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COMPETITIVE AND SUSTAINABLE GROWTH PROGRAMME

SOURDINE II

D4-1-3b
Noise Results Madrid Barajas

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<u>*Sourdine Consortium:*</u>

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AENA	*Entidad Pública Empresarial Aeropuertos Españoles y Navegación Aérea*	*ESP*
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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 third airport Madrid Barajas, Spain.

The noise analysis was performed using a version of the US FAA's Integrated Noise Model, specially developed by the FAA to cover the needs of the Sourdine II project (INM7s), with special data supplied both by Airbus and, with funding from NASA, Boeing. These data could not, however, cover the entire fleet at Madrid Barajas (around 80%) and various substitutions had to be made to enable representative noise analysis.

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 only within the 3.5NM immediately after the end of the runway, whereas the "distant" procedure provides benefit from 2NM after the runway end.

The noise analysis was brought a step further and the difference in the impacted population was estimated.

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1. Introduction

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 impact assessment, as well as expert panels.

This report provides the results of the noise and emission assessment for Madrid Barajas airport as performed by Aena.

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

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
KTS	Knots
Lden	Day-Evening-Night. It is a descriptor of noise level based on energy equivalent noise level (Leq) over a whole day with a penalty of 10 dB(A) for night time noise (22.00-7.00) and an additional penalty of 5 dB(A) for evening noise (i.e. 19.00-23.00).

Term	Description
Lnight	Night level with a penalty of 10 dB(A).
NM	Nautical Mile
RNAV	Area Navigation
RTD	Research, Technology development and Demonstration
RTS	Real time simulations
RWY	Runway
SES	Single Event Simulations
SID	Standard Instrument Departure
SOURDINE	Study of optimisation procedures for decreasing the impact of noise
ToC	Table of Contents

References

Short Reference	Author / Organisation, Title, Edition, Date and Reference
[D3-1.2]	Detailed definition of new noise abatement procedures
[D3-1.1]	Definition of new noise abatement procedures (Sect.2.4 Barajas Airport Operational Concept)
[SII_D2_1]	SOURDINE II "D2.1 Validation Methodology Report", April 2004
[SII_D2_1_Appt]	SOURDINE II "D2.1 Validation Methodology Report, Appendixes", April 2004
[D5-2]	Noise & Emission modelling methodology
[D4-1-1b]	Noise & Emissions Results Summary Appendix I *"Aircraft Substitution for the Noise Modelling study"*

2. Description of the Analysis

Madrid Barajas Airport

In 1928 it was decided a big city needed a big airport and a piece of wasteland at Barajas, only 15 kilometres (9 miles) from central Madrid, was cleared for the job.

By the beginning of the 21st century it was handling over 34 million passengers a year and, with a projected 46.6 million a year by 2010, development is already under way. A new satellite terminal is planned and two new runways, bringing the total to four.

Barajas already has the longest runway in Europe, enough to cope with new generation heavy aircraft.

Madrid-Barajas (LEMD) Runway Configuration and Mode of Operation:

Airport Configuration: North (33 L/R for Arrivals, 36 L/R for Departures)

- Two sets of parallel runways.
- Segregated arrivals and departures.

Traffic load and runway allocation scheme

- Runway allocation by origin/destination.
- During night period (23:00-7:00 local time) only two runways are open: 33R and 36R.
- Traffic load slightly unbalanced.

Noise Modelling Method

The United States (US) Federal Aviation Administration (FAA's) Integrated Noise Model (INM) is a de facto standing 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".

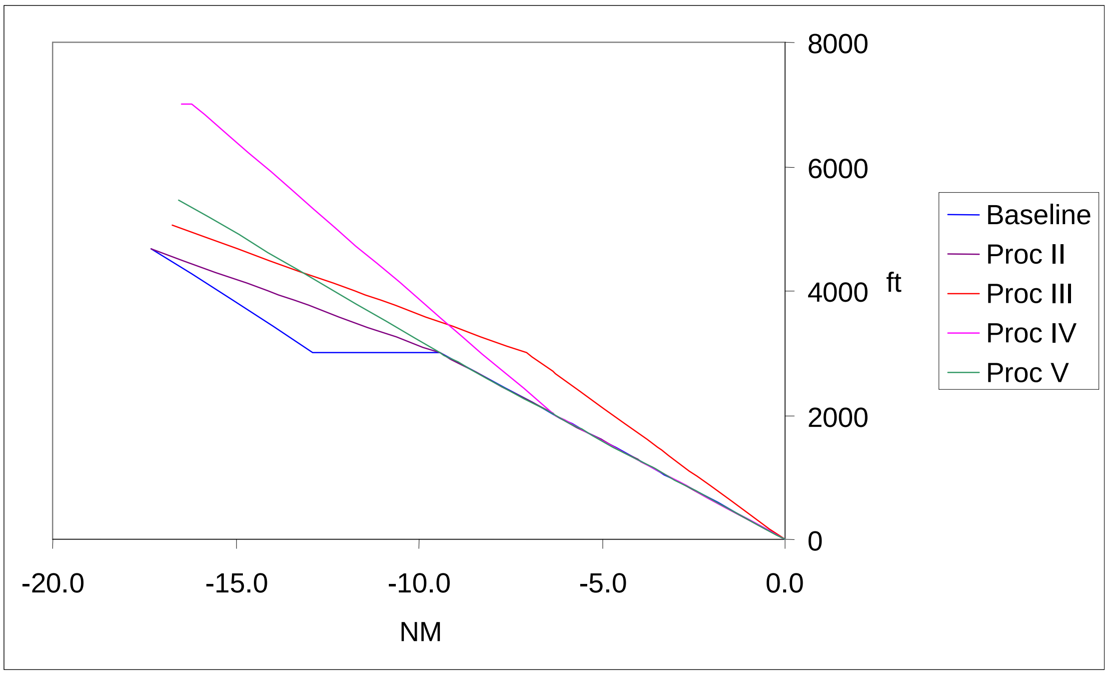
Data used for modelling aircraft noise in this study come from Sourdine II procedure flight profiles specially supplied by Airbus and Boeing for height, speed, thrust and configuration information, and from the paths used for the capacity simulations for the ground track.

Simulations were run using a Westerly configuration only – arrivals on 33R and 33L, departures on 36L and 36R. The routes used are shown in Section 0.

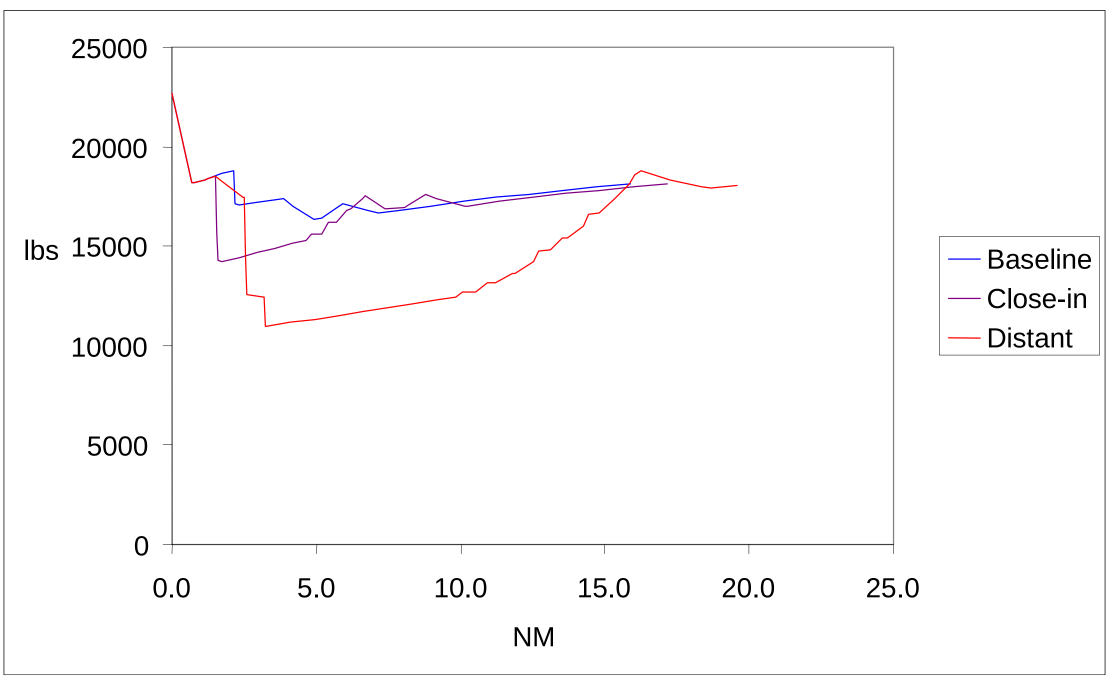
Procedures Modelled

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 WP3.1-2 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 vertical profiles in the following diagram:



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



3. Input data and modelling assumptions

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).

TOTAL MOVEMENTS **1799**

Aircraft Type	Total Nº. 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%

Aircraft Type	Total Nº. 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)**
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 3-1 Day time 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 **914**

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%

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)**
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 3-2 : Day time distribution of departure aircraft movements

ARRIVALS : nº **885**

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%

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)**
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%

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)**
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 3-3: Day time distribution of arrival aircraft movements

Performed substitutions

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

Original aircraft type	INM70-SII aircraft
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

Original aircraft type	INM70-SII aircraft
SW3	NONE
SH36	NONE

<u>Resulting Fleet Mix</u>

The following tables provide the final fleet mixes per route and runway for the Arrivals and Departures' simulations. Capacity constraints imply that the aircraft do not always follow the same routes or land on the same runway from one procedure to another – this difference is noticeable when comparing these tables.
These tables 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.

ARRIVALS

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-props (the second column indicating "None" in this case).

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%

Runway	Route/track	Aircraft type	Day	Evening	Night
		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%

Runway	Route/track	Aircraft type	Day	Evening	Night
		737800S	17%	0%	0%
		757RRS	17%	0%	0%
		A320-211S	17%	0%	0%
		A320-232S	17%	0%	0%
		A321-232S	17%	0%	0%

Table 3-4 Arrivals aircraft substitutions used

DEPARTURES

The table below provides the substitution mapping for Departures.

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-props (the second column indicating “None” in this case).

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%

Runway	Route/track	Aircraft type	Day	Evening	Night
		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%

Runway	Route/track	Aircraft type	Day	Evening	Night
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 3-5: Departure aircraft substitutions used

Runways – Route/track description

No track dispersion was used (RNAV ARRIVAL routes only).

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.

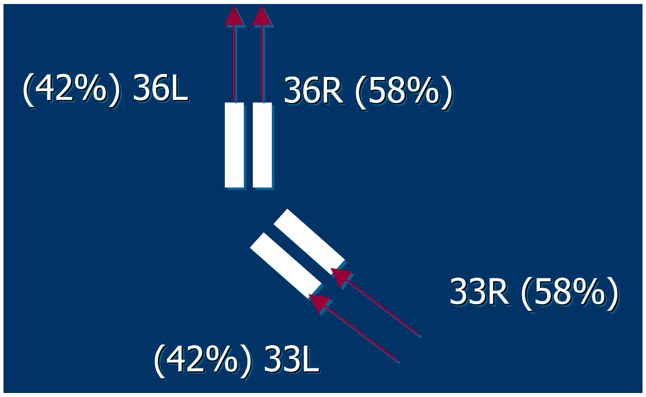


Figure 3-1 Runway configuration during operation

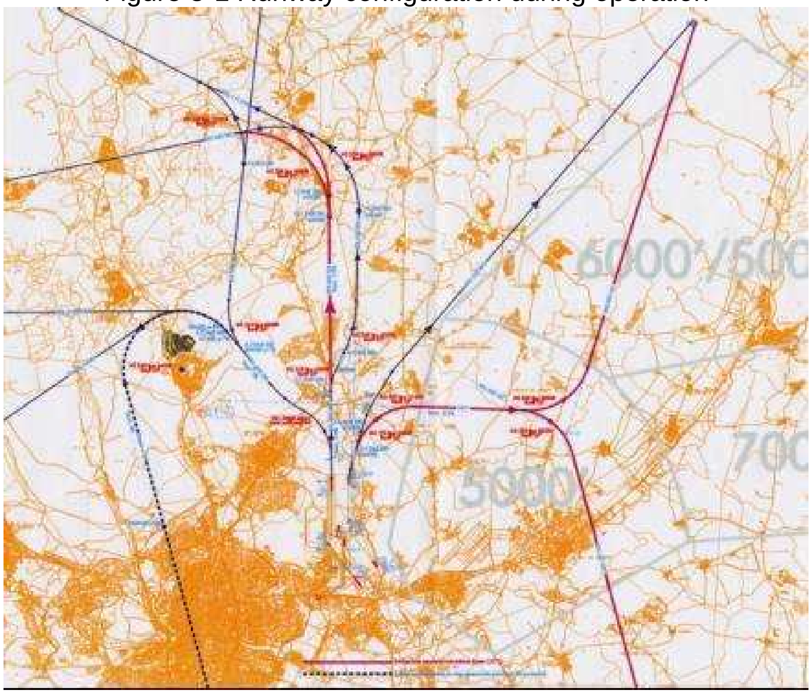


Figure 3-2 Departure Procedures (SIDs)

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

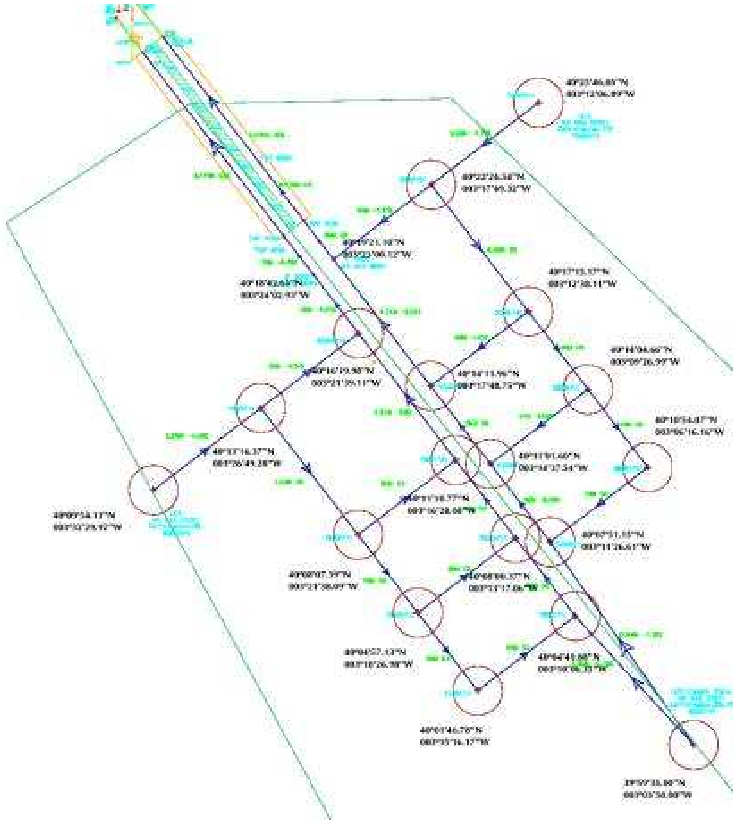


Figure 3-3 ARRIVAL PROCEDURES (STARS)

The above diagram 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.

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

Study/Case parameters description

Values specific for Madrid-Barajas Airport, Spain.

Airport elevation: 2000 ft	Temperature: 33ºC ⇒ 91.4 F
Pressure: 29.92 in-Hg	Humidity: 70%
Headwind: 8 kt	

Other Information

In particular, for the Madrid Barajas case, the standard approach procedure contained in the INM7.0 version was compared with the SII' s baseline procedure as well as with the rest of the SII NAAPs.

The additional standard arrival procedure (NAAP at 3000ft contained in INM 7.0) is comparable with current operational practice in Madrid's Barajas Airport [D3.1-2].

Sourdine II's baseline is in fact already a very challenging procedure from the noise impact point, added value is thus foreseen from this comparison (see section 0).

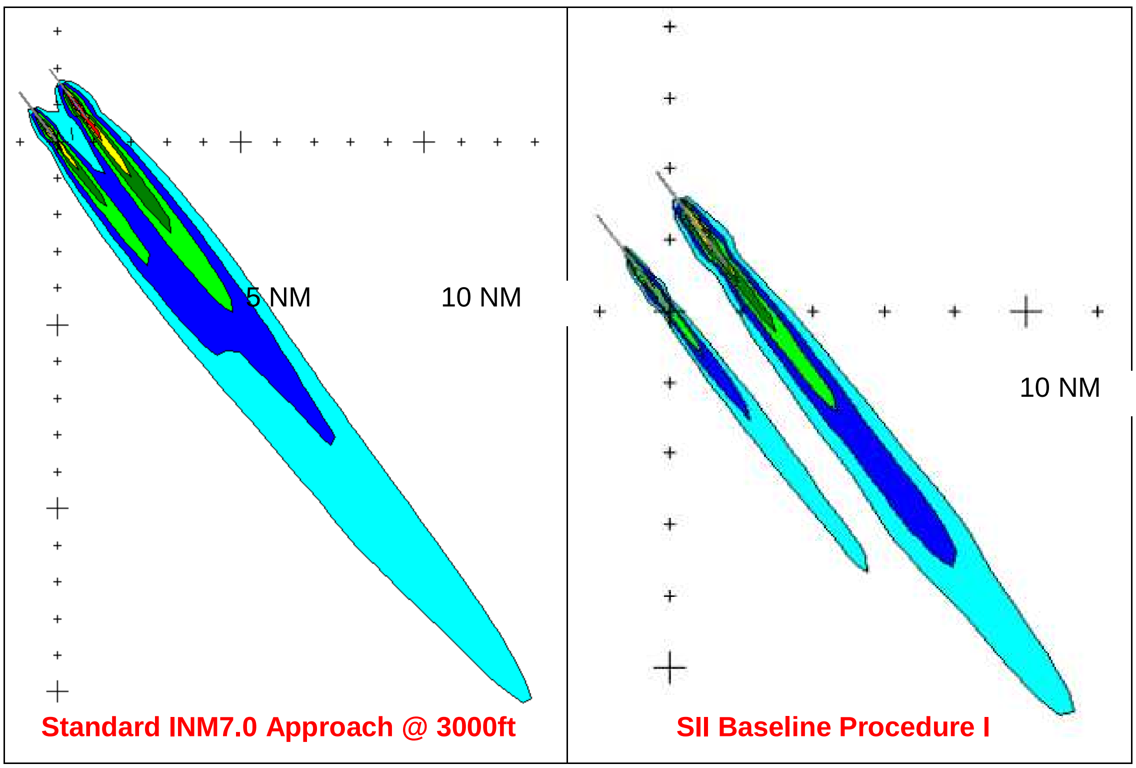


Figure 3-4 Standard Approach procedure vs. SII Baseline Procedure I

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.

<u>Noise Contours</u>

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

Arrivals Lden

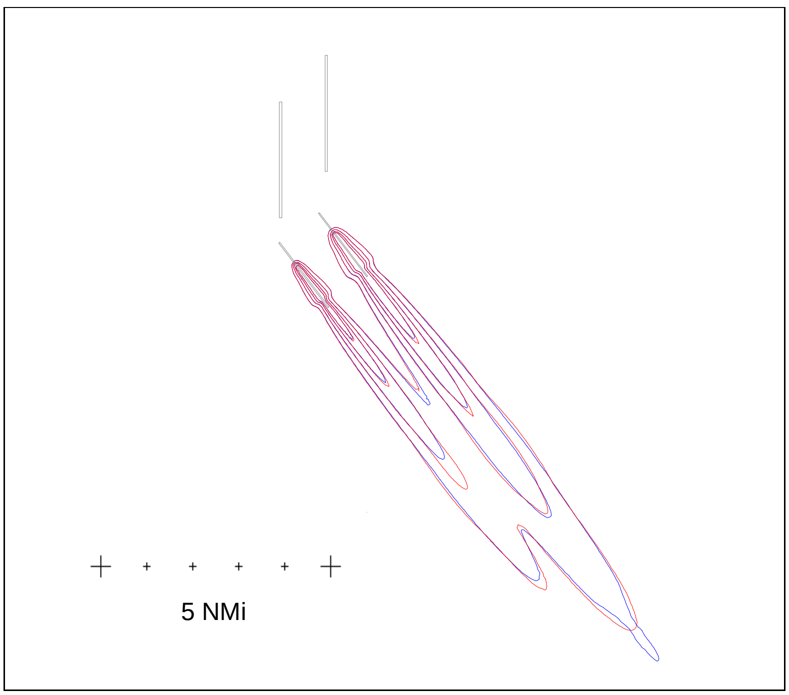


Figure 4-1 Arrivals Lden Baseline procedure (red) and Procedure II (blue) contours overlapping

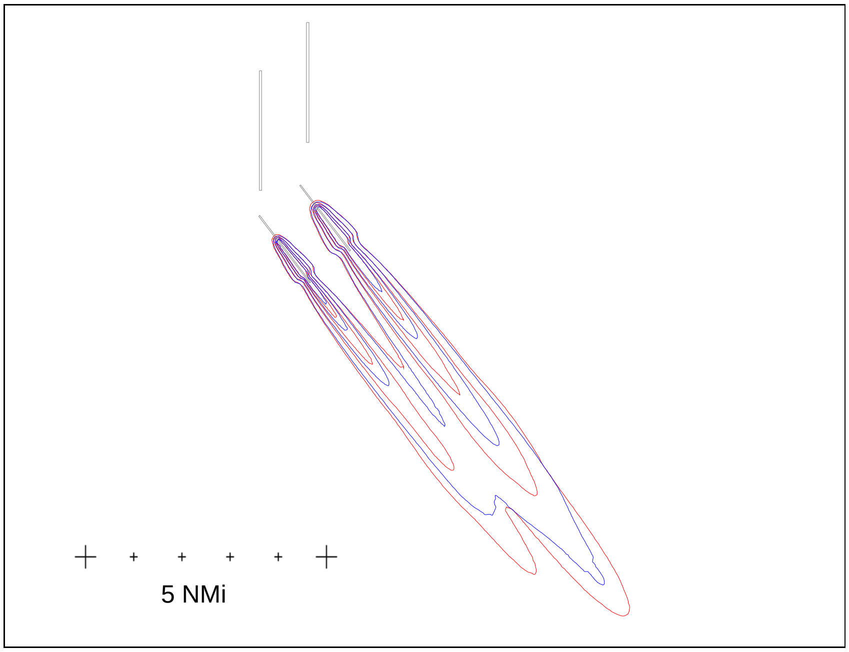


Figure 4-2 Arrivals Lden Baseline procedure (red) and Procedure III (blue) contours overlapping

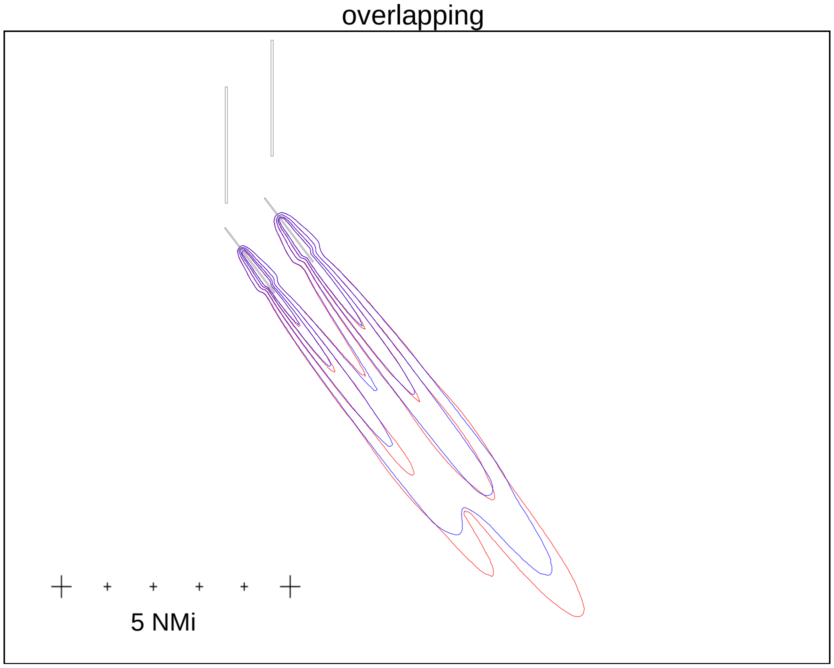


Figure 4-3 Arrivals Lden Baseline procedure (red) and Procedure IV (blue) contours overlapping

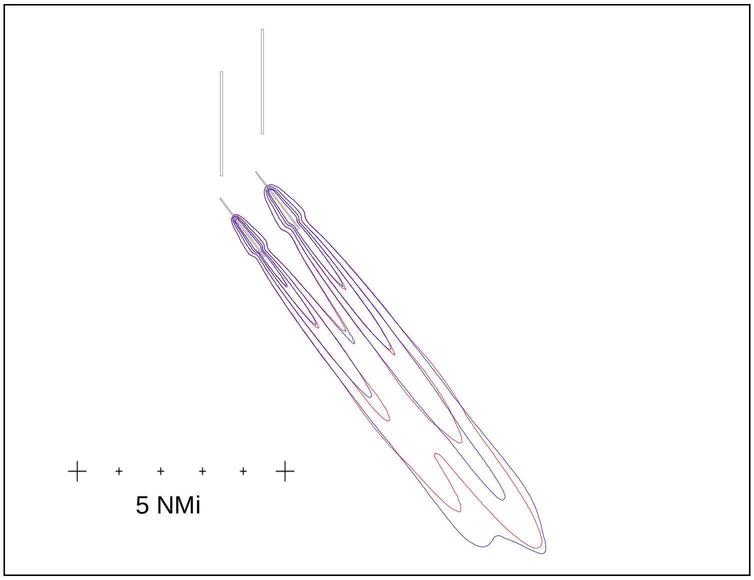


Figure 4-4 Arrivals Lden Baseline procedure (red) and Procedure V (blue) contours

Arrivals Lnight

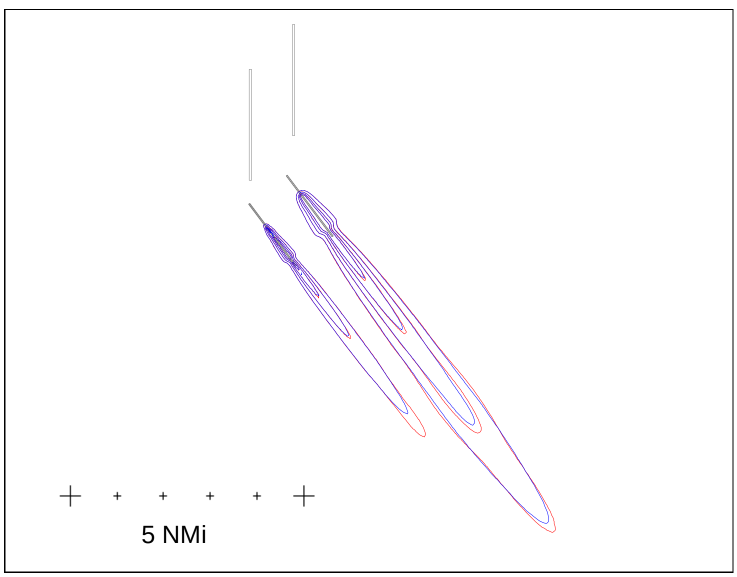


Figure 4-5 Arrivals Lnight Baseline procedure (red) and Procedure II (blue) contours

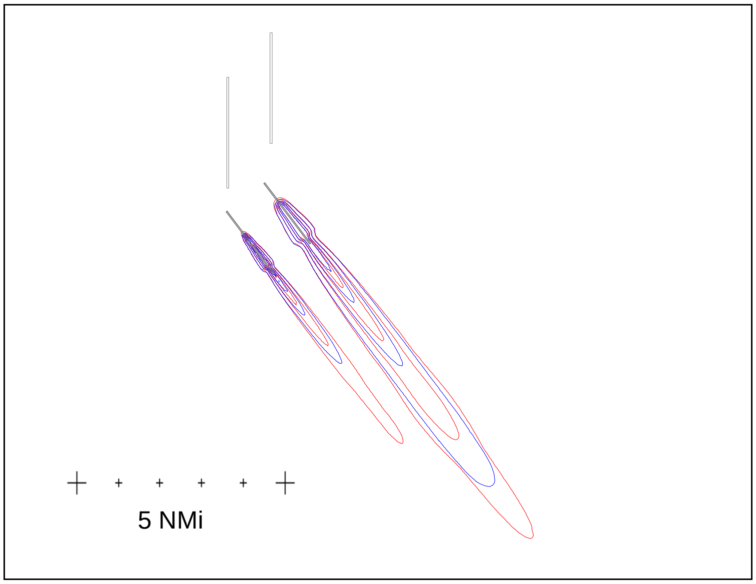


Figure 4-6 Arrivals Lnight Baseline procedure (red) and Procedure III (blue) contours

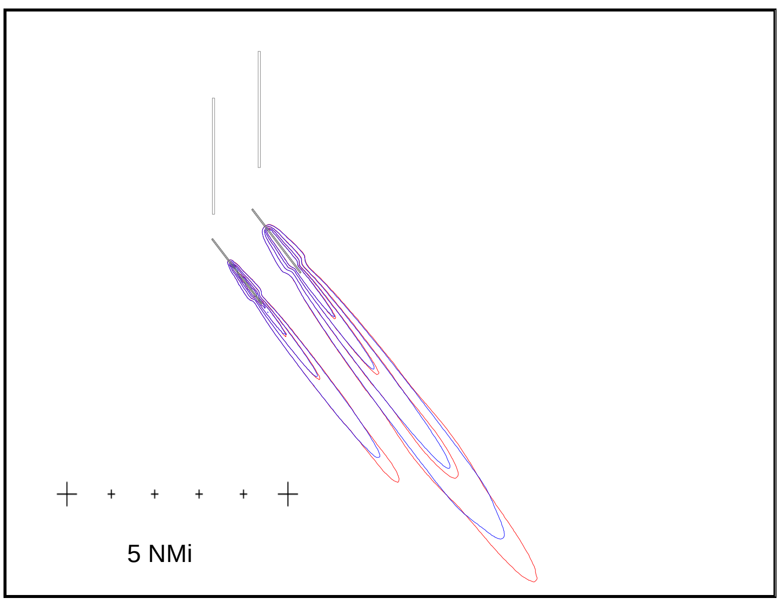


Figure 4-7 Arrivals Lnight Baseline procedure (red) and Procedure IV (blue) contours overlapping

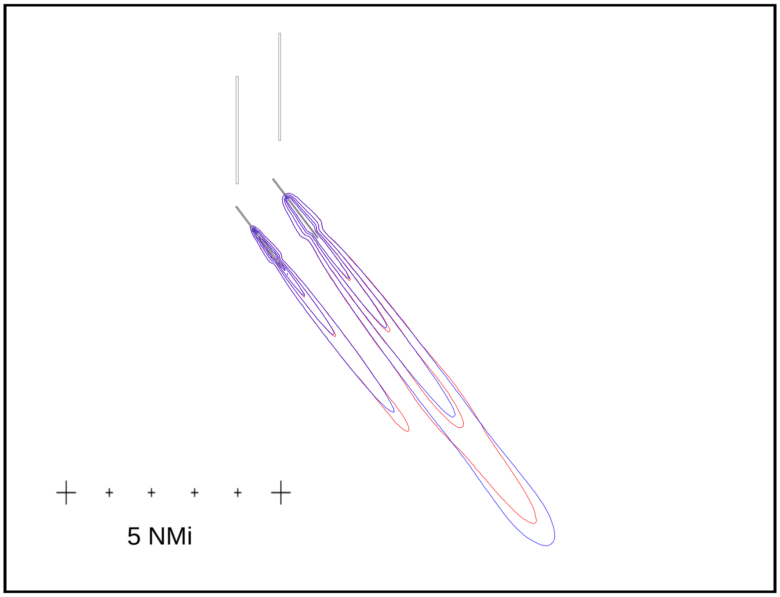


Figure 4-8 Arrivals Lden Baseline procedure (red) and Procedure V (blue) contours overlapping

Departures, Lden

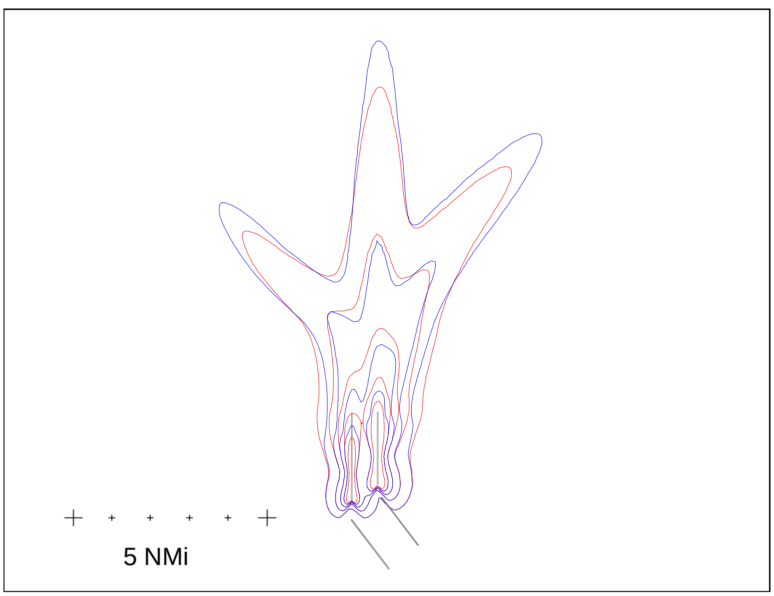


Figure 4-9 Departure Lden Baseline procedure (red) and close_in (blue) contours overlapping

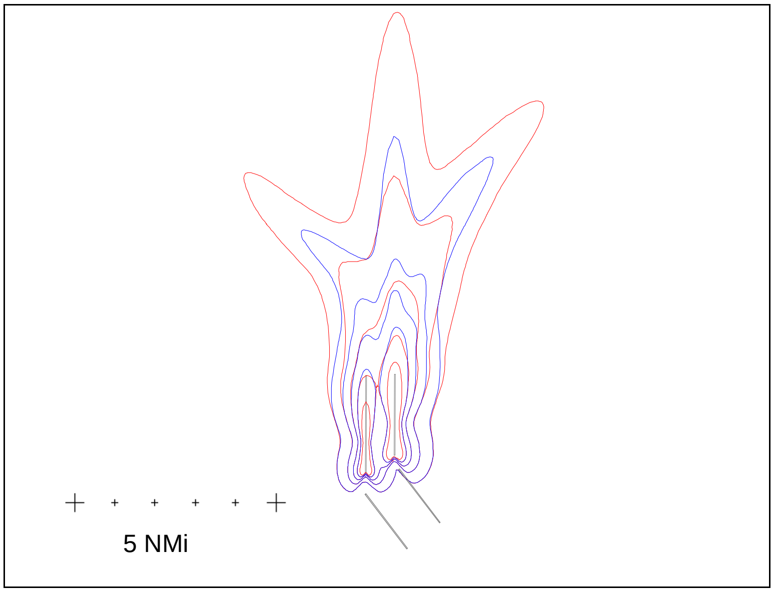


Figure 4-10 Departures Lden Baseline procedure (red) and Distant (blue) contours

Departures, Lnight

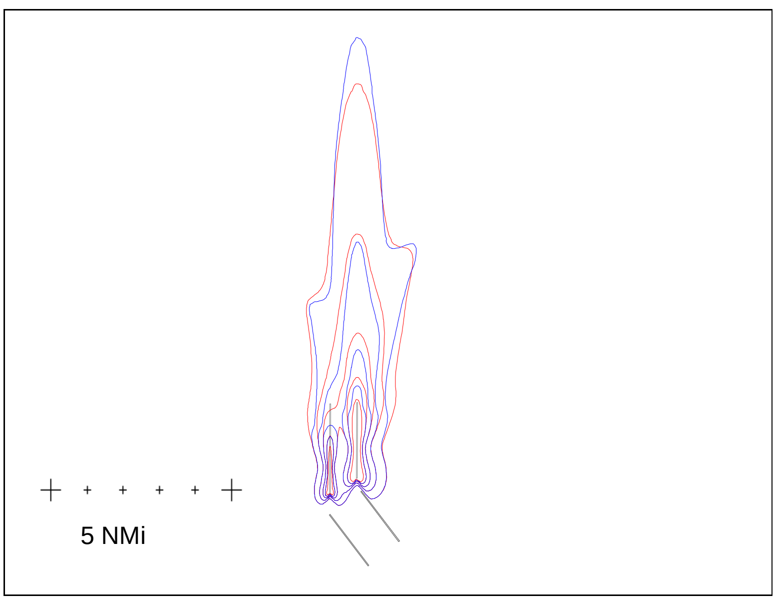


Figure 4-11 Departures Lnight Baseline procedure (red) and Close-in (blue) contours

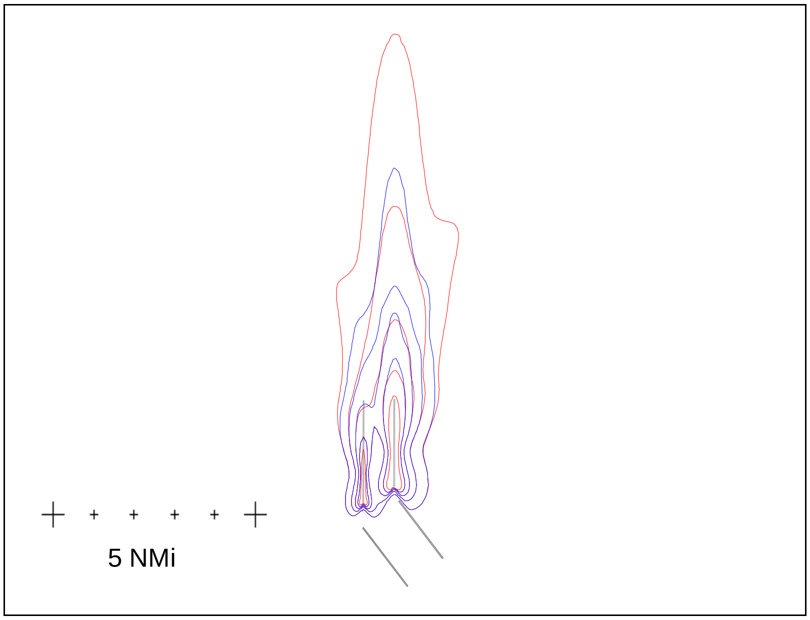


Figure 4-12 Departure Lnight Baseline procedure (red) and distant (blue) contours overlapping

Arrivals, additional baseline 3000 ft, Lden

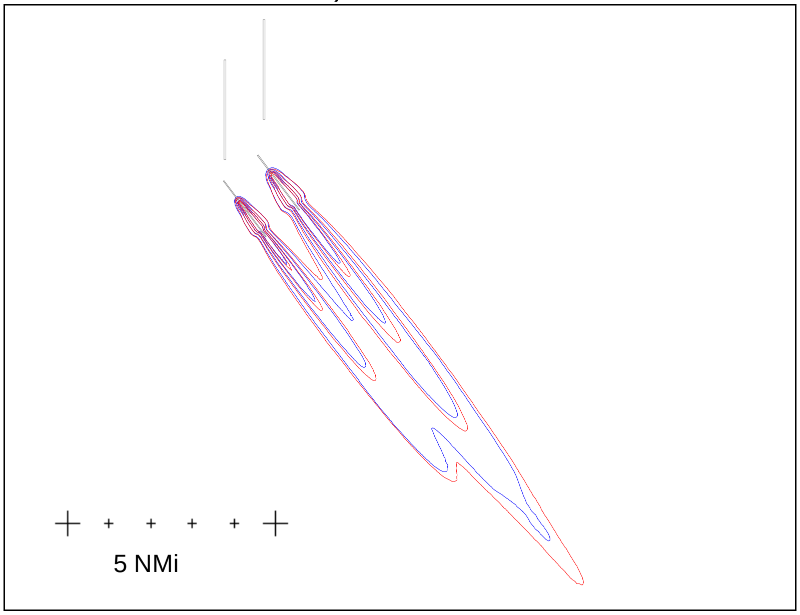


Figure 4-13 Arrivals Lden Baseline_3000ft procedure (red) and Procedure II (blue) contours

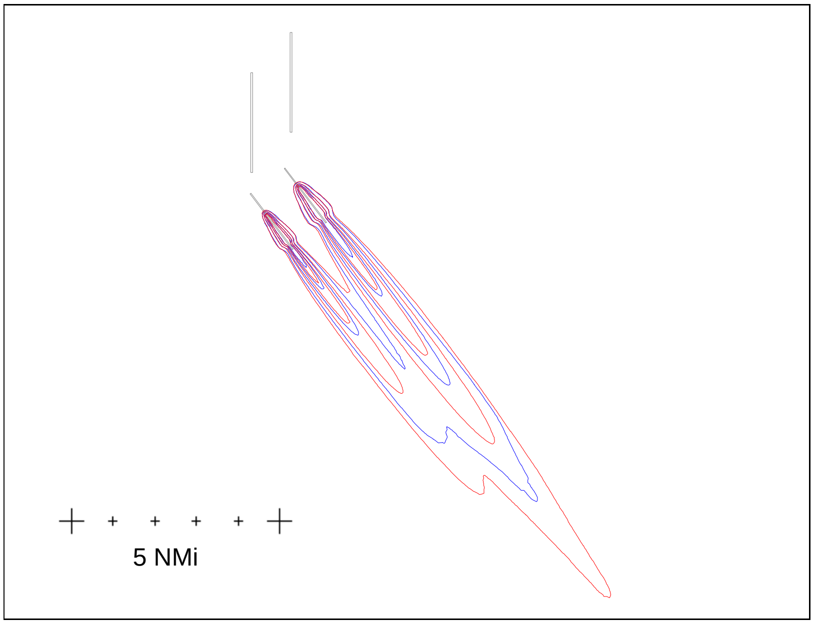


Figure 4-14 Arrivals Lden Baseline_3000ft procedure (red) and Procedure III (blue) contours

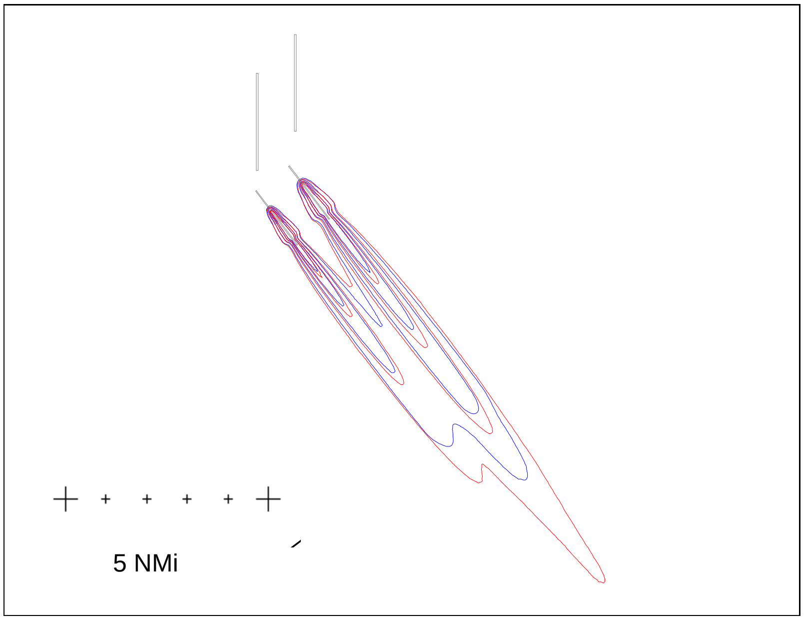


Figure 4-15 Arrivals Lden Baseline_3000ft procedure (red) and Procedure IV (blue) contours

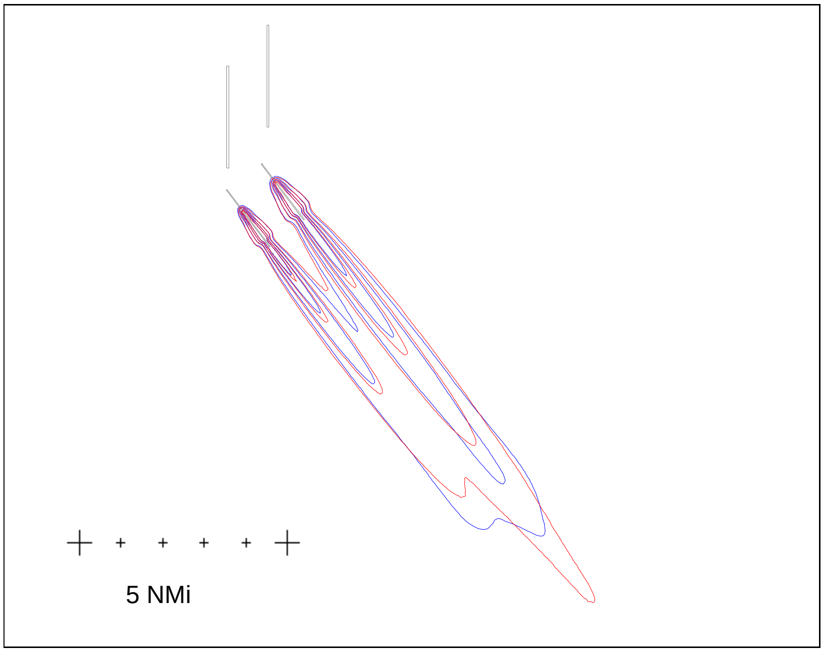


Figure 4-16 Arrivals Lden Baseline_3000ft procedure (red) and ProcedureV (blue) contours

Arrivals, additional baseline 3000 ft, Lnight

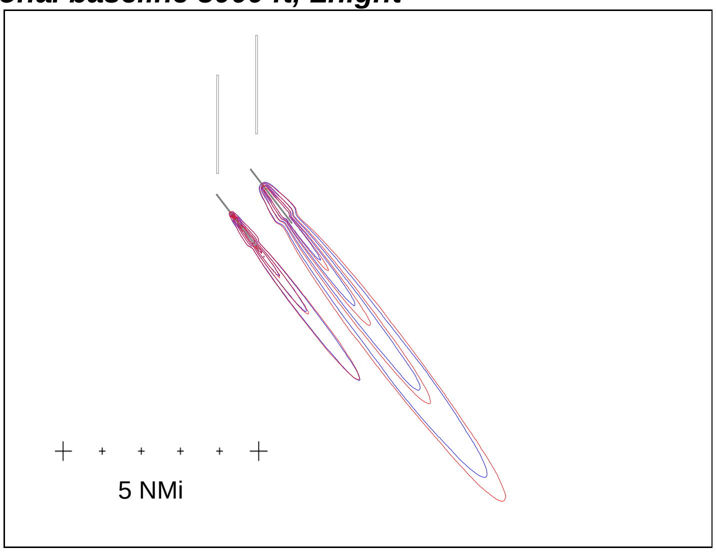


Figure 20: Arrivals Lnight Baseline_3000ft procedure (red) and Procedure II (blue) contours

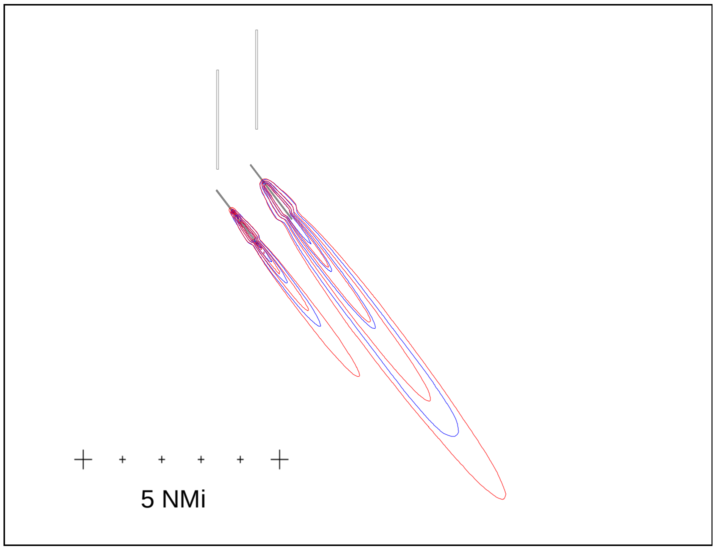


Figure 4-17: Arrivals Lnight Baseline_3000ft procedure (red) and Procedure III (blue) contours

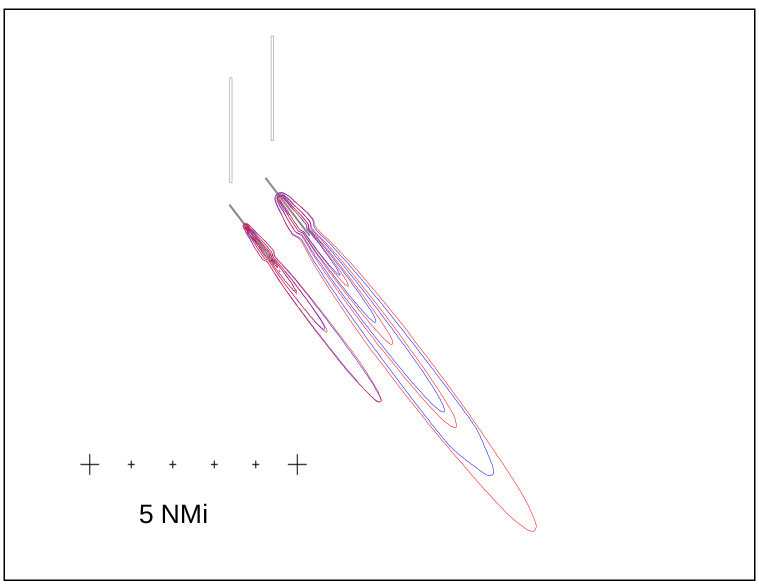


Figure 4-18: Arrivals Lnight Baseline_3000ft procedure (red) and Procedure IV (blue) contours

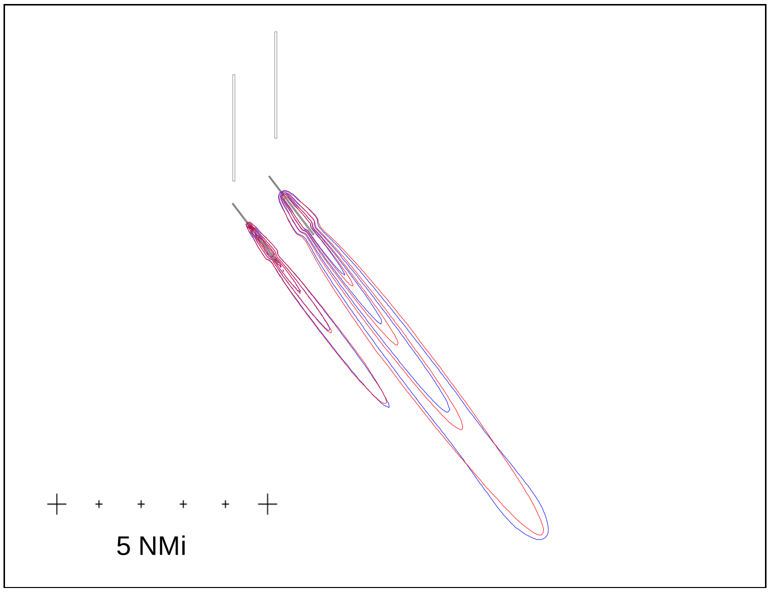


Figure 4-19 Arrivals Lnight Baseline_3000ft procedure (red) and Procedure V (blue) contours

Contour Area Tables

Lden values

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

	Contour area (Km^2)				
Contour level	Baseline	Proc 2	Proc 3	Proc 4	Proc 5
> 55 Lden	64,13	61,68	50,89	54,78	71,09
> 60 Lden	24,52	22,48	15,46	22,28	25,15
> 65 Lden	8,05	7,56	5,17	7,55	7,65
> 70 Lden	2,86	2,67	2,07	2,66	2,68
> 75 Lden	1,08	1,01	0,89	1,01	1,01

Table 4-1Arrival 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 (%)				
Contour level	Baseline	Proc 2	Proc 3	Proc 4	Proc 5
> 55 Lden		-4%	-21%	-15%	11%
> 60 Lden		-8%	-37%	-9%	3%
> 65 Lden		-6%	-36%	-6%	-5%
> 70 Lden		-7%	-28%	-7%	-6%
> 75 Lden		-6%	-18%	-6%	-6%

Table 4-2 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 (Km^2)				
Contour level	Baseline	Proc 2	Proc 3	Proc 4	Proc 5
> 50 Lnight	34,74	32,41	25,01	29,98	37,51
> 55 Lnight	13,53	12,22	7,85	12,09	12,21
> 60 Lnight	4,34	4,08	2,90	4,05	4,10
> 65 Lnight	1,51	1,43	1,16	1,42	1,44
> 70 Lnight	0,54	0,51	0,46	0,51	0,52

Table 4-3 Arrivals' Lnight Contour Area

Lnight values

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

	Contour area change (%)				
Contour level	Baseline	Proc 2	Proc 3	Proc 4	Proc 5
> 50 Lnight	Reference	-7%	-28%	-14%	8%
> 55 Lnight		-10%	-42%	-11%	-10%
> 60 Lnight		-6%	-33%	-7%	-6%
> 65 Lnight		-5%	-23%	-5%	-5%
> 70 Lnight		-4%	-15%	-4%	-4%

Table 4-4 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 (Km^2)		
Contour level	Baseline	Close in	Distant
> 55 Lden	143,71	156,87	83,07
> 60 Lden	59,87	52,84	38,40
> 65 Lden	26,18	20,68	23,49
> 70 Lden	11,20	8,53	11,61
> 75 Lden	4,67	4,09	4,83

Table 4-5 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.

	Contour area change (%)		
Contour level	Baseline	Close in	Distant
> 55 Lden		9%	-42%
> 60 Lden		-12%	-36%
> 65 Lden		-21%	-10%
> 70 Lden		-24%	4%
> 75 Lden		-12%	3%

Table 4-6 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 (Km^2)		
Contour level	Baseline	Close in	Distant
> 50 Lnight	85,87	84,08	49,99
> 55 Lnight	37,53	30,16	27,23
> 60 Lnight	15,36	11,31	15,13
> 65 Lnight	6,21	5,30	6,53
> 70 Lnight	2,75	2,53	2,83

Table 4-7 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 (%)		
Contour level	Baseline	Close in	Distant
> 50 Lnight	Reference	-2%	-42%
> 55 Lnight		-20%	-27%
> 60 Lnight		-26%	-1%
> 65 Lnight		-15%	5%
> 70 Lnight		-8%	3%

Table 4-8 Departure Lnight Percent Variation of each procedure contour area vs baseline procedures

Bar-charts

Arrivals

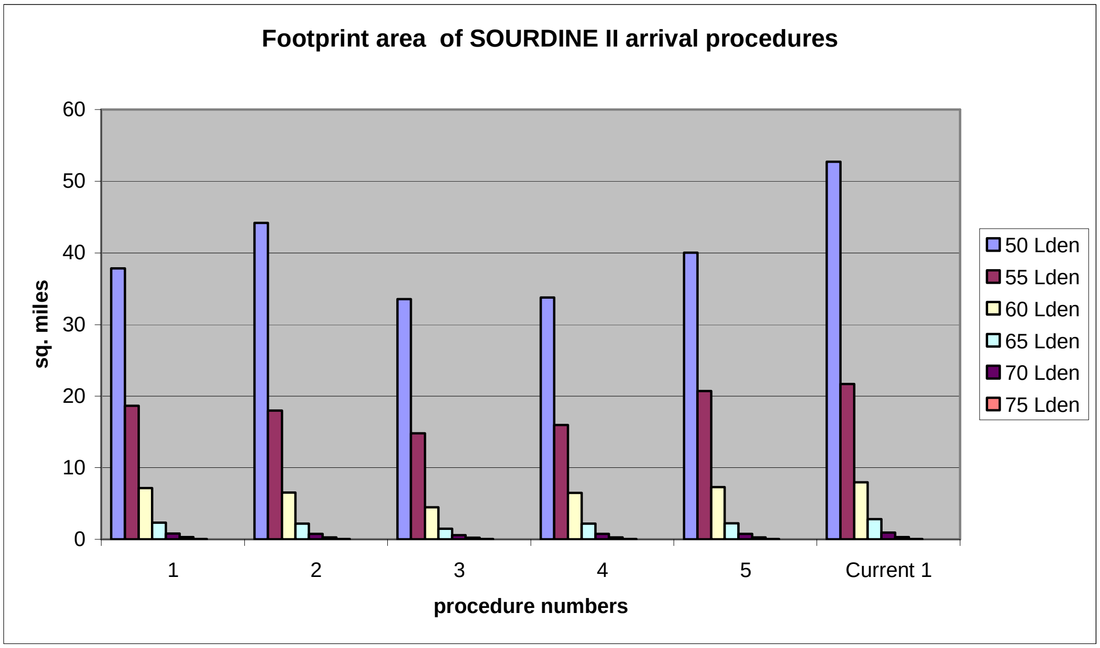


Figure 4-20 Comparative footprint area of SII arrival procedures

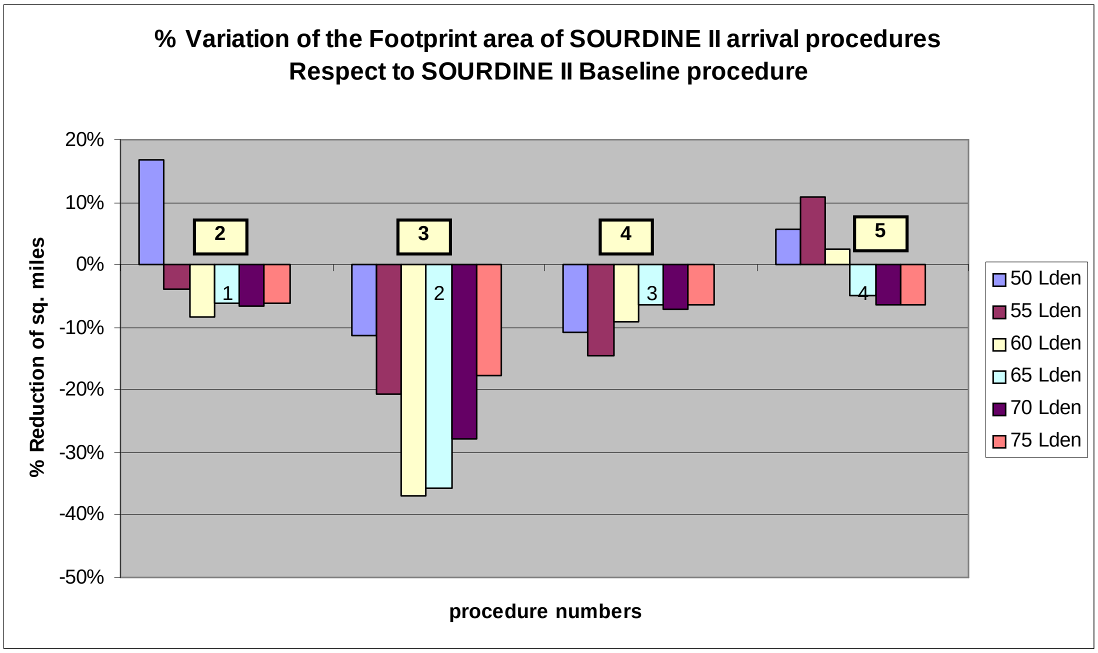


Figure 4-21 Arrivals Lden relative contour area bar charts (SII Baseline)

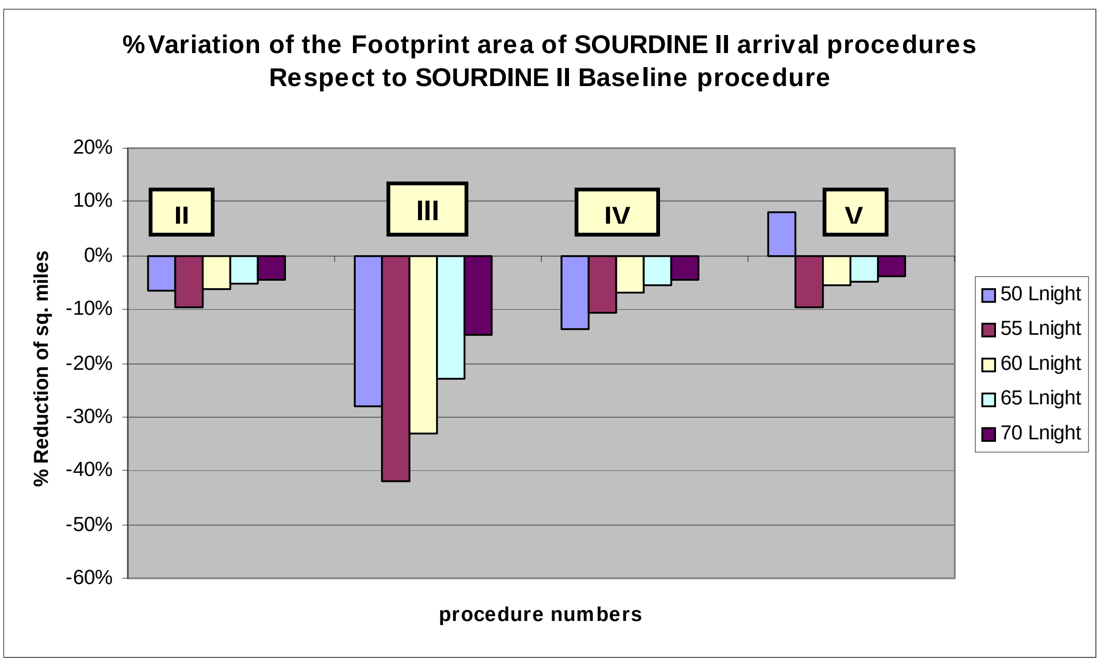


Figure 4-22 Arrivals Lnight contour area bar charts (SII Baseline

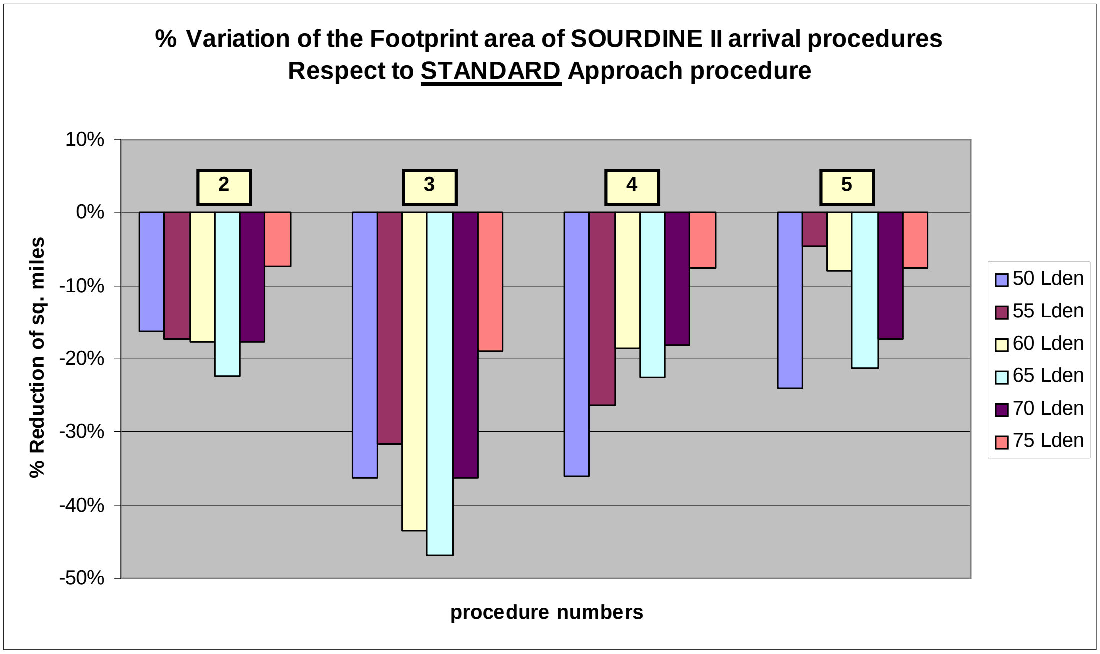


Figure 4-23 Arrivals Lden relative contour area bar charts (Standard Approach)

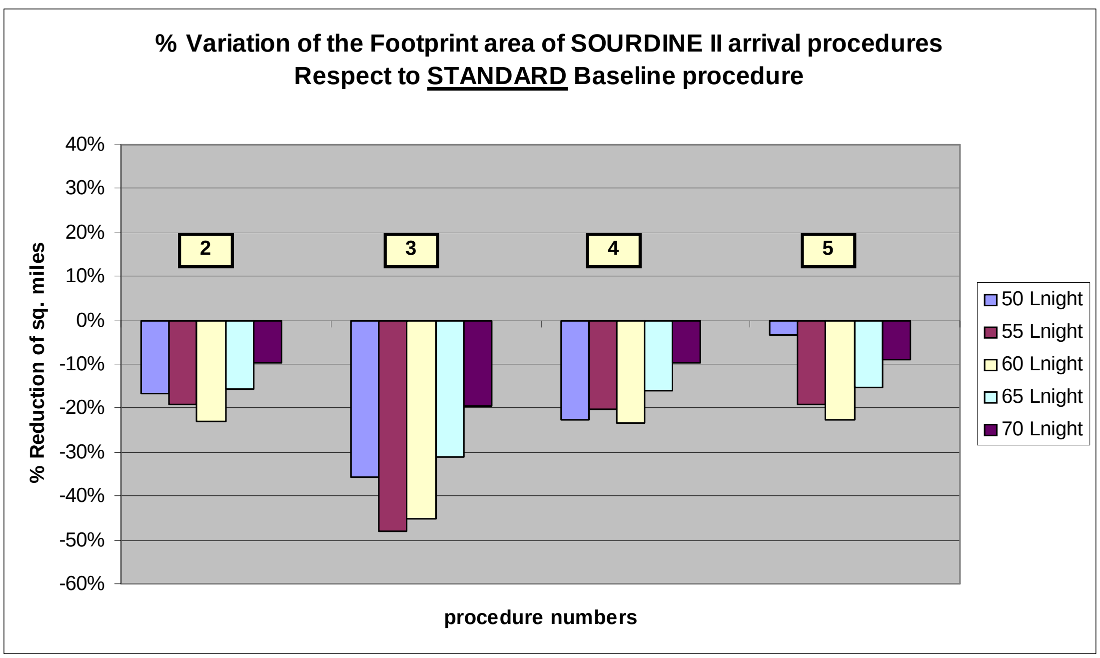


Figure 4-24 Arrivals Lnight contour area bar charts (Standard Approach)

Departures

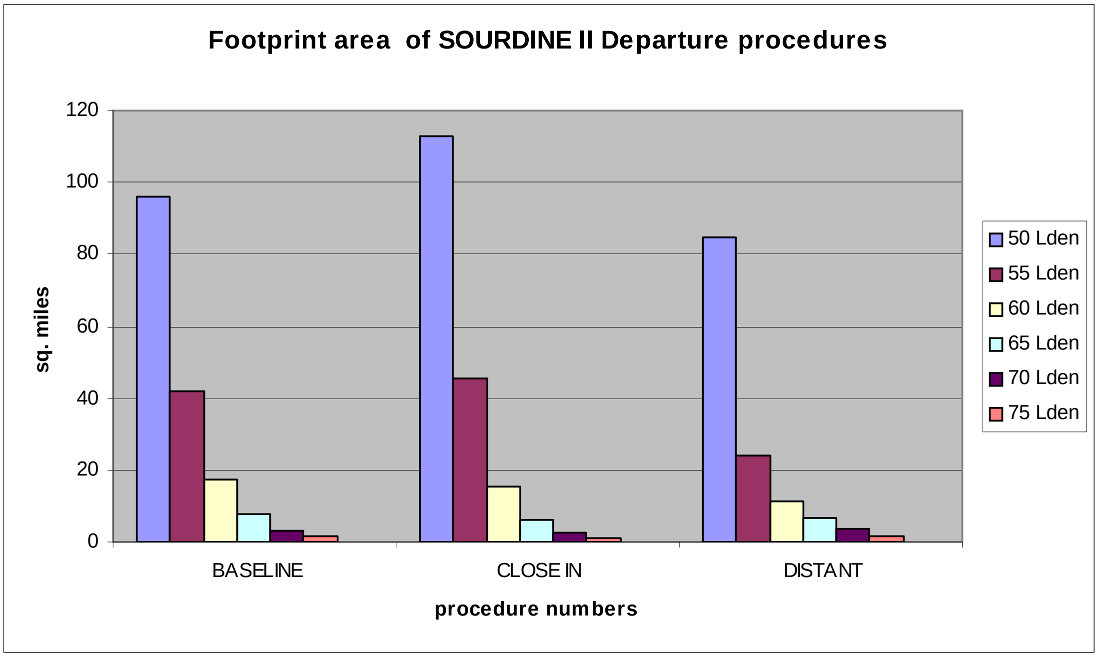


Figure 4-25 Departures Lden contour area bar charts

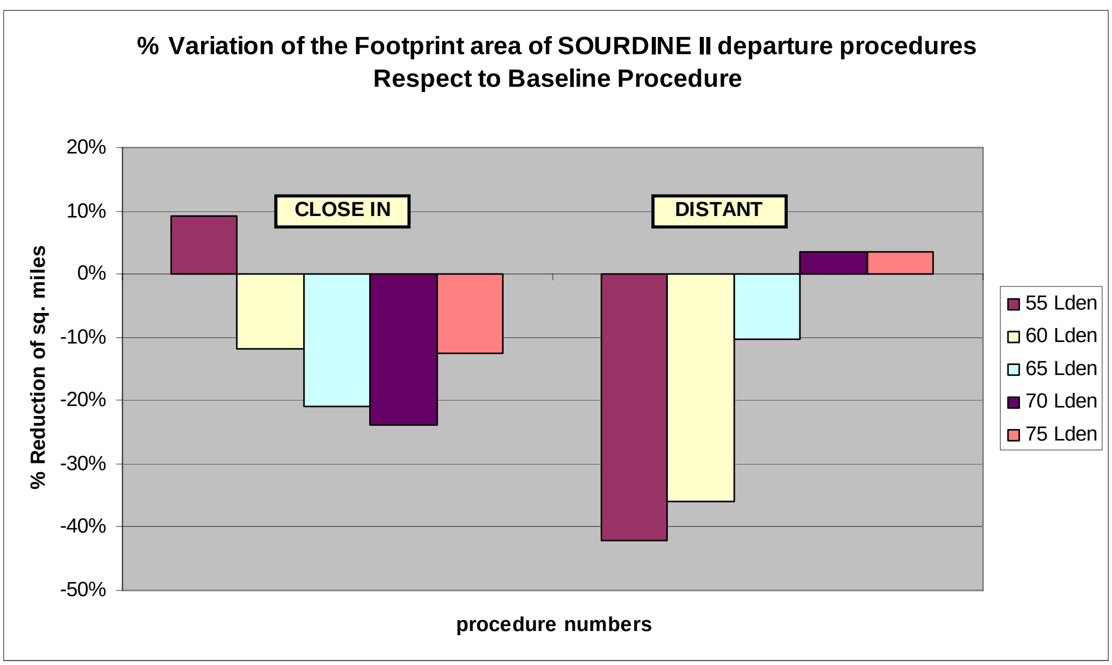


Figure 4-26 Departures Lden relative contour area bar charts

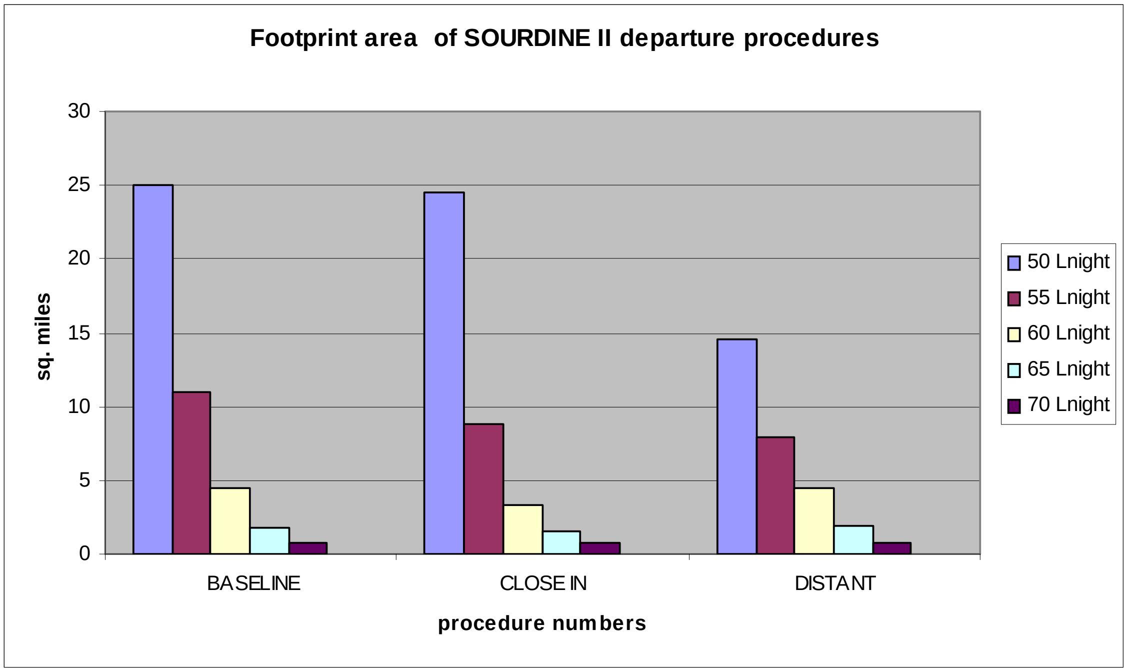


Figure 4-27 Departures Lnight contour area bar charts Figure

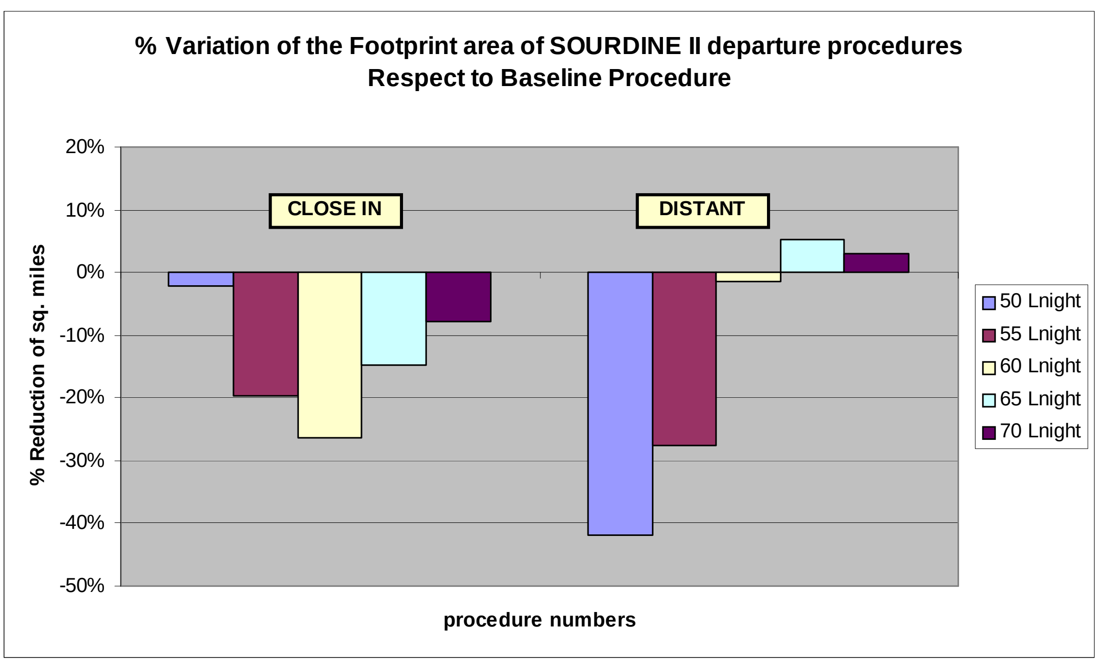


Figure 4-28 Departures Lnight relative contour area bar charts

5. Analysis of noise results

The noise contours of the Sourdine procedures have been compared with those produced by their respective baseline procedures. The analysis of the differences is given in this section.

Lden, Arrivals

5.1.1. Procedure II (Figure 4-1)

The contours for procedure II are slightly better than the baseline but otherwise are the same. The benefits coming from a higher altitude between 9NM and 17NM are below the 55db value. 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 there is a slight thinning between 5 and 3.5 NM on RWY 36L.

5.1.2. Procedure III (Figure 4-2)

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. The noise level difference is also increased by lower thrust settings and a cleaner configuration.

5.1.3. Procedure IV (Figure 4-3)

As The same as 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 height of the aircraft before approx. 6.5NM and reduces the noise correspondingly. And again the unbalanced traffic for RWY 33L gives an added benefit on the 60db between 3.5 and 5 NM.

5.1.4. Procedure V (Figure 3-1)

The 55dB contour for procedure V is approx. 2NM shorter and fatter than that of the baseline, the contours melt into one, making no difference between the RWYs, whereas the 60dB contour is longer and thinner, showing the unbalanced traffic distribution effect encountered in all the previous procedures. The altitude profiles are the same after 10NM from the runway threshold which explains the shortening of the 55dB contour. So the rest of the changes probably result from the different aircraft thrusts and configurations necessary for maintaining speed over the continuous 3º descent in procedure V.

Lden, Departures

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.

5.1.5. Close-in

Benefits can be seen up to 2.5-3NM from the RWY threshold, the contours are smaller up to the 60db contour where they coincide. From there onwards the SII Close-in procedure makes more noise than the baseline. This is the desired result aimed for in a close-in procedure: benefit the populated areas nearest to the airport.

The differences compared to the baseline relate to the SII's lower thrust which delivers benefits on the first 3NM, benefits which are later dissipated by flying at a lower altitude.

5.1.6. Distant

For this procedure, we can observe the benefits beginning from the 65db contour down to the 55db (the last being very good), the above comprised between 2 and 6 NM from the RWY threshold. The 70db contour is slightly longer while 75db coincide. The benefits come from a lower thrust value, lower also than the close-in procedure, and an earlier change to clean configuration. Compared to the close-in procedure the earlier gain in altitude should be noticed, which enhances the noise abatement effect.

The procedure delivers benefits as shown by its definition as a distant procedure.

Lnight, Arrivals

The Lnight contours for procedures II, IV and V 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 (see procedure V) due to differences in thrust and configuration, as well as the cumulative duration effect which changes with aircraft speed. In procedure IV 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, as is the case for the Lden values, shows a marked reduction in contour size. Again this is almost all due to the height difference between the two procedures.

Lnight, Departures

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

6. Conclusion

In conclusion, the sizes of the contours are generally a function of the altitude profiles, which is the most reflected mitigation by the INM software for Arrivals, while for Departures the level of thrust is the predominant noise mitigating component.

Arrivals

In general the main mitigating parameter is altitude or distance from the ground:

- All SII procedures reduce the Noise Contour Areas with respect to the Baseline scenario.
- Procedure III shows the biggest reduction of Noise contour area around Madrid-Barajas Airport this is again mainly coming from the increased angle (ILS glidepath) of descent at lower altitudes.
  - Again making a list from best to less best we have:

    PROC III > PROC IV > PROC V » PROC II

The study has also shown that this reduction in noise is especially significant during the night period.

- Applied to the study on affected population all the procedures do imply a significant reduction of affected population, specially over 65 dB.
  - PROC III > PROC II > PROC IV » PROC V

For Madrid Barajas the different traffic volumes to the RWYs are such that differences can be appreciated between the approaches to the two runways . The contour for the lowest noise level considered (55 dB) extends to approx. 10 NM from the runway threshold, and this contour's size is, therefore reduced accordingly at its extremity. If traffic volumes were less, this effect would not be noticeable. Thus is why the two lists above are slightly different (Proc.II instead of Proc IV and viceversa).

It must be reminded that the Baseline Procedure (Proc. I) is very challenging from the noise impact point of view.

Departures

These procedures since their name are very airport population distribution dependant (close.in/distant), lower thrust levels are the main noise mitigation solution.

Close-in Benefits can be seen up to 2.5-3NM from the RWY threshold.

The differences compared to the baseline relate to the SII's lower thrust which delivers benefits on the first 3NM, benefits which are later dissipated by flying at a lower altitude.

<u>Distant</u>

This procedure, delivers benefits between 2 and 6 NM from the RWY threshold. The benefits come from a lower thrust value, lower also than the close-in procedure, and an earlier change to clean configuration.

ANNEX A – AFFECTED POPULATION

Thanks to the information available at Madrid Barajas Airport on population distribution in the surrounding areas a preliminary study on the number of population affected by noise and the subsequent benefits of the SII was conducted.

This study does not try to obtain realistic figures about the number of population affected by airport operations. It should be understood always from a comparative point of view between a baseline scenario and several Sourdine II scenarios that share the same hypothesis and assumptions. Obtaining a refined approximation of the number of population affected by the future activity of Madrid-Barajas airport is not the goal of this study and all the figures showed in this document shall not be used for any purpose different from this theoretical approach.

A1 – Methodology and Assumption

The variation in population impacted by these procedures was studied for Madrid –Barajas using the following assumptions:

- We have assumed an Homogeneous distribution of population in each populated area.
- Statistical data obtained from official sources: census 2001.
- Overlap Noise contours over the map of the surrounding populated areas
- Determine the part of each populated area inside the different noise contours.
- Calculate population inside 50dB, 55dB, 60dB, 65dB, 70dB, 75dB, 80dB, 85dB and 90 dB.

Following the current Methodology applied in Madrid-Barajas airport we have also considered Barajas' (expansion), including:

1. Isolation Acoustic Plan:
   - LAeq > 65dB day
   - LAeq > 55dB night
   - More than 50.000 received funding from the Plan
2. Adaptation to European Union legislation Plan
   - Lden and Lnight:
   - Lden > 55dB day
   - Lnight > 50dB night

Populated areas considered

In Figure 0-1 and Figure 0-2 the graphical distribution of the populated areas, with their respective names, around the airport identified under the Approach and Departure procedures i.e.:

- Departures: San Sebastián de los Reyes, Fuente el Saz, Prado Norte, Tres Cantos, Soto, etc..
- Arrivals: Torrejón, Coslada, San Fernando de Henares and Loeches

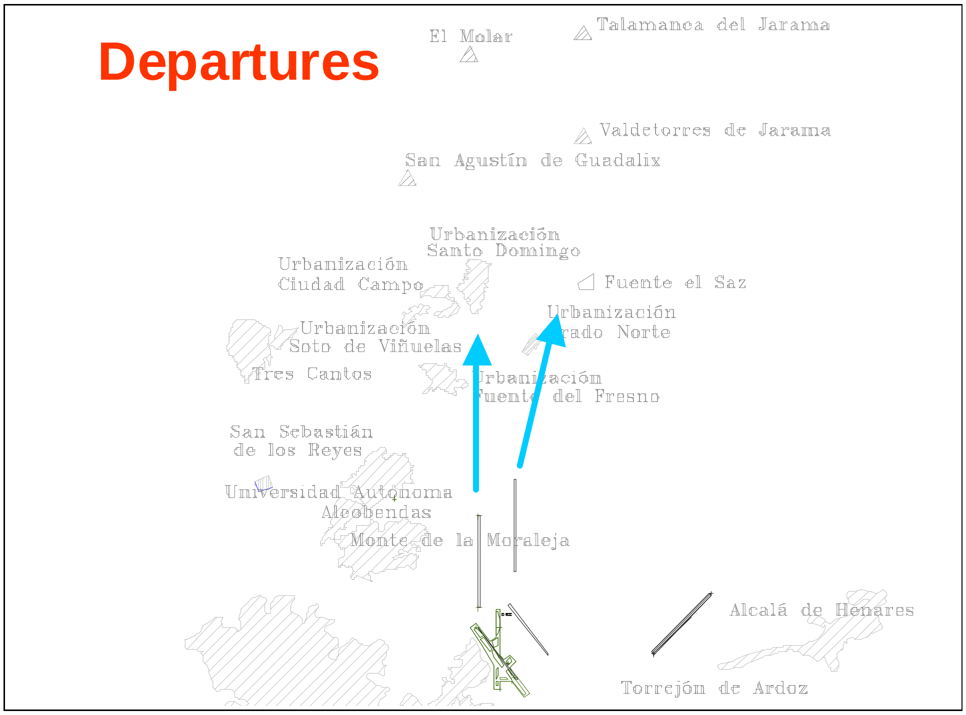


Figure 0-1 Affected population on Departures (areas, towns, etc..)

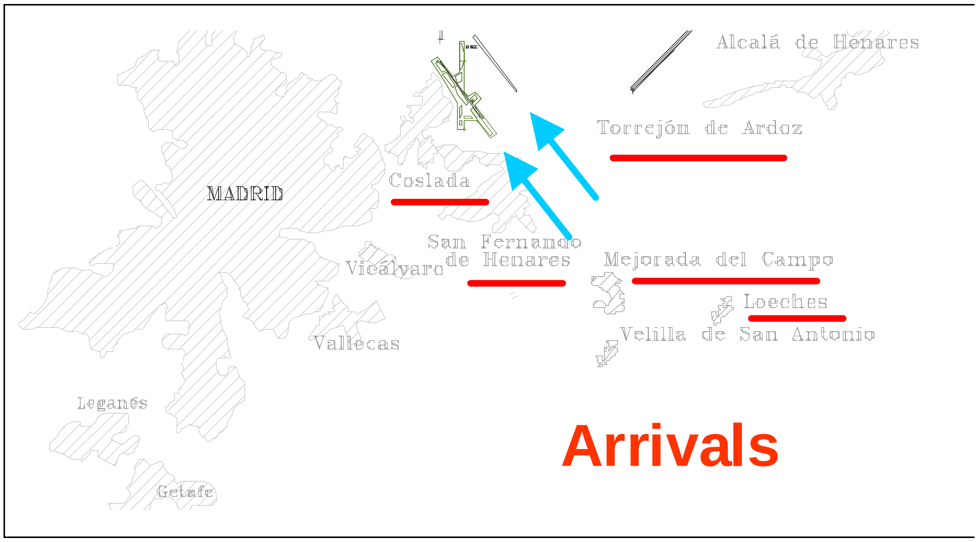


Figure 0-2 Affected population on Arrivals (areas, towns, etc..)

A2 – Population

DEPARTURE PROCEDURES (CLOSE-IN & DISTANT)

LDEN

Centre	Pop. Nº.	Pop. Nº.	Pop. Nº.
El Molar	Baseline	Close in	Distant
>50 Lden	2607	4275	0
>55 Lden	0	0	0
> 60 Lden	0	0	0

Fuente el Saz	Baseline	Close in	Distant
>50 Lden	4878	4878	4861
>55 Lden	160	3055	0
> 60 Lden	0	0	0

Monte de la Moraleja	Baseline	Close in	Distant
>50 Lden	37	0	0
>55 Lden	0	0	0

> 60 Lden	0	0	0

Urb. Ciudalcampo	Baseline	Close in	Distant
>50 Lden	201	315	0
>55 Lden	0	0	0
> 60 Lden	0	0	0

Urb. Fuente del Fresno	Baseline	Close in	Distant
>50 Lden	1379	1379	1344
>55 Lden	1246	1198	96
> 60 Lden	0	0	0

Urb. Prado Norte	Baseline	Close in	Distant
>50 Lden	423	423	423
>55 Lden	423	423	0
> 60 Lden	0	0	0

Urb. Santo Domingo	Baseline	Close in	Distant
>50 Lden	2443	2465	988
>55 Lden	554	617	0
> 60 Lden	0	0	0

General Results

Total	Baseline	Close in	Distant
>50 Lden	11968	13735	7617
>55 Lden	2382	5293	96
>60 Lden	0	0	0

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

DEPARTURE PROCEDURES (CLOSE-IN & DISTANT)

LNIGHT

Centre	Pop. Nº.	Pop. Nº.	Pop. Nº.
El Molar	Baseline	Close in	Distant
>50 Lnight	0	0	0
>55 Lnight	0	0	0

Fuente el Saz	Baseline	Close in	Distant
>50 Lnight	0	0	0
>55 Lnight	0	0	0

Monte de la Moraleja	Baseline	Close in	Distant
>50 Lnight	0	0	0
>55 Lnight	0	0	0

Urb. Ciudalcampo	Baseline	Close in	Distant
>50 Lnight	0	0	0
>55 Lnight	0	0	0

Urb. Fuente del Fresno	Baseline	Close in	Distant
>50 Lnight	0	0	0
>55 Lnight	0	0	0

Urb. Prado Norte	Baseline	Close in	Distant
>50 Lnight	318	232	0
>55 Lnight	0	0	0

Urb. Santo Domingo	Baseline	Close in	Distant
>50 Lnight	226	344	0
>55 Lnight	0	0	0

General Results

Total	Baseline	Close in	Distant
>50 Lnight	545	576	0
>55 Lnight	0	0	0

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

SII Arrival Procedures

LDEN

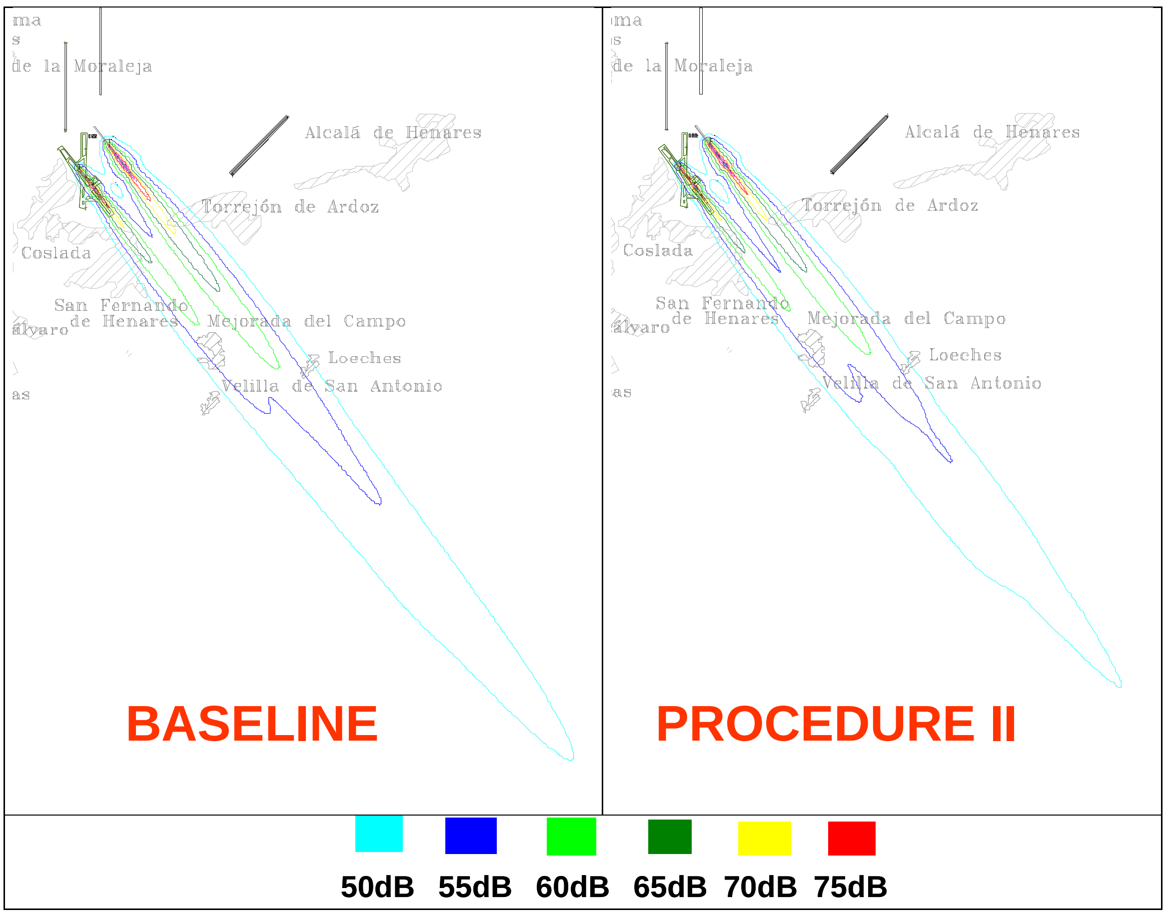


Figure 0-3 Overlap of noise contour on population distribution map (Proc.II).

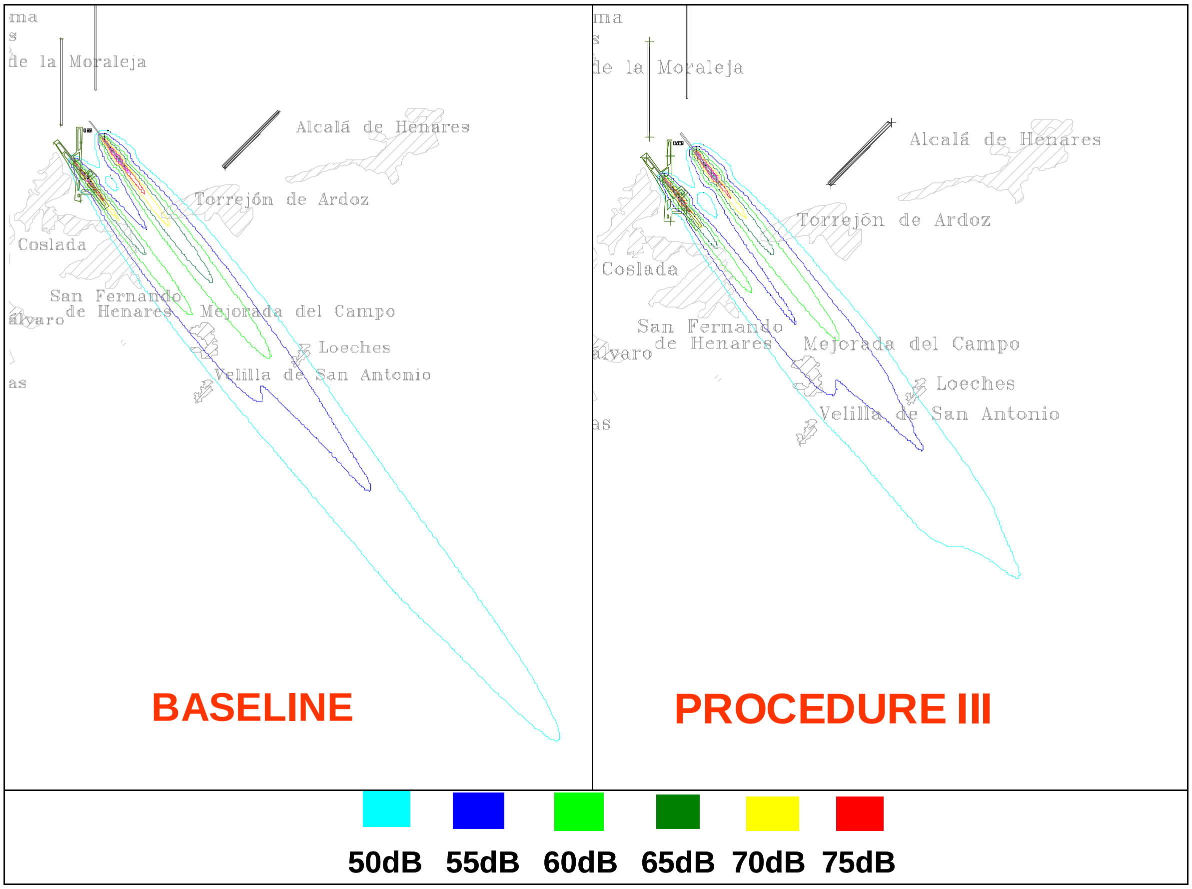


Figure 0-4 Overlap of noise contour on population distribution map (Proc.III)

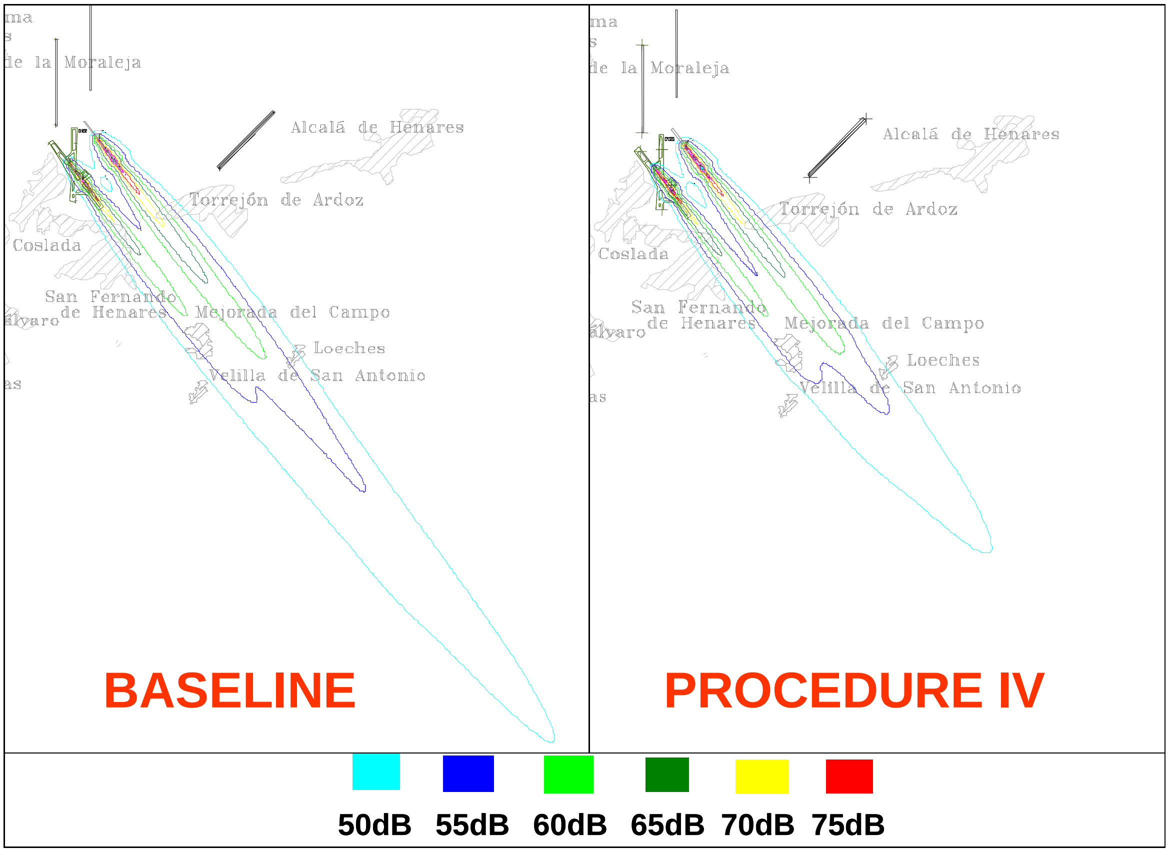


Figure 0-5 Overlap of noise contour on population distribution map (Proc. IV)

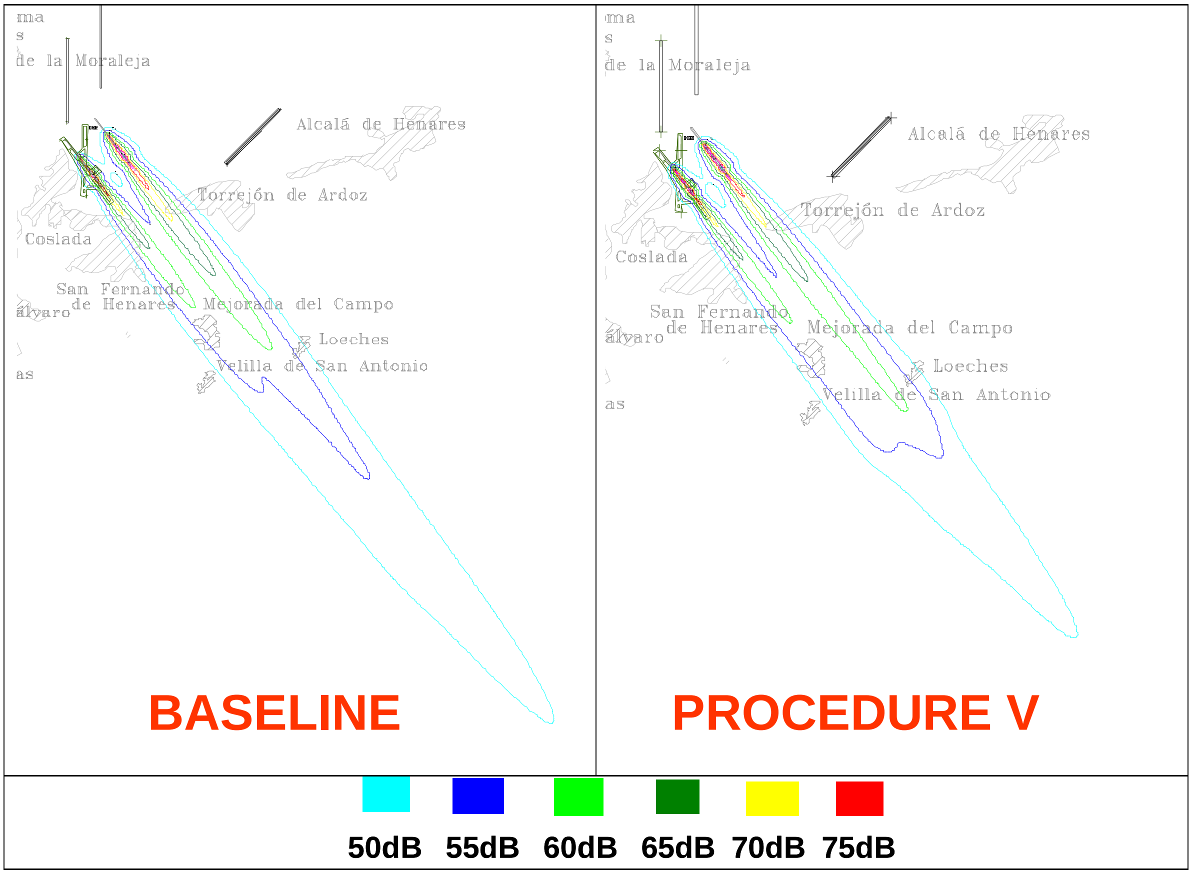


Figure 0-6 Overlap of noise contour on population distribution map (Proc. V)

Torrejón	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden	16388	14413	13895	13891	13892	13877
>55 Lden	9798	8505	8211	8014	8227	8219
>60 Lden	5655	4801	4606	4180	4637	4609
>65 Lden	2744	2245	2139	1475	2174	2137
>70 Lden	787	0	0	0	3	0
>75 Lden	0	0	0	0	0	0

Coslada	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden	24151	22794	22347	22165	22191	22403
>55 Lden	18344	16757	16354	15671	16108	16409

Coslada	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>60 Lden	12624	11422	11076	9954	10904	11153
>65 Lden	7894	6914	6447	401	6301	6481
>70 Lden	0	0	0	0	0	0

San Fernando de Henares	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden	7855	6415	6125	5798	5970	6174
>55 Lden	3590	2973	2795	2478	2727	2793
>60 Lden	1494	1156	1061	654	1008	1066
>65 Lden	389	285	243	0	224	241
>70 Lden	0	0	0	0	0	0

Mejorada del Campo	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden	17089	17089	16974	16910	16927	16986
>55 Lden	14009	13876	13722	11303	13691	13830
>60 Lden	0	1	0	0	0	0
>65 Lden	0	0	0	0	0	0

Loeches	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden	1956	1536	1280	1225	1093	2272
>55 Lden	238	59	0	0	0	628
>60 Lden	0	0	0	0	0	0

Total	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden	67440	62247	60621	59990	60072	61711

Total	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>55 Lden	45979	42171	41082	37466	40753	41879
>60 Lden	19773	17381	16744	14789	16548	16828
>65 Lden	11028	9444	8830	1877	8700	8858
>70 Lden	787	0	0	0	3	1
>75 Lden	0	0	0	0	0	0

Variation in percentage against the Standard Approach

% Vs Standard Baseline	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lden	-10%	-11%	-11%	-8%
>55 Lden	-11%	-19%	-11%	-9%
>60 Lden	-15%	-25%	-16%	-15%
>65 Lden	-20%	-83%	-21%	-20%
>70 Lden	-100%	-100%	-100%	-100%

Variation in percentage against the SII Baseline Approach (Proc. I)

% 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%

LNIGHT

Torrejón	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight	8056	6839	6567	6111	6444	6597
>55 Lnight	4454	3628	3436	2810	3349	3470
>60 Lnight	2001	1508	1376	0	1326	1403
>65 Lnight	0	0	0	0	0	0

Coslada	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight	11389	10902	10808	9615	10878	10837
>55 Lnight	6665	6440	6183	0	6201	6282
>60 Lnight	0	0	0	0	0	0

San Fernando de Henares	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight	930	1015	989	579	1003	1024
>55 Lnight	249	225	215	0	217	209
>60 Lnight	0	0	0	0	0	0

Mejorada del Campo	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight	0	0	0	0	0	0

Loeches	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight	0	0	0	0	0	11
>55 Lnight	0	0	0	0	0	0

Total	Standard baseline	Baseline Proc I	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight	20375	18755	18363	16305	18324	18470
>55 Lnight	11367	10293	9834	2810	9767	9961
>60 Lnight	2001	1508	1376	0	1326	1403
>65 Lnight	0	0	0	0	0	0

% Vs Standard Baseline	Procedure II	Procedure III	Procedure IV	Procedure V
>50 Lnight	-10%	-20%	-10%	-9%
>55 Lnight	-13%	-75%	-14%	-12%
>60 Lnight	-31%	-100%	-34%	-30%

% 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%

A3 – Overall Results of Analysis

Reduction in affected people

> 55 Db	TORREJÓN	COSLADA	SAN FERNANDO DE HENARES	MEJORADA DEL CAMPO	LOECHES	TOTAL
STANDARD BASELINE	9901	19817	3945	13903	233	47799
BASELINE PROC I	8547	18824	2854	13914	64	44203
PROCEDURE II	8184	16926	2649	13602	0	41361
PROCEDURE III	8191	16117	2458	11346	0	38112
PROCEDURE IV	8250	17286	2754	13727	0	42017
PROCEDURE V	8287	17362	2554	13822	689	42714

Table 0-1 Reduction of affected population (>55dB):

- With Respect to Procedure I: 6%/14%/5%/4%.
- With Respect to the Standard Baseline: 13%/20%/12%/11%.

> 65 Db	TORREJÓN	COSLADA	SAN FERNANDO DE HENARES	MEJORADA DEL CAMPO	LOECHES	TOTAL
STANDARD BASELINE	2737	9550	740	0	0	13027
BASELINE PROC I	2272	8105	330	0	0	10707
PROCEDURE II	2110	6649	244	0	0	9003
PROCEDURE III	1441	457	0	0	0	1898
PROCEDURE IV	2232	6696	185	0	0	9113
PROCEDURE V	1999	6942	157	0	0	9098

Table 0-2 Reduction of affected population (>65dB)

- With Respect to Procedure I: 16%/82%/15%/15%.
- With Respect to the Standard Baseline: 31%/85%/30%/30%.