Distant** |
| **50 Lnight** | 83.988 | 92.562 | 57.114 |
| **55 Lnight** | 33.189 | 26.976 | 23.346 |
| **60 Lnight** | 11.939 | 9.234 | 11.903 |
| **65 Lnight** | 4.955 | 4.209 | 5.126 |
| **70 Lnight** | 1.982 | 1.920 | 2.006 |

**Table 17: Departure Lnight Contour Area**

The Table below provides the departures Lnight variation in percent values of the contour areas of each procedure vs Baseline procedure.

| Contour area change (%) | | | |
|---|---|---|---|
| **Lnight Contour level** | **Baseline** | **Close_in** | **Distant** |
| **50 Lnight** | **Reference** | 10.21% | -32.00% |
| **55 Lnight** | | -18.72% | -29.66% |
| **60 Lnight** | | -22.66% | -0.30% |
| **65 Lnight** | | -15.06% | 3.45% |
| **70 Lnight** | | -3.13% | 1.21% |

**Table 18: Departure Lnight Percent Variation of each procedure contour area vs baseline procedures**

## 4.3. Bar-charts

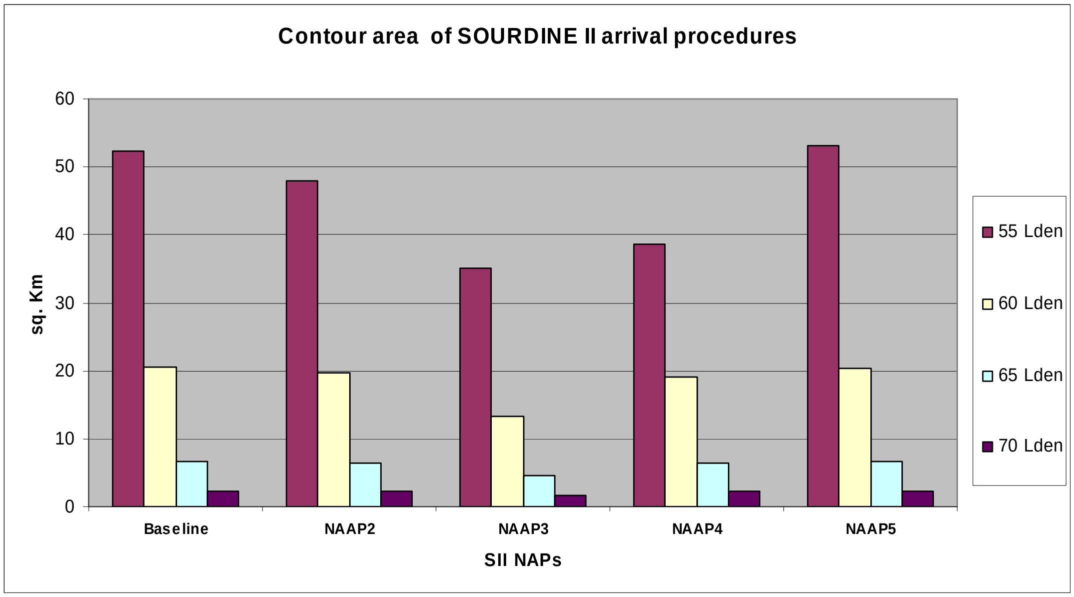


Figure 15: Arrivals Lden contour area bar charts

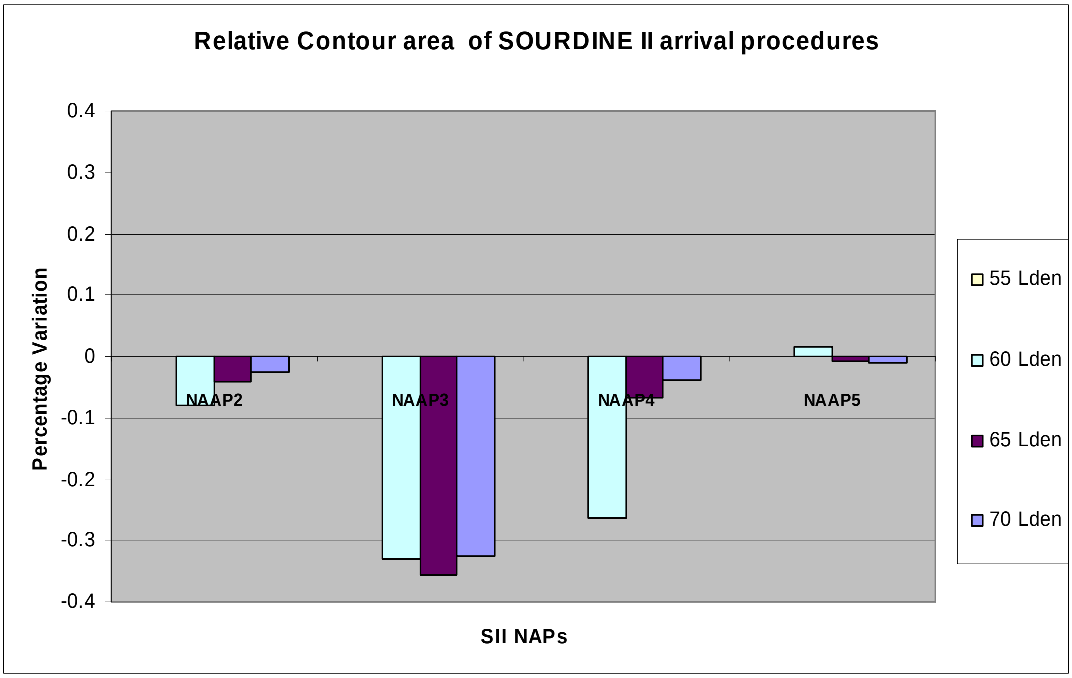


Figure 16: Arrivals Lden relative contour area bar charts

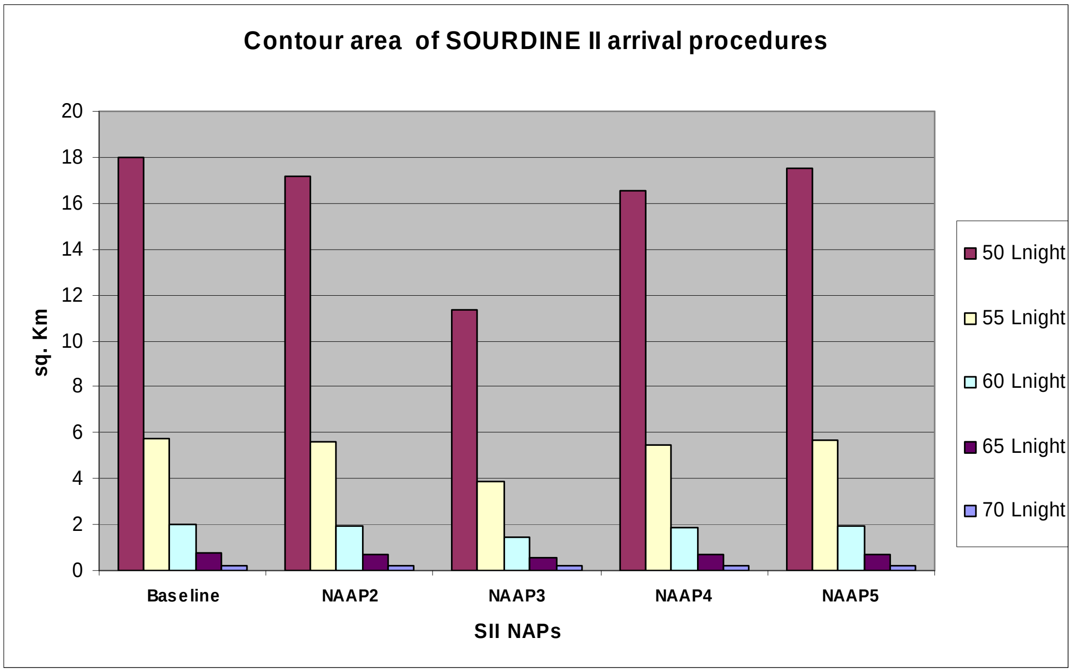


Figure 17: Arrivals Lnight contour area bar charts

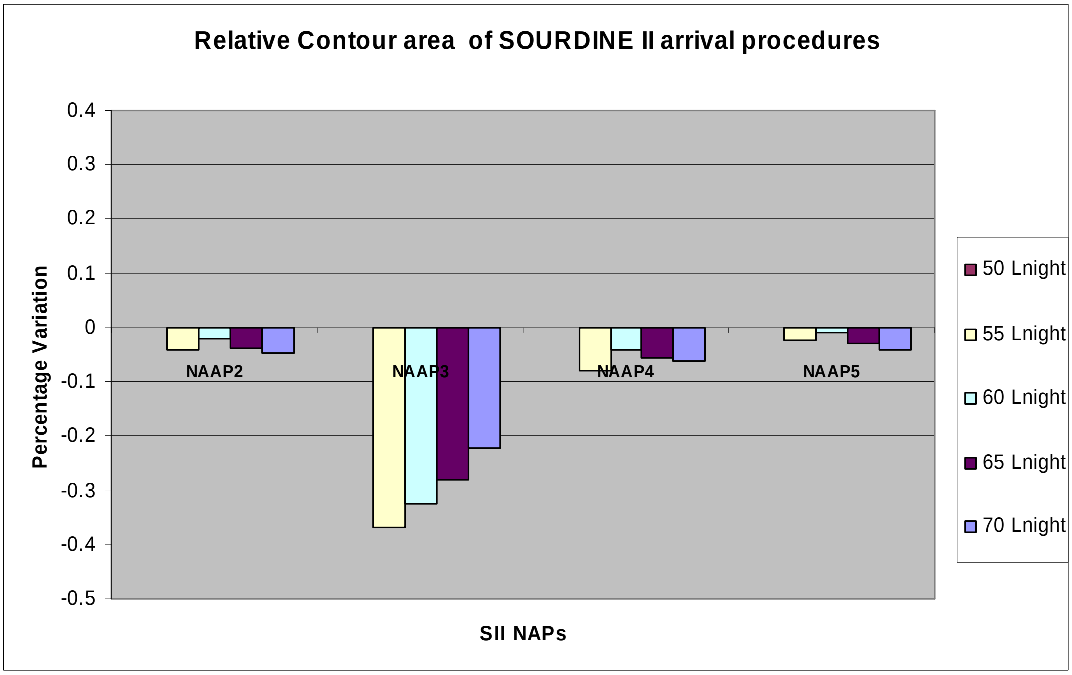


Figure 18: Arrivals Lnight relative contour area bar charts

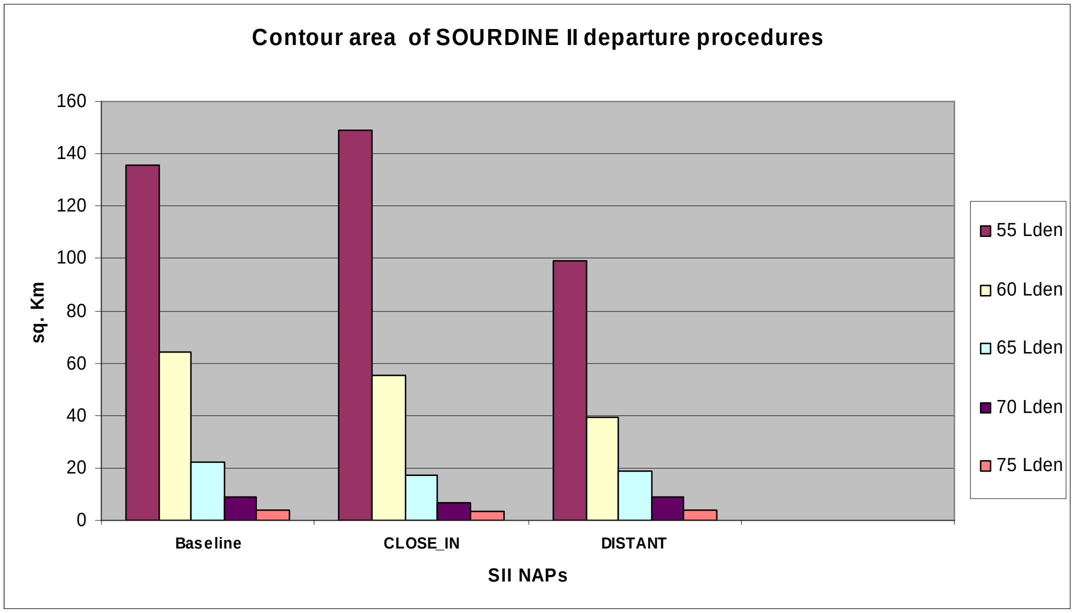


Figure 19: Departures Lden contour area bar charts

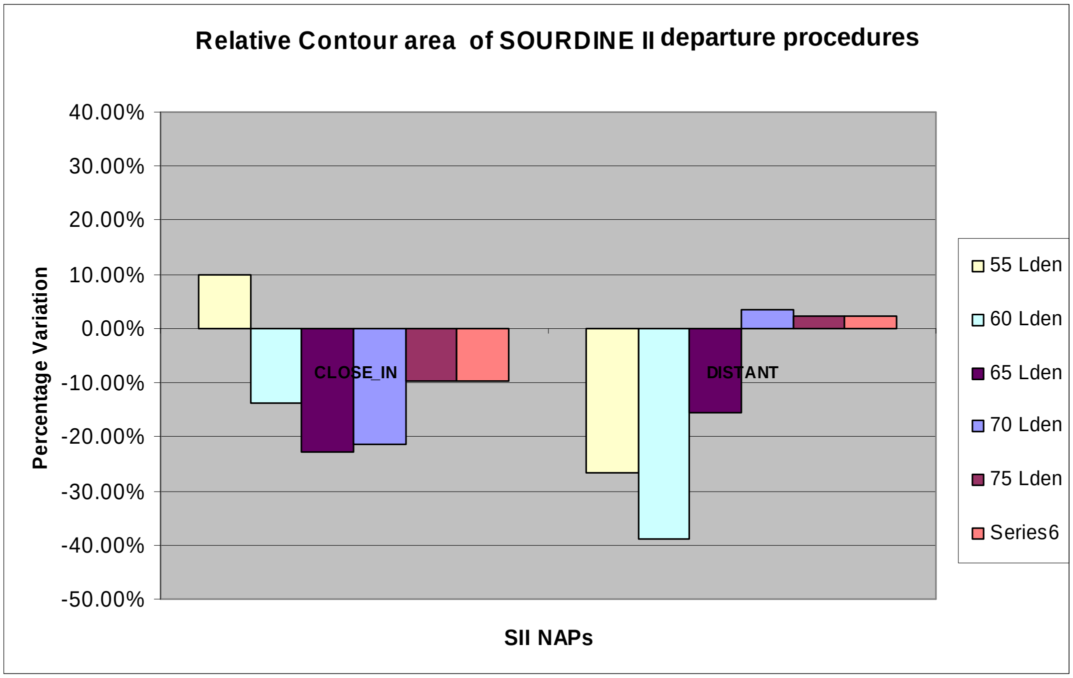


Figure 20: Departures Lden relative contour area bar charts

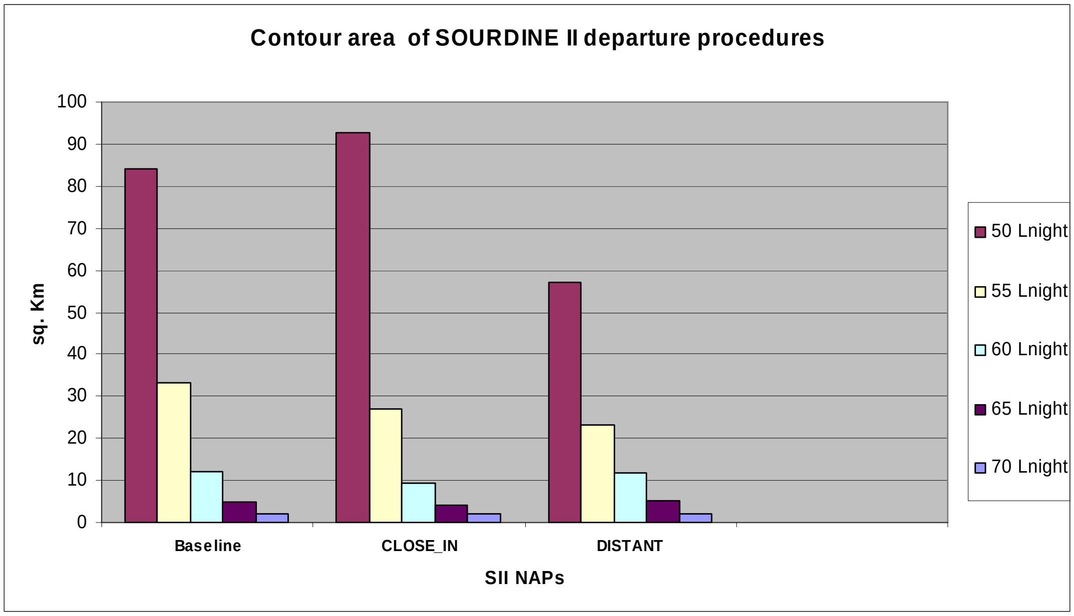


Figure 21: Departures Lnight contour area bar charts

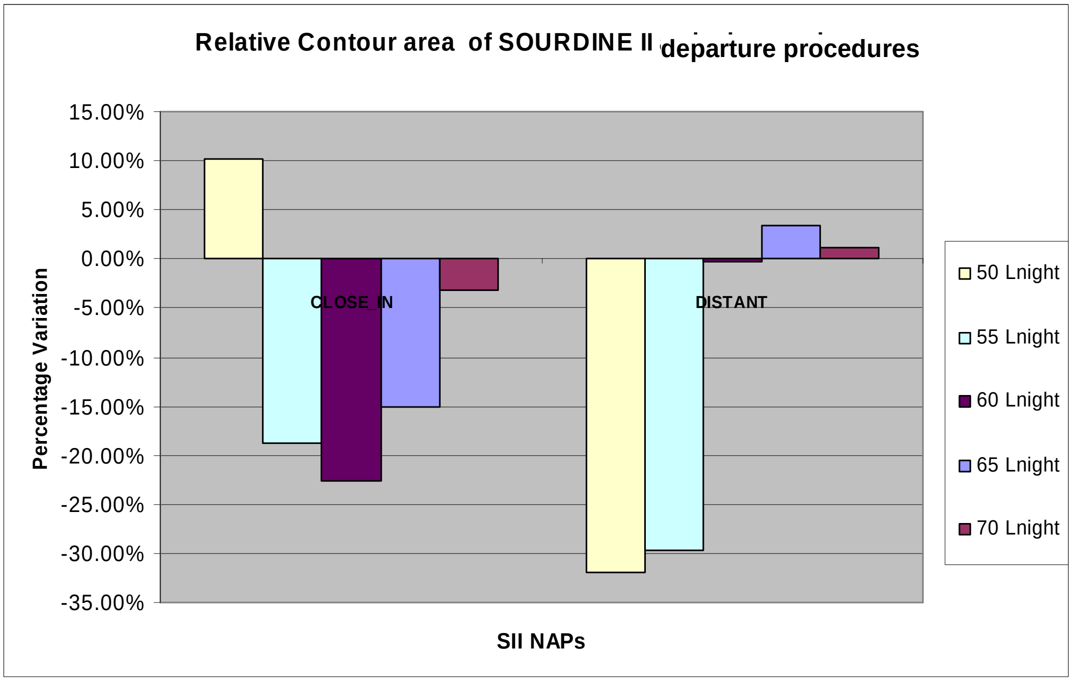


Figure 22: Departures Lnight relative contour area bar charts

## 4.4. Impacted population:

The variation in populations impacted by these procedures was not studied for Paris CDG as the required population data were not available.

# 5. Analysis of noise results

## 5.1. Arrivals – Lden

It should be first noted that the baseline approach procedure already represents a noise efficient procedure (the level segment at 3000ft is flown at minimum thrust as it is used for deceleration purpose only). Comparisons with additional baseline procedures which better reflect operational practice at Schiphol can be found in deliverable D4-1-2b.

### *5.1.1. Procedure II (Fig. 3)*

The outer procedure II contour (55 dB) is about 1NM 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 different thrust levels on the final segment, and the cleaner configuration used for the Sourdine procedure do not appear to have significantly modified the size of the other contours, although there is a slight thinning between 5 and 3.5 NM (this can be explained by the fact that, for some aircraft, the final speed in procedure II is slightly higher than in baseline procedure, resulting in higher airframe noise which tends to cancel the noise benefit coming from the other parameters).

### *5.1.2. Procedure III (Fig. 5)*

Procedure III contours are significantly smaller than the baseline. This is a result of the final descent slope for Procedure III, 4°, whereas the baseline's is 3° and again, most of this difference is caused by the difference in height of the two profiles which gives a reduction of around 2.5 dB.

### *5.1.3. Procedure IV (Fig. 7)*

As with procedure II, only the 55dB contour is affected by this procedure (with, again, a thinning of the 55dB and 60dB contours between 5.5 and 3.5 NM). The sharp initial approach angle increases the heignt of the aircraft before approx. 6.5NM and reduces the noise correspondingly.

### *5.1.4. Procedure V (Fig. 9)*

The 55dB contour for procedure V is shorter and fatter than that of the baseline, whereas the 60dB contour is longer and thinner. As the length of these contours is less than 10NM, they are produced by the aircraft when on the final 3º descent segment from 3000ft to touchdown, which is common to the two procedures. Therefore, the observed noise differences come from differing thrust and configuration/speed profiles between the baseline and Proceure V.

## 5.2. Arrivals - Lnight

The Lnight contours for procedures II, IV and V (figures 4, 8 and 10) show little difference as they are all in the area where the aircraft follow the same 3º vertical flight path. Some variations are visible, especially in the 50dB contour due to differences in thrust (through modification of the engine noise component) and configuration/speed (through modification of the airframe noise component).

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

## 5.3. Departures – Lden

The differences in the two Sourdine II departure procedures are very nicely illustrated by the variations in width and length of the contours they produce compared with the baseline.

### *5.3.1. Close-in*

The two largest contours (55dB and 60dB) of the close-in procedure are longer and thinner than those of the baseline, whereas the contours associated to higher noise levels are smaller all round. This is the desired result of the close-in procedure, the noise reduction being achieved within 4.5NM (on average) of brake release. The noise reduction close to the airport is due to the reduced power settings (deep cutback) in the case of the Sourdine II procedure. The increased length of the larger contours for the close-in procedure is due to the higher thrust level associated to the restored maxclimb power, whereas the altitude reached by the aircraft is equal or less than for the baseline procedure (and speed is lower as the aircraft have not started to accelerate, which increases noise exposure through the duration effect).

### *5.3.2. Distant*

In this scenario, the 70 and 75dB are longer, and very slightly narrower, for the Sourdine II procedure, whereas the 55-65dB contours are significantly smaller for this procedure compared with the baseline. In some places, the Sourdine II procedure 55dB contour overlaps the baseline 60dB contour – a 5dB reduction in noise levels. In fact, the Sourdine II procedure is quieter than the baseline after 3.5NM from brake release. A notable exception here is the extended 55dB contour off the South runway which shows that different aircraft react differently to the procedure definition; the differences in fleet-mix over the two runways shows this up.

## 5.4. Departures - Lnight

There are no differences in the conclusions for Lnight contours compared with the Lden contours.

# 6. Conclusions

The airport-scale noise analysis of the selected Sourdine II procedures has been performed in the context of Paris Charles de Gaulle Airport. For each of these procedures, noise contours have been calculated and compared with those resulting from baseline procedures, using the Sourdine II-specific version of the Integrated Noise Model described in [D5-2].

The main conclusions are:

- The size of the contours for arrival procedures is mainly influenced by the altitude profiles. However, the influence of configuration and speed (combined with thrust) is also visible on final segments with identical glide slope.
- The size and shape of the contours for departure procedures are widely influenced by engine power settings. The deep thrust cutback has a direct effect on the noise reduction in the area where it is applied, despite the associated reduced rate of climb.

**Arrivals:**

- Procedure V (Proc V) has noise contours similar to the baseline procedure, all the other procedures generating smaller contours.
- The most significant reduction is obtained with Procedure III. The ranking of the reductions is:

  Proc III > Proc IV > Proc II > Proc V
- The same ranking is found for both Lden and Lnight.

**Departures:**

- As expected, the close-in procedure yields some reduction in contour size close to the airport (due to the thrust cutback), but at longer distances, the contours (associated to lower noise level thresholds) are bigger, because of the higher thrust level associated to the restored maxclimb power, whereas the reached altitude is equal or less than for the baseline procedure (and speed is lower as the aircraft have not started to accelerate, which results in an additional increase of noise exposure through the duration effect).
- The distant procedure produces significantly smaller noise contours than the baseline procedure (except at short distances). This is explained by the thrust cutback, which is applied over long distances and is even deeper than for the close-in procedure (as the deep cutback is applied when the aircraft are in clean configuration, so with minimum drag to compensate).