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COMPETITIVE AND SUSTAINABLE
GROWTH PROGRAMME

SOURDINE II

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Final report

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Summary

With the continuing growth of air traffic as well as the ever increasing level of urbanisation around most airports in Western Europe, the impact of aircraft noise and emissions on the quality of life for the surrounding communities has become a serious issue to be dealt with. Many European airports already face the conflicting problems of increasing their airport capacity to meet the amount of traffic, and the increasing pressure from the general public to reduce environmental impact, particularly noise and emissions, of the increased traffic volume. Many efforts are already being undertaken to reduce the source noise itself by the introduction of more silent aircraft and engines. On the other hand, a further solution to noise reduction around an airport is the definition of **new approach and departures procedures**. By modifying or optimising the operations and traffic flow of aircraft around the airport, it should be possible to achieve noise reduction.

The conclusions of the initial Sourdine project have already clearly indicated that the introduction of new noise friendly operating procedures can only be successful provided the current airport capacity and safety levels are not negatively affected. Current noise abatement measures are often accompanied by a reduction in capacity, mainly due to a lack of enabling technology in this field.

Therefore, the objectives of Sourdine II have been set at the development of new procedures and supporting technology:

- Development of new advanced and innovative environmental friendly approach and departure procedures. The results from the Sourdine I project will be used as an initial input.
- 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.
- Development of enabling technology to achieve the successful introduction of the selected departure and approach procedures, such as ATC controller tools, automated aircraft-ATC interaction and cockpit monitoring tools
- Achievements will consist of quantified results for each procedure in terms of safety, capacity and environmental benefits, as well as associated costs or benefits. Objective evaluation of these issues will be performed by comparing controller and pilot workloads during baseline scenarios, i.e. current day, with future procedures. Metrics to be used will be in line with standardised European metrics and stakeholders' metrics.

The Sourdine II consortium included Airbus France (Toulouse), EUROCONTROL Experimental Centre (Brétigny), AENA (Madrid), INECO (Madrid), Isdefe (Madrid), SICTA (Naples) and NLR (Amsterdam). The consortium was supported by an expert panel, which provided feedback on intermediate results during the various expert panel sessions.

The project started with the generation of an overview of current practices and future technology related to the environmental friendly approach and departure procedures. Based on those results and after feedback from the expert panel a first set of potential procedures was developed. Those procedures were assessed using single event simulations (SES) with Airbus aircraft performance and noise calculation tools. Aircraft included in the study are the short/medium-range twinjet A320-200 and the long-range, four-engines A340-300. The performance studies involved computation of operational trajectories based on the procedure descriptions. These studies enable a first selection of the initial procedures based on aircraft performance limitations and provide trajectories that reflect performance characteristics and limitations of the aircraft. The trajectories are used as input for single event noise prediction carried out with Airbus Noise Level Calculation Program (NLCP).
This assessment led to the selection process where 5 approach and 3 departure procedures were selected to be further assessed in detail during the project.

Approach procedure I (reference approach procedure): Baseline FMS approach procedure: This procedure features a standard vertical flight path, with a level segment at 3000ft which is flown completely decelerating, with idle thrust.

Approach procedure II: Basic CDA with 2º initial FPA: this procedure follows a fixed 2-degrees path angle from 7000ft up to ILS intercept at 3000ft.The aircraft decelerates at idle thrust in clean configuration during this part of the flight, deploying the cleanest possible landing configuration on landing.

Approach procedure III: Basic CDA with 2º initial FPA and increased final glide slope: the difference between procedure II and procedure III is the steeper flight path angle on the ILS (3º proc II vs. 4º proc III).

Approach procedure IV: CDA with constant speed, variable FPA segment at landing configuration: the procedure is largely flown, from 7000ft to ILS intercept, with idle thrust and in landing configuration.

Approach procedure V: CDA with constant speed, variable FPA segment at landing configuration: the procedure is similar to procedure nº IV, with the difference that the variable FP is the result of an idle thrust descent from 7000ft to ILS intercept on an intermediate landing configuration.

Departure procedure 1 (reference departure procedure): this is the baseline departure procedure (NAP ICAO-A)

Departure procedure 2: Sourdine optimised close-in: this is the optimised close–in departure procedure, for which the noise relief is located relatively close to the runway. The procedure features a deep cutback in thrust, followed by a gradual increase in thrust starting at 3000ft. Upon reaching max climb thrust, acceleration and flap retraction takes place.

Departure procedure 3: Sourdine optimised distant: this is the optimised distant departure procedure, for which the noise relief is further away from the runway. The procedure features a deep cutback in thrust applied upon reaching Vzf (zero flap speed), followed by a gradual thrust increase starting at 5000 ft

In the following phase the above-mentioned procedures were assessed on different aspects, including safety, capacity, noise, emissions, user acceptance and cost benefit.

The **safety assessments** for the various procedures have been executed with different levels of detail. Because complete detailed safety analysis would be a very elaborate and demanding effort, part only of the four approach and two departure procedures were identified to fall within the scope of detailed evaluation. Therefore, a further selection of these procedures was made. To accomplish such a selection, an initial high-level safety evaluation of all six procedures was first done. It is noted that these procedure definitions do not include an embedding of the procedure in an operation.

Based on the initial high-level safety evaluation and on inputs not related to safety the Sourdine II management made a selection of three procedures for safety assessment. For each of these three procedures an operation was defined on a specific airport, including also specific human roles and technical systems. For each of these three operations, a safety assessment was performed, based on the TOPAZ safety assessment methodology.

The **capacity assessment** has been focused exclusively on the arrival noise abatement procedures designed by Sourdine II Project. Two platforms have been used to validate the new set of procedures from the capacity point of view: TAAM (Total Airport and Airspace Modeller) from Preston Aviation Solution and SIMMOD (Airport and Airspace Simulation Model) from ATAC Corporation. They have been used as the fast time simulation tools for the different phases of the Sourdine II project. Amsterdam-Schiphol, Paris-Charles de Gaulle and Madrid-Barajas airports validation activities used TAAM for simulation purposes. Naples Capodichino airport selected SIMMOD as the FTS platform to validate the new procedures.

There is a decrease in the peak hour arrival airport capacity when NAAPs designed within Sourdine II are implemented. This decrease in capacity is caused by the extended separation required to compensate the speed differences between aircraft. The more speed differences between aircraft types, the more separation was needed in order to maintain minimum safe separation between successive aircraft (e.g. wake turbulence). This increase of separation affects arrival delay negatively and therefore arrival capacity decreases.

The lack of speed control between the beginning of the CDA and the runway leads to larger spacing between successive arrivals. An increased arrival separation at 30NM from the runway threshold is required to achieve the necessary wake turbulence separation at the runway.

Another factor which plays a role in the delay is the route structure close to the airport: the effect of speed differences mentioned above will play a more severe role when the number of RNAV-routes available is smaller. In that case, more aircraft will have to fly a longer trajectory on the same RNAV route.

When an airport is operated in a way that the demand is exceeding the available peak hour arrival capacity during some periods of the day, the introduction of the new procedures will lead to additional delay. However, when the arrivals are distributed more regularly over the day, delays will decrease, or even not occur. When traffic is scheduled in this way and hourly arrival demand does not exceed the available airport capacity, for the traffic foreseen for the year 2015 in the four airports considered in this analysis, there exists no sustained capacity problem.

The airport **noise assessment** analysis was performed using a research version of the US FAA’s Integrated Noise Model (INM), specially developed by the FAA to cover the needs of the Sourdine II project, with special data supplied by both Airbus and Boeing (with funding from NASA). These data covered a limited set of representative aircraft types determined based on the fleet mixes of the four airports. Per airport the actual fleet was replaced by a substitute fleet composed of these aircraft.

During this project it became clear that (see section7.4) it would not be possible to perform any comparative analyses of fuel-burn and CO2 production. Analysis of pollutants produced below 3000ft that contribute to a deterioration of local air quality was, however, carried out. This analysis showed that nearly all of the procedures produced more unburnt hydrocarbons (HC) and Carbon Monoxide (CO), Sourdine II arrival procedure III being the notable exception for mid-sized aircraft and procedure IV for heavy aircraft. Arrival procedure III also produced much less Nitrogen Oxide (NO_X). The other arrival procedures were beneficial in terms of NO_X for mid-sized aircraft. Sourdine II departure procedures did not affect NO_X production.

Within the **user acceptance assessment** two simulation experiments – a flight simulation and an ATC simulation - were carried out in order to evaluate the SII procedures. The flight simulation covered the evaluation of SII procedures with respect to its impact on the crew’s tasks and performance as well as on a number of specified flight parameters. The ATC simulation covered the evaluation of the SII procedures with respect to the impact on the controllers’ tasks as well as on safety, efficiency and capacity in handling air traffic.

From the various assessment results as well the activities to have a balance analysis and the first step towards an implementation plan the following conclusions can be drawn.

The noise assessment results show that all Sourdine II procedures provide significant noise reduction as compared with current day practice.

With single event simulations, it has been demonstrated that the SOURDINE II reference approach procedure shows benefits more than 5dBA in a very large range of the procedure.

From all approach procedures Sourdine II arrival procedure III, featuring an increased final glide path angle, provides the largest noise benefit compared to the reference procedure.

1. The optimized departure procedures featuring optimized thrust management provide noise reduction in the targeted zones compared to current PANS-OPS procedures, either close-in or at distant positions.
2. The distribution of the fleet mix will influence the shape of the noise contours considerably (i.e. unbalanced use of runways).
3. Noise assessment conclusions are the same (i.e. slight differences depending on fleet-mix flow) for all scenarios.

4. Major noise benefits are mainly determined by higher altitudes for approaches while for departures on the thrust settings.

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 2.5NM after the runway end.

In general it can be stated that both procedure II and II-A (variation of procedure II including speed constraints) are acceptable for pilots and controllers. Procedure II-A basically leads to more time between the various configuration changes and therefore makes it more controllable for the pilot. This has the risk however of leading to a negative noise impact as compared with a more noise-ideal procedure II. It was suggested by some of the controllers to extend the current implementation of the ATC monitoring aid with an alert when the separation minima are violated and the controller needs to intervene. To get to an implementation of these noise abatement procedures it is important that the pilots will strictly follow the prescribed procedures.

Controllers also need to get hands-on experience concerning the "new" speed profiles and aircraft performance. Due to the fixed RNAV routes inside the TMA there are fewer possibilities to make changes to the arrival sequence and therefore an arrival manager and an accurate hand-over from ACC to APP (30-60 seconds accuracy) is required. The current implementation of the RNAV shortcuts provided sufficient flexibility for the controllers. The combination of parallel runways with CDA procedures is an identified problem. Possible solutions on this subject that need further exploration are for example the use of curved approaches based on approach procedure with vertical guidance (APV procedure) or to have a short level segment for one of the runways.

It is recommended to perform flight trials to get detailed feedback on aircraft performance as well as pilot and controller acceptability from hands-on experience. Results from these flight trials can support additional assessments like performed in this project to reach the ultimate goal: continuous descent approaches during peak-hour operations at major European airports while maintaining or even improving capacity and safety.

TABLE OF CONTENTS

1 Introduction

1.1 Purpose

With the continuing growth of air traffic as well as the ever increasing level of urbanisation around most airports in Western Europe, the impact of aircraft noise and emissions on the quality of life for the surrounding communities has become a serious issue to be dealt with. Many European airports already face the conflicting problems of increasing their airport capacity to meet the amount of traffic, and the increasing pressure from the general public to reduce environmental impact, particularly noise and emissions, of the increased traffic volume. This has already resulted in specific local constraints to the operation of aircraft, not only around major airports such as Schiphol, Gatwick or Frankfurt, but also at more regional airports that are already experiencing the pressure to impose constraints to aircraft movements. Therefore, reduced nuisance to the community is a serious issue for the airline transport industry if the projected sustained growth is to be pursued.

Many efforts are already being undertaken to reduce the source noise itself by the introduction of more silent aircraft and engines. Several projects funded by the EC investigate the technology required to achieve this objective for the European aviation industry. Results of these programmes such as RANNTAC, RESOUND, RAIN and DUCAT are made public through the X-Noise thematic network.

On the other hand, a further solution to noise reduction around an airport is the definition of **new approach and departures procedures**. By modifying or optimising the operations and traffic flow of aircraft around the airport, it should be possible to achieve noise reduction.

1.2 Background

The new air traffic management (ATM) concept, which the Sourdine II project intends to address, is to improve the impact of aircraft noise and emissions around most airports by the definition of new approach and departure procedures.

Before new procedures can be implemented, it needs to be demonstrated that they do indeed solve the ATM problem they were designed to solve in a satisfactory way. After this, an accepted implementation plan will be studied within the project to provide information and improve acceptance in Europe.

Sourdine II will use validation to ensure the quality and suitability of the new air navigation procedures that Sourdine II proposes to solve part of current problems in European ATM. Validation is the process which an ATM concept undergoes throughout its lifecycle in order to ensure that it addresses the ATM problem for which it was designed and that it achieves its stated aims.

Homogeneity of experiment results has been ensured through the elaboration of a validation plan and the set up of a suitable validation management structure. The validation plan is based on existing ATM validation frameworks (MAEVA) and emphasises exercises to build confidence in the airport approach and departure procedures developed within Sourdine II.

A programme of validation exercises has also been defined, using the most suitable validation techniques and sequencing for each lifecycle phase, to establish objectively the performance benefits that Sourdine II can deliver.

1.3 Document Structure

Chapter 1 provides an introduction to the Sourdine II project, including the objectives of the project. Within chapter 2 the working and validation (including monitoring of the validation activities) methodology is explained. The following chapter, chapter 3, shows the definition and the design of new noise abatement procedures to be used within the single event simulations. The results of those single event simulations are described in chapter 4 and chapter 5 shows the procedure selection process based on the single event simulation results.

A detailed description of the selected procedures (5 arrival and 3 departure procedures) is given in chapter 6. In chapter 7 it is stated which procedures are assessed in which level of detail during the various assessments. The results of those assessments (capacity, safety, noise, emission, user acceptance and a preliminary cost benefit analysis) are described in chapter 8. The results of a comparative analysis of the assessment results can be found in chapter 9 and a description of the implementation plan in chapter 10. Finally, chapter 11 provides the final conclusions including an overview of all the deliverables and places where Sourdine II results have been disseminated.

1.4 Partnership

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1.5 Objectives of the project

The Sourdine II project is the follow-up project of the 4th Framework Programme Sourdine. The Sourdine project provided an inventory of noise abatement procedures and provided an initial demonstration of associated noise reduction potential. In addition it indicated that the introduction of new noise friendly operating procedures can only be successful provided the current airport capacity and safety levels are not negatively affected. Current noise abatement measures are often accompanied by a reduction in capacity, mainly due to the constraints of the current ATM system, current operating procedures and hand-on experience of experts as well as lack of enabling technology in this field.

Therefore, the objectives of Sourdine II were set at the development of new procedures and supporting technology:

- Development of new advanced and innovative environmental friendly approach and departure procedures, based on the results from the Sourdine I project.
- 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.
- Development of enabling technology to achieve the successful introduction of the selected departure and approach procedures, such as ATC controller tools and cockpit monitoring tools
- Achievements consist of quantified results for each procedure in terms of safety, capacity and environmental benefits, as well as associated costs or benefits. Objective evaluation of these issues is performed by comparing controller and pilot workloads during baseline scenarios, i.e. current day, with future procedures.

1.6 Glossary

Term	**Description**
AAA	Amsterdam Advanced ATC system
ACC	Area Control Centre
ACL	ATC clearances
ADS	Automatic Dependant Surveillance (-Addressed-Broadcast-Contract)
AMAN	Arrival Manager
ACC	Area Control Centre
ACDA	Advanced Continuous Descent Approach
AIP	Aeronautical Information Publication
AMAN	Arrival MANager
APP	Approach Control
APV	Approach Procedure with Vertical guidance
ARR	Arrival Control
ASAS	Automatic Separation Assurance System
ATC	Air Traffic Control
ATC	Air Traffic Control
ATCo	Air Traffic Controller
ATFM	Air Traffic Flow Management
ATIS	Automated Terminal Information Services
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATOP	Advanced Technologies and Oceanic Procedures
ATS	Air Traffic Service / Air Traffic Server
ATS	Air Traffic Services
CAA	Civil Aviation Authority
CBA	Cost Benefit Analysis

Term	Description
CDA	Continuous Descent Approach
CM	Context Management
CNS	Communication, Navigation, Surveillance
CTR	Controller or Control Zone
Dep.	Departure procedure
DCL	Departure Clearance
DCO	Departure Controller
DLIC	Datalink Initiation Capability
DM	Decision Maker
DMAN	Departure Manager
ECIP	European Convergence and Implementation Plan
EFL	Executive Flight Level
ETO	Estimated Time Over
FAF	Final Approach Fix
FAP	Final Approach Point
FAS	Final Approach Speed
FDR	Feeder
FIR	Flight Information Region
FL	Flight Level
FLIPCY	Flight Plan Consistency check
FMS	Flight Management System
FPA	Flight Path Angle
FPM	Flight Path Monitoring
FTS	Fast Time Simulation
GBAS	Ground Based Augmentation System
GRACE	Generic Research Aircraft Cockpit Environment
GS	Glide slope
IAF	Initial Approach Fix
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
ICD	Increase drag coefficient
IFP	Initial Flight Plan
ILS	Instrument Landing System
INM	Integrated Noise Model (developed by the FAA)
ISA	Instantaneous Self Assessment
KTS	Knots
LNAV	Lateral Navigation
LVNL	Luchtverkeersleiding Nederland ATC The Netherlands
MAEVA	Master ATM European Validation Plan
MONA	Monitoring Aid
NAAP	Noise Abatement Approach Procedure
NADP	Noise Abatement Departure Procedure
NAP	Noise Abatement Procedure
NARSIM	NLR ATC Research Simulator
NCW	Non-Conformance Warning
NDLS	NARSIM Datalink Server
NLCP	Noise Level Calculation Program
NLR	Nationaal Lucht- en Ruimtevaartlaboratorium National Aerospace Laboratory
NM	Nautical Mile
NPA	Non-Precision Approach
NTZ	Non Transgression Zone
OCD	Operational Concept Document
OEI	One Engine Inoperable
PA	Precision Approach

Term	Description
PTC	Pre-Taxi Co-ordination
PVD	Primary View Display
QFU	Runway in use
R/T	Radio Telephony
RNAV	Area Navigation
RTS	Real Time Simulation
RWY	Runway
SES	Single Event Simulations
SI	Study of Optimisation procedURes for Decreasing the Impact of NoisE
SID	Standard Instrument Departure
SII	Sourdine II Project
SML	Small-Medium-Large
SML term	Short-Medium-Long Term
SOURDINE	Study of optimisation procedures for decreasing the impact of noise
SOURDINE II	Study of Optimisation procedURes for Decreasing the Impact of NoisE II
STCA	Short Term Conflict Alert
TMA	Terminal Manoeuvring Area
TMB	Technical Management Board (of Sourdine II)
TOD	Top Of Descent
TOGA	Take-off / Go-around
TWR	Tower
UPS	United Parcel Service
VGH	Validation Guideline Handbook
VNAV	Vertical Navigation
VOR	Very High Frequency Omni-directional Range
WG	Wind Gradient
WP	Work Package
WPT	Way point

1.7 Reference documents

Short Reference	Description
[TA]	SII Technical Annex.
[D1-1]	SII D1-1: Identification document
[D2-1]	SII D2-1: Validation Methodology Report, version 0.9
[D3-1-1]	SII D3-1-1: Generic definition of New Noise Abatement Procedures
[D3-1-2]	SII D3-1-2: Detailed Definition of New Noise Abatement Procedures
[D3-2]	SII D3-2: Requirements document for the pilot and controller tools
[D4-1]	SII D4-1: Report on the global results of capacity, noise & emission, safety and cost benefit analysis assessment
[D5-1]	SII D5-1: Noise and Emission Modelling requirements
[D5-2]	SII D5-2: Noise and Emission Modelling methodology
[D5-3]	SII D5-3: Results of optimisation and preliminary impact analysis
[D5-4]	SII D5-4: Results of noise and emission impact analysis
[D6-1]	SII D6-1: Prototyping results ATC simulator
[D6-2]	SII D6-2: Prototyping results flight simulator

[D6-3]	SII D6-3: Real Time Simulation results
[D6-4]	SII D6-4: Experiment Design ATC simulations
[D6-5]	SII D6-5: Experiment Design Flight simulations
[D6-6]	SII D6-6: Concept of operation for Schiphol airport simulations
[D7-1]	SII D7-1: Validation process control and balance analysis
[D7-2]	SII D7-2: Comparative analysis of results
[D8-1]	SII D8-1: Implementation plan
[VGH]	MAEVA Validation Guideline Handbook

2 Working and validation methodology

This chapter describes the working method as applied during the SII project as well as the validation methodology.

2.1 Working methodology

The project started with the work package called “identification” and the work package for the definition of the validation methodology to be applied in the project. In the “identification” work package, a review was made of related research and implementation projects, existing noise abatement procedures, regulations, standards, traffic forecasts and methodologies for the assessment of noise abatement procedures with respect to noise, emissions, capacity, user acceptance (for both pilot and air-traffic controller) and cost benefits. Based on this inventory, the following activities were started:

- Definition of new noise abatement procedures (procedure design, see figure below)
- Definition of requirements for the development of the assessment tools needed in the SOURDINE – II project.
  The main part of the tool development was devoted to improve capacity assessment of CDAs using TAAM and the improvement of the method for the airport noise assessment. Also, some activities were performed to further develop emissions assessment and CBA methodology.

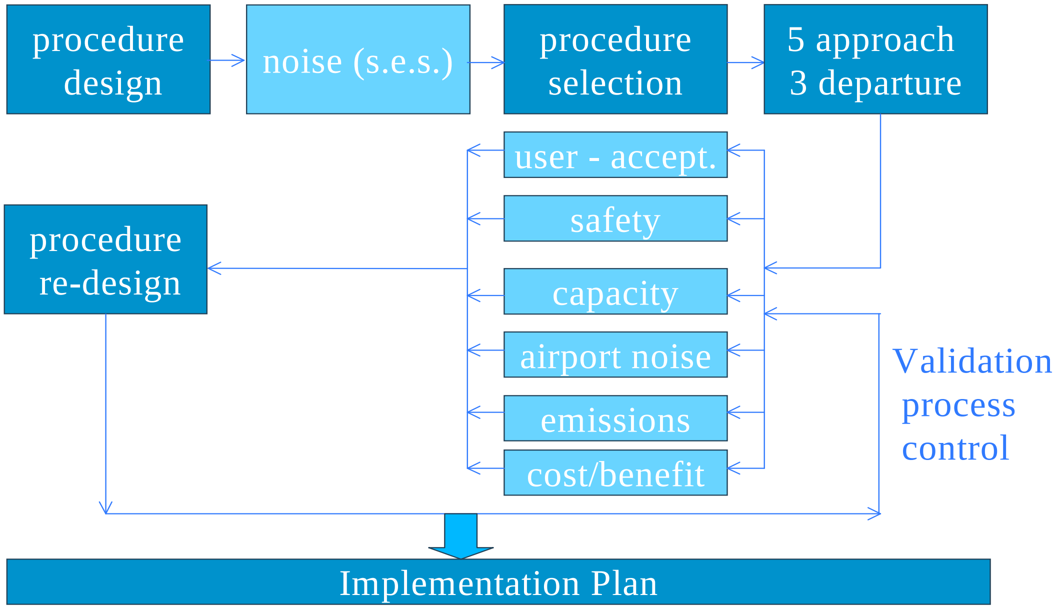


Figure 2-1 Overall working method applied in Sourdine-II

In first instance, a large number (70 – 80) of procedures (both arrival and departure) were defined. For this procedure definition, the consortium organised expert sessions with an international panel especially composed for this task (see figure 2.2 also); both to have input of all expertise areas involved, as well as to get commitment for future implementation of the procedures. All procedures defined were first assessed with respect to noise on an individual basis by in-house developed tools of Airbus for the A-320 and A-340 aircraft (noise single event simulations, SES), see figure 2.1. Based on the results of these simulations, 5 approach procedures (including an approach reference procedure) and 3 departure procedures (including a departure reference procedure) were selected for further evaluation. This further evaluation included (see figure 2.1) user acceptance (of both pilot and air-traffic controller), safety, capacity, airport noise, emissions and cost benefits. Evaluations were done using the methodology as defined in WP2 (see section 2.2 also). Based on these evaluations, a small adaptation of procedures was foreseen, as well as a second assessment with respect to some of the relevant parameters above. To summarise the assessment results in a very condensed way, the selected flight procedures have been ranked for the various parameters (see chapter Comparative analysis of results).

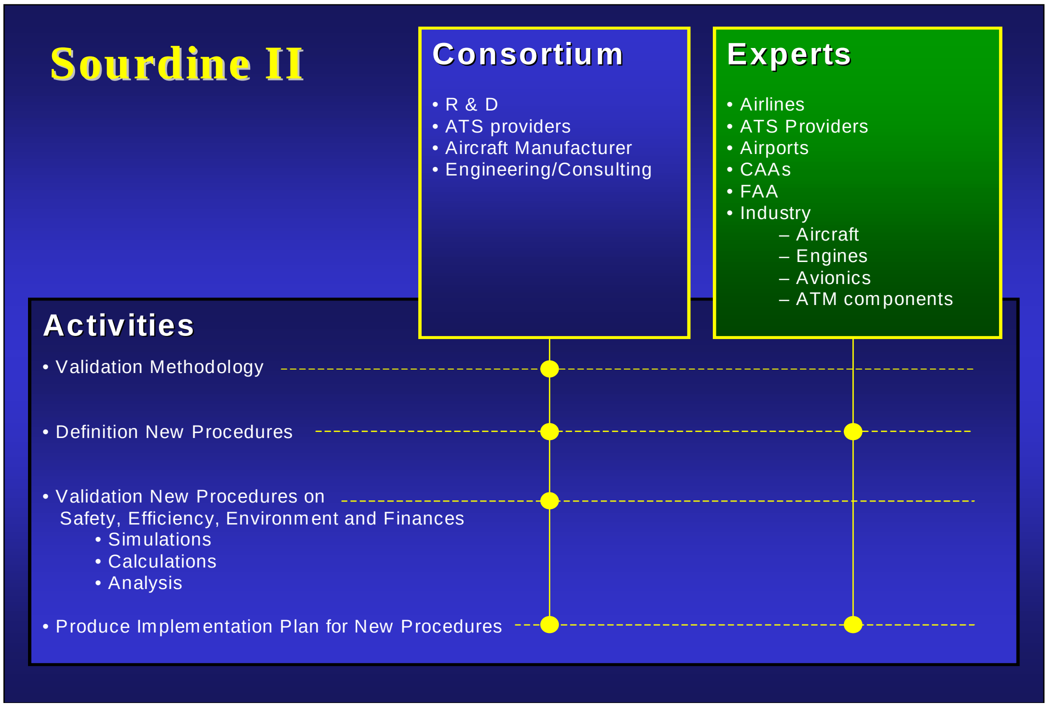


Figure 2-3 Roles of the expert panel

A separate work package was devoted to identify the issues related to *when, where,* and *how* the Sourdine-II procedures can be implemented. Also for this workpacakge, the Sourdine-II consortium organised workshops together with the expert panels (see fig. 2-2).

It was recognised by the consortium that early involvement and commitment of all stakeholders is of paramount importance to promote implementation of Noise Abatement Procedures. Both through the organisation of expert panels with key-players during the project, as well as presenting (intermediate) results on many events (see section 11.3) the consortium disseminated the results obtained in the project.

2.2 Validation methodology

MAEVA is the Validation Methodology selected to validate SII project. The MAEVA methodology is described in the Validation Guideline Handbook, [VGH].

The following paragraphs describe how this methodology has been applied in SII project and summarize the results of its application.

The MAEVA Methodology is based on five main steps, as follows:

1. Identification of Validation aims, Objectives and Hypothesis
2. Validation Design – Plan and prepare the Validation exercise
3. Conduct of Validation Exercise Runs
4. Analysis of Results
5. Develop and Report conclusions and Recommendations.

The first activity performed has been the description of the ATM Problem addressed by SII: "The reduction of noise and emission impacts produced by the air traffic in the terminal areas". The goal for SII is to develop and validate different NAPS in order to reduce present sound and emission rates. Six SII NAPs (two departures and four approaches) implementation have been identified and detailed in the SII Operational Concept Description (OCD) [D6-6].

The main Validation Aims derived from the SII Operational Concept are to demonstrate that the proposed SII NAPs have a positive effect in the environment in terms of noise reduction and, if possible, emissions reduction, maintaining current safety and levels. The economic effects of the new procedures, as well as the acceptance by the aviation community, specially controllers and pilots, are also considered as SII Validation Aims.

Following the MAEVA Methodology SII Validation High Level, and subsequently Low-Level Objectives have been identified based on the SII Validation Aims and the ATM 2000+ Strategic Objectives. These objectives are related to Environment, Safety, Capacity, Economics and Acceptance-feasibility.

Taking into consideration the ATM Problem, the SII OCD and the SII Validation aims, the SII Validation Platform requirements have been identified. These requirements comprise the ATM Scope, inputs, measurements (outputs), geographic, time-based, fidelity and resolution, and other additional requirements to be meet by the SII Validation Platform.

Hypothesis, Metrics and Indicators were then identified, based on the Low-Level Objectives and the SII Validation Platform requirements and capabilities.

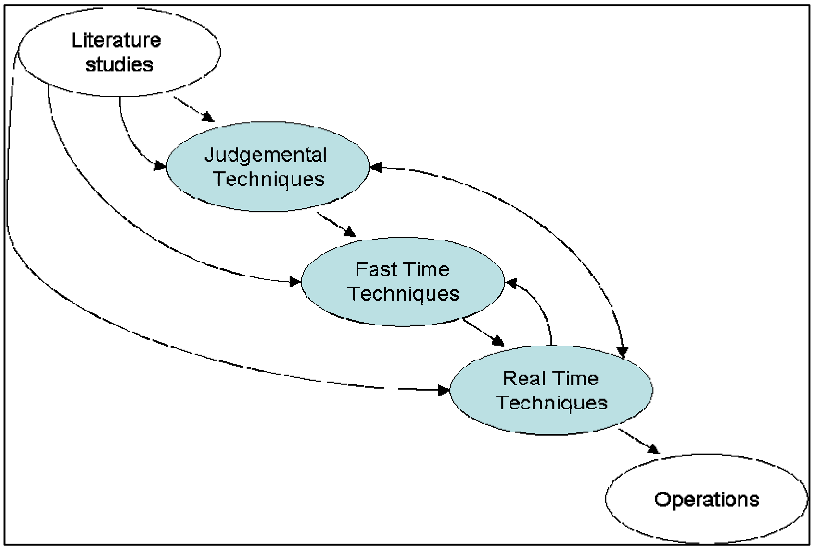


Figure 2-3 SII Validation Techniques route map

Knowing the objectives, the metrics and indicators, the procedures to simulate, the components of the ATM system to consider and, that the approach and departure procedures are the main changing elements to evaluate, the number of exercise runs required to obtain significant results was estimated. Taking into account the preliminary selection of the type and number of procedures to simulate and an estimate of the project resources, it was recommended to use FTS runs to be able to obtain statistical significance with the objective of running the experiments several times for a procedure/s. Limited RTS was also proposed because some of he studies proposed could not be performed at some circumstances. The High Level Experimental Design contains all this information.

On the basis of the state of maturity of the operational concept proposed in Sourdine II, the validation techniques chosen by validation specialists have been judgmental studies, fast-time simulations and real-time simulations.

Each technique addresses the different validation requirements for each stage in the development lifecycle of an ATM operational concept. For example, with the increasing maturity of the concept, there is a tendency to use validation platforms with higher fidelity and closer to the anticipated operational environment.

The validation techniques defined in Sourdine II are consequently sequenced following the path in which the main 'flow' is from the top left node to the bottom right node or technique (Figure 2-3), however the route taken was not be straightforward and frequently involved “looping” back up the route map.

As a result of the looping back up in the route map, results of each validation exercise are dependent of each other, not only to refine operational concept but also to improve modelling assumptions in the previous and following nodes.

Three validation stages have been defined for SII Validation: Judgement Techniques, 1st Cycle and 2nd Cycle. Several validation tools have been chosen in SII as the most suitable for each stage of the implementation of NAPs and for each location, taking into account the use of existing software and simulation set-ups available within the SII partnership. Economics and safety analysis have been estimated and calculated combining results of the platforms tools as well as suitable safety and economic models. The SII selected tools, methods and tool variants are summarized in Table 2-1. Note that the Single Event Simulations (SES) were used as input of the validation process and are therefore not listed in the validation methodology. More details can be found in the SII Validation Methodology Report [D2-1].

	SII Validation Techniques, tools and methods.		
Areas of interest	**Judgemental Techniques**	**1º cycle**	**2º cycle**
Noise – Emissions	Expert Panels (Delphi, AHP, Brainstorming Sessions)	INM TBEC	INM
Capacity - Workload		TAAM / SIMMOD / PUMA (a/c manufacturer tools to provide trajectories)	NARSIM GESIMO / GRACE
Safety		TOPAZ Safety Methodology	Safety Methodology
Cost and Benefits		CBA Methodology	CBA Methodology
Acceptance and Feasibility			RTS Tools and Questionnaires

Table 2-1 SII Validation Techniques, tools and methods

Once having selected the validation platforms, techniques and stages, the exercise (MAEVA Step 2) for each technique were elaborated.

Expert Panels have been selected to perform the Judgement Techniques within a large range of expertise in order to obtain useful advice in a lively discussion to explore all aspects of the SII ATM Concept. The members of these Expert Panels included ATCos, pilots, procedure designers, environmental managers, CNS technological experts, airport managers and regulators. The exercise plan for these techniques includes expression of interest, list of experts, expert panel preparation, meetings realization, processing of the information collected, elaboration of conclusions and dissemination of the information.

Once a consensus was reached among SII partners and experts, and the Validation Platforms were selected, the 1st Cycle stage was launched. This stage included FTS, safety and CBA methodologies to obtain the first set of results in terms of environment, capacity, safety and economic aspects.

It was agreed to investigate the timeframe 2015, when SII operational concept could take place. To evaluate the fidelity of the predicted traffic models, some preliminary trials have performed in a well known timeframe: 2001 or 2002. This allowed calibrating the platform parameters and settings to guarantee that quality of the output data.

In order to apply a particular ATM concept to a general European TMA, SII selected four airport areas to perform the 1st cycle runs. These areas have different characteristics in terms of traffic, infrastructures, geographical constraints, etc, and were used as test beds to demonstrate the benefits of the selected Sourdine II procedures. These airports are the following:

- **Paris Charles de Gaulle** as a large, international airport with an intense traffic flow.
- **Amsterdam-Schiphol** as a large, international airport with an intense traffic flow.
- **Madrid-Barajas** as a medium, international airport with medium traffic intensity.
- **Naples Capodichino** as a small, national-international airport with a low traffic flow.

This combination of areas has been selected as the most representative of the European environment.

The 1st cycle process was divided in different assessments that were performed separately for the identified areas of interest: Noise, emissions, capacity-workload, safety and economics. Table 2-2 summarises 1st cycle assessments (tools and methodologies):

	1st cycle (WP4) assessments (tools and methodologies).				
Airport areas	**Capacity-Workload**	**Noise**	**Emissions**	**Safety**	**Economics**
Paris Charles de Gaulle	TAAM	INM	TBEC	TOPAZ Safety Assessment Methodology	CBA Assessment Methodology
Naples-Capodichino	SIMMOD	INM	TBEC		
Madrid-Barajas	TAAM - PUMA	INM	TBEC		
Amsterdam-Schiphol	TAAM	INM	TBEC		

Table 2-2 1st cycle assessments (tools and methodologies)

1st Cycle was performed in two phases to enable the possibility to perform an intermediate analysis at the end of the first phase. The second phase took into account the recommendations and new elements in the baseline and SII concepts.

Three different exercise scenarios were selected for the SII validation exercises: Calibration Scenario (known model 2001 or 2002), Baseline Scenario (2015) and SII Scenarios (2015). The validation exercise scenarios were run in the four selected airports allowing comparison of the results.

The results of the different 1st Cycle assessments provide information about noise-emissions, capacity, safety and economic aspects for specific procedures. The hypothesis identified in Step 1 were checked and verified again in order to evaluate if the new SII concept acceptable on the basis established. All the results were brought to expert sessions in order to make final judgements.

The 2nd Cycle of SII validation process, based on RTS simulations, was designed to complement the 1st cycle and take advantage of both processes characteristics. The 2nd Cycle refined part of the results obtained during the 1st Cycle, mainly in terms of noise and capacity. Also, additional results were provided in terms of feasibility-acceptance, workload of controllers and pilots, safety and economics.

The RTS was only performed in Amsterdam Schiphol Airport. Schiphol is a large, international airport with an intense traffic flow that enables complex and multiple simulating options comprising the airport TMA (including several ACC sectors and tower-TWR).

The approach followed in the 2nd Cycle was to use the baseline concept, described in terms of the operational concept foreseen for 2015, to enable assessing differences with the new 2015 SII concept. These differences were evaluated in different assessments according to safety, economics, workload, and others. Comparisons between the baseline and the new noise abatement procedures and the air traffic controller and pilot tools established the differences between both concepts.

The experimental process has been divided in two phases:

- Phase 1: Prototyping of pilot and controller tools (GESIMO and NARSIM simplified trials for prototyping).
- Phase 2: NARSIM and GRACE preparation, simulations execution and assessments (NARSIM and GRACE full-scale trials).

The SII concept selected for each 2nd Cycle phases was specific for each one depending on the phase objectives and the expert, pilot or controller, expectations. The first proposal of procedures was based on the 1st Cycle results, Expert Panels judgement and internal consortium analysis of the SII procedures. Phase 1 and 2 considered the most demanding SII procedure from a pilot point of view for GESIMO and GRACE pilot simulations, and the most demanding SII procedure from a controller point of view for NASRIM controller simulations.

At the end of the simulations the results from different scenarios had to be compared to establish operational concept differences in terms of the baseline and SII concept, so the scenarios were described equally except for those elements or characteristics that were compared.

Several simulations were conducted with the ATC simulator, with the flight simulator and later with the combined platform. Different kinds of data were obtained and post-processed in the required formats, as a result of the simulation runs. Based on the simulations execution and data gathered the following analyses were performed:

- Controller and pilot acceptance-feasibility assessment,
- Capacity and Workload assessment,
- Safety Assessment,
- Noise Assessment, and
- Cost Benefit Analysis

2.3 Monitoring Methodology

The monitoring process was developed to ensure that the different teams performing validation exercises followed correctly the guidelines defined in the SII Validation Methodology and that the exercises were executed with a high level of confidence. It also evidences all performances of the validation activities: correctness of the exercises, proper gathering of data, deviations, and problems encountered and corrective actions proposed. The process also foresees and reports possible changes or refinements of the validation methodology in order to meet the validation objectives. As a result it has been possible to guarantee that the different results are compatible and comparable and that the final results are not affected by a wrong execution or design of the experimental process.

The validation process control has one main objective that is to monitor and analyse the execution of the validation processes as defined in Validation Methodology, [D2-1]. The results of this process evidence the performances of the validation activities: exercises, gathering of data, deviations, problems encountered and corrective actions proposed. The process foresaw also possible improvements or refinements of the validation methodology in order to meet the validation objectives

The monitoring of the validation activities was done according to the plan set in the Validation Methodology. Each partner was given particular reporting responsibilities regarding the monitoring of specific validation exercises. The distribution of monitoring activities and reporting responsibilities was done following the criteria established and agreed amongst the consortium: each partner was responsible of monitoring a specific validation exercises in which he was not involved.

The following is a summary of the activities conducted in parallel to the validation exercises:

- **Identification of incompatibilities (proposed validation plan against real constraints):** i.e. when something proposed in the experimental plan cannot be fulfilled.
- **Identification of deviations with respect to the validation plan:** when the experimental process is being executed in a different way (compared to the proposed plan).
- **Identification of inconvenient data or results:** analysing the outputs of the simulations and assessments.
- **Intermediate real-time analysis of the data and results:** analysing intermediate data and results from the simulations and assessments.
- **Additionally, recommend solutions for other unexpected situations:** i.e. non-operational simulator, non-assistance of an expert to the simulating sessions, etc…
- **Additionally, propose intermediate changes or improvements of the process:** possibility to propose, study and incorporate, if necessary, changes in the experimental process.

For the FTS and RTS runs more detailed activities were defined. The next is a summary of these activities:

- Verify platform settings: setting of tools, tool constraints, tool operators, etc.
- Monitor the calibration process: adjustments or tuning or the platform and scenarios.
- Verify and accept the models represented in the platform: including scenarios, traffic mixes assumptions, etc.
- Monitor the execution of the simulation runs and subsequent assessment, including measurement and data processing, as defined in the Validation Methodology.
- For each of the previous steps evaluate deviations from the planned processes.

Additionally the following monitoring processes were implemented for the validation assessments:

- FTS Capacity Assessment Monitoring

- RTS Capacity and Workload Assessment Monitoring
- Monitoring of Noise and Emissions Assessment
- Monitoring of the Fly-ability and User Acceptance
- Monitoring of Safety Assessment
- Monitoring of the Expert Panels

The following points were also part of the responsibilities planned for the monitoring staff whenever identifying deviations or unforeseen situations:

- Identify the problem.
- Communicate with partners and validation leader (if necessary).
- Propose and agree corrective actions.
- Execute corrective actions.

Fill-up template documents were created by the monitoring responsible and completed during the assessments by the exercises teams. This was very useful in order to supervise the validation processes and collect all the necessary data in the appropriate format.

The following figure shows the different simulations and assessments of the project for which monitoring activities were planned:

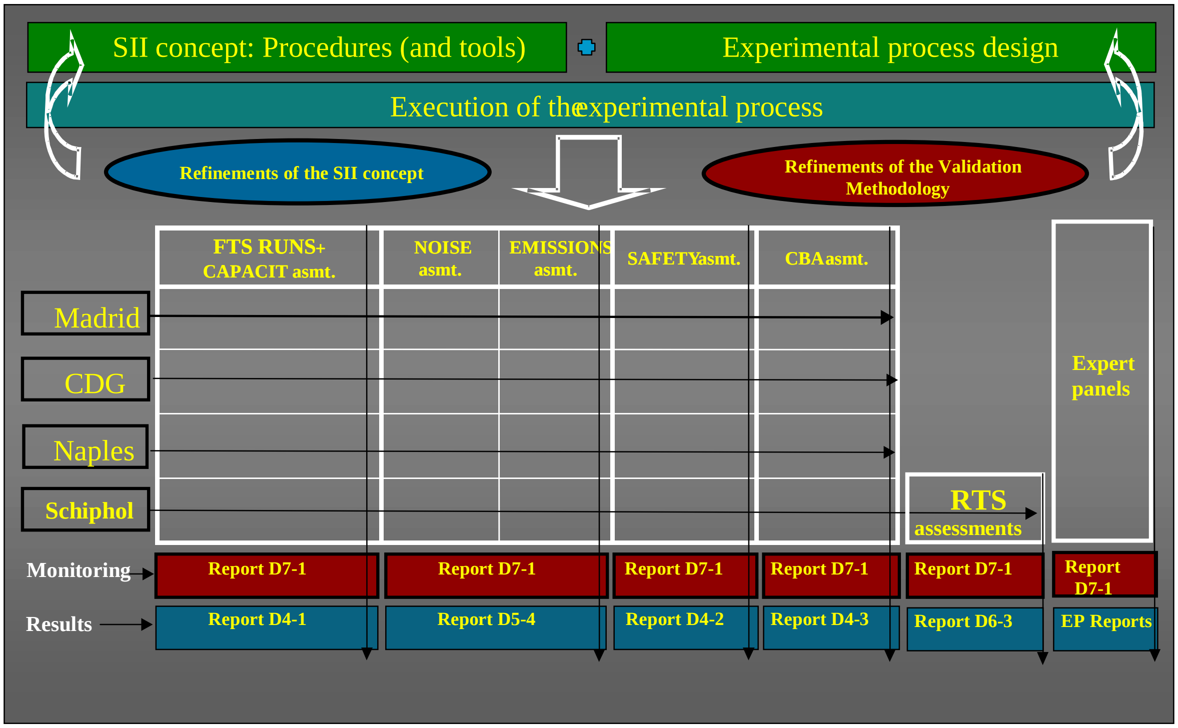


Figure 2-4 Simulation and Assessments Monitored (Inputs and Outputs)

3 Definition and design of new NAPs for single event simulation

3.1 Introduction

The main activity described in the following chapter is the design and construction of new advanced Noise Abatement Procedures (NAPs) for the long-term (2010-2015 horizon). The section initially focuses on “generic” procedures, which are not influenced for example by geographical features; furthermore it includes a baseline of short-term noise procedures for comparative study, defined by a baseline ATM concept. The real body of the work can be found in section 3.2, where the methodology, design and construction process of the NAPs is described.

3.1.1 Background

The definition of new procedures is the core of the Sourdine II project. The objective of this working document is the identification and development of new Noise Abatement Procedures (Approach and Departure) in the time horizon of this task, according to the expected technological advances in CNS-ATM and in line with the objectives of the ECAC Navigation Strategy. Through an iterative approach, the selected procedures will be refined according to the results of the validation process. [SII_TA]

3.1.2 Purpose

The main purpose of this section is to specify and describe the new noise abatement procedures (NAPs) and NAP variants to be evaluated during the single event calculations performed by Airbus. As the single event runs will be carried out along an extended runway centreline (‘straight-in’), the focus of this document has been laid on procedure variants in the vertical plane. The variants have been designed taking into account the initial ideas for NAPs as presented during the Sourdine II meetings, as well as the results of the Expert Panel meeting.

3.1.3 Known Noise Abatement Procedures

At present the noise abatement procedures around airports are based upon the aircraft avoidance on the horizontal and vertical axis of densely populated areas.
Avoidance can be obtained by either going around the area or making sure there is enough vertical distance between the source of the disturbance (the a/c) and the populated area.
Other procedures can also be included which are based on power management and configuration.
During the Sourdine I project NAP procedures were divided in two categories:

- Short term: including those procedures, which could be flown without the need for additional equipment or tools for the ATC and aircraft and which do not require a major modification of the airport TMA;
- Medium term NAPs those, which would need extra certification, modifications both on the aircraft and the ATC and adaptation of the airport TMA.

The Sourdine II project was tasked to develop long term NAPs, for example advanced Continuous Descent Approach procedures ‘ACDA (see 3.3.3).

- Long term NAPs: including procedures, which would require adapted aircraft technology and ground infrastructures and TMA design in order to support advanced procedures without negative effects on Safety, Capacity, etc...

The same definition has been used for simplicity in this chapter.

3.2 Procedure design methodology

3.2.1 Timeframe

Two of the main objectives of Sourdine II have been set at the development of new procedures and supporting technology:

- *Development of new advanced and innovative environmental friendly approach and departure procedures. The results from the Sourdine I project will be used as an initial input.*
- *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.*

These two objectives have been used as a basis for the design methodology of the new Noise Abatement Procedures (NAPs). The new NAPs outlined in this document have been designed taking into account the predicted technology level of 2015. However, a broad set of procedures has been defined, which also include some procedures resulting from the Sourdine I project. It is expected that not all the new defined NAPs will require the technology available in 2015.

By estimating which technology will be available when, and investigating the minimum required technology for each procedure, a roadmap for implementing the new NAP variants between now and 2015 can be constructed. Furthermore, it has been decided that two scenarios should be run within the fast time simulations:

- Baseline scenario → Current technology, procedures and traffic densities.
- 2015 →Future technology, advanced procedures, increased traffic density.

3.2.2 Generic procedure design

The Sourdine II objectives also imply that the designed NAPs should be as generic as possible in order to be able to implement them at several airports without having to redo the design work. After this 'generic' design, the NAPs can be customised and evaluated for each airport under consideration.

The main parameter that is used for this customisation is the horizontal flight path. As this customisation will be done at a later stage of the project, before the fast time simulations and only for a select number of NAP variants, this section will mainly focus on the parameters that fix the vertical profile of an approach or departure. An important assumption that has been made is that vertical and horizontal path design are not coupled and can therefore be defined separately.

3.2.3 Baseline procedures

In order to effectively validate any noise abatement solution, a reference has to be determined that is representative to airline operations into most European airports today. It is obvious that such a reference procedure can only be determined for the vertical plane, since each airport has its particular approach and departure routing over the ground. To determine the impact of a certain noise abatement procedure at a specific airport, both the baseline and the proposed procedure have to be implemented identically in the horizontal plane.

3.2.4 Departure procedure

The ICAO-A Noise Abatement Procedure (see below) has a wide application at many airports within Europe. Therefore it has been chosen as the baseline departure procedure against which the other departure procedures will be compared. See also reference [D8-1].

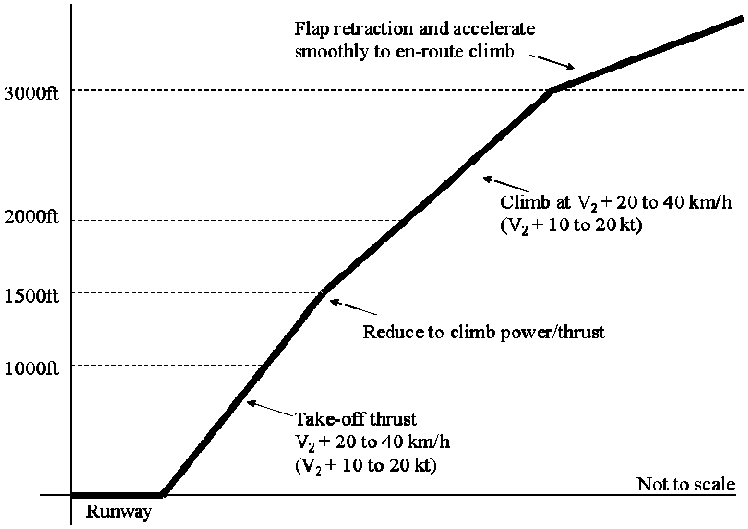


Figure 3-1 Baseline departure ICAO A procedure

3.2.5 Approach procedure

Although a lot of variation exists between the approach operations at various airports in Europe, as a result of traffic density and airport configuration, a typical baseline approach procedure can still be determined by looking at the operation within a representative airline, often described in the Aircraft Operating Manual.

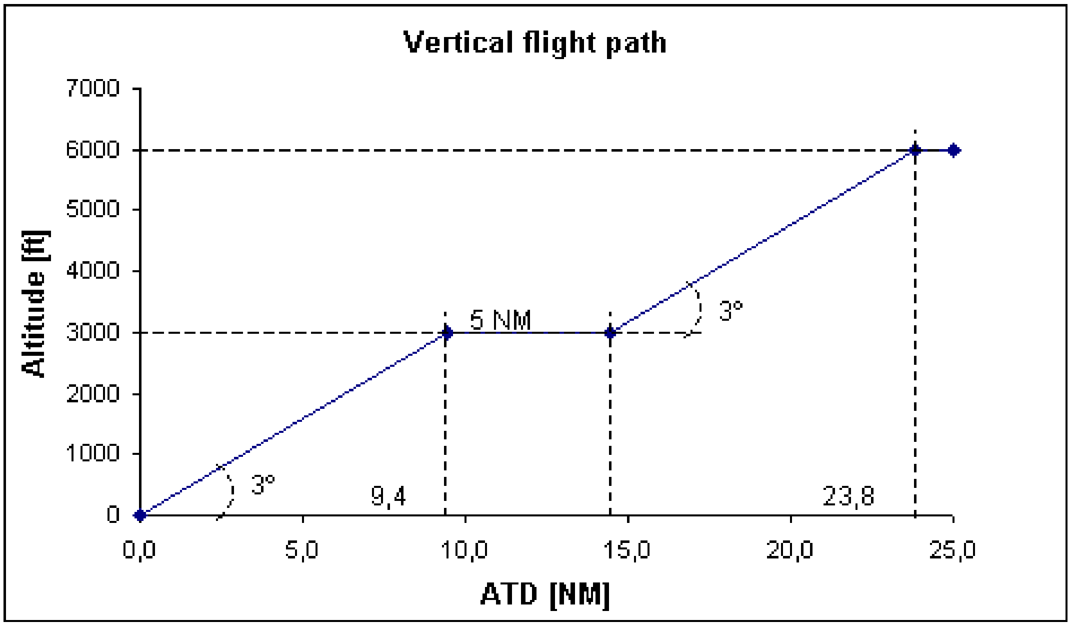


Figure 3-2 3000 ft ILS approach – Baseline

The typical parameters during a ‘standard’ approach are:

- ILS approach with a 3° glide slope.
- Intermediate approach segment with glide slope intercept altitude between 2000ft and 4000ft. Different interception altitudes are encountered throughout Europe, typically ranging between 2000 and 4000ft.
- Minimum stabilisation altitude of 1000 ft, with respect to speed and landing configuration.

The vertical profile during an average normal approach depends on the traffic density. When the traffic density is high, the aircraft will perform stepwise descents to maintain separation with other aircraft. Typically, the approach will include a level intermediate approach segment of at least 5 NM length, which is used for speed and configuration adjustments for entry into the final approach segment.

Due to it’s noise benefits compared to a ‘2000ft’ approach, a ‘3000ft’ (glide-slope intercept at 3000ft) has been implemented in many European airports as the standard IFR (Instrument Flight Rules) approach procedure published in the AIP (Aeronautical Information Publication). Therefore it has been decided to use this as the ’baseline’ approach, see 3-2.

During the approach, ILS-capture will take place at about 9.4 NM before the runway threshold. The speed profile is dependent on ATC instructions and will vary per type of aircraft; thrust is used to follow the required speed profile.

3.3 Noise Abatement Procedures – Vertical plane

3.3.1 Departure noise abatement procedures

<u>Introduction</u>

During take-off and the subsequent phases of flight, called departure procedure, the effects, in terms of noise, come from different variables. This section outlines these parameters and explains some ways to improve the noise characteristics of a departure procedure.

Basically, the noise perceived on the ground generated by a departing or arriving aircraft depends on the amount of source noise emitted and the amount of noise energy that is lost due to propagation effects. Parameters driving departure source noise for a given weight are thrust and speed. With increasing propagation distance sound attenuation due to spherical spreading and atmospheric absorption increase. Meteorological conditions such as temperature and humidity and presence of wind or turbulence play a role. For observers at lateral positions from the track lateral attenuation also affects the perceived noise level, depending on elevation angle, distance and engine position.

1. The parameters on the vertical flight profile that have influence on perceived noise on the ground are:
2. Thrust cutback altitude.
3. Acceleration/Flap retraction altitude
4. Thrust setting (Max Take-off, Max. Climb, cutback thrust setting, etc…)
5. Take-off flap setting
6. Climb Speed

See also reference [D3-1-1] and [D1-1].

As explained previously, the design of the noise abatement procedures was meant to be as generic as possible. For this reason the focus was put on trying to find measures in the vertical plane that minimise noise in specific noise sensitive area, either close or further away from the brake release point. The emphasis of the procedure design work resided in defining candidate noise-optimal combinations of the first three parameters mentioned above. Modification of takeoff flap setting and associated climb speed are part of the aircraft specific NADP design. Flap settings and associated speeds depend also on local conditions, such as presence of obstacles or runway length, and individual aircraft performance. For these reasons and to limit scope to a feasible limit, the last two parameters have not been considered in the project.

Once these combinations (NAP variants) have been defined, single event simulations will be carried out for a limited number of aircraft types in order to determine the noise benefits of a certain variant.

Two fundamentally different forms of departure NAPs have been identified:

- ‘Close-in’ NAP, expected to give noise relief close to the airport
- ’Distant’ NAP, expected to give noise relief further away from the airport

“Close to the airport” and “further away from the airport” should be read as a zone close respectively further away from the brake release point, along the flight track.

To simplify the design and testing of the NAP variants, a generic departure until 10.000 ft altitude has been divided into three segments: A, B, C, with transition altitudes H1 (A → B) and H2 (B → C).

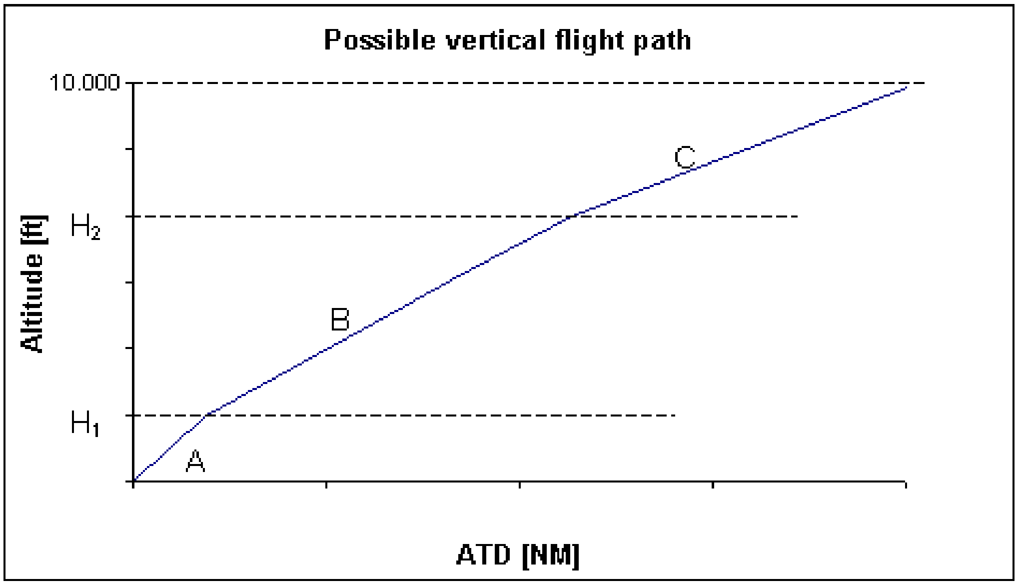


Figure 3-3 Generic noise abatement departure

During a departure the vertical speeds and climb gradients will vary depending on aircraft type, weight and even aircraft operator. Consistent with current departure NAP definitions, thrust and speed schedules may be specified for each segment. This means that although the segments have been drawn as straight lines, the aircraft’s paths will probably not be straight.

The segmentation allows, theoretically, the definition of three different speed and velocity regimes throughout the departure.

‘Close-in’ noise abatement procedures

Where noise sensitive areas are close to the airport (close to the brake release point for a given aircraft) a ‘close-in’ noise abatement departure procedure (NADP) is defined. This means that during the second segment of the departure (segment ‘B’ of 0) the noise impact should be reduced to a minimum. This type of NAP corresponds to the ‘old’ PANS-OPS ICAO-A noise abatement procedure procedure or the ‘new’ NADP-1 [D8168_I].

Reducing noise impact could be performed by prescribing a power reduction at or above the minimum altitude (H1 of 0) and the delay of flap/slats retraction until the prescribed maximum altitude (H2 of 0) is attained. Above the prescribed maximum altitude (segment ‘C’ of 0), accelerate and retract flaps/slats on schedule while maintaining a positive rate of climb, and complete the transition to normal en-route climb speed.

‘Distant’ noise abatement procedures

In case there are noise sensitive areas further away from the airport a ‘distant’ noise abatement departure procedure (NADP) is defined. This procedure reduces noise to a minimum during the third segment of the departure (segment ‘C’ of 0). This type of NAP corresponds to the ‘old’ ICAO-B NADP and the ‘new’ NADP-2 [D8168_I].

Reducing noise impact could be performed by accelerating retracting flap/slat and increasing altitude as much as possible in the first segment of the departure (segment ‘B’ of 0) and afterwards (segment ‘C’ of. of 0) reduce thrust and acceleration while maintaining a positive rate of climb. After passing the noise sensitive area or reaching a certain altitude, the transition to normal en-route climb speed is completed.

3.3.2 Departure variants selected for single event noise evaluation

During the single event calculations, noise footprints will be calculated for a limited number of aircraft. In order to investigate what would be the most noise-efficient departure procedure, the parameters that affect noise during the procedure should be selected, systematically varied, and the noise impact of each variant should be calculated to find the optimum.

As mentioned earlier, segment A is to be left untouched (except for the segment end height H1), so, for segments B and C the following parameterisation has been selected:

- **Velocity**: ‘Maintain’ or ‘Increase’

- **Thrust**: ‘Take-off’, ‘Climb-thrust’, ‘Reduced thrust’ or ‘Gradual increase’

It is assumed that the crew will choose an optimal rate of climb (climb gradient) corresponding to the prescribed thrust and speed settings and that the flap/slat are retracted on schedule.

Investigation of all the variants would mean 2 (segments B & C) x 2 (velocity schedules) x 4 (thrust schedules) = 16 possible combinations. However, the resources and time available to carry out the single event noise calculations only allow a limited number of variants to be investigated. Therefore six different speed/thrust combinations have been designed for the three segments A, B and C; see the following table. Note again that segment A is the same for all combinations.

	Segment A		Segment B		Segment C	
	Velocity	**Thrust**	**Velocity**	**Thrust**	**Velocity**	**Thrust**
I	Increase	Take-off	Maintain	Climb thrust	Increase	Reduced thrust
II	Increase	Take-off	Maintain	Reduced thrust	Increase	Climb thrust
III	Increase	Take-off	Maintain	Reduced thrust	Increase	Gradual increase
	Velocity	**Thrust**	**Velocity**	**Thrust**	**Velocity**	**Thrust**
IV	Increase	Take-off	Increase	Climb thrust	Maintain	Reduced thrust
V	Increase	Take-off	Increase	Reduced thrust	Maintain	Climb thrust
VI	Increase	Take-off	Increase	Reduced thrust	Maintain	Gradual increase

Table 3-1 Speed/Thrust combinations

Combinations II, III and V are expected to give noise relief close to the airport and are therefore used for NAP 1: Close-in. Whereas, combinations I, IV and VI are expected to give noise relief further away from the airport and are therefore used for NAP 2: Distant.

The combinations II and IV have been selected for detailed evaluation. For these combinations, the altitudes at which a change in segment takes place (H1 and H2) have been varied in order to assess its impact on the noise distribution. This information is also expected to allow faster customisation of a certain departure NAP to a certain situation.

The altitudes are varied in the following way:

H1 (ft)	2000	3000	4000	5000	6000
H2 (ft)	400	800	1000	1500	2000

Although 400 ft for the first transition (H1) is expected to probably give problems with respect to safety requirements (800 ft was determined as minimum altitude during the establishment of NADP1,2), it was decided to include it anyhow to see what the potential noise benefits would be.

Note that when in case H1 and H2 are equal (2000 ft), the second segment (segment B) disappears from the departure path.

To carry out a systematic variation of all the parameters would mean: 5 (altitudes H1) x 5 (altitudes H2) x 6 (thrust/speed combinations) = 150 variants for each aircraft. Due to the limited amount of time and resources available this was not possible, therefore a selection was made. The following table gives an overview of some of the variants proposed for the SES simulation/ calculation. The total number of departure procedure variants is 39.

Note that procedures 1-13 and 2-13 are the ‘new’ NADP1 and NADP2 published in [OPS1]. Furthermore, procedures 1-16 and 2-19 are equivalent to the optimised close-in and distant departures respectively developed during Sourdine I. (i.e. The full table can be found in document D3.1).

Baseline departure		**H1 (ft)**	**H2 (ft)**	**Thrust / Speed Combination**	
BD	1	1500	3000	-	ICAO A
NAP 1: Close-in		**H1 (ft)**	**H2 (ft)**	**Thrust / Speed Combination**	
1-1		400	2000	II	
1-4		2000	2000	II	
………………………		………..	……….	………………….	
1-13		800	3000	II	ICAO NADP-1
………………………		………..	……….	………………….	
1-16		1000	5000	III	Optimised Sourdine I departure
………………………		………..	……….	………………….	
2-13		800	3000	IV	ICAO NADP-2
………………………		………..	……….	………………….	
2-19		1000	5000	VI	Optimised Sourdine I departure

Table 3-2 Departure Single Event simulation variants

3.3.3 Approach noise abatement procedures

Introduction

During descent and approach, the aircraft has to lose its energy, i.e. speed and altitude, in a controlled manner to arrive at the final stabilisation point on the final approach with the correct speed and in the landing configuration. From top-of-descent down (TOD) to the ground the aircraft has to decrease speed and altitude, in addition, the aircraft changes its aerodynamic configuration and engine thrust setting. The variables on the flight path that can influence the intensity of noise and the noise footprint on the ground are:

In the vertical plane:

- Height at a given position.
- Speed, influencing airframe noise
- Aircraft configuration: position of slats/flaps, spoiler and landing gear), influencing airframe noise.
- Thrust level, driving engine noise level
- Descent angle or gradient, determining profile height, deceleration distance and thrust requirement
- Threshold displacement (shift of touchdown position at the runway) is considered as a solution to move of the noise footprint closer to the airport.

In the horizontal plane:

- Accurate RNAV versus conventional navigation capability from current aircraft. An improvement of precision in navigation can reduce this spread of noise.
- Radar vectoring or (strictly) prescribed arrival/approach routes. If substantial vectoring by air traffic control occurs for arrivals, much larger dispersion should be considered. [D3v83]

For the Sourdine II project it has been decided to investigate variations in approach gradient and descent speed in order to find the optimal noise pattern. The selection of flaps/slats is closely coupled to the followed velocity profile. Selection of landing gear generates drag and additional airframe noise; therefore it is assumed that the selection of landing gear ‘down’ will take place as late as possible taking into account safety considerations.

Threshold displacement will not be studied, since the noise benefit is evident and reported in projects like Sourdine.

Due to its high potentials for noise abatement, demonstrated during the Sourdine I project, the CDA has been chosen as the basic form for the approach procedures. The target timeframe of the Sourdine II project (between now and 2015) allows the ‘enhancement’ of CDAs to Advanced CDAs. The following section will explain this in more detail.

Advanced Continuous Descent Approaches – ACDAs

An Advanced CDA (ACDA) is a CDA that is enhanced with future infrastructure, ATC tools and crew tools in order to meet demands of capacity and safety. During an ACDA, the requirements for ATC speed control may be relaxed, or even removed, and additional constraints may be added; for example to execute a part of the approach with thrust idle or to follow a certain fixed vertical flight path.

The following table indicates the similarities and differences between CDAs and ACDAs:

	CDA	**ACDA**
Vertical profile	Continuously descending	Continuously descending
Descent rate	At pilot discretion	Depending on ACDA type it may be linked to a prescribed flight path.
Speeds	Prescribed by ATC	Depending on ACDA type it may be at pilot discretion or as programmed/advised by the aircraft's FMS.
Thrust setting	Depends on aircraft type and weight, chosen descent rate, ATC speed requirements and weather conditions.	Depending on ACDA type it may be prescribed (minimum thrust level depending on aircraft type)
Technology	Current	Future

As part of a first theoretic approach, three types of ACDA procedures have been distinguished based on assumed combinations of flight control parameters thrust , speed and path or descent angle:

A1) 'Variable thrust ACDA': Thrust settings are adapted, to follow a given flight path and speed profile

A2) 'Variable vertical flight path ACDA': The flight path is adapted to follow a given speed profile with a fixed thrust setting

A3) 'Variable speed ACDA': the combination of a given thrust profile and flight path results in a certain speed profile (depending on aircraft type and configuration).

For the approaches, the three ACDA-types have been used as a basis to derive variants. For the fixed flight-path ACDAs (A1 and A3) the vertical path has been segmented in two parts: above and below a certain altitude (Hs), this will allow the definition of two different approach angles, see figure 3-4 below.

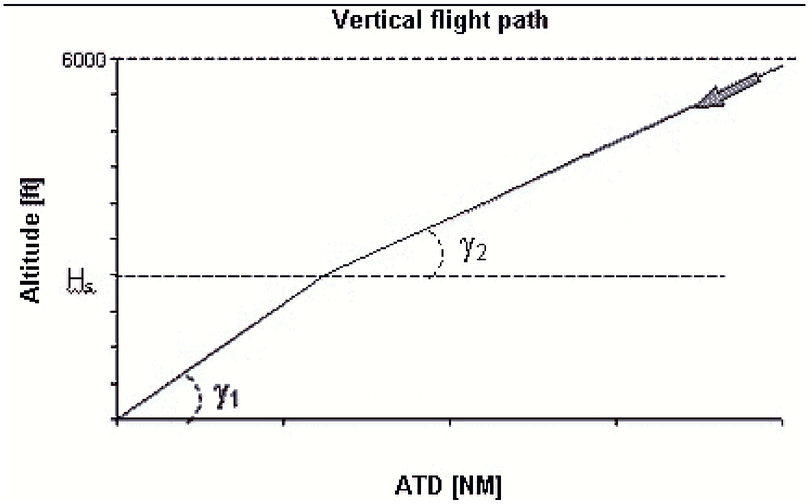


Figure 3-4 Parameterisation of 'Variable Thrust' and 'Variable Speed' ACDAs

Note that in the figure above and the figures in the next sections, the runway threshold is located at the origin of the altitude – distance axis.

Variable thrust ACDA

With the 'Variable thrust ACDA' the flight path is prescribed (published) and the speed profile is determined by ATC and by the aircraft's performance limitations. Thrust is used to follow the velocity profile, see the example figures below. It should be noted that due to the fact that the aircraft flies a constant 3-degree glide slope, and modern aircraft are aerodynamically smooth, the power settings will probably remain nearly idle for most of the wide-bodies.

An advantage of this NAP variant is the predictability of the aircraft's behaviour. As speed and flight path are prescribed, the exact aircraft position in time can be determined throughout the whole procedure. A disadvantage is that the thrust profiles will be different for each aircraft type: some aircraft will need more thrust than others to follow the prescribed speed profile.

Variable vertical path ACDA

With the 'Variable vertical flight path ACDA' the geometry of the vertical flight path is used as control variable. The aircraft's Flight Management Computer (FMC) calculates a vertical profile and a top-of-descent based on thrust-idle power settings and the aircraft-specific speed profile. During this ACDA, the aircraft performs a thrust-idle flight until a point before ILS-localiser interception. The distance from this point to ILS-localiser is used as a buffer in case it is required to reduce the speed further to landing speed.

An advantage of this NAP variant is that thrust remains idle, thus minimising engine noise. A disadvantage is that the predictability of the procedure is lost: every aircraft type will have to fly a specific vertical profile in order to follow the prescribed speed profile with thrust idle. As the vertical profiles are different, the exact location in time will vary depending on the aircraft type.

Variable speed ACDA

With the 'Variable speed ACDA' the flight path and thrust profile (power settings idle) are fixed. If the forces acting on the aircraft have a component along the flight path opposite to the flight direction (drag force higher than the combined thrust and weight components), the aircraft will decelerate. A way to influence the speed profile without using thrust or a change in vertical flight path is by changing the configuration.

An advantage of this NAP variant is that thrust remains idle, thus minimising engine noise. A disadvantage is that the predictability of the procedure is lost: every aircraft type will have a specific speed profile resulting from the prescribed vertical profile with thrust idle. As the speed profiles are different, the exact location in time will vary depending on the aircraft type.

Approach variants selected for single event noise calculation

During the single event calculations, noise footprints will be calculated for a limited number of aircraft. In order to investigate what would be the most noise-efficient departure procedure, the parameters that affect noise during the procedure should be selected, systematically varied, and the noise impact of each variant should be calculated to find the optimum.

The following parameterisation has been selected:

ACDA Type	**g1 (deg)**	**g2 (deg)**	**Hs (ft)**	**Velocity**
Variable thrust	3.0	2.0	500	High, fixed
Variable vertical path	4.0	3.0	1500	Low, fixed
Variable speed		4.0	3000	
		6.0		

Table 3-3 ACDA parameterisation

It is assumed that the crew will select flaps/slats on schedule and the landing gear ‘down’ as late as possible.

Inverse Section investigation of all the variants would mean 3 (ACDA types) x 3 (g1) x 4 (g2) x 3 (Hs) x 2 (velocity regimes) = 144 possible combinations. However, some combinations are not feasible (e.g. a fixed flight path and fixed thrust and fixed speed); furthermore, the resources and time available to carry out the single event noise calculations only allow a limited number of variants to be investigated. Therefore a selection has been made. The following table gives a short an overview of all the variants that were to be simulated / calculated. The total number of approach procedure variants is 39, (i.e. table example below).

Baseline approach		**g1 (deg)**	**g2 (deg)**	**Velocity**	**Thrust**	**Hs (ft)**
BA	1	3.0	0.0	Fixed	Variable	3000
A1 Variable Thrust		**g1 (deg)**	**g2 (deg)**	**Velocity**	**Thrust**	**Hs (ft)**
A1-1		3.0	2.0	High, fixed	Variable	3000
…………………		……….	……….	……………..	……………	………
A1-20		3.0	6.0	Low, fixed	Variable	500
A2 Variable V-path		**g1 (deg)**	**g2 (deg)**	**Velocity**	**Thrust**	**Hs (ft)**
A2-1		3.0	Variable	High, fixed	Idle, fixed	3000
…………………		……….	……….	……………..	……………	………
A2-6		4.0	Variable	Low, fixed	Idle, fixed	500
A3 Variable Speed		**g1 (deg)**	**g2 (deg)**	**Velocity**	**Thrust**	**Hs (ft)**
A3-1		3.0	2.0	Variable	Idle, fixed	3000
…………………		……….	……….	……………..	……………	………
A3-12		3.0	6.0	Variable	Idle, fixed	500

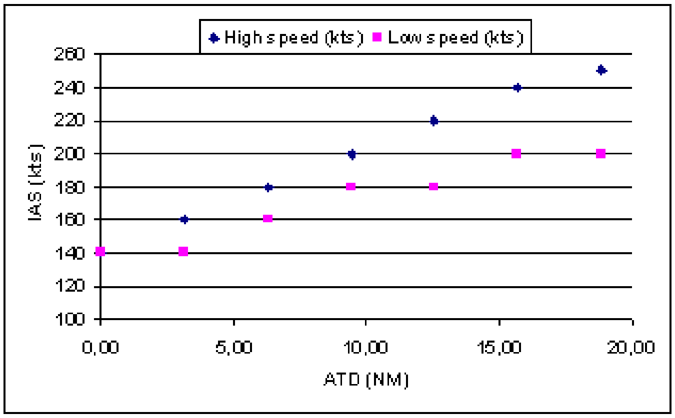
Table 3-4 i.e. variants for Single Event Simulation (more details in reference [D3-1-1])

Velocity profile

For the procedures which have fixed, prescribed, velocity profiles, the idea is to provide speed targets at fixed points or altitudes during the approach.

The purpose of the ‘high’ and ‘low’ velocity profiles for the variable thrust and variable vertical path ACDAs is to check whether a “fast and clean” approach is more or less noise beneficial than a “slow and dirty” approach. The following table gives an example of possible speed targets at different altitudes:

H (ft)	High speed (kts)	Low speed (kts)
0	140	140
1000	160	140
2000	180	160
3000	200	180
4000	220	180
5000	240	200
6000	250	200



This table is only meant as an example, the actual velocity profile(s) may have to be fine-tuned to accommodate specific categories of aircraft.

3.4 Noise abatement Procedures – horizontal plane

3.4.1 Introduction

Although a detailed design of the horizontal path is not part of WP3, this section will outline some important considerations for noise abatement measures that can be taken in the horizontal plane. These considerations are mainly related to system capabilities and availability (section 3.4.2), requirements and constraints for ATC / ATFM (section 3.4.3) and aircraft performance / crew constraints (section 3.5).

As explained in section 3.2.2, an important assumption that has been made is that vertical and horizontal path design are not coupled and can therefore be defined separately. This means that measures in the horizontal plane may be used in combination with measures in the vertical plane.

3.4.2 System considerations

The workpackage to identify the required/available systems: ATC / crew tools, displays, and infrastructure was started in the very beginning of the project (see [D1-1]). The results of this workpackage, as well as input of two expert panels, made it possible to estimate which systems would be available when and what the percentage of equipped aircraft / airports will be. The following systems could be key enablers for new, advanced NAPs:

- Controller Pilot Data-link Communications (CPDLC)
- Arrival Manager (AMAN)
- Departure Manager (DMAN)
- Area Navigation (RNAV)
- Adapted Flight Management System (FMS) and/or engine control systems

More information on these systems can be found in reference [D1-1].

3.4.3 ATC / ATFM considerations

When standard approach procedures are being flown, ATC guides the aircraft with speed control and radar vectoring to the ILS-localiser in such a way that the separation criteria during approach and on final are met. It is not important for the expected time of arrival to a runway threshold to be equal to the actual time of arrival, as long as the separation is guaranteed. The planning system takes care of the fact that not too many aircraft enter the TMA and the landing interval is based on the separation criteria on final applied at that time. During a CDA, the situation is different; here the air traffic controller is expected to intervene as little as possible and landing intervals might increase.

It is expected that the tools mentioned in the previous section will be necessary in order to enable ATC / ATFM to ensure separation, integrate arriving traffic flows, separate departing from arriving traffic and achieve an optimal sequence without ‘spoiling’ the noise abatement procedure.

3.5 Crew / aircraft considerations

This section will discuss briefly some aspects related to the interaction between aircraft / crew performance and the design of a ground track for noise abatement purposes:

- Minimum straight segment after departure or before touch-down point
- Minimum turn radius
- Minimum distance between two turning points
- Wind influence

Minimum straight segment

If the straight segment before the runway threshold can be reduced to a minimum (during a departure as well as during an approach), the procedure designer has more freedom of avoiding potentially noise sensitive areas.

Previous research concerning the introduction of MLS showed that, within certain constraints, i.e. adequate approach minima, guidance, turn radius and glide path interception position, curved path procedures are flyable with appropriately equipped wide-body aircraft. During the simulator trials of this MLS research, it was shown that, for all of the tested pilots (40 pilots), the minimum operationally acceptable straight-in segment for a wide-body curved path instrument approach is 3.0NM under Cat I and below weather conditions. For higher weather minima, shorter straight-in segments may be acceptable.

Wind influence

Wind can affect an aircraft track significantly. Many RNAV / FMS systems take account of the calculated, or forecast, wind when computing a turn. A strong tail wind will cause the turn to start early, with a larger than normal turn radius, while a strong head wind will result in a late turn and a smaller than normal radius. Some RNAV / FMS systems calculate the turn beforehand and only re-assess the situation as the turn is nearing completion when the following subsequent track is ‘captured’ - the turn itself is considered to be frozen - while others make continual reassessments and adjustments during the turn.

4 Single event simulations

4.1 Introduction

The set of procedures established in the first procedure design phase has been analysed in terms of noise reduction potential based on single event noise prediction. This study is documented in Sourdine II deliverable D5-3 [D5-3]. The objective of the noise analysis was to identify procedures that are efficient in terms of noise reduction for large commercial jet aircraft. In addition to the initial procedures, also the outcome of the Sourdine project and results of two Sourdine II expert workshops that took place in 2002 have been taken into account. The outcome provided a basis for more detailed definition of procedures for further evaluation in the fast time simulations on airport scale.

The single event noise exposure study covered both noise abatement approach and departure procedures. The study was focused primarily on approach procedures due to the complexity of the evaluated approach procedures and because of expected noise reduction potential compared to conventional approach procedures. The benefits of part of the proposed departure procedures have already been demonstrated in a comprehensive way during Sourdine project.

In addition to the identification of efficient concepts, the study provided further insight in the relation between noise exposure and operational flight parameters, further to studies available from the first Sourdine project.

The single event noise study has been carried out using Airbus performance and noise calculation tools. Aircraft included in the study documented in D5-3 are the short/medium-range twinjet A320-200 and the long-range, four-engines A340-300. The performance studies involved computation of operational trajectories based on the procedure descriptions. These studies enable a first selection of the initial procedures based on aircraft performance limitations and provide trajectories that reflect performance characteristics and limitations of the aircraft. Operational feasibility, regulatory and pilot perception aspects were not subject of this study and have been examined in a later stage of the project. The trajectories are used as input for single event noise prediction carried out with Airbus Noise Level Calculation Program (NLCP).

4.2 Approach

All evaluated noise abatement approach procedures are Continuous Descent Approach procedures. The performance calculations enabled a first selection of CDA procedures in terms of maximum descent angle. For a continuous decelerating descent, without deployment of airbrakes or other drag-creating devices, flight path angles steeper than -2 to -2.5 degrees (depending on aircraft type and weight) result in insufficient deceleration capability. Steeper angles are feasible only in case of a constant speed descent or through deployment of drag creating devices, i.e. with the aircraft in intermediary or landing configuration or with airbrakes or landing gear extended.

The remaining approach procedures were included in the noise study. As basis of the comparison a reference approach procedure was used with a level segment at 3000ft AGL along which the deceleration from 250kt to intermediate configuration speed is accomplished. This procedure resembles FMS approach procedures and represents today's capability in terms of aircraft performance. Given the variability of conventional approach procedures – every airport has its tailored procedure – a non-arbitrary reference procedure was preferred for noise comparison.

To appreciate the noise performance of the selected reference procedure compared to conventional procedures a noise comparison was made between an approach procedure currently used at a large European airport and the reference procedure. Figure 4-1 shows the result of this comparison for an aircraft of the A319 family. Due to the extended level segments at 4000ft and 3000ft AGL, the conventional procedure is overall considerably shallower. The maximum noise difference below track is 8dBA in terms of peak A-weighted noise level (DBAmax) in favour of the reference procedure.

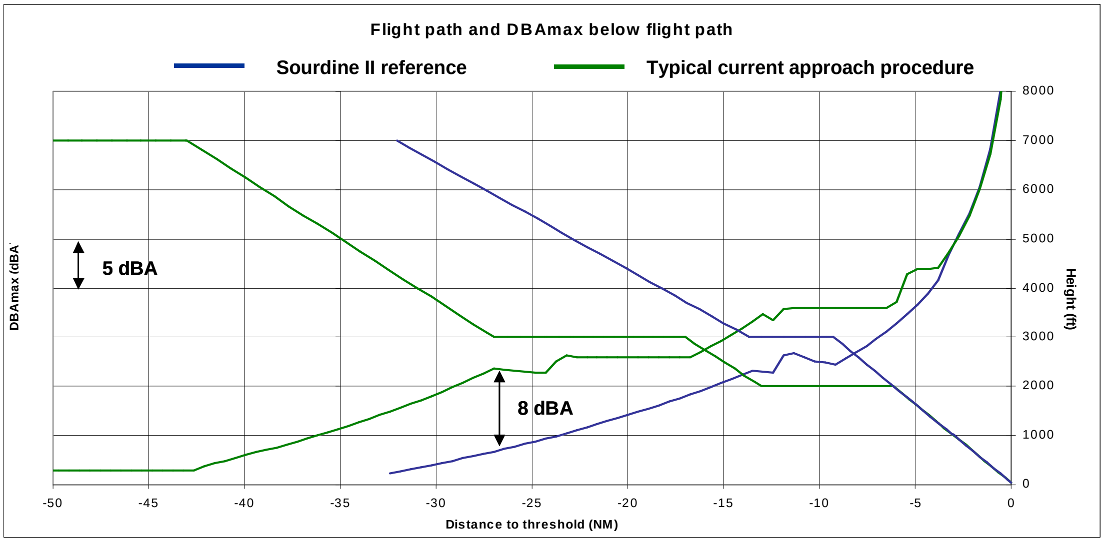


Figure 4-1: Comparison of the S II reference approach procedure and typical current practice approach

The following figures show noise comparison of the reference procedure and evaluated CDA procedures. Figure 4-2 compares noise below track for a CDA with a -2°FPA against the reference procedure. Noise reduction for this CDA variant compared to the selected reference procedure is local. The noise peaks are due to deployment of high-lift devices and subsequent deceleration. The influence of these and other parameters on noise are described in detail in D5-4.

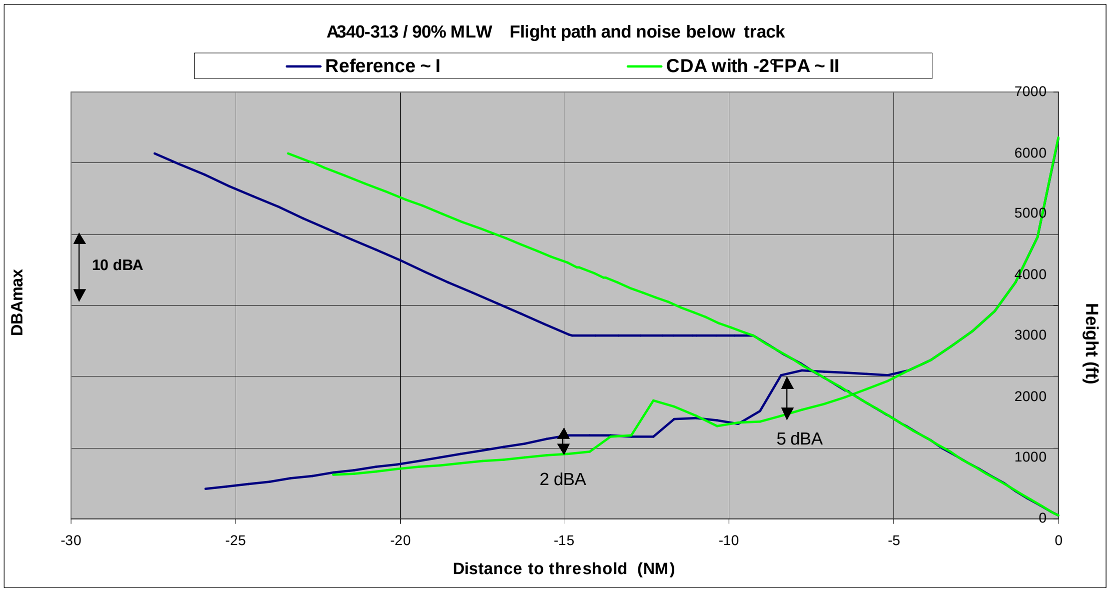


Figure 4-2: CDA with –2°FPA and reference approach procedure

Figure 4-3 shows the results of a procedure combining CDA with increased (–4°) final glide slope. Due to the increased difference in terms of height profile the noise reduction of this procedure relative to the reference procedure reaches 3dBA underneath the CDA part and 7dBA around the glide slope intercept point.

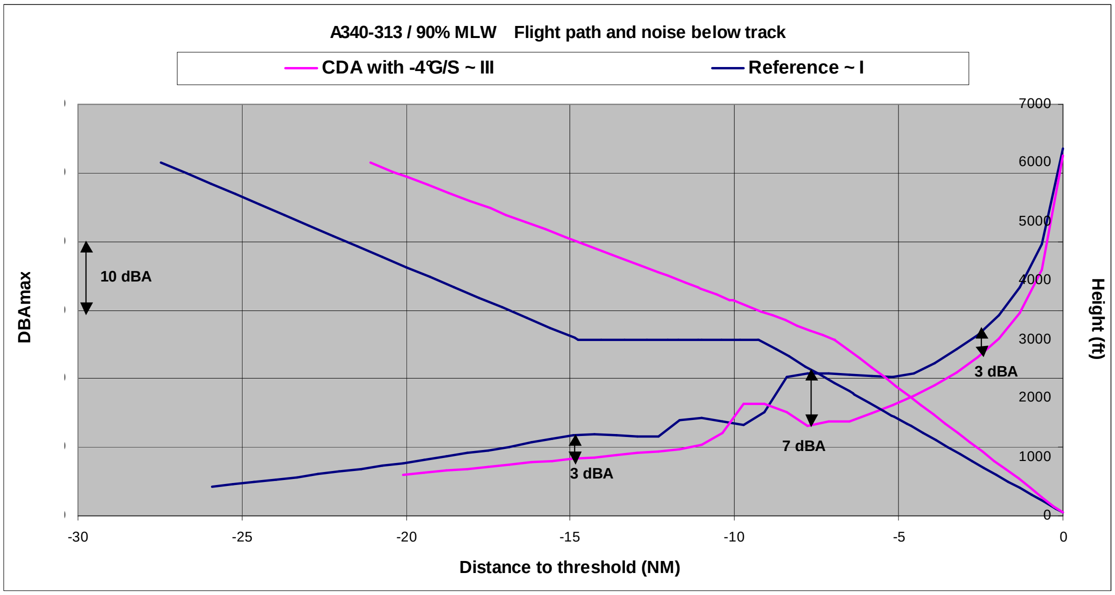


Figure 4-3: CDA combined with increased glide slope and reference approach

Figure 4-4 and Figure 4-5 show noise performance for a different category of CDA procedures. This category features steep constant-speed variable-path segments from 7000ft to respectively 2000 and 3000ft. Apart from the glide slope intercept height, the difference between these variants resides in the speed and configuration in which this intermediate segment is accomplished and the resulting FPA. In the case of figure 4-4 the CDA procedure features starts at 7000ft with the aircraft in landing configuration and speed, resulting in a steep segment (FPA ~ -5°). Noise reduction below track is up to 7dBA. The variant in figure 4-5 features an intermediate segment at intermediate configuration and corresponding speed. The resulting profile is shallower than the first example (FPA ~-3°), but compared to reference procedure steep enough to provide a considerable reduction of noise below track, with a maximum of 4dBA.

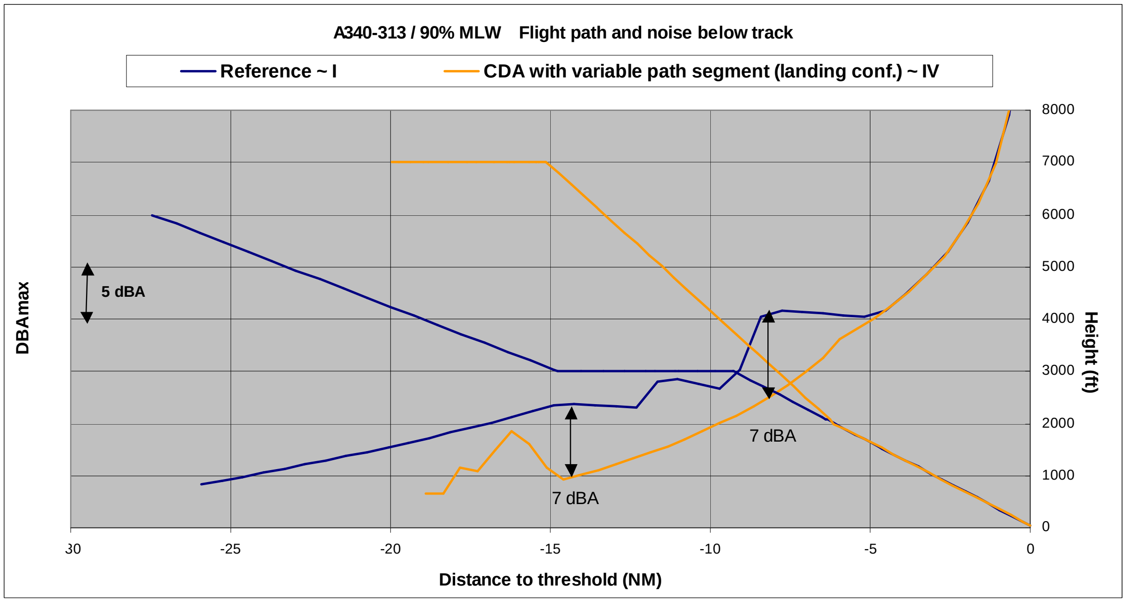


Figure 4-4: Variable path CDA (landing conf.) and reference approach

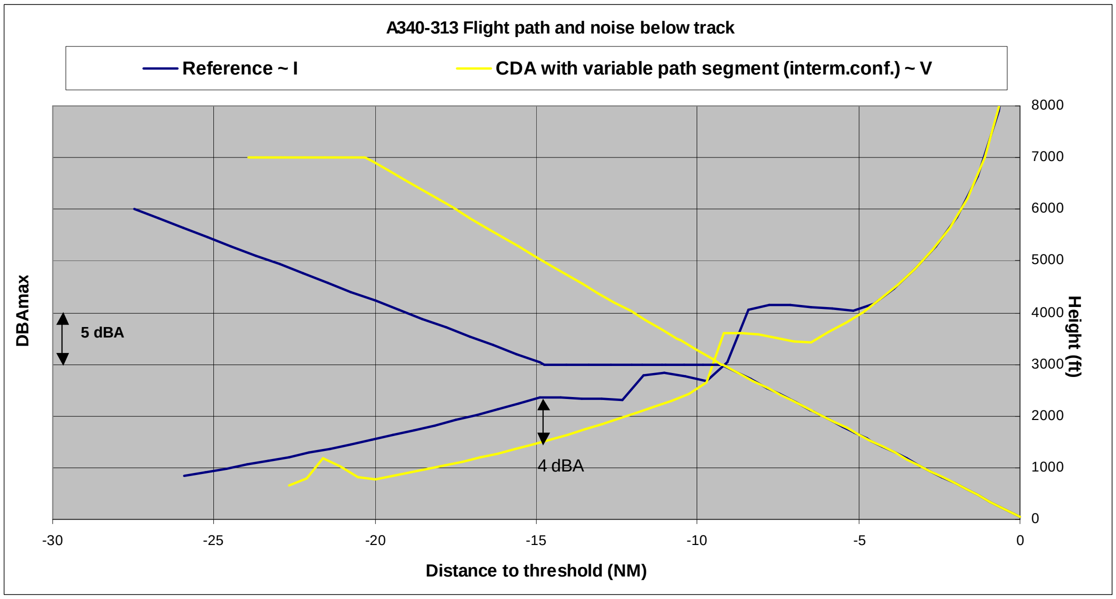


Figure 4-5: Variable path CDA (intermediate conf.) and reference approach

4.3 Departure

The single event evaluation of departure procedures was limited to the optimized procedures developed in the first Sourdine project and variants of PANS-OPS noise abatement procedures. The reference ICAO A procedures is considered representative for today's operations at many airports.

The noise studies have been performed for maximum takeoff weights and for operational takeoff weights. Thrust settings included in the study are Takeoff Go-Around thrust (full takeoff power), Max Climb and cutback thrust settings limited by engine inoperative climb thrust requirements. It is recognized that current operations usually feature use of reduced thrust settings (de-rated or flex-takeoff thrust), which through reduced climb performance may lead to increased noise. Given the limited resources and scope this has not been taken into account in the study. The scope of the single event study was limited to reconfirming the effect of the optimized thrust management techniques evaluated in the Sourdine project, in anticipation of airport-wide studies later on in the project. The optimized thrust management techniques feature full power initial climb, followed by a deep cutback once the noise critical zone is reached and ending with a gradual transition to climb power at the end of the noise reduction zone.

Figure 4-6 and figure 4-7 show noise reduction potential of this optimised thrust management applied for Close-in and Distant procedures, compared to the baseline procedure. The optimized Close-in procedure in figure 4-6 provides noise reduction until the 13NM point with a maximum reduction of 2.5dBA at 3.5NM from brake release. The optimized Distant procedure (figure 4-7) provides noise reduction in the 6 to 21NM zone, with a maximum of 4dBA. At larger distance from brake release noise levels, although higher than for the ICAO A procedure, are considered non-critical.

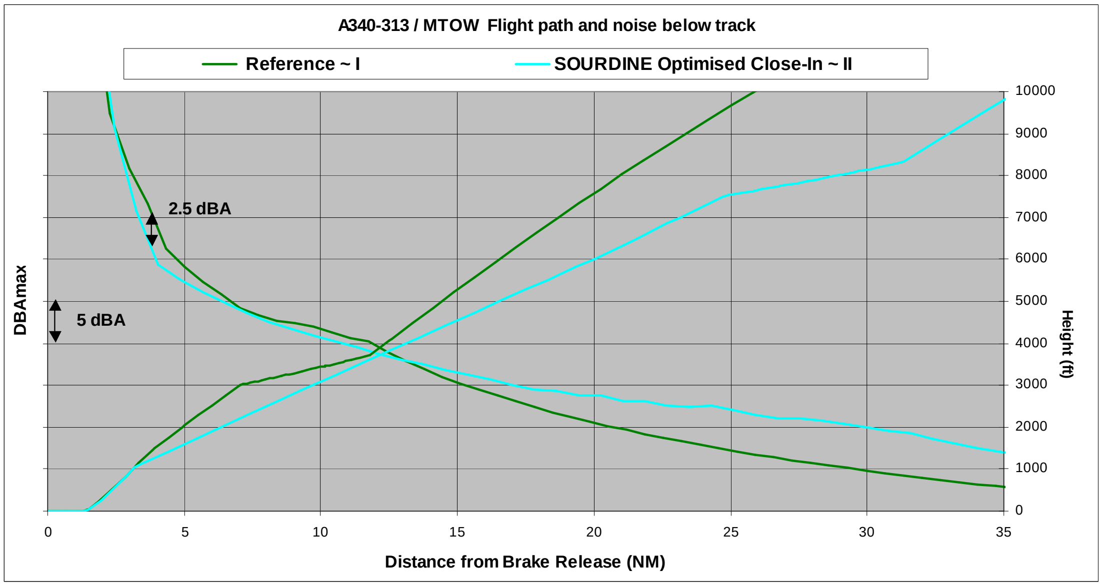


Figure 4-6: Optimized Close-in and ICAO A departure procedures

The examples both consider A340 operations. It is recognised that optimisation of departure operations and especially the detailed optimisation of thrust management is aircraft- and weight specific. The overall impact on noise exposure when applied on an entire fleet at airport scale is evaluated as part of airport studies.

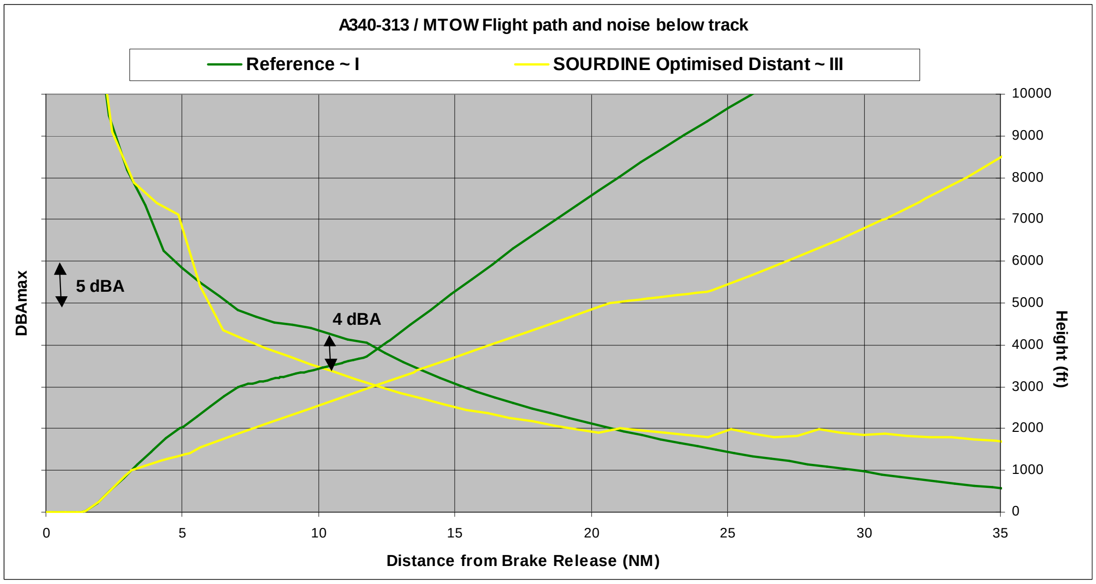


Figure 4-7: Optimized Distant and ICAO A departure procedures

5 Procedure selection based on Single Event Simulation

5.1 Introduction

5.1.1 Purpose

The purpose of this chapter is to highlight the preliminary procedure selection based on the single event noise calculation or simulation (SES) (D5.3) results and post-analysis and the results of the third expert panel meeting, which took place in June 2003.
The procedures selected during this first filtering step were then passed for further evaluation to the Fast Time and Real Time simulation trials.

5.1.2 Structure

The chapter is meant to describe the first selection stage of the procedures and is divided into two parts:

Part 1: The first step towards the selection of the most promising procedures was the single event noise evaluation of the SII D3.1 matrix (the results of these assessments can be found in D5.3). This section offers the criteria used to compare and obtain the most noise
beneficial procedures.

Part 2: The second step includes in the selection loop further information and evaluation aspects as the information gathered from the third brainstorm and the in post processing done in depth by done by Airbus (post-data analysis). Those aspects of the procedures which deliver the greatest noise mitigation benefits were here highlighted.

5.1.3 Background

The work is based upon the work done in D3-1-1 and D5-1: the first delivering the designs and the options (proposed as a list or matrix of procedures); while the second working on the list, evaluating it using Airbus performance software to compute operational trajectories and the Airbus NLCP to calculate the noise impact per procedure.
This enabled filtering out those procedures that were not flyable (from a pure aircraft performance point of view) and identify noise reduction potential of remaining procedures.
The results, specifically, of D5.3 take into account Airbus aircraft A340 and A320, migration of the results to other kind of aircraft should not be done with simplicity. The numbers of the procedures are the same as those used in D5-3.

5.2 Procedure selection step 1

5.2.1 Selection method and criteria

In general in order to choose the best noise performing procedures, the results following from the D5.3 document were divided into Approach procedures and NADPs; including the subdivision by aircraft performing such procedure.

The following criteria were applied for:

APPROACH

1. Benefits below flight path in zones where noise levels are above 55dBA
2. Reduction of noise below track and of footprint area, compared to reference.
3. Trend from least beneficial to most beneficial

DEPARTURES

1. Best Localised Noise performance (Distant/Close-in)
2. Benefits below flight path in zones where noise levels are above 55dBA.

5.2.2 *Approach procedures evaluated for A340*

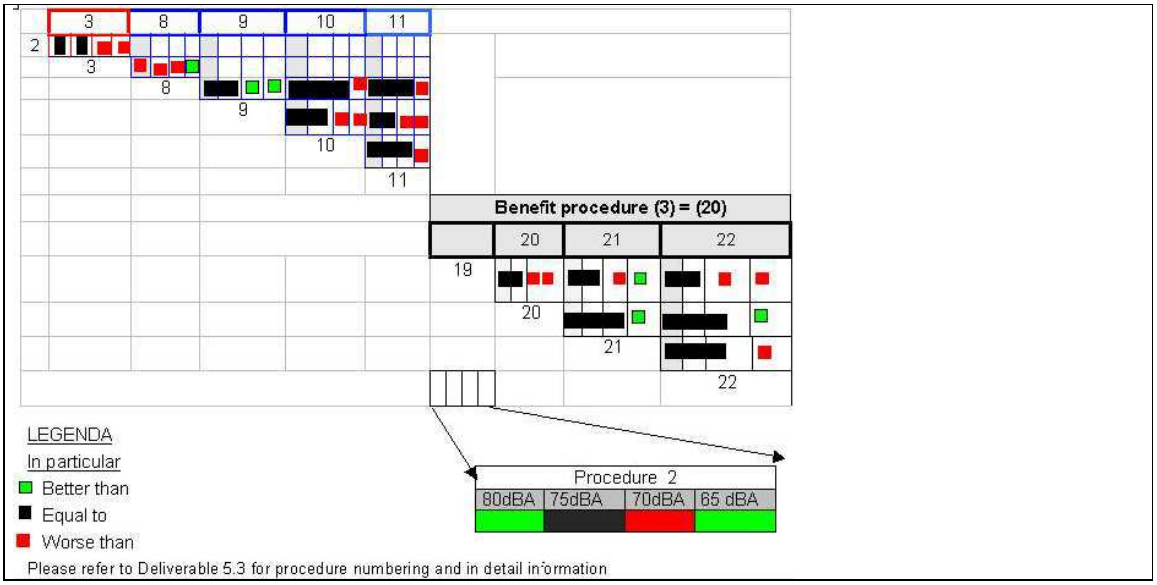


Table 5-1 Noise evaluation of the procedures (comparison table)

The above table shows the comparison made among the procedures on the basis of the noise levels.

Since procedures number (3) and (20) have the same footprint benefits relatively to the reference procedure, while procedure number (8) is better than number (3). Hence resuming, in order from most beneficial to less beneficial procedure (in terms of noise footprint) we have:

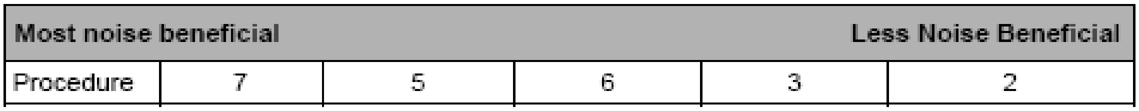
Most noise beneficial									Less Noise beneficial
Procedure	11	10	8	3-20	22	21	9	2	19

Table 5-2 A340 Procedures listed by noise benefit

5.2.3 *Approach procedures evaluated with A320-211*

By comparison as in the table above the selection of the procedures resulted in the table below.

For the A320-211 the noise footprint comparison is straight forward, the best noise performing procedures in order of (%) benefit are:



Most noise beneficial					Less Noise Beneficial
Procedure	7	5	6	3	2

Table 5-3 A320 Procedures listed by noise benefit

5.2.4 Departure procedures

As done by D5.3 the NADPs were divided into Close-in and Distant procedures, the first giving noise relief closer to the airport while the second noise relief further away. The amount and location of noise relief depends on the procedures themselves and the aircraft type and weight.
The zone where noise relief is required and therefore the need for a Close-in or Distant procedure is rather dependent on the necessities of the airport (i.e. the location of noise sensitive zones relative to the departure runways). We may notice that a procedure that relieves noise in all areas throughout the departure does not exist. It is therefore more helpful to refer to the conclusions given by the D5.3 (par 5.2-“Departure Procedures”), which covers the general question.

5.3 Procedure selection step 2

The following sub sections continue the selection work of section 2, where only the noise abatement characteristics were weighed. In this second step in fact the results from step one will indicate which aspects among the various procedures are the most noise beneficial, meaning that it is not the specific aircraft procedure we are aiming for, rather from which characteristics do we obtain the most benefits. In the following subsections the analysis goes more in detail on certain results obtained for certain procedures which are numbered following the aircraft the SES was simulating on. The conclusion will highlight which best concepts will be brought forward to the further steps of validation.
Taking into account both the noise performance of the procedures plus the comments from the third Expert Panel meeting (mostly in the case of increased GS on ILS) the following procedures were proposed for their preliminary sound abatement benefits. To notice that the basic idea is not the creation of aircraft specific procedures: as such the A320 and A340 were used as test beds to obtain a first filtering out in order to obtain the most noise beneficial features of the procedures.

Approach Procedures

Procedure 10 and 11
Procedure 11 is a procedure which is only considered in the starting phase of the Single Event Simulations: it consists of an initial, decelerating descent at 2 deg FPA, starting at 6000ft, 220 kts, clean configuration. Reaching FAS in full configuration, a steep segment at constant speed (FAS) is flown until the interception (from above) of a 4 deg ILS.
Procedure 10 is a much more simple procedure: 2 deg FPA, decelerating, until the interception at 3000 ft of a 4 deg ILS.
Although procedure 11 had some advantageous noise characteristics relative to procedure 10, in the end procedure 10 was selected as a good representative of an increased GS CDA with good noise abatement performance.

Procedure 10 and 7
A good example of this stepped analysis are the good results obtained for both aircrafts with a high GS procedure, in fact procedure (10) A340 and (7) A320 are very similar and indicate that the general characteristics or concept behind the specific aircraft outcome during the SES, deliver noise abatement benefits.
The general procedure based upon the (10-7) can be found described further on in section 4.

Procedure 2
Was chosen as the standard basic CDA procedure.

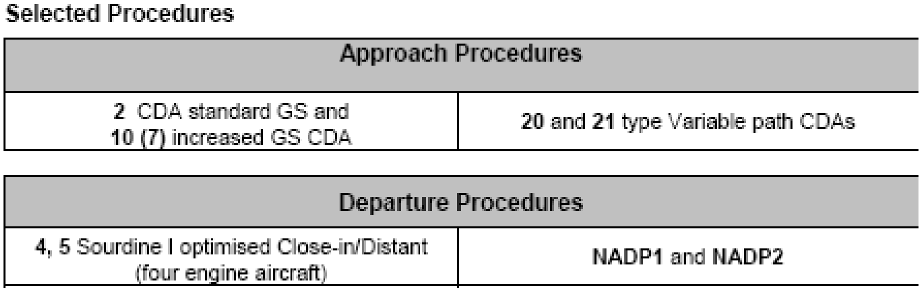
Procedure 20 & 21

Both represent a Variable path CDA procedure and behaved quite well for the A340 resulting in good noise relief.
On the other hand no procedure of this type was simulated on the SES for the A320 at the beginning, although the basic concept is thought to be of great aid in decreasing noise.
Therefore in a second moment the two procedures were simulated for the A320, in order to see if the basic concept would work on another aircraft and the results were fairly good (reference D5.3).
The two procedures have been chosen in order to keep supporting the research on Variable path concept and the construction of a general Variable Flight Path CDA.

General
The results from all the previous steps have shown that certain procedure concepts pursued during the design process do result in noise benefits. This achievement not only makes the procedures general but overall gives the possibility of adapting the concept to the specific necessities (fleet-mix, airport, etc..) as far as possible. The procedures have proven beneficial for A340 and A320 and the same results are expected for similar aircraft.

Departure Procedures

The selection for the departure procedures fell on the Sourdine I optimised and the NADP1 and NADP2 procedures. The Sourdine I procedures, featuring a cutback to a level that is significantly lower than the Max Climb rating, have proven beneficial for a four engine aircraft. For some aircraft taking off at a takeoff weight that is close to their maximum takeoff weight, the possibility to cutback to a level significantly lower than Max Climb may not me available due to the way their Climb rating has been optimised. In this case the procedure will remain based on the Climb rating.
The study conducted in D5.3 confirms that noise reductions obtained with identical procedures depend much on aircraft type and weight [Ref. D5.3]



Selected Procedures

Approach Procedures	
2 CDA standard GS and **10 (7)** increased GS CDA	**20** and **21** type Variable path CDAs

Departure Procedures	
4, 5 Sourdine I optimised Close-in/Distant (four engine aircraft)	**NADP1** and **NADP2**

The above procedures will be tested against a NAAP baseline (FMS approach procedure) and an NADP baseline (ICAO A in this case).

6 Selected procedures

6.1 Introduction

The following are the final Sourdine II procedures (approaches and departures) following the first filtering and selection made by the project (details can be found in the previous section). Further analysis was made by the consortium with the support of the Expert Panel, to make sure only the best procedures would be thoroughly studied.

Preliminary results from the FTS and RTS assessments were also included to fine tune and enhance the procedures without influencing the core noise benefits.

6.2 Brief description

The Sourdine II procedures which were described at the end of the previous section were later renumbered for clarity:

D5-3 deliverable Procedures	Sourdine II Procedures
1	Procedure I: Reference FMS procedure with level deceleration at 3000ft
2	Procedure II: Basic CDA with 2° initial FPA
10	Procedure III: CDA with 2° initial FPA and increased final glide slope (4º)
20	Procedure IV: CDA with constant speed, variable FPA segment at landing configuration
21	Procedure V: CDA with constant speed, variable FPA segment at intermediate configuration
ICAO A	Procedure 1 (ICAO A)
Sourdine 4	Procedure 2 (Sourdine I)
Sourdine 5	Procedure 3 (Sourdine I)

Table 6-1 Procedure renumbering for use in the following assessments for clarity

Arrivals	
I	Procedure I: Reference FMS procedure with level deceleration at 3000ft
II	Procedure II: Basic CDA with 2° initial FPA
III	Procedure III: CDA with 2° initial FPA and increased final glide slope (4º)
IV	Procedure IV: CDA with constant speed, variable FPA segment at landing configuration
V	Procedure V: CDA with constant speed, variable FPA segment at intermediate configuration
Departures	
1	Procedure 1: ICAO A
2	Procedure 2: SII Optimised Close-in
3	Procedure 3: SII Optimised Distant

Table 6-2 Selected procedures

The Sourdine II procedures defined in detail in D3.1-2 were designed following and combining three major concepts and only describe the vertical flight operation:

For Approaches

- ‘Variable thrust CDA’: Thrust settings are adapted
- ‘Variable vertical flight path CDA’: The flight path is adapted
- ‘Variable speed CDA’: Fixing thrust profile and flight path results in a certain speed profile

They define a vertical or speed profile to which the following noise mitigating operations were combined:

- *Low Power /Low Drag (thrust idle or use of thrust as low as possible)*
- *Increased Height profile and steep angles*

For departures
Using the following operational thrust operation definitions

- “Cutback Thrust”
- “Gradual thrust increase” [proposed in the previous Sourdine project]

All the procedures are based on the application in an RNAV airspace (lateral flight path), this is one of the assumptions made in all the simulations and assessments done (FTS, RTS, etc.).

6.3 Detailed procedures

The following is the general description of the procedures, were the speed and vertical profile are defined together with thrust and configuration changes. Due to its nature customisation (i.e. choice of lateral track) needs to be done to adapt them to the specific environment in which they will be tested.

The specific part of the following procedures will be found in the operation of concept section related to each simulation platform document.

Approach procedures

Overall assumptions:

- Aircraft at 90% MLW when starting approach (standard MLW per aircraft)
- Standard ISA atmospheric conditions
- Airport/runway elevation: Sea Level

Approach procedure I: Reference with level deceleration at 3000ft

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

Procedure II: Basic CDA with 2°initial FPA

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

Procedure III: CDA with 2°initial FPA and increased final glide slope

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

Procedure IV: CDA with constant speed, variable FPA segment at landing configuration

Condition	Parameter values
7000 ft (Fixed height)	– Speed 250 KTS CAS – Level flight – Clean configuration – Landing Gear up
	– Idle thrust – Decelerate, landing gear down and change to landing configuration (+), – Decelerate to final approach speed (FAS)
Landing configuration reached (Resulting FPA)	– Descend at constant speed (FAS) to 2000ft – Idle thrust
2000 ft (Fixed height)	– Adapted thrust for descent at 3° – Constant speed (FAS) descent to 50 ft.

Procedure V: CDA with constant speed, variable FPA segment at intermediate configuration

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

(+) Minimum allowable flap deployment

(++) Depending on aircraft type and weight, this segment may be steeper than the final approach (3°G/S angle) and therefore result in a G/S intercept from above

Departure procedures

Assumptions

Atmospheric

- Standard ISA atmosphere
- Airport/runway elevation: Sea Level

Takeoff weights

Two weight options:

- TOW = 85% MTOW
- TOW = 100% MTOW

THRUST Operation Definitions

CUTBACK Thrust definition

In this study, *CUTBACK THRUST* is defined as that thrust level (value of N1 or EPR) that in case of one engine inoperative, using the remaining engines, ensures a climb gradient of 1.2% for twinjet, 1.5% for 3 engines aircraft and 1.7% for 4 engines aircraft.

GRADUAL THRUST INCREASE definition

GRADUAL THRUST INCREASE means a gradual increase of thrust from the CUTBACK THRUST to Max Climb thrust. It can only be applied in case CUTBACK THRUST is smaller than Max Climb thrust.

The GRADUAL THRUST INCREASE is designed to avoid noise increase below track during the transition from CUTBACK THRUST to Max Climb thrust. This is accomplished (automatically, requiring adapted engine control systems) using an optimised rate of increase of thrust per unit height increase or unit time.

Departure procedure 1 Reference (ICAO-A):

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

Departure procedure 2 (Sourdine optimised close-in):

Condition (altitude ft)	Parameter values
0 ft	– TOGA (Take-off Go Around) thrust – Brake release and acceleration to rotation speed (*) – Rotation and lift-off
	– Retraction of undercarriage – Climb out at a speed of V2 + 10-20 KTS IAS (**)
At 800ft [1]	– Reduce thrust to *CUTBACK* (***) or Max Climb, whichever is lowest – Maintain V2 + 10-20 KTS IAS
3000 ft	– If *CUTBACK* thrust was selected: perform *GRADUAL THRUST INCREASE* (****) to Max Climb thrust – Maintain V2 + 10-20 KTS IAS
Upon achieving Max Climb	– Accelerate and retract flaps/slats on schedule to clean configuration – Continue acceleration to 250KTS – Climb to 15000ft

Departure procedure 3 (Sourdine optimised distant):

Condition (altitude ft)	Parameter values
0 ft	– TOGA (Take-off Go Around) thrust – Brake release and acceleration to rotation speed (*) – Rotation and lift-off
	– Retraction of undercarriage – Climb out at a speed of V2 + 10-20 KTS IAS (**)
At 800ft [1]	– Accelerate to zero-flap speed (Vzf) – Retract flaps/slats on schedule to intermediate configuration
Upon reaching Vzf	– Complete flaps/slats retraction to clean configuration – Reduce thrust to *CUTBACK* (***) thrust or Max Climb, whichever is lowest – Maintain speed (Vzf)
5000 ft	– If *CUTBACK* thrust was selected: perform *GRADUAL THRUST INCREASE* (****) to Max Climb thrust – Maintain speed (Vzf)
Upon achieving Max Climb	– Accelerate to 250 KTS IAS – Climb to 15000 ft

(*) Cleanest possible takeoff configuration

(**) V2+10 where possible

(***) Defined in section 4.3.2.

(****) Defined in section 4.3.2.

[1] Dependent on local airport

6.4 Conclusion

The five NAAPs and the two NADPs chosen by the SII are the result of both the support of the Expert Panel and the evaluation through SES in the first place followed by the continuous input by the later validation test-beds (FTS and RTS).

The five NAAPs are based on the CDA idea while the NADPs come from the enhancement and the evaluation of the first Sourdine project departure procedures.

Great care was taken during the design and the monitoring of the later assessments of the procedures that if any small redesign was needed, that it should be included without hindering the procedures core benefits. Small changes came most of all from the pilots and ATC feedbacks during the RTS.

7 Overview of the assessments

Within the SII project various assessments have been performed and those assessments have not always been performed in the same level of detail for all procedures. This chapter will provide an overview of these assessments, including which procedures have been assessed in which level of detail. Also the rationale behind the choices will be explained in this chapter.

7.1 Capacity

The capacity assessment started with vertical and speed profiles generated by the simulator. When comparing those profiles with the profiles generated by the aircraft manufacturers it appeared essential to include the aircraft manufacturers' profiles to perform the capacity assessment with the required accuracy. Because the approach procedures, due to their aircraft dependant speed and/or vertical profile, are much more critical regarding capacity then the departure procedures the capacity study is limited to the approach procedures. All approach procedures were assessed, where arrival procedures III and IV were divided between the four partners according to the following table.

Procedure	Madrid Barajas	Paris CDG	Amsterdam Schiphol	Naples Capodichino
Arr I (baseline)	Yes	Yes	Yes	Yes
Arr II	Yes	Yes	Yes	Yes
Arr III	Yes	Yes	No	No
Arr IV	Yes	No	Yes	Yes
Arr V	Yes	Yes	Yes	Yes
Dep 1	Yes	Yes	Yes	Yes
Dep 2	No	No	No	No
Dep 3	No	No	No	No

7.2 Safety

For the safety assessment an initial high-level safety evaluation has been conducted for all four approach and two departure noise abatement procedures; the baseline procedures have not been considered on safety. With those results available the most promising procedures, based on safety and inputs not related to safety, were selected for a more detailed qualitative and/or quantitative safety assessment for a concept of operation on a specific airport. The selected procedures were approach procedure II (and a variant of procedure II including various speed constraints indicated as procedure II-A) and V and departure procedure 2. For approach procedure II (II-A) a concept of operation on Schiphol airport has been considered; for approach procedure V and departure procedure 2 a concept of operation on Madrid airport.

Procedure	Initial high level safety evaluation	Qualitative and/or quantitative assessment
Arr I (baseline)	No	No
Arr II(-A)	Yes	Yes (Schiphol)
Arr III	Yes	No
Arr IV	Yes	No
Arr V	Yes	Yes (Barajas)
Dep 1	No	No
Dep 2	Yes	Yes (Barajas)
Dep 3	Yes	No

7.3 Noise

The noise assessment was based on the lateral tracks and the fleet mix distribution of the capacity study. For the noise assessment the detailed aircraft performance data as well as the multi-configuration NPD curves from 8 Airbus and 4 Boeing aircraft were integrated in the INM research version 7.0S, developed for the Sourdine II project. With this approach results were obtained for all the SII arrival and departure procedures. Besides the absolute values of the noise contours also results relative to a baseline were produced. For the departure procedures this baseline was always the ICAO-A procedure, but for the arrivals there were additional reference procedures besides the SII procedure I, which will be described in this section.

Madrid Barajas added a single baseline representing the current practice at this airport. The same was done for Amsterdam Schiphol, but here two additional baseline procedures were added also representing the current practice at this airport. The difference between the two additional Schiphol baseline procedures is the flown altitude at base-leg, being 3000ft or respectively 4000ft.

Procedure	Madrid Barajas	Paris CDG	Amsterdam Schiphol	Naples Capodichino
Madrid current practice	Yes	N/a	N/a	N/a
Schiphol 3000ft current practice	N/a	N/a	Yes	N/a
Schiphol 4000ft current practice	N/a	N/a	Yes	N/a
Arr I (baseline)	Yes	Yes	Yes	Yes
Arr II	Yes	Yes	Yes	Yes
Arr III	Yes	Yes	Yes	Yes
Arr IV	Yes	Yes	Yes	Yes
Arr V	Yes	Yes	Yes	Yes
Dep 1	Yes	Yes	Yes	Yes
Dep 2	Yes	Yes	Yes	Yes
Dep 3	Yes	Yes	Yes	Yes

7.4 Emission

Emissions were calculated only for the segment of the procedure which was below 3000 ft.

During the project it became clear that it would not be possible to perform any comparative analyses of fuel-burn and CO2 production. For such an analysis to be meaningful, it is necessary to calculate fuel-burn for the trajectories being compared from the same starting point to the same ending point. In the case of Sourdine II, data were only available from 7000ft for the approaches and the different procedures are are very different distances from the runway threshold at this height. Similarly, departure procedures do not provide for the same rates of climb, and do not co-incide within the zone examined by the project.

Local emission analysis of hazardous pollutants - CO, NO_X and unburnt hydrocarbons (HC) - produced below 3000ft was, however, carried out in the context of Sourdine II. This was performed using fuel-flow data supplied by Airbus for a mid-sized and a heavy aircraft and was not based on flights at any given airport.

7.5 User acceptance

The assessment of the user acceptance consisted of three parts, namely questionnaires, prototyping sessions and full-scale exercises. During the prototyping sessions arrival procedures I, II and IV and departure procedures 1 and 2 were selected based on the available noise, safety and capacity results. During this prototyping it became clear that arrival procedure IV was not acceptable both from a pilot's and ATCo's point of view, main reasons were that there is no control available for flight crew (engines on idle, configuration changes have been made) and speed brakes are inhibited in many aircraft once landing configuration has been set. There is also a large uncertainty for the controllers in the moment of deceleration and flown speed profile. This procedure was therefore replaced by procedure V for the full-scale exercises, as recommended by the pilots.

To limit the uncertainty in the flown speed profile and to lower the speed differences between the various aircraft types the controllers recommended including speed constraints along the profile. As a results an adapted procedure II was created, called procedure II-A. This procedure was identical to the original procedure II but contained four speed constraints along the profile.

Arrival procedure III is due to the increased glide slope angle of four degrees relying on at least a new certification of auto-pilot systems as well as extensive pilot training due to the increased vertical speed and therefore more difficult flare manoeuvre. This procedure has therefore only been assessed by means of questionnaires.

For the full-scale trials it was important to also have a scenario representing the controllers' current working environment. This meant that their needed to be a baseline where controllers were vectoring aircraft. This also allowed investigation of the influence of RNAV routes, since there were now two baseline scenarios, one with vectoring and one with RNAV routes, but both with current vertical profiles.

Procedure	Questionnaires	Prototyping sessions	Full-scale exercises
Vector baseline	Yes	Yes	Yes
Arr I (baseline)	Yes	Yes	Yes
Arr II	Yes	Yes	Yes
Arr II-A	Yes	Yes	Yes
Arr III	Yes	No	No
Arr IV	Yes	Yes	No
Arr V	Yes	No	Yes
Dep 1	Yes	Yes	Yes
Dep 2	Yes	No	Yes
Dep 3	Yes	No	No

8 Assessment results

8.1 Capacity assessment results

This chapter summarises the main results deriving from the capacity assessment carried out within Sourdine II activities of a series of new noise abatement arrival procedures on Madrid-Barajas, Naples-Capodichino, Amsterdam-Schiphol and Paris-Charles de Gaulle airports and provides general conclusions about the impact on the airport capacity of the new Sourdine II Noise Abatement Approach Procedures (NAAP)s.

The capacity assessment has been focused exclusively on the arrival noise abatement procedures designed by the Sourdine II project. Two departures procedures were also produced but they are comparable to the ICAO-A procedure. Therefore, no capacity problems are foreseen due to the implementation of these procedures at the airport.

The Sourdine II procedures are based on data provided by Airbus and are simulated in each airport situation in 2015. A description of the SII procedures is provided in chapter 6.

As a reference, a baseline scenario based on the SII procedure NAP I is used. In this scenario, controllers actual practice related to speed control actions in order to provide homogeneity between aircraft speed profiles during final approach, is included. If needed, controllers could apply speed actions maintaining the vertical profile since thrust and speed are not fixed in current practice.

Two platforms have been used to validate the new set of procedures from the capacity point of view: TAAM (Total Airport and Airspace Modeller) from Preston Aviation Solution and SIMMOD (Airport and Airspace Simulation Model) from ATAC Corporation. They have been used as the fast time simulation tools for the different phases of the Sourdine II project. Amsterdam-Schiphol, Paris-Charles de Gaulle and Madrid-Barajas airports validation activities used TAAM for simulation purposes. Naples Capodichino airport selected SIMMOD as the FTS platform to validate the new procedures.

There is a decrease of the peak hour arrival airport capacity when (NAAP)s designed within Sourdine II are implemented (see table 8.1-1). This decrease in capacity is caused by the extended separation required to compensate the speed differences between aircraft. The more speed differences between aircraft types, the more separation was needed in order to maintain minimum safe separation between successive aircraft (e.g. wake turbulence). This increase of separation affects arrival delay (see table 8.1-2) negatively and therefore arrival capacity decreases. The lack of speed control between the beginning of the CDA and the runway leads to larger spacing between successive arrivals. An increased arrival separation at 30NM from the runway threshold is required to achieve the necessary wake turbulence separation at the runway.

The effect of the fleet mix is obvious: when the fleet is composed of a wide variety of aircraft types, (for instance turboprop aircraft also) more differences in speed will occur and consequently capacity will drop more as compared to a rather uniform fleet.

Another factor which plays a role in the delay is the route structure close to the airport: the effect of speed differences mentioned above will play a more severe role when the number of RNAV-routes available is smaller. In that case, more aircraft will have to fly a longer trajectory on the same RNAV route.

These two effects are well demonstrated in table 8.1-2. The impact of the procedures on the arrival delay for Schiphol is much larger than for Charles de Gaulle. This is caused by the effect that for Schiphol a larger percentage of turboprop aircraft is assumed, as well due to number of RNAV routes applied. In de CdG study 16 RNAV routes are applied; for the Schiphol study only two.

When an airport is operated in a way that the demand is exceeding the available peak hour arrival capacity during some periods of the day, the introduction of the new procedures will lead to additional delay. However, when the arrivals are distributed more regularly over the day, delays will decrease, or even not occur. When traffic is scheduled in this way and hourly arrival demand does not exceed the available airport capacity, for the traffic foreseen for the year 2015 in the four airports considered in this analysis, there exists no sustained capacity problem.

ARRIVAL CAPACITY					
Airport	Baseline	NAP II	NAP III	NAP IV	NAP V
Madrid	78-80	70-72	70-72	68-70	72-74
Paris-CDG	81-83	80-82	80-82	x	80-81
Amsterdam	72-74	69-71	x	59-61	66-68
Naples	31-33	30-32	x	28-30	30-32

Table 8.1-1 Arrival Capacity

AVERAGE ARRIVAL DELAY (Minutes)					
Airport	Baseline	NAP II	NAP III	NAP IV	NAP V
Madrid	1,8	3,9	3,6	4,6	3,8
Paris-CDG	3,0	3,2	3,3	x	3,3
Amsterdam	3,9	4,9	x	8,6	5,6
Naples	2,7	2,9	x	4,4	3,7

Table 8.1-2 Average Arrival Delay

8.1.1 Arrival procedure II, III and V

The Sourdine II procedures II, III and V are affected by an increased arrival delay respect to the baseline scenario[1].

This increasing of arrival delay is caused by the extended separation required to compensate the speed differences between aircraft. The more speed differences between aircraft types, the more separation was needed in order to maintain minimum safe separation between successive aircraft (e.g. wake turbulence). This increase of separation affects arrival delay negatively and therefore arrival capacity decreases.

A variant of Procedure II, called Procedure II-A, has been analysed in Amsterdam-Schiphol airport. Procedure II-A is basically procedure II with some speed constraints that increase the homogeneity between speed profiles during approach. Because of the minor speed differences between the speed profiles of the different aircraft types, the performance of this procedure is more in line with the baseline scenario. The speed constraints were selected in such a way that all aircraft were able to fly the profile (deduced from a generic CDA).
For the capacity effects, the airspace structure as well as the number of RNAV-routes plays an important role. It is estimated that an Arrival Manager (AMAN), in combination with multiple RNAV routes would be required, as well as a device to calculate the suitable speed for each aircraft to optimise separations. Other requirements would be to begin sequencing and speed control actions at a higher altitude (FL240) or to change the TMA structure (extended TMA).

The lack of speed control between the beginning of the CDA and the runway leads to less refined spacing between successive arrivals. An increased arrival separation at 30NM from the runway threshold is required to achieve the necessary wake turbulence separation at the runway.

8.1.2 Arrival procedure IV

Procedure IV obtained the worst results in terms of delay and capacity of all the set of arrival procedures considered in SII Project.

Procedure IV has significant speed differences, especially FAS values, between the slower aircraft (e.g. F50 FAS 100kts) and the faster aircraft (e.g. A340 FAS 139kts) and, in this procedure, aircraft have to fly the FAS over the last 15NM before the runway threshold. Flying at the Final Approach Speed at a very early stage has a negative impact on spacing and therefore on capacity.

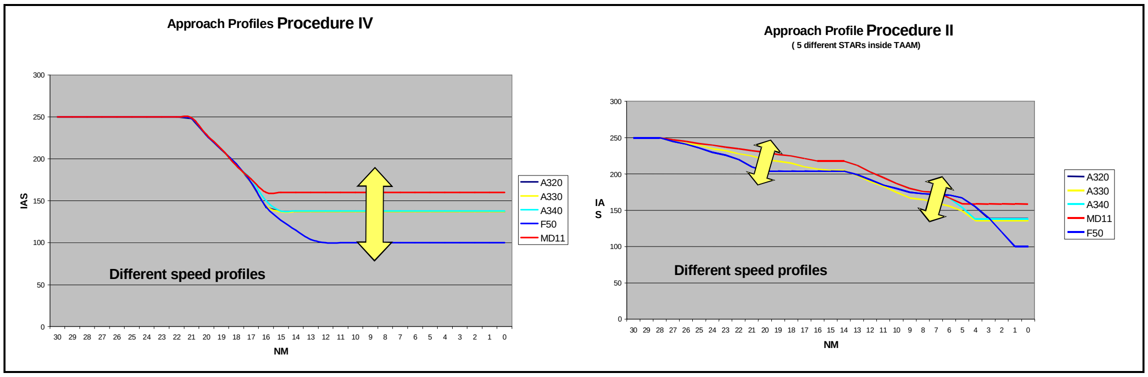


Figure 8.1-3 Different speed profiles Procedure IV vs. Procedure II

The arrival separation is increased at 30NM from the runway threshold to achieve wake turbulence separation at the runway:

- Differences between speed profiles are bigger than in the rest of scenarios, especially in the baseline scenario, where controllers usually apply speed constraints.

- At the end, more separation means less capacity.

8.1.3 Final Conclusion

There is a decrease of the arrival capacity for the presented Sourdine II scenarios. However, for the traffic foreseen for 2015 there exists no sustained capacity problem. Arrival procedures II and V, which were simulated at the four airports, appear to be the most promising procedures in terms of capacity. Procedure III (simulated for two airports, Madrid and CdG shows comparable results. Procedure IV is the only arrival procedure where a large loss of peak hour capacity occurs (approximately 16 percent).

The main results obtained in this study have shown that the composition of the fleet mix may influence the performance of the ATM system significantly when implementing these CDAs. The speed differences between aircraft types can be considered as a major problem when introducing

CDAs within a high traffic dense environment: The more speed differences between aircraft types, the more separation needed in order to maintain minimum safe separation between successive aircraft (e.g. wake turbulence). This increase of separation affects arrival delay negatively and therefore arrival capacity decreases.

Wind speed and direction and pilot response uncertainties could even decrease arrival capacity.

8.2 Safety assessment results

The safety analyses of the four approach and two departure noise abatement procedures are documented in D4.2-1, D4.2-2 and D4.2-3. The baseline procedures were not analysed with respect to safety. Document D4.2-1 is the top-level document of the safety work, and contains the overall approach, the main results and the conclusions. D4.2-1 is supported by documents in which the safety assessments are described. The safety assessment of approach procedure II-A is described in the documents constituting D4.2-2. The safety assessments of approach procedure V and departure procedure 2 are described in D4.2-3. The full deliverable structure is:

D4.2-1		Safety assessment of Sourdine II procedures (Top-level document).
D4.2-2		Safety assessment of approach procedure II-A at Schiphol airport.
	a	Main document
	b	Argumentation-based analysis
	c	Simulation-based analysis
	d	Collection of expert interviews
D4.2-3		Safety assessment of approach procedure V and departure procedure 2 on Barajas airport.

Set-up of the study

Because complete detailed safety analysis would be a very elaborate and demanding effort, part only of the four approach and two departure procedures were identified to fall within the scope of detailed evaluation. Therefore, a further selection of these procedures was made. To accomplish such a selection, an initial high-level safety evaluation of all six procedures was first done. It is noted that these procedure definitions do not include an embedding of the procedure in an operation.

Based on the initial high-level safety evaluation and on inputs not related to safety the Sourdine II management made a selection of three procedures for safety assessment. For each of these three procedures an operation was defined on a specific airport, including also specific human roles and technical systems. For each of these three operations, a safety assessment was performed, based on the TOPAZ safety assessment methodology.

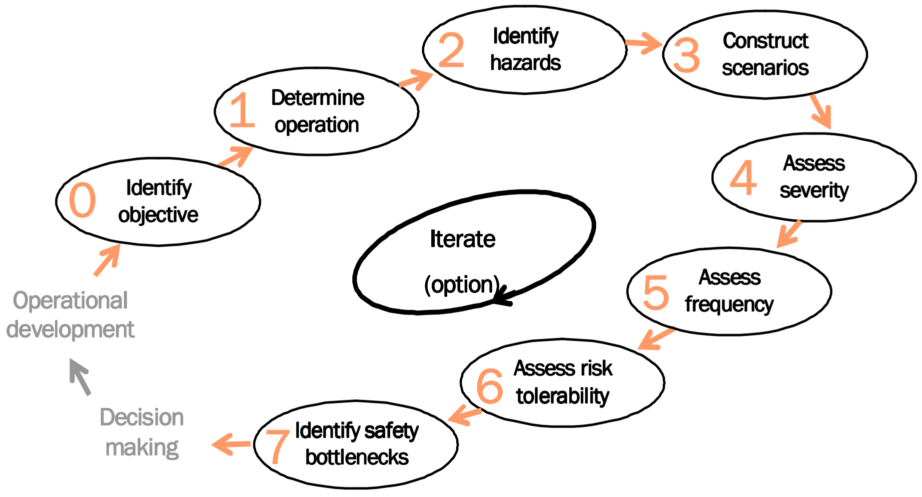


Figure 8-2: Overview of the steps in a TOPAZ safety assessment cycle.

In step 0 of this methodology the objective of the study is determined, as well as the safety context, the scope and the level of detail of the assessment. The actual safety assessment starts by determining the operation that is assessed (step 1). Next, hazards associated with the operation are identified (step 2), and clustered into conflict scenarios (step 3). Using severity and frequency assessments (steps 4 and 5), the risk associated with each conflict scenario is classified (step 6). For each conflict scenario with a (possibly) UNACCEPTABLE risk, safety bottlenecks are identified (step 7), which can help operational concept developers to find improvements for the operation. Should such an improvement be made, a new cycle of the safety assessment should be performed to investigate whether all risks have decreased to an acceptable level.

The main differences in the application of this methodology to the three operations were whether hazards were judged individually or first structured into conflict scenarios, whether all severity classes were considered or only the worst case class, and whether the frequency analysis was performed purely qualitatively or also using partly quantitatively.

Initial high-level safety evaluation and selection for safety assessment

The initial high-level safety evaluation identified the following main safety issues for the four approach procedures:

II. Basic CDA with 2° initial FPA;

- A possible excess speed at glide slope intercept possibly leading to an unstabilised approach.

III. Basic CDA with 2° initial FPA and increased final glide slope;

- A possible excess speed at glide slope intercept possibly leading to unstabilised approach; more severe than for procedure II due to the fact that the excess speed is more difficult to control on a steep final segment;
- The steep final glide slope is a non-standard operation and potentially leads to higher workload. This operation requires special analysis in relation to acceptance and to obstacle clearance surfaces.

IV. CDA with constant speed, variable FPA segment at landing configuration;

- A possible steep intermediate approach segment resulting to glide slope interception from above, with the potential consequences of a glide slope undershoot and an unstabilised approach;
- Potential flight path control problems, which could lead to an increased workload and an unstabilised approach in case the path is too shallow;

V. CDA with constant speed, variable FPA segment at intermediate configuration;

- The same issues as for procedure IV, though both less severe.

The main safety issues related to each of the two departure procedures are:

2. Sourdine optimized close-in procedure;
   - Speed control problems at low power setting at OEI climb thrust
3. Sourdine optimized distant procedure;
   - The same issue as for procedure 2, but less severe.

Because procedure II is expected to cause a limited capacity decrease, a variant of procedure II was defined by Sourdine II operational designers, called procedure II-A. In procedure II-A, speed constraints are imposed on the 2 degree flight path angle segment. The procedures selected for safety assessment were: approach procedure II-A, approach procedure V, and departure procedure 2.

Safety assessment of approach procedure II-A at Schiphol airport

A safety assessment was performed for an operation considering Sourdine II approach procedure II-A in the context of Schiphol airport. The risk was assessed with respect to risk criteria that combine the [ESARR 4] severity classification with the well-known frequency classification of JAA; the risk was classified per conflict scenario to be NEGLIGIBLE, TOLERABLE, or UNACCEPTABLE.

Five conflict scenarios were identified that describe in which way an accident or incident could occur:

1 Conflict between two aircraft merging onto one route

2 Conflict between two aircraft on the same route

3 Conflict between two aircraft established on their respective localizers

4 Conflict between two aircraft (one for 18R and one for 18C) of which at least one is turning to intercept its localizer, the other aircraft may also be turning in or already be established on its own localizer.

5 An approaching aircraft encounters the wake vortex of another aircraft in approach.

Scenario 4 was analysed using a detailed mathematical model and Monte Carlo simulations; the other scenarios were analysed in a more qualitative way, based on argumentations constructed more directly from expert opinions and historic data. The risks of conflict scenarios 1 and 3 were classified as TOLERABLE, and the risks of conflict scenarios 2, 4 and 5 were classified as being either TOLERABLE or UNACCEPTABLE.

The uncertainty in the latter results is related to the use of data retrieved from experts, who assessed a future operation by extrapolating their experiences with the current operation; to details of the operational description that remain to be specified; and to the scarceness of statistical data on model parameter values.

When considering to which extent the identified (possibly) UNACCEPTABLE risks are generic for the vertical flight profile considered, irrespective of the Schiphol implementation considered, the following conclusions hold:

- The possibly UNACCEPTABLE risk for conflict scenarios 2 and 5, related to longitudinal separation problems caused by an insufficient initial separation at the IAF and by a reduced ability to provide separation in case of 34 aircraft per hour, may be generic for the vertical flight profile considered.
- The possibly UNACCEPTABLE risk for conflict scenario 4, caused by aircraft overshooting the ILS while turning in for parallel approach, while vertical separation of 1000ft has not been guaranteed, is not generic for the vertical profile. However, when considering a generic implementation of this profile on parallel runways, it is very well possible that the risk is possibly UNACCEPTABLE, depending of course on the distance between the runways, the staggering between the runways, and the exact implementation of the procedure.

Since the operation has risks that were classified as (possibly) UNACCEPTABLE, the operation should be improved before implementation. Safety bottlenecks were identified that could serve as a starting point for the operational concept designers for the identification of risk mitigating measures. It is considered most logical to do a new cycle of the safety assessment once the operation has been improved; then also for conflict scenarios 2 and 5 a more quantitative approach may be used.

Safety assessment of approach procedure V on Barajas airport

The outcome of the safety assessment for approach procedure V on Barajas airport revealed a series of safety significant issues, which are recommended for further analysis. A distinction is made between those related to the inherent characteristics of the Sourdine II approach procedure V and those for which the particular parallel runway set-up is the determining factor when performing simultaneous and independent CDAs to both runways.

1. *Sourdine II approach procedure V issues:*
    - Non-adherences to CDA speed descent profiles may cause aircraft to breach longitudinal separation (e.g. catch up aircraft ahead or be caught up by trailing aircraft). As a potential result, the probability of wake vortex encounters is likely to also increase. The risk of wake vortex encounter has been classified as possibly unacceptable without further mitigation.
2. *Parallel runway CDA safety issues*
    - Non-adherences to vertical CDA profiles may breach the 1000ft vertical separation that by design, should be maintained at all times between aircraft established on the parallel localisers prior to reaching the area parallel to the NTZ.
    - Separation between aircraft established on the parallel localisers is based on 1000ft vertical separation at all times prior to reaching the area parallel to the NTZ. As a consequence, small-excursion overshoots followed by rapid localiser interceptions would only be associated with an erosion of safety margins whereas wide-excursion overshooting developing into wrong localiser interception or adjacent sector non-authorised incursion would pose a safety critical issue.

The qualitative safety assessment showed that the Sourdine II approach procedure V adapted to the future Barajas Airport parallel runway configuration exhibits some safety significant issues that are in need of a more detailed and quantitative analysis. It is recommended that decision support tools such as an Arrival Manager (AMAN) and safety-net additional functionality to monitor potential longitudinal breaches of separation for localiser-established consecutive aircraft are considered in future safety assessments.

Safety assessment of departure procedure 2 on Barajas airport

The Sourdine II departure procedure 2 aims at reducing the noise impact around the SID footprint closest to the runway, causing the aircraft to operate at reduced performance with OEI (One Engine Inoperable) power settings. Hence, the main procedure risks will be associated with airport obstacle limiting surface infringements that may lead to loss of separation with obstacles and/or ground. The main emphasis of the high level assessment was placed on whether the procedure-induced departure from the aircraft optimal climbing performance could erode safety margins.

The safety assessment showed that the most significant risks associated with the Sourdine II departure procedure 2 are due to either engine loss or sudden adverse meteorological conditions that could impair the aircraft airworthiness. However, it is deemed that aircraft could recover from these situations despite flying at reduced power settings and therefore, the procedure does not degrade safety margins. The conducted high level assessment concluded with all identified risks associated with the departure procedure having been preliminarily classified as acceptable.

8.3 Noise assessment results

This chapter summarises the different results derived from the noise assessment of the Sourdine II noise abatement procedures (NAPs) for arrival and departure applied to Madrid-Barajas, Naples-Capodichino, Amsterdam-Schiphol and Paris-Charles de Gaulle airports. It provides general conclusions on the noise impact on the airports' surrounding areas for the new Sourdine II NAPs.

A study has also been conducted into the variation in population impacted by noise based on the different procedures used, both for Noise Abatement Departure Procedures (NADPs) and Noise Abatement Arrival Procedures (NAAPs). The study only looks at the Madrid-Barajas scenario since the, theoretical, necessary population density information was only available at this airport.

Four NAAPs and two NADPs were analysed and compared with a conventional 3000ft arrival procedure defined within the baseline scenario (already a noise-efficient procedure) and, specifically for the Schiphol and Madrid-Barajas scenarios, with current approach procedures.

The Sourdine II procedures are based on data provided by Airbus and were simulated for each airport situation projected to 2015.

Analysis was performed using a version of the US FAA's Integrated Noise Model, especially developed by the FAA to cover the needs of the Sourdine II project, with special data supplied both by Airbus and Boeing. These data did not, however, cover the entire fleet at the selected airports and various substitutions had to be made to enable representative noise analysis.

Major noise benefits are mainly determined by higher altitudes for approaches and by thrust setting for departures.

The distribution of the fleet mix influences the shape of the noise contours considerably (eg. unbalanced use of runways).

8.3.1 Arrival procedures

The results of the analysis indicate that the sizes of the contours are generally a function of the altitude profiles. Since procedure III is continually above the baseline, due to its 4º glide-slope as opposed to the baseline's 3º, it is this procedure that gives the best results. This reduction in noise is of the order of 2.5dB - 10 log (sin4º/sin3º)^2 - across the board.

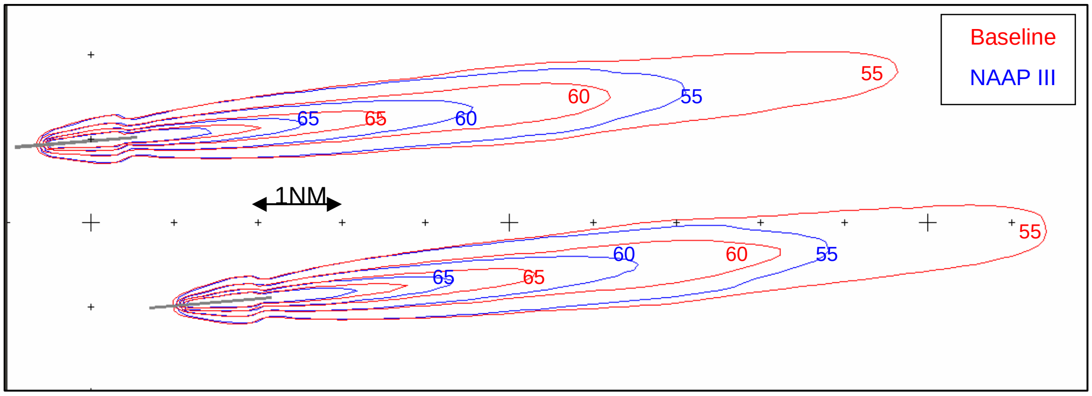


Figure 8.3-1. - Paris CDG Lden contours for arrivals - Baseline vs. Procedure III

The other procedures are only higher before 6.5NM (procedure IV) or 10NM (procedures II and V) and thus give better results where the contours are further from the runway threshold than this. This is particularly visible for Procedure IV in the following bar-charts of change in contour areas at CDG and Naples-Capodichino. These charts are representative of the results for all four airports, the values for the change in the larger contours (55dB) being smaller, the smaller the baseline area of that contour.

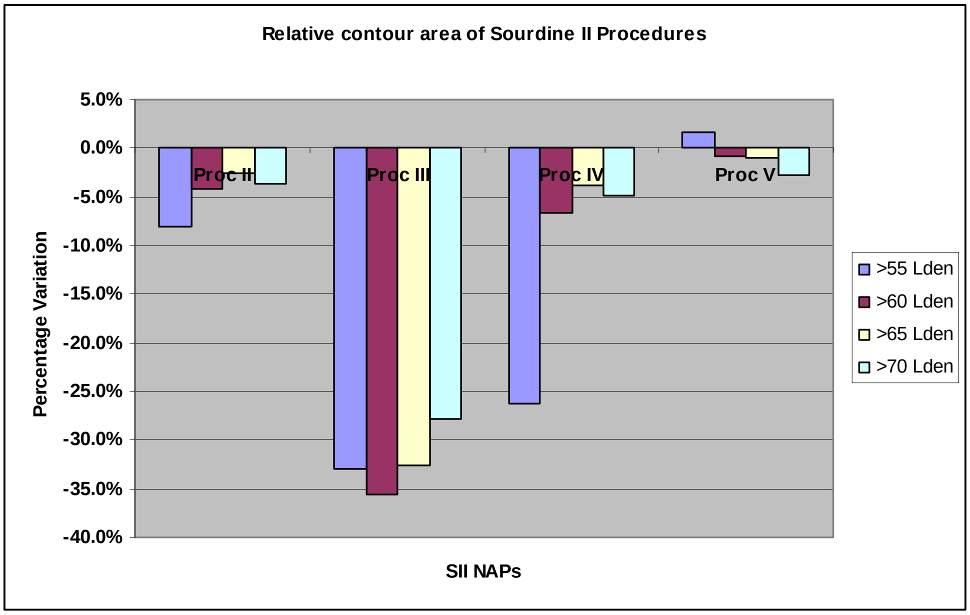


Figure 8.3-2. - CDG Arrival relative Lden contour area bar chart

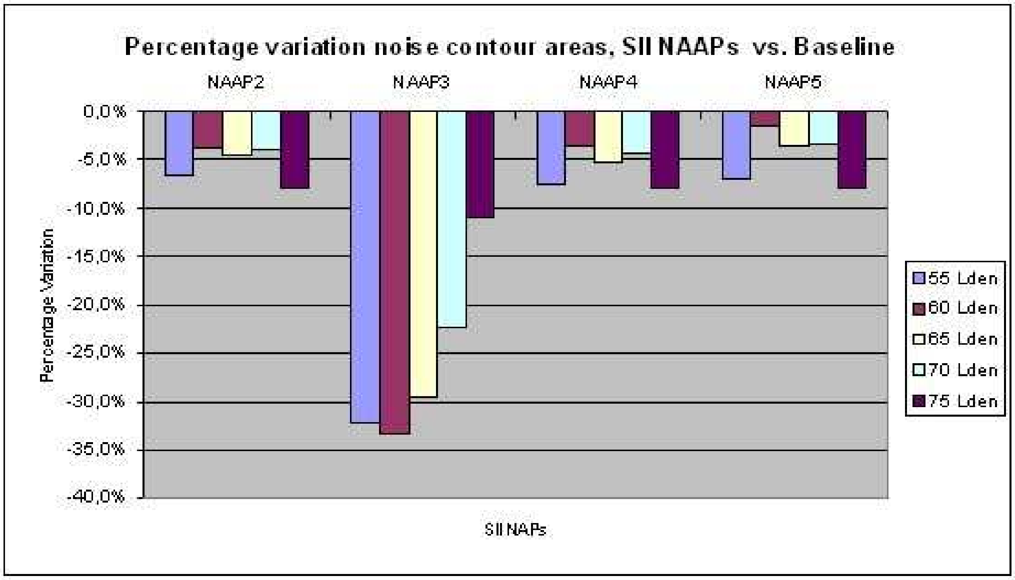


Figure 8.3-3. - Naples-Capodichino Arrival relative Lden contour area bar chart

Lden

For Paris-CDG, Amsterdam-Schiphol and Madrid-Barajas the traffic volumes are such that the Lden contour for the lowest noise level considered (55 dB) extends to 10 or 11 NM from the runway threshold in the baseline, and the contour sizes are therefore reduced accordingly at their extremity by Procedures II, IV and V. Where traffic volumes are less dense, at Napoli Capodicchino, this effect is less noticeable and, as can be seen below, there is even a slight negative effect due to increased speed in the given case.

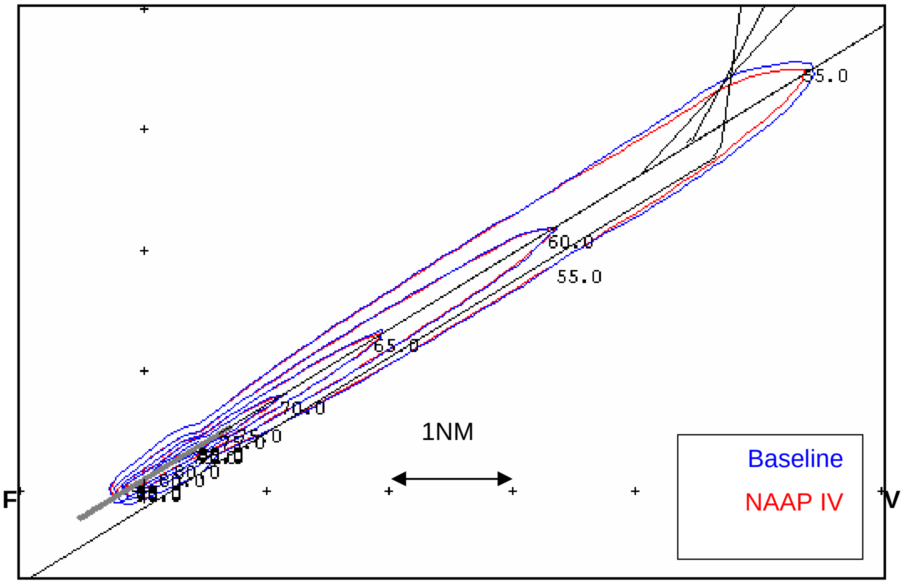


Figure 8.3-4. – Napels Lden contours for arrivals - Baseline vs. Procedure IV

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

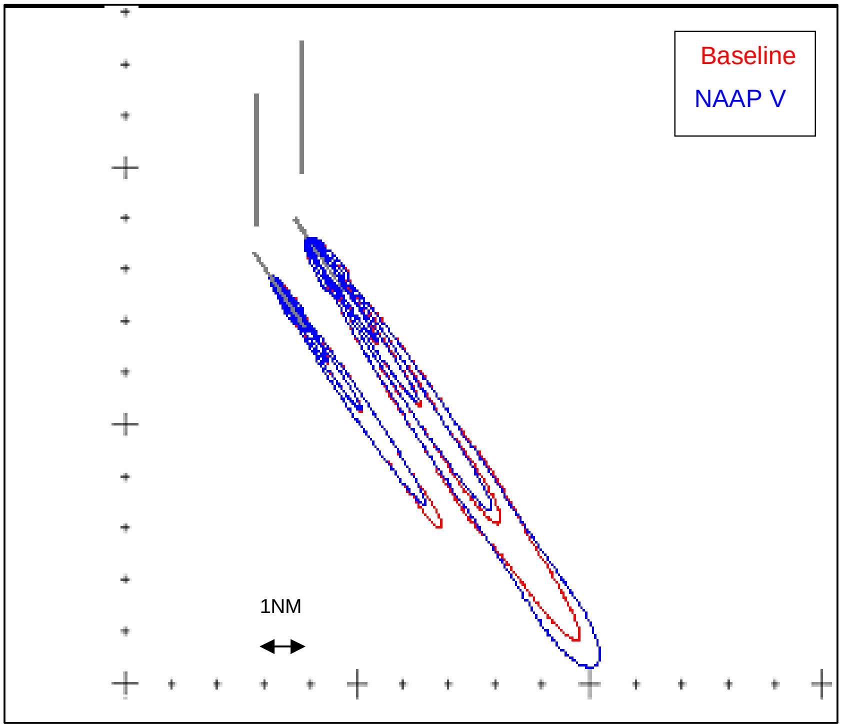


Figure 8.3-5. - Madrid Lden contours for arrivals - Baseline vs. Procedure V

Lnight

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

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 due to differences in thrust and configuration, as well as the cumulative duration effect which changes with aircraft speed. In procedure IV one can 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, as shown for Madrid Barajas.

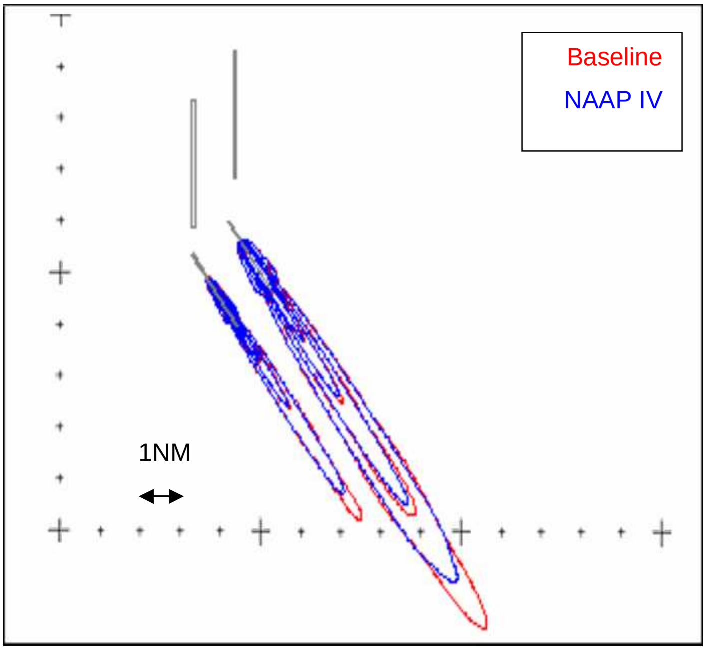


Figure 8.3-6. - Madrid Arrivals Lnight Baseline vs. Procedure IV

8.3.2 Departure procedures

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

The noise-impact crossover points– where reduction gives way to increase, or vice-versa – are located at:

- about 5.5Nm for the optimised close-in procedure, i.e. the optimised close-in procedure produces smaller contours than the baseline at less than 5.5Nm from brake release, but longer ones further out. This generally concerns those areas within the 60dB and greater contours;
- about 3.5Nm for the distant procedure i.e. the distant procedure starts producing shorter contours after 3.5Nm from brake release, but longer ones closer in. This generally concerns the 65dB and lower contours.

This is best illustrated with in the following table.

Lden Contour level	Close In			Distant		
	CDG	Schiphol	Barajas	CDG	Schiphol	Barajas
55 Lden	+9.90%	+9%	+9%	-27%	-32%	-42%
60 Lden	-13.62%	-2%	-12%	-39%	-40%	-36%
65 Lden	-22.94%	-24%	-21%	-15%	-23%	-10%
70 Lden	-21.26%	-25%	-24%	+3%	-3%	+4%
75 Lden	-9.60%	-17%	-12%	+2%	+5%	+3%

Table 8.3-7.- Percent Lden Variation of departure procedure contour areas

As for the Approach procedures, the results of the noise analyses are common for all the four selected airports with a slight difference due to fleet-mix and the unbalanced use of the runways.

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

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

In conclusion, it can be seen that in terms of general impact, the distant procedure has a positive impact on nearly all areas around the airport, unless there is population very close (less than 3.5 Nm from brake release). The Close-in procedure, on the contrary, only benefits the worst hit populations, within 5.5nm of brake release – though benefitting those between 3.5 and 5.5 Nm more than the Distant procedure does – while being disadvantageous to those further out.

It should be noted that the baseline used was a close-in type procedure (ICAO-A). These results show quite clearly, therefore, that the Sourdine II optimised close-in procedure is better than ICAO-A at reducing noise close to the airport.

The pertinence of a comparison between the Sourdine II optimised distant procedure and the ICAO-A close-in procedure is less obvious, however. It is only to be expected that the new procedure will out-perform the baseline far from the airport. What is important is the proximity to the airport of the point where this procedure's noise improvements begin, and the fact that it's negative effect on the louder contours, closer to the airport, is relatively small (≤5% increase).

8.3.3 Impacted Population

At Madrid Barajas Airport, a preliminary study of population affected by noise in the surrounding areas was conducted in order to analyse the influence of the proposed Sourdine II procedures, in these areas. 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.

For this purpose the statistical data-on population distribution from the 2001censuswas used. Noise contours previously obtained were placed over the map of the surrounding populated areas, obtaining this way numerical results.

Arrivals

All four Sourdine II approach procedures showed reductions in impacted population. Procedure III was responsible for the greatest change in impacted population with major reductions in affected populations inside all contours. All 1500 or so people were removed from the 60dB Lnight contour. Procedure IV, and to a lesser extent procedure II, also produced noticeable reductions in numbers under the 60dB Lnight contour. These results are summarised below.

%Change in Lden vs. Baseline	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%

%Change in Lnight vs. Baseline	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%

Table 8.3-7. - Percentage change in populations affected by given aircraft noise levels through using Sourdine approach procedures

Departures

None of the populations studied were in areas close enough to the airport to benefit from the Close-in procedure. In fact this procedure's increase in noise further away from the airport more than doubled the number of people in the 55 Lden contour.

On the other hand, the Distant procedure nearly halved the number of people in the 50 Lden contour and removed nearly everyone from the 55 Lden contour. It also removed all of the 545 people subjected to 50 Lnight from the contour whereas their number increases by 6% when using the close-in procedure.

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

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

Table 8.3-8. - Percentage change in populations affected by given aircraft noise levels through using Sourdine departure procedures

8.4 Emission results

During this project it became clear that it would not be possible to perform any comparative analyses of fuel-burn and CO2 production. For such an analysis to be meaningful, it is necessary to calculate fuel-burn for the trajectories being compared from the same starting point to the same ending point. In the case of Sourdine II, data were only available from 7000ft for the approaches and the different procedures are are very different distances from the runway threshold at this height. Similarly, departure procedures do not provide for the same rates of climb, and do not co-incide within the zone examined by the project.

Local emission analysis of hazardous pollutants - CO, NO_X and unburnt hydrocarbons (HC) - produced below 3000ft was, however, carried out in the context of Sourdine II. This was performed using fuel-flow data supplied by Airbus for a mid-sized and a heavy aircraft and was not based on flights at any given airport.

Results for arrival procedures may be summarised as follows:

- Procedure II shows a 25% reduction in NO_X for a mid-sized aircraft but a 16% increase in CO and HCs for the same aircraft. It has almost no effect of emission production for a heavy aircraft.
- Procedure III gives a 40-50% reduction in NO_X. This procedure has little or no effect, however, on production of CO and unburnt hydrocarbons.
- Procedure IV gives a reduction of around 10% in CO and HCs for heavy aircraft, but an increase of about the same in these pollutants for a mid-sized aircraft. However, NO_X production, while remaining at baseline levels for a mid-sized plane, increases by over 30% for a heavy one.
- Procedure V is generally detrimental in terms of emission production, with increases across the board of 10-20%, with the exception of a 12% reduction in NO_X for mid-sized aircraft.

As explained above, the Sourdine departure procedures perform different functions in terms of their noise impact. It is, however, worthwhile to compare their effects on local air quality to have an idea of the trade-offs implied.

The analysis of the departure procedures was performed for the same aircraft as was that of the arrival procedures but at both Maximum Take-Off Weight (MTOW) and at 85% MTOW.

It was found that neither procedure has any marked effect on NOX production at either weight for either size of aircraft.

For HC and CO emission, the Close-in procedure is nearly always better than the Distant one. This better position of the Close-in procedure compared with the Distant is due in part to the fact that an aircraft following the Distant procedure travels 20-25% more distance under 3000ft than one following the Close-in procedure. It should be noted that the degradations in pollution are sometimes quite severe, unburnt HCs doubling, for example for a heavy aircraft.

8.5 User acceptance and performance results

Within the user acceptance assessment two simulation experiments – a flight simulation and an ATC simulation - were carried out in order to evaluate the SII procedures. The flight simulation covered the evaluation of SII procedures with respect to its impact on the crew's tasks and performance as well as on a number of specified flight parameters. The ATC simulation covered the evaluation of the SII procedures with respect to the impact on the controllers' tasks as well as on safety, efficiency and capacity in handling air traffic.

Figure 8-3 GRACE flight simulator and NARSIM ATC simulator

8.5.1 Objectives

The general aim of the real-time simulations was to present the users (pilots and controllers) with and to investigate the usability and acceptability of the new noise abatement procedures (NAPs) and proposed tools. The impact of the proposed NAPs and tools was assessed on among others safety, workload, situational awareness and acceptance.

8.5.2 Trial set-up

Flight simulation

Prior to the full-scale simulations some prototype sessions [D6-2] have been performed. During these sessions valuable feedback was gathered on the pilot tool implementation and various procedures. Based on the prototype results it was decided not to use arrival procedure IV during the full-scale trials due to the low acceptance rate by both pilots and controllers during the prototype sessions.

Five crews consisting each out of two airline pilots participated in the full-scale experiment and conducted several experimental runs. In these runs, three NAPs (procedure I, II and V) were flown under different experimental conditions (for example, with different wind conditions, with and without the use of pilot tools, etc.).

Subjective data were collected by means of questionnaires. The participants completed a post-run questionnaire after each experimental run, which asked for the participants' experiences during that specific run. A debriefing questionnaire after the experiment asked for participants' overall opinion on the procedures, the tools used, and the experiment. Pilots were asked, by means of a rating scale, to rate the flight efficiency, noise friendliness and safety. It should be noted that these are subjective ratings and should be seen as expert judgement feedback of the experiment and not as objective results.

Objective data were collected by recording of flight parameters, such as the use of speed brakes during the approach, configuration settings (flaps, landing gear) and fuel consumption of the aircraft in order to investigate the performance of the flight crews for the various procedures.

ATC simulation

Prototype sessions have also been performed before the full-scale ATC simulations. Again during these sessions valuable feedback was gathered and several adjustments have been made to the radar display and the supporting controller tools. The results of these sessions are documented in D6-1 [D6-1].

Three trials with duration of two days (one had an additional half a day of training) have been executed. During the trials two controller roles in the Schiphol TMA were used:

- The Feeder/Departure Controller (FDR/DCO) for the TMA West, and
- The Arrival Controller (ARR).

Like the flight trials, subjective data was collected by means of questionnaires. The participants completed a post-run questionnaire after each two runs of a specific procedure, which asked for the controllers' experiences during that procedure acting both as a FDR/DCO and an ARR controller. A general debrief was held at the end of the two-day experiment.

8.5.3 Pilot and controller tools

Pilot tools

In support of the Sourdine II procedures, the following items were added on the flight deck (also shown in figure 8-4):

- Configuration change points (flap and gear deployment points)
- Vertical navigation display

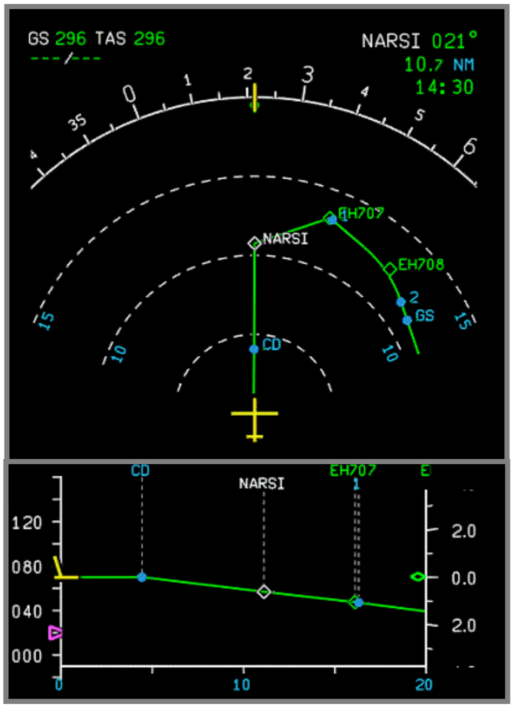


Figure 8-4: Configuration change points and vertical navigation display

Controller tools

Controllers were provided with two tools when working with the Sourdine II procedures. These were Ghosting and monitoring aids.

Ghosting

A ghosting tool projects the position of an aircraft onto another plane. This provides the controller with information about the relative positions of the aircraft on the two inbound routes, prior to merging into a single stream.

The current version of the tool uses a basic ghosting algorithm that determines the distance to go (along track) to a projection-point on the route. This distance is then backtracked across a given path in order to determine the location of the ghost plot. This path can either be a straight line or a predefined route

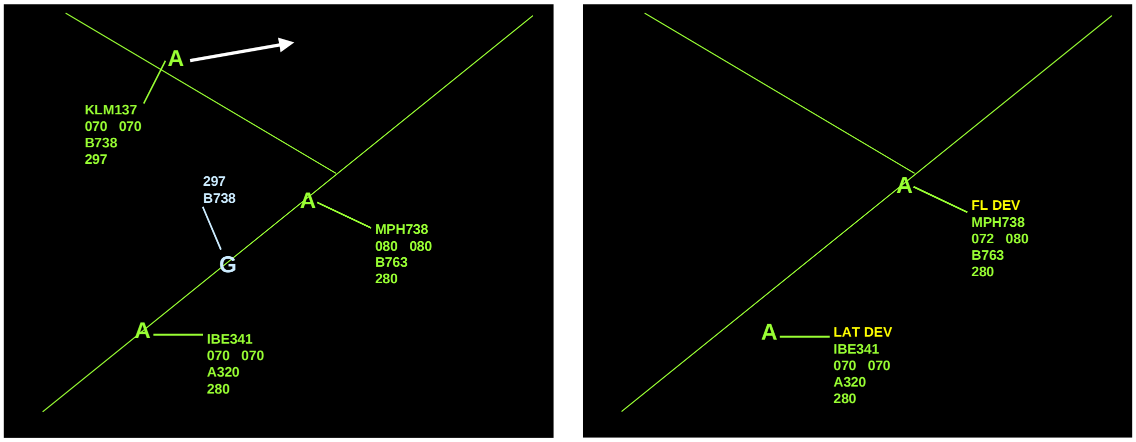


Figure 8-5 Ghosting tool and Monitoring tool

Monitoring

Monitoring aids compare the current flight data with the system trajectory and detects any deviations from the cleared flight level or the cleared lat/long route. In case, a deviation of the flight from the system trajectory is detected, a non-conformance warning (NCW) is issued. These NCWs are displayed in line 0 of the label and have the following meaning:

- FL DEV means that a deviation from the cleared flight level has been detected,
- FL Bust means that the cleared flight level has been busted,
- LAT DEV means that the deviation from the cleared route has been detected.

8.5.4 Results

The overall rating of the user acceptance for the pilots as well as the air traffic controllers is illustrated in the graph below.

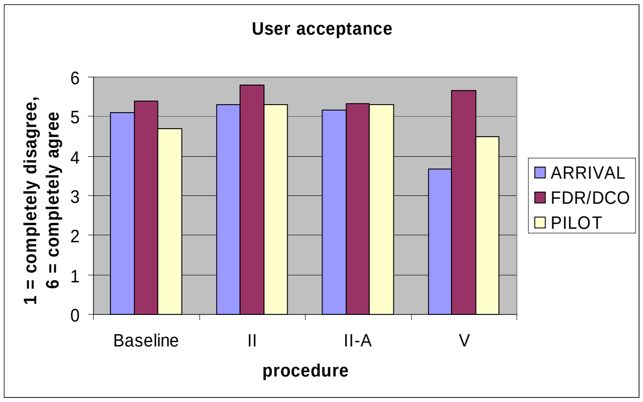


Figure 8-6: User acceptance rating

Arrival procedure I

This procedure is the baseline arrival procedure. For the flight simulations there was actually one baseline procedure, but for the ATC simulations the baseline procedure was represented by the current practise (vector baseline using heading instructions) as well as RNAV procedures (RNAV baseline using fixed RNAV lateral profiles). For both procedures (vector and RNAV baseline) the vertical and speed profiles of the aircraft were instructed by the controllers.

Arrival procedure II

Procedure II is rather robust for unexpected tailwind and is perceived as more fuel-efficient and noise friendly than procedure I and V. This is the perception of the pilots and needs verification with the noise and emission calculations as performed in WP4 of the Sourdine II project. Controllers indicated that procedure II together with the RNAV procedures leads to a very high situational awareness. Controllers prefer to actively give some (limited) speed instructions to maintain separation. The task changes are the shift from controlling to more monitoring and the fact that the FDR/DCO should perform most of the sequencing tasks instead of the arrival controller. Controllers stated that this procedure could be used in real operation with an expected capacity of 30-32 arrivals per runway per hour, compared with today’s peak-hour capacity of 33-36. This number could be increased once controllers get more hands-on experience concerning the "new" speed profiles and aircraft performance. The described procedure will not lead to a loss of capacity compared to the baseline procedure once the demand (during off-peak periods) does not exceed the number of 30-32 arrivals per runway per hour.

Arrival procedure II-A

Procedure II-A has the same vertical profile as procedure II but now also includes some speed constraints. These speed constraints result in a more stable approach for the pilot. The FMS calculations result in more time between the various configuration changes and therefore a more flyable procedure. Due to the speed constraints the controllers were getting more re-active and therefore felt less comfortable when compared with the situation of procedure II. When aircraft were running into each other controllers were relying sometimes on the speed constraints to solve this. Controllers therefore indicated that they should at least be able to overrule the speed constraints in the procedure. This is identical to the current implementation of procedure II-A. The speed constraints for procedure II-A result in a graph of the 'actual separation - required separation', indicating the excess separation distance that is almost equal to that of the RNAV procedure and slightly better when compared to procedure II. Pilots appreciated the use of speed constraints because the deceleration was spread over a longer time leading to a more predictable flight. In addition the localizer intercept became more stable since the speed on localizer intercept was lower when applying speed constraints compared to procedure II without speed constraints.

Arrival procedure III

Pilots are reluctant towards this procedure because of the increased glide slope angle of four degrees instead of three degrees. Although this procedure might be acceptable after extensive training, pilots do expect energy management problems after G/S intercept. This is the reason why this procedure is only evaluated by pilot and controller comments and not in simulations. The vertical speed on the ILS will be higher, which can result in:

- difficulties with (unexpected) tailwind,
- possible higher minimum descent altitudes (MDA),
- more difficult to decelerate the aircraft (early configuration and/or gear deployment needed, etc.),
- more noise because of extra drag due to early configuration,
- different flare manoeuvre than for 3 degree path (requires additional training),
- higher rate of descent can trigger (E)GPWS ((Enhanced) Ground Proximity Warning System).

Arrival procedure IV

This procedure was only evaluated during prototyping runs in APERO and NARSIM. Due to the negative feedback of both pilots and controllers this procedure was not selected for the final real time simulation trials. For the completeness of this overview the main results of the prototyping sessions [D6-1 and D6-2] are stated below. Procedure IV is defined as a variable vertical profile where the aircraft is flying from 7000ft with full landing configuration and idle thrust. Pilots indicated that there is no control available for the crew, because engines are on idle, configuration changes have been made and speed brakes are inhibited in many aircraft once landing configuration has been set. After G/S intercept, high trust is needed to maintain 3 degree path due to the configuration setting. Also aircraft are not designed to fly in landing configuration for long time (structural fatigue, higher maintenance costs) and the autopilot is not certified for these conditions. Another technical issue is that the ground proximity warning system (GPWS) might be triggered because of the steep descent (could be over five degrees before GS intercept)

Arrival procedure V

Procedure V is defined as a variable vertical profile where the aircraft is flying from 7000ft with intermediate configuration and idle thrust. Pilots mentioned that this procedure is more sensitive to unexpected tailwind in comparison with procedure II. There is a lack of control options, especially with this unexpected tail wind (increased risk of being too high and/or too fast). Due to the combination of the configuration and the idle thrust there is little margin available for speed reduction. Controllers stated that there is more uncertainty about the intentions of the aircraft (speed and vertical). They experienced procedure V as a too drastic change from current working procedure.

Departure procedure 1

This procedure is the baseline departure procedure and represents the current practise ICAO-A departure procedure.

Departure procedure 2

The general opinion concerning departure procedure 2 is that the pilots did not appreciated the early thrust cutback and therefore rated this procedure as less efficient, safe and therefore also less acceptable when compared to the current ICAO-A procedure. Lowering the thrust reduction altitude from 1500ft (ICAO A) down to 800ft was considered as being too drastic. Even though the thrust cutback and the restoration were performed automatically based on FMS settings made pre take-off, pilot did not appreciate the 800ft. This negative rating should be seen keeping in mind that the pilots did not expect these procedure to have a significant noise impact and therefore were reluctant to the ‘pay the price’ in lowering the cutback altitude. The aim of the Sourdine optimised close-in departure procedure is less noise due to a lower thrust setting. However, this advantage is mainly for the area close to the airport, and therefore this procedure is efficient only for airports with noise sensitive areas close to the airport. Additional disadvantages mentioned by the participants are less terrain clearance (not possible with limiting obstacles), bad passenger comfort, less economic and relatively low thrust at critical stage of flight. Some of these disadvantages can be overcome by good training of the aircraft crew. It will take time to get used to such a departure procedure; it is possible, but not preferred.

Departure procedure 3

The moment of acceleration and changing from take-off configuration to clean configuration differs between departure procedure 2 and 3. Both procedures however are characterised by reducing thrust shortly after take-off leading to a lower climb rate while being close to the ground. All feedback given by the pilots indicate that reducing thrust while being at low altitude in the climb has a negative impact on safety perception and noise reduction is questioned. It should be noted that no pilot has flown procedure 3 and the above made comment is purely subjective based upon pilot feedback on procedure 2 compared to the baseline procedure 1.

8.5.5 Conclusions

In general it can be stated that both procedure II and II-A are acceptable for pilots and controllers. When implementing procedure II a solution should be provided to increase the time between the various configuration changes as calculated by the FMS. If it is decided to implement also speed constraints (procedure II-A) the monitoring aid should be extended with an alert when the separation minima are violated and the controller needs to intervene. To get to an implementation of these noise abatement procedures it is important that the pilots will strictly follow the prescribed procedures.

Regarding the departure procedures, pilot did not appreciate the thrust cutback altitude of 800ft. It was considered to have a negative safety impact, not being efficient while the pilots were not convinced of a significant noise benefit.

Controllers also need to get hands-on experience concerning the "new" speed profiles and aircraft performance. Due to the fixed RNAV routes inside the TMA there are fewer possibilities to make changes to the arrival sequence and therefore an arrival manager and an accurate hand-over from ACC to APP (30-60 seconds accuracy) is required. The current implementation of the RNAV shortcuts provided sufficient flexibility for the controllers. The combination of parallel runways with CDA procedures is an identified problem. Possible solutions on this subject that need further exploration are for example the use of curved approaches based on approach procedure with vertical guidance (APV procedure) or to have a short level segment for one of the runways.

8.6 Framework for Cost Benefit analysis of NAPs

Once assessed the SII NAPs on capacity, noise, emissions, safety and users acceptance point of view, having evaluated for the change in the airport capacity, in the delay values, in the noise contours and in the other selected metrics, the further step has been assess on which stakeholders the measured values could have an impact, as investors or as beneficiary.

To this purpose, appropriate Cost/Benefit models permit the extrapolation of costs over time as well as projections of financial measures of the benefits that may be expected. Last, but not least, very often CBA is necessary to convince investors to support the implementation of the “solution”, especially when large expenditures and/or relevant infrastructures are required.

In the SII project case, the first step was to set up a CBA methodology able answering to the following questions:

- -“How much is it convenient to apply a SII NAPs?”
- -“When it will be convenient to apply a SII NAP?”
- -“Who will benefit from the use of a SII NAP use?
- -“Who will have to pay for achieving the SII objective?”

On the basis of guidelines supplied from the CBA methodology, the economic analysis was developed through a sequence of steps:

- Cases identification: Do-nothing case and alternative case(s)
- Valuation types: Quantitative(€) or Qualitative(Improvement or Worsening of valuation parameters)
- Actors identification
- Cost categories identification and evaluation for each actor/stakeholder and for the identified cases
- Benefit categories identification and evaluation per each actor/stakeholder and for the identified cases
- Final assessment

The do-nothing case is equivalent to the Baseline scenario, as called in the FTS assessment, while each SII NAP represents an alternative case.

Two kinds of evaluation were proposed, the first one was quantitative and the second one was qualitative. The choice of one of the two methods depended on the available output data and in the SII case most of evaluation types were qualitative.

Much attention has been paid to the actors/stakeholders selection, avoiding the risk of excluding some of the actors from the list of those who have to pay or that can benefit from the SII NAPs implementation.

The further step has been to select the costs/benefits categories within the SII project:

- Investment costs
- Operational costs
- Social costs
- Noise charges
- Airport efficiency change (capacity/delay decrease)

- Decrease in noise levels benefits
- Decrease in emissions levels benefits

Many inputs are necessary for the SII Cost Benefit Analysis, some of those are expected to come from the Fast Time Simulations, while others from Real Time Simulations and others from literature studies and experts opinions.
Once identified the actors/stakeholders and the costs/benefits category, it has been calculated the impact of introducing the SII NAPs with respect to the Baseline scenario and they are here reported for each identified actor:

8.6.1 Assessment of Costs/Benefits for Airport and Air Traffic Service Provider

The SII NAAPs are conceptually procedures keeping constant one of the three performance parameters (speed, altitude and thrust) and playing on the other two performances. So once a NAAP has been started, only configuration changes linked to the NAP are allowed. This means that the inbound traffic has to be managed before the CDA starts and this can be done with support of arrival management/monitoring tools developed for the SII NAPs, together with the Ghosting tool, foreseeing the aircraft position when merging a/c flows in approach and letting to sequence earlier and making easy the monitoring. So ANSP have to invest on new supporting tools for implementing the SII arrival NAPs such as:

- Monitoring/Management tools
- Ghosting tool

The introduction of new systems and procedures require also training of the operational staff, because ATCO have to become confident and have to feel safe in using them. Fewer constraints impose the SII noise abatement departure procedures, because they imply fewer changes in the controllers operating way.

Supposing an average employment cost of €69 per ATCO-hour [ATM_ACE], and 3 days training as sample (preliminary RTS results), the following costs should be considered from the ANSP for the SII implementation:

	Number of controllers	**Costs for one hour ATCo (€)**	**Training costs(€)**
Madrid - Barajas	70	70,6€*	118.608,00 €
Naples -Capodichino	35		59.304,00 €
Amsterdam- Schiphol	75		127.080,00 €

8.6.2 Assessment of Costs/Benefits for Airlines

As expected, airlines are the main actors in the SII NAPs implementation because pilots are in charge to apply the SII NAPs. Relevant investment costs will be asked to the airlines, because new tools are required for both approach and departure procedures, such as flap deployment cue and vertical navigation display, demonstrated a pilot because he has more information on the NAP he is flying and he can act on the aircraft performances to reach the target required from the CDA

Investment cost

Airlines have to take into account that if they want to become more environmental compliant, flying a new NAP, they have to invest on the following items:

- Additional aids on the flight deck
    - Flap deployment cue
    - Vertical Navigation display

- Additional tools/modifications
  - Tool for automating the thrust and reaching the gradual thrust increase
  - Modifications on FMS
- Training of pilots on the new NAPs

As it was expected if an aircraft flies a new NAP some changes have to be planned for the aircraft and its operations, which means changes in the operating costs in charge of airlines.
The operating costs include all the costs linked to the aircraft operations, so in the SII project three items have been addressed in this costs category:

- Maintenance and overhead costs: In the SII project case some of the arrival procedures could require a decrease of flown hours between two succeeding checks, because flaps and speed brakes are used for longer time, so related checks could be re-scheduled. About the departure procedures, past studies have demonstrated that the use of de-rated thrust can affect the maintenance costs. In the SII project case, assess these costs it could also more difficult because it should be necessary to assess a "typical derate", but this a bit more difficult to define, as it is highly dependant upon the runway characteristics and takeoff environment conditions, and of course the aircraft TOW and the installed thrust. Further analyses are required for investigating the possible effects of the de-rated thrust on the engines maintenance/overhaul.
- Delay costs: As seen from the fast time simulations assessment, the new arrival NAPs bring about an increase in the average delay per flight, which has been quantified for each airport and for all the SII NAAPs. Since the delays calculated within the SII project are related just to the use of the SII arrival procedures, and they have been calculated on the last part of the flight (from 7000ft to the THR), for using the average value of €72 per minute [SICBA, Eurocontrol Standard input for Eurocontrol Cost Benefit Analysis], it has been assumed that the delay costs here calculated have suppose that all aircraft flying a SII NAAP have accumulated an ATFM delay of 15 minutes before they start a CDA. Using the average arrival delay coming from the FTS, taking into account the movements number planned to fly at 2015 by the four airports, the percentage variation of the delay costs due to the SII NAPs implementation with respect to the Baseline are listed in the following table:

	Percentage Variation of delay costs with respect to those of the Baseline ones **(figures refer to the part of the flight below 7000 ft)**			
	NAAP_II vs. Baseline	***NAAP_III vs. Baseline***	***NAAP_IV vs. Baseline***	***NAAP_V vs. Baseline***
Naples	7,41%		62,96%	37,04%
Madrid	116,67%	100,00%	155,56%	105,56%
Schiphol	25,64%		120,51%	43,59%
Paris	10,34%	13,79%		13,79%

Noise charges

The noise charges are primary based on the certificated aircraft noise-level [SII_D1_1], according to the standards of ICAO, Annex 16 or FAR Part 36 and on their MTOW. They are different for each country, where the local government fixes the taxes rate, but the basic principle is the same. It could be then proposed to add as third factor for the noise charges calculation the use of a noise abatement procedure. In fact, the new SII NAPs deliver noise reduction,therefore a foreseeable lightening of the noise charges.

8.6.3 Assessment of Costs/Benefits for Airport Operator Company

The airport operator company will benefit from the use of the SII NAPs, because, as first qualitative aspect, the relationship with people living in the airport surroundings will improve, due to the decrease in the noise levels around airports.

On economic point of view they will save money, because the noise contour size will be reduced and in all probability the number of houses within a noise contour will decrease, which means the number of houses to insulate could decrease.

8.6.4 Passengers and cargo

As seen from the fast time simulations assessment, the new arrival NAPs bring about an increase in the average delay per flight, which has been quantified for each airport and for all the SII NAAPs.

The average delay per flight should be taken into account for passengers too, because it is a satisfaction index for the customers, but it is referred to the delay accumulated from the departure gate to the arrival gate, so it has been decided to leave out this assessment parameter form the SII CBA.

8.6.5 Third parties/Citizens living around airports

In the airport financial view, the noise and more in general the environment, is considered such as an externality, because the environmental aspects are not relevant for who takes decisions, but they influence community life.

There is a considerable literature on this type of problems. Also a few studies exist that aim at pricing the external effects due to aircraft noise nuisance. These studies either use revealed preference methods (e.g., the hedonic price method), or direct stated preference methods (e.g., the contingent valuation method)[SII_D4-3]. In the SII project case the Hedonic pricing method was selected and as metric for the evaluation of the noise assessment was selected the Noise Sensitivity Depreciation Index (NSDI), that is the average percentage change in property prices per decibel. That means, if the Noise Depreciation Index is about 0.5-0.7 and the noise nuisance increases by 10 units, then, property prices decrease by 5-7%.

Many studies have been performed about the economic value of aircraft noise and they suggest to use a value of NSDI between 0.5% and 1%, so a proposal could be to make an assessment with a minimum, a maximum and an average value of proposed NSDI range and analyze the economic effects of choosing on of them through the sensitivity analysis. The selected methodology for assessing monetarily externalities generated from the SII NAPs leaves out the effects on human health, very difficult to assess in the SII project case. Unfortunately data on number of houses within the four SII airports have not been calculated, so the mentioned methodology was not applicable and a qualitative analysis of the results has been done.

The introduction of new NAPs generate a decrease in the noise contour sizes, that could mean a decrease in the number of houses within noise levels, but it should be assesses airport by airport, and NAP by NAP because people is not uniformly distributed within the noise contours. It is really probably that the SII NAPs could increase the property values of houses around the airport and improve quality of life for a greater population number

9 Comparative analysis of results

This section summarizes the process of data analysis carried out in SOURDINE II project in order to achieve some conclusions about the approach and departure procedures studied in the project. The main objective of the Balance Analysis is to give high level results; specific conclusions and recommendations to allow decision makers have a primary approach about the goodness of proposed procedures.

Over the course of the SOURDINE II project, several partners of the consortium have run several simulation exercises in several airports. Those simulations have provided specific information and data about the influence of the new procedures in the areas of NOISE, SAFETY, CAPACITY, WORKLOAD - pilots and controllers -, ECONOMICS and ACCEPTANCE - of pilots and controllers. The whole set of data and results have been put together in this document and a balance analysis of them is given.

Conclusions related to EMISSIONS data have not been included in this comparative analysis. This is done because the emissions data calculated do not reflect the effect of the whole procedure; only the emssions impact of the segment below 3000 ft has been calculated (see section 7.3 and 8.4 also)

Project partners agreed in the first stages of the project to a list of metrics and indicators that had to be measured so as to provide accurate information for each area. The list can be found in the deliverable D2-1. This list has been refined after the simulations runs, since new metrics have been added and others have been removed. Some indicators and metrics have also been broken down into more specific ones. The final list of metrics and indicators measured can be found in annex A of the present document.

Since data comes from different simulation exercises' runs, from different groups of people involved and from different airports, some assumptions have been made in order to provide uniformity and coherence to the calculations. Among these assumptions, how to group indicators or give different weights to metrics to calculate averages are the main ones.

All the results shown in D7-2 are expressed in percentages. The reason is that all the figures are referred to the reference procedure or baseline, so, each result has to be read as how much better or worse is the procedure for the correspondent indicator with respect to the reference. In some cases, a negative percentage will mean improvement – e.g., reduction of noise contour - and in others it will mean worsening – e.g., throughput of the airport. This fact has been also taken into account to calculate averages.

Tables of data in D7-2 present the results for each indicator and for each airport. Not all the cells are filled in, since for the areas of SAFETY, WORKLOAD and ACCEPTANCE only numerical data from RTS in Amsterdam – Schiphol are available. Some other indicators are missing due to different reasons, which can be found in the deliverable D7-1. For departure procedures, only noise results are available.

The balance analysis has the following outputs:

- Comparison bar charts by area and airport.
- Comparison bar charts by procedure and airport.
- Conclusions.
- Recommendations.

A general overview of the whole methodology is given in figure 9.1:

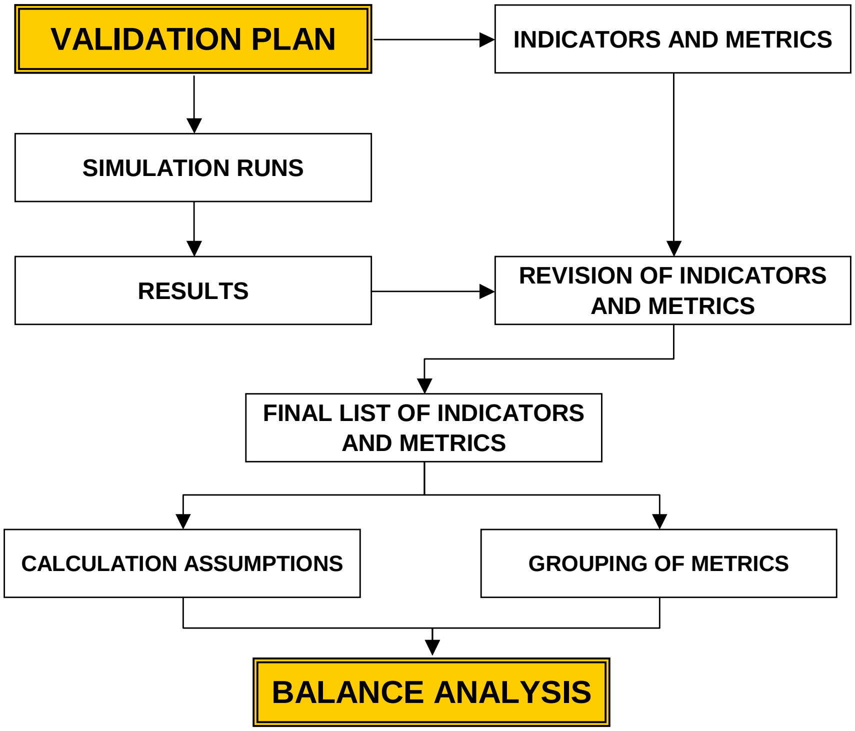


Figure 9-1 Methodology of the balance analysis

It was decided to divide the balance analysis in four different tasks:

- Selection and refinement of procedures process: during the project the various procedures identified went through a refinement process as part of the validation plan. It must be remembered that the selection of procedures was done with respect to several criteria agreed amongst the consortium. This process ended with the selection of 4 final approach procedures and 2 departure procedures.
- Overview and analysis of results in all areas of interest for each procedure: this task intends to gather all the results obtained for each procedure. The results are all compared to the baseline. In order to better visualise the results and comparisons with the baseline several colour codes were defined and displayed in a comparison table.
- Evaluation and comparison the procedures with respect to the results obtained: once the results overviewed and analysed this task intends to compare procedures together to evaluate in what aspects which procedures are the best. For this is necessary to define specific airport needs to define the selection criteria and lead the selection of procedures.
- Elaboration of conclusions and recommendations: this final task will provide conclusions about the balance analysis and recommend the most promising procedures.

The following figure, figure 9-2, summarises how the previous task are related together and what are the inputs required in each of them:

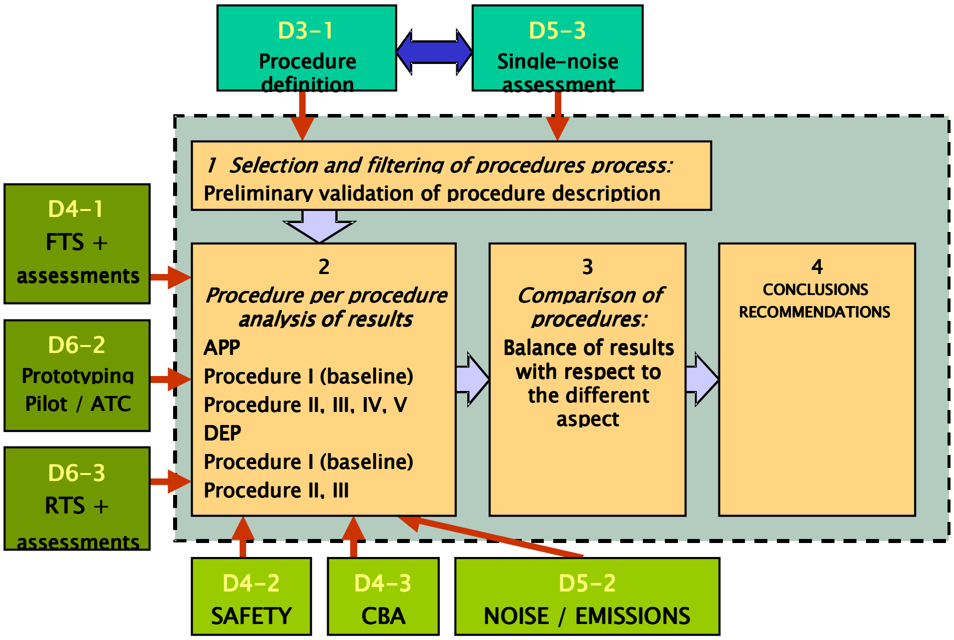


Figure 9-2 Balance analysis process diagram

The conclusions of the balance analysis have to be revised considering that the main objective of the project is providing a primary overview of the effects implementing the noise abatement procedures and making a comparative analysis amongst them highlighting the most promising ones.
All the arrival noise abatement procedures cannot be implemented as they are due to safety related problems, marked and widespread improvements both in cockpit avionics and in controllers HMI are envisaged for their implementation. Furthermore being able to reduce the assumptions on which the SII project is based could provide a clearer view of the problem.
In the meanwhile the balance analysis is the appropriate approach in providing the decision makers with a good picture about each procedure and the relative performances.

From the comparison chart by area and airport, the main conclusions obtained for arrivals are:

- NOISE: all of the procedures have more or less the same conclusions for all of the airports. Procedure III dramatically reduces noise, procedure IV reduces it moderately and procedures II and V reduce it slightly.
- SAFETY: procedure II and II-A do not have significant influence in the level of safety reached with the reference procedure whereas procedure V shows a slight increment of risks. There is no figure for procedures III and IV.
- CAPACITY: a general loss of capacity of the airports is reported from simulations, ranked from a moderate one in Paris – CDG for procedures II, III and V to a great one with procedure IV in Amsterdam – Schiphol.
- WORKLOAD: both controllers and pilots experience a decrease of their workload with procedures II and II-A, but pilots have a significant increment with procedure V whereas controllers still have a reduction. There is no data available for procedures III and IV.
- ACCEPTANCE: pilots are willing to accept procedures II and II-A but they reject procedure V, always comparing with the baseline. Controllers do not show significant acceptance or rejection for procedures II and II-A but a strong rejection for procedure V. There is no data available for procedures III and IV.

With respect of departure procedures lesser investigated than the arrivals ones, we can say that they are strictly airport and airport surroundings dependant, meaning as airport surroundings not only the geographical area but also the settlement degree. The number on total movement per day also influences the choice of the departing noise abatement procedures.

From the comparison chart by area and airport, the main conclusions obtained for departures are:

- The noise abatement effectiveness of departure procedures is strictly airport related, so even if on average we obtain some benefits in noise reduction we can observe, a significant difference (worsening) between the application of “Close in” procedure on Madrid airport with respect to the others two airports.

From the comparison chart by procedure and airport, the main conclusions obtained are:

- PROCEDURE II: this procedure is better than the reference for NOISE, SAFETY, WORKLOAD and ACCEPTANCE – above all, of the pilots – but implies a significant amount of delays with respects the baseline and a slight loss of throughput of the airports.
- PROCEDURE II-A: results for II-A are the same as the procedure II with less reduction of NOISE.
- PROCEDURE III: out of the results available – NOISE and CAPACITY -, this procedure shows a huge reduction of noise with a slight loss of throughput and a moderate increment of delays.
- PROCEDURE IV: out of the results available – NOISE and CAPACITY -, this procedure shows a significant reduction of NOISE, but an exaggerated increment of delays. Throughput has a significant loss, as well.
- PROCEDURE V: only NOISE and WORKLOAD of controllers improve with regards the reference procedure. Delays, WORKLOAD of pilots and ACCEPTANCE of controllers are severely penalized.

	Procedures **<---- Best ----------------- Worst ---->**					
AREAS	**ARRIVAL PROCEDURES**					
NOISE	**III**	**IV**	**V**	**II**	**I**	
EMMISSIONS	**-**	**-**	**-**	**-**	**-**	**-**
SAFETY	**II**	**II A**	**I**	**V**		
CAPACITY - Throughput	**I**	**III**	**II A**	**II**	**V**	**IV**
CAPACITY - Delays	**I**	**II A**	**III**	**II**	**V**	**IV**
WORKLOAD - Controllers	**II**	**II A**	**V**	**I**		
WORKLOAD - Pilots	**I**	**II A**	**II**	**V**		
ECONOMICS	**I**	**II**	**II A**	**V**		
ACCEPTANCE - Controllers	**II**	**I**	**II A**	**V**		
ACCEPTANCE - Pilots	**II / II A**	**I**	**V**			

Table 9-1 Ranking of arrival procedures per area

	Procedures <- Best ------ Worst ->		
AREAS	**DEPARTURE PROCEDURES**		
NOISE	3	2	1
EMMISSIONS	-	-	-
SAFETY	1	2	
CAPACITY - Throughput	-	-	-
CAPACITY - Delays	-	-	-
WORKLOAD - Controllers	-	-	-
WORKLOAD - Pilots	2	1	-
ECONOMICS	-	-	-
ACCEPTANCE - Controllers	-	-	-
ACCEPTANCE - Pilots	2	1	-

Table 9-2 Ranking of departure procedures per area

10 Implementation plan

10.1 Introduction

The Implementation Plan describes the necessary steps necessary to turn the Sourdine II procedures over to the real operational world. As a Plan it focuses on three main implementation aspects: the “WHEN?”, the “WHERE?” and the “HOW?”. For each aspect synthesised by a question, the actors/stakeholders’ of the ATM System are identified and how they are affected by the project’s outcome (SII procedures). The timeframe is 2015 but the time-schedule is dependant both on the changes in the ATM system needed by the introduction of the new NAPs and on the state and strategy pursued by the “local” Decision Maker.

10.1.1 Purpose

The purpose of the Implementation Plan is to guide and give support to the Decision Maker by showing which constraints and mitigation possibilities the introduction of the Sourdine II procedures make on the ATM System. The Decision Maker will also rely for support on future choices regarding the introduction of the SII procedures on the CBA and the Balanced Analysis which deal with other facets influenced by the SII procedures.

The Sourdine II implementation plan should be weighed as a preliminary plan (and as a tool for the Decision Maker) to the introduction of the procedures; further steps are needed to close the loop. As well as extra tailoring for the local situation be it airport wise, country wise or European wise are needed.

10.2 The time-schedule and system constraints (WHEN?)

The Sourdine II procedures when implemented will influence in different ways totally or partially the ATM system with its stakeholders. The following section will try to show the method used with which the main constraints affecting the current system where identified and its influence towards the introduction beginning with:

- What the procedure affects
- Who the procedure affects directly
- Which domain does it affect
- The solutions SII proposes.

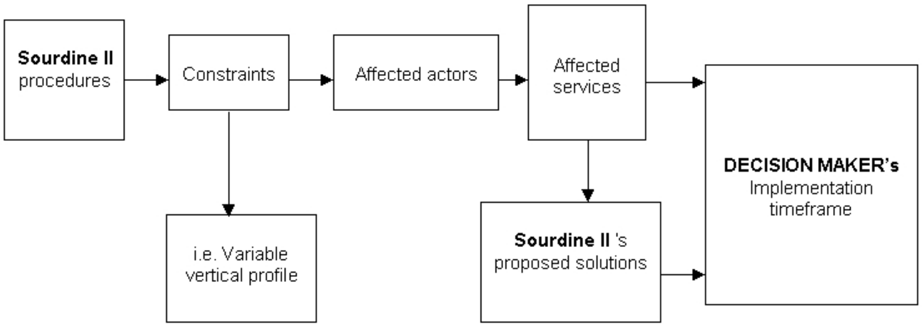
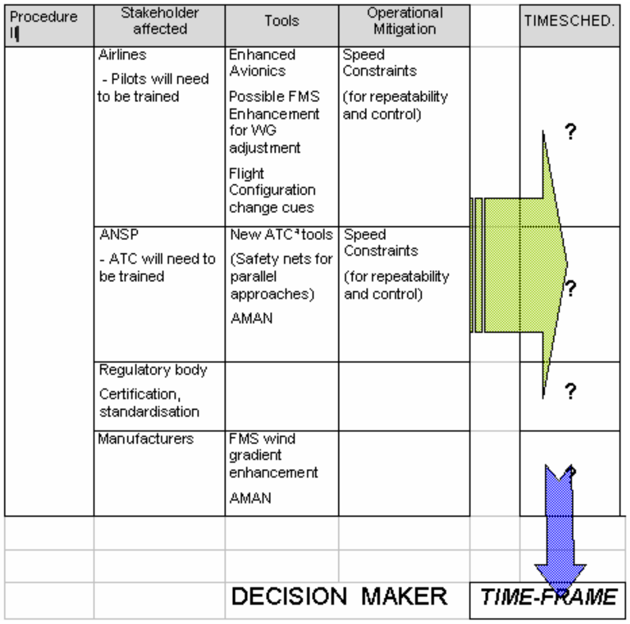


Figure 10-1 Cut-out of analysis performed for estimation of implementation time schedule

The result of this method is the creation of a matrix, one for each SII procedure, having on the columns the “stakeholders affected”, the “tools necessary for the operation”; the “operational constraints” (i.e. see below). For each of the lines of the matrix the decision Maker has the capability and the knowledge of the timeframe he will be able to apply those changes. The Matrices clearly synthesize and make simpler the identification of those bottlenecks or changes where more endeavour should be directed (investment, infrastructure, change in philosophy, etc.).



Procedure II	Stakeholder affected	Tools	Operational Mitigation		TIMESCHED.
	Airlines - Pilots will need to be trained	Enhanced Avionics Possible FMS Enhancement for WG adjustment Flight Configuration change cues	Speed Constraints (for repeatability and control)		?
	ANSP - ATC will need to be trained	New ATC[3] tools (Safety nets for parallel approaches) AMAN	Speed Constraints (for repeatability and control)		?
	Regulatory body Certification, standardisation				?
	Manufacturers	FMS wind gradient enhancement AMAN			?
		DECISION MAKER		TIME-FRAME	

Table 10-1 Matrix of constraints timeframe implementation estimation (supports in the DM’s choices).

Based on these matrices and comparing them we may also rank the SII procedures, relying on the fact that the procedures which introduce fewer changes will have an early implementation, (the results were also supported by a dedicated workshop on Implementation (“Expert workshop: Deloitte Rome, 27 April 2005”).

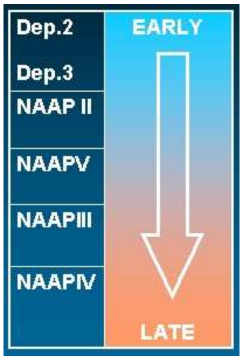


Figure 10-2 Implementation schedule based on constraints to the ATM System

Figure 10-2 shows the implementation trend for the Sourdine II procedures, from the most simple to the most complicated (procedures are ranked on estimated implementation time). The estimation is based, as stated earlier, mostly on the work performed during the whole project (see specific deliverables for further information) and the feedback from the workshops, in which current ATM representatives gave us an estimation dependant on what was shown in the matrices of the time-schedule.

10.3 Introduction to the Airports (WHERE?)

From the previous section we obtained the method with which to estimate the necessary time the actors will need to implement the solutions for the implementation of the procedures, and the decision maker to introduce them in the ATM system, but we have to bare in mind that the constraints there identified and studied during the project are dependant on high traffic density.

From the RTS and FTS assessments (the later made for four European airports), it is clear that many of the constraints or, to see it the other way round, many of the changes needed by the ATM system to take total advantage of the SII procedures depends on the traffic density. Traffic density is directly linked with airport size.

Many of the procedures' constraints (i.e. safety parallel runways, etc.) do in fact disappear or can be easily mitigated by applying them to lower traffic density, which is directly proportional to the size of the airport. Thus the airport defined as small-medium-large (see D1) works out to be the first mitigation tool in the implementation time-schedule.

The "WHERE?" basically mitigates and reduces the "WHEN?" question. Or otherwise the implementation calendar is different depending on the airport the procedures are introduced.

The features characterizing each generic airport as in S-M-L can be divided in four categories:

- Layout (number and type of RWYs)
- Traffic (kind of traffic using airport and density)
- Procedures and airspace structure associated to the airport
- ATC services available on the airport

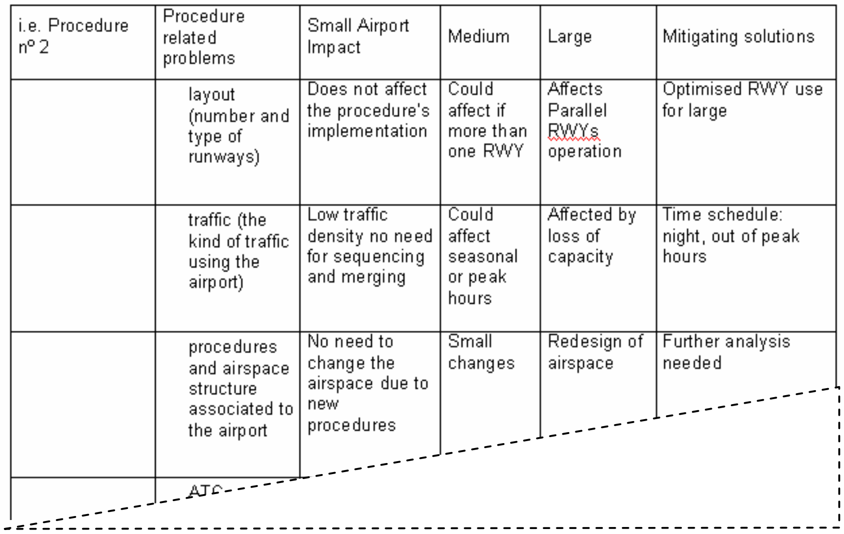
By applying these categories to the matrices from the previous section, we find out that where the needs are not airborne specific, that the implementation time-schedule may shift even earlier just by applying the procedures to different size airports. The table below is the application of the above described mitigation process.

Airborne and Enhanced avionics

The mitigation by way of the site the procedures are applied does not take into account the airborne (or enhanced avionics) requirements, on the other hand the full use of the current airborne systems and the introduction of new in the short-term does prospect the validity of the above table.

Users' Feedback for Procedure IV

In particular the pilots and ATCos did not accept Procedure IV (for more information refer to sec.5.4 in D6-3), on both technical and operational grounds, for this reason although present in the previous analysis, procedure IV must be put aside until further assessments can change the negative user feedback.



i.e. Procedure nº 2	Procedure related problems	Small Airport Impact	Medium	Large	Mitigating solutions
	layout (number and type of runways)	Does not affect the procedure's implementation	Could affect if more than one RWY	Affects Parallel RWYs operation	Optimised RWY use for large
	traffic (the kind of traffic using the airport)	Low traffic density no need for sequencing and merging	Could affect seasonal or peak hours	Affected by loss of capacity	Time schedule: night, out of peak hours
	procedures and airspace structure associated to the airport	No need to change the airspace due to new procedures	Small changes	Redesign of airspace	Further analysis needed
	ATC				

Table 10-1 Procedure system requirements when applied to airport class (further information can be found in the deliverable).

10.3.1 Airport Analysis and Mitigating solutions

<u>Small Airports</u>

The Sourdine II approach procedures could all be implemented in small airports due to small traffic density, the only constrain being that for procedure IV and V further enhanced airborne avionics would be necessary, while for procedure III the 4º descent could lead to the design of an APV type of landing (since no ILS is available).

- *No restriction on hour of operations.*
- *No necessity for extra ATC tools.*

<u>Medium Airports</u>

In medium airports with medium density traffic, controller tools will be needed to keep the capacity-value, mostly during those seasonal periods with the most density. On the other hand, mitigating solutions could be introduced as the spreading of these traffic peaks along all the operative day or the use of the procedures during out of peak hours and at night time.

The arguments regarding the pilots' tools side do apply here as well. But Procedure III is the only procedure which would have a PA landing system constrain, as changes in ILS on a large scale are not at all foreseeable. On the other hand an APV procedure is in the short to medium term foreseeable.

<u>Large Airports</u>

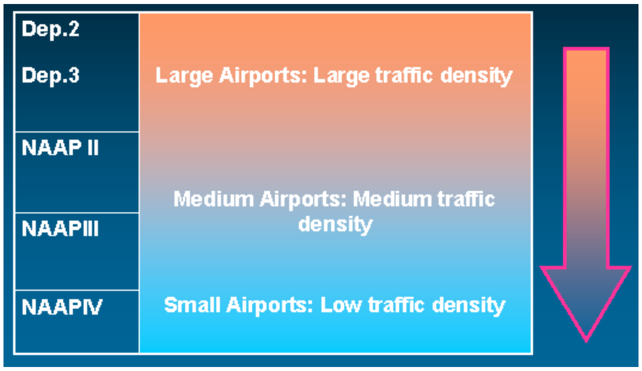
Large airports in order to maintain the current capacity will follow a stepped implementation of the procedures, introducing the one which less imposes changes on the ATM system to move to the one which does (and gives better environmental benefits). Thus Procedure II could be implementable in the short-term, followed by procedure V and IV which do impose greater changes. High density traffic requires flight deck, controller and cockpit tools with advanced guidance. Procedures needed for all aircraft types, thus not being an optimal "CDA". Significant further noise reduction expected. One of the challenges is to define procedures that can be used by flight crew with no significant change in workload and to find ways to maintain minimum separation of aircraft.

An operational mitigating solution is the introduction of the procedures at night time to move on to off peak hours once the maturity of the procedures and of the system are provided.

On the economical side further improved ground equipment and training will be acceptable for large airports which have an interest in modernising their installations and gaining environmental benefits on top.

Departure procedures for Airports

Departure procedures will be only affected by Obstacle clearance requirements and Pilot thrust management tools (gradual increase/cutback), the first is Airport Topographic specific, while the second is technological. Only based on the traffic density thus on the airport size the following table can be extrapolated:



Dep.2 Dep.3	Large Airports: Large traffic density
NAAP II	
NAAPIII	Medium Airports: Medium traffic density
NAAPIV	Small Airports: Low traffic density

Table 10-2 Implementation to different size airports ranked upon influence of traffic density (procedures are implementable from the top to the bottom)

10.4 The stepped Implementation (HOW?)

This section is the result of merging the "When?" and the "Where?": the when was taken into account as the primary imposition further mitigated by the where.

Here we suggest the implementation steps "How?", to be followed in order to introduce the new Sourdine II noise abatement procedures. The cycle is an iterative loop which aims to build up experience while in parallel taking into account that solutions are deployed for the high traffic density case. The following steps should be tailored to the specific current situation.

Step 1

- Introduce the CDAs which are less intrusive in dense traffic airports at night time
- Introduce the CDAs which do not need enhanced ATC and pilots tools into medium traffic during off peak hours and night time
- Introduce CDAs which can fully use the current technology into small airports during all day.

Step 2

- Analyse the situations for Step 1 and build up on experience from small to medium to large density traffic in order to improve the introduction of more conflictive procedures.

Step 3

- Check that the deployment phases for ground and airborne improvement accept the migration to higher density traffic of those procedures which give the more benefits, pass to a higher level of use thus go from step 3 to 2 to 1.

Step 4

- Continue research and improvement, discarding procedures which are not beneficial.

Bare in mind that the systems or improvements the SII procedures need are not beneficial only for their own deployment, the benefits of these systems are widespread to all the parts of the ATM. Three clear examples are the Ghosting tool[2] with which ATCo's manage the merging of traffic to the same point on a RNAV route, whatever type of procedures are used; the vertical navigation display, regarded as very useful by the users (Pilots) in delivering navigational awareness independent of the procedure used [see D6-1 & D6-3 for further details]; and last but not least the Datalink, on which systems and services like the Airborne Separation Assurance System (ASAS)[3], Automatic Dependant Surveillance (ADS-A-B-C)[4], etc. are based, already enhancing the ATM's CNS domain.
The reader should be aware that the implementation Plan's steps should be evaluated towards the outcome of the balanced analysis, where the procedures are weighted for their benefits and the CBA.

The stepped implementation is valid either for the introduction of one procedure (if that is the case or choice) or different procedures: there may be a migration from one un-optimal procedure to an optimised procedure or a stepped migration from one procedure i.e. Procedure II to a further more noise beneficial procedure Proc III.

10.5 Regulatory aspects (a step beyond)

Further to the Sourdine II Implementation Plan, the introduction of new procedures will need to comply with the following required path towards full implementation into the real world.

In general, implementation may follow two paths depending on complexity and number of changes involved in the ATM system:

a. The first path which is the shortest is based on the fact that the operational procedures do give benefits and are readily applicable (follow the PANS_OPS, etc), i.e. the airline, based on previous design studies, simulates the procedure both in the simulator and then in flight tests, training is given to pilots and results are then analysed. The positive outcome of the tests are then sent for the safety assessment (SA) to the ANSP which will then search for approval by the Local Regulatory bodies (CAA, DGAC, ENAC, etc..) depending on the country the regulatory bodies may change. Once the SA is approved the airline is then given permission to fly the procedure, updating all the necessary manuals and operational aspects which are influenced by the new procedure.

This would be the most likely scenario for the SII Departure procedures and the less demanding Approaches.

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[2] "Ghosting" is based on the Converging Runway Display Aid (CRDA). CAASD developed CRDA for the FAA and licensed it to NavCanada. CRDA is being used in Calgary, and NavCanada is planning to expand its use to Toronto. In the United States, CRDA is used in terminal areas in Philadelphia and St. Louis. A controller display tool used in performing the staggering required for the converging runway operations. It has two modes of operation called "stagger" and "tie". In the stagger mode, a reference target (called the "ghost" target) is displayed at a reference location with respect to which controllers must space the real aircraft. (see Feldman, 1992 and FAA, 1994)[GT].

[3] "SafeRoute": UPS is expected to start flight tests (2006) of this system that will enable pilots to monitor spacing between aircraft during approaches and to guard against RWY incursions on the ground. The SafeRoute system is a series of automatic dependant surveillance-broadcast (ADS-B) software applications that are designed to enhance situational awareness through two main sub functions: surface area movement management (SAMM) and the "merging and spacing" feature.

[4] "ATOP": an air traffic system that allows controllers to reduce space between aircraft over U.S. oceanic air space is now fully operational at its first site—the New York Air Route Traffic Control Center. It will use ADS-A (automatic dependent surveillance addressed position report messages) and CPDLC (controller-pilot datalink communications) along with RNP (required navigation performance) capability to reduce aircraft spacing requirements to increase airspace capacity and efficiency.

b. The second path or case is when the introduction of the new procedures requires deep changes to the whole ATM system as: airspace redesign, new ATC/Pilot tools (which are not available), change in the operational tasks (i.e. ATC monitoring versus active control), etc. Being more complex and involving all the actors, the implementation process would be longer and more complex.

This was seen as the most probable case for the SII arrival procedures, where the changes involved all the ATM stakeholders. Great emphasis was in fact given to making sure the actors were well informed and brought in to the implementation as early as possible, in order to make room for flexibility.

Once the choice is made to use the Sourdine II procedures the following steps should be taken by the Decision maker to confirm the implementation to the regulatory requirements covering the introduction of new procedures.

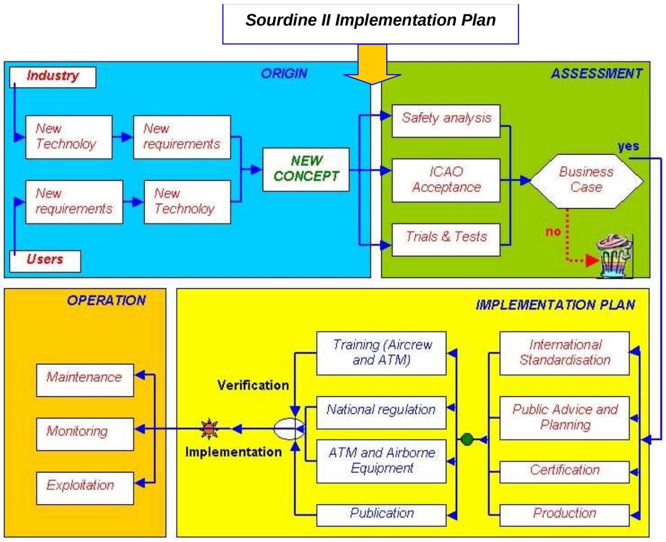

Figure 10-2 General Implementation Cycle of a Concept

10.6 The ECIP

The objectives and the implementation schedule of the ECIP were taken into account during the writing of this document.

The ECIP objectives provide the means to apply the ATM system changes needed to meet the performance target.

The ECIP 2005 –2009 contains 62 implementation objectives. These support different types of operational improvement in the European ATM system, and are spread over a number of ATM domains. Many of these implementation objectives closely include the introduction of SII NAPs in the ATM system, either directly (ENV01 Basic CDA, 2008) or by delivering solutions (ATC06 Implement arrival management tools) to the constraints SII NAPs impose. By taking the objectives date of implementation, a time schedule based on a concrete year could be produced, on the other hand we prefer to give this flexibility to the decision maker, conscious of the situation his ATM system is and responsible for deciding the future steps.

Other sources of information were also used to support the assumptions made during the analysis made for the implementation plan and can be found for an interested reader inside the project's deliverables.

10.7 Conclusions

The Sourdine II Departure procedures

The project has shown that the Sourdine II departure procedures are found to be currently implementable, while the arrivals should follow a stepped implementation.

The Sourdine II Arrival procedures in Step 1 (of the implementation cycle)

- Procedure II can be implemented in large airports
- Procedure V in medium airports
- Procedure III in small airports

Procedure IV should be further assessed for maintenance evaluation, feasibility and acceptance by the users (more information can be found in section 8.2, safety results and section 8.5.4, user acceptance results "Arrival Procedure IV").

The implementation has been divided into three main steps characterised by defining an iterative improvement cycle:

1. The stepped approach begins with the current situation by taking full advantage of existing technology.
2. The less intrusive procedures can be implemented in the short-term in a busy traffic ATM system.
3. The more intrusive procedures can be implemented in the short term in low density traffic.

The later (2) should be introduced in high density traffic once the challenges to define operational procedures that can be used by flight crew with no significant change in workload are solved and ways are found among all as to maintain minimum separation between aircraft resulting in keeping the airports' safety and capacity level.

Certain drawbacks on capacity and safety can be solved by attending the requirements the project highlighted for the near future.

The general cycle is drawn for the implementation of a new procedure as seen by ICAO and as required by the regulatory bodies. The project has shown that the Sourdine II procedure departures are found to be currently implementable, while the arrivals should follow a stepped implementation.

The aspect which has not being included into the implementation plan but of vital importance to the introduction of new procedures, is the dissemination phase. The projects outcome should be marketed and knowledge should be disseminated for two purposes:

1 to improve the knowledge on CDA based NAPs and

2 to show the public that efforts are being made, and changes and improvements can be achieved towards decreasing the environmental impact of the aviation industry.

Above all, this must be followed by improvements in all the other driving forces of the balanced approach.

11 Final conclusions and dissemination

This chapter describes the final conclusions and provides information where results are published.

11.1 Final conclusions

The SOURDINE-II project has defined a selected number of advanced Noise Abatement Procedures (both arrival and departure) which have been assessed with respect to noise, capacity, safety and acceptance by the end user (pilot and air-traffic controller). Also attention has been paid to emissions, cost-benefit and implementation issues.

Although a complete set of assessment data is indispensable for decision making on Noise Abatement Procedures, it turned out at the various occasions that Sourdine-II was presented (see 11.3), that the broad assessment within the SOURDINE II project was quite unique.

From the various assessments and the feedback during the expert panels, workshops and the final meeting at Amsterdam on July 12th 2005 the following conclusions can be drawn. The conclusions are split in process and content oriented conclusions.

Process

The procedure definition has been done by experts within the consortium; however, during the process of defining and selecting the SOURDINE II procedures, expert panels have also been organised to consult and involve experts from outside the consortium.

The validation process, where the various selected procedures were assessed on different parameters like noise, safety, capacity, acceptance and workload, gave a broad view and was well appreciated by all stakeholders involved. It provides the broad scope that is of paramount importance during discussions about implementing these kind of noise abatement procedures.

The project aimed at generic instead of airport specific procedures. Therefore, the impact of the newly designed procedures was done by assessments for four different airports: Charles de Gaulle (Paris), Barajas (Madrid), Schiphol (Amsterdam) and Capodichino (Napels).

When assessing these new flight procedures it is essential to have performance data from manufacturers as input for the various simulations. This ensures that all assessments use precisely the same procedures. The accurate aircraft performance and especially the differences in aircraft performance between various aircraft types (but in real life also FMS systems, airlines and even crews) have a large impact on issues as safety, capacity and acceptance. The Sourdine-II consortium had the opportunity to work with very accurate aircraft performance data of various aircraft types provided by Airbus and Boeing.

Apart from the aircraft performance data, also the noise characteristics of different aircraft types were needed. The number of aircraft types for which these data became available had to be large enough to represent actual and future fleet mixes at the four airports; also, these data had to be available for different configurations, speeds and thrust values. The Sourdine-II consortium has succeeded to get access to these data, again provided by Airbus and Boeing, and has applied these data in the analysis for airport noise at the four airports.

Fast time simulators like TAAM originally have been developed to be used for the simulation of air traffic using standard (non – CDA) procedures. Due to close co-operation of the four groups working on the capacity figures for the four different airports, ways have been found to also model CDAs in an accurate way in the Fast Time Simulators.

Both for the real-time flight simulations as well as the real-time ATC simulations, first prototyping sessions were performed to gather valuable feedback from pilots and air traffic controllers on the proposed tools. After further tool development on basis of this feed back, full-scale real time simulations were performed with both flight simulator and ATC simulator.

Content

The procedures evaluated in the Sourdine II project comprise five approach procedures, including one reference procedure, and three departure procedures, also including one reference procedure.
Below, a brief description of the procedures is included. For detailed description of the SOURDINE II procedures, the reader is referred to chapter 6.

<u>Approach procedure I (reference approach procedure): Baseline FMS approach procedure:</u> This procedure features a standard vertical flight path, with a level segment at 3000ft which is flown completely decelerating, with idle thrust.

<u>Approach procedure II: Basic CDA with 2º initial FPA:</u> this procedure follows a fixed 2-degrees path angle from 7000ft up to ILS intercept at 3000ft.The aircraft decelerates at idle thrust in clean configuration during this part of the flight, deploying the cleanest possible landing configuration on landing.

<u>Approach procedure III: Basic CDA with 2º initial FPA and increased final glide slope:</u> the difference between procedure II and procedure III is the steeper flight path angle on the ILS (3º proc II vs. 4º proc III).

<u>Approach procedure IV: CDA with constant speed, variable FPA segment at landing configuration:</u> the procedure is largely flown, from 7000ft to ILS intercept, with idle thrust and in landing configuration.

<u>Approach procedure V: CDA with constant speed, variable FPA segment at landing configuration:</u> the procedure is similar to procedure nº IV, with the difference that the variable FP is the result of an idle thrust descent from 7000ft to ILS intercept on an intermediate landing configuration.

<u>Departure procedure 1 (reference departure procedure):</u> this is the baseline departure procedure (NAP ICAO-A)

<u>Departure procedure 2: Sourdine optimised close-in:</u> this is the optimised close–in departure procedure, for which the noise relief is located relatively close to the runway. The procedure features a deep cutback in thrust, followed by a gradual increase in thrust starting at 3000ft. Upon reaching max climb thrust, acceleration and flap retraction takes place.

<u>Departure procedure 3: Sourdine optimised distant:</u> this is the optimised distant departure procedure, for which the noise relief is further away from the runway. The procedure features a deep cutback in thrust applied upon reaching Vzf (zero flap speed), followed by a gradual thrust increase starting at 5000 ft

All Sourdine II procedures provide significant noise reduction as compared with current day practice.

With single event simulations, it has been demonstrated that the SOURDINE II reference approach procedure, as compared with current practice, shows benefits more than 5dBA in a very large range of the procedure (see chapter 4).
As compared with the reference, even more noise reduction can be achieved, especially with procedure III and IV. Procedure III providing noise relief at all noise levels; procedure IV mainly at the lower (~55 Lden) noise levels.
A population impact study was performed at Madrid-Barajas airport and all four approach procedures showed reductions in impacted population. Procedure III was responsible for the largest change in impacted population. However, procedure IV, and to a lesser extent procedure II produced noticeable reductions in numbers under the 60dB Lnight contour.

The Sourdine II departure procedures cannot be compared against each other since, unlike the approach procedures, they have different objectives: reduction of noise close to or (relatively) far away from the airport. The noise analysis has shown that these procedures perform their required tasks. Compared with the ICAO A reference procedure the optimised Close-in procedure provides noise reduction at distances close to the airport. Compared with the reference procedure the optimised distant procedure was found to have a positive impact on nearly all areas around the airport, except for the region less than 3.5 Nm from brake release. The Close-in procedure was found to only benefit the populations within 5.5nm of brake release while being disadvantageous to those further out.
The population impact study performed for the Madrid airport showed that for the given population distribution around the airport the optimised distant procedure was the most efficient solution, reducing the number of people in the 55Lden contour by 50%. For the Madrid situation the close-in procedure did not appear to be the appropriate solution given the concentration of population in the distant zone were the optimised close-in procedure is noisier than the ICAO A and optimised distant procedure.

Application of the SOURDINE II approach procedures will lead to a reduction of the peak hour capacity. Obviously, this is especially the case for procedure IV, where a long distance is flown at low speed (FAS). However, for procedure II, III and V, relatively small reductions in peak hour capacity occur. This capacity reduction only presents a problem during operations where demand exceeds the capacity. In off-peak hours or in the situation where traffic is scheduled more regularly over the day, no sustained capacity problem would occur at the four airports considered in this analysis when procedure II, III, or V would be implemented. This is even true at 2015 traffic volumes.
It is assumed that implementation of the departure procedures will have no capacity impact.

The pilots and air traffic controllers were positive on procedure II and II-A (variation of procedure II including speed constraints). Procedure II-A basically leads to more time between the various configuration changes and therefore makes it more controllable for the pilot. Speed constraints have the risk however of leading to a negative noise impact as compared with a more noise-ideal procedure II. It was suggested by some of the controllers to extend the prototyped version of the ATC monitoring aid with an alert when the separation minima are violated and the controller needs to intervene.

To get to an implementation of these noise abatement procedures it is important that the pilots will strictly follow the prescribed procedures. Controllers also need to get hands-on experience concerning the "new" speed profiles and aircraft performance. Due to the fixed RNAV routes inside the TMA there are fewer possibilities for making changes to the arrival sequence and therefore an arrival manager and an accurate hand-over from ACC to APP is required to assist the controller in building up a stable sequence. The ghosting tool and monitoring tool for the air traffic controller, which were introduced in the real-time simulations to cope with the RNAV operations, were very well appreciated by the controller. The prototyped cue for the pilot, which indicated the configuration change points in the Navigation Display, was very well appreciated as well. It supported the pilot with the punctual flap deployment, which is important for the proper execution of the CDAs. Procedure V was less appreciated by the air traffic controllers than procedure II and II-A because it provides less possibility for the controller to influence the sequence of aircraft. Procedures III and IV do not obtain a high acceptance from especially pilots. Due to the steeper parts in these procedures, they become rather sensitive to unexpected tailwind and (small) pilot errors. For procedure III, no all-weather implementation is estimated to be realistic on the medium term due to the absence of autoland systems suitable for ILS flight path angles higher than 3 deg.

The combination of parallel runways with CDA procedures is an identified safety issue. This operation is not in line with the current ICAO guidelines for parallel approaches, i.e., 1000ft vertical separation is required until aircraft on both approaches are locked on the ILS Localiser signal. Possible solutions on this subject that need further exploration are for example the use of curved approaches based on approach procedure with vertical guidance (APV procedure) or to have a short level segment for one of the runways. Also the approach with the optimised level segment (SII reference) may be an option here.

During the expert panels and the final meeting various experts emphasised the importance to have a generic noise abatement procedure and no tailor made procedures for each airport. This recommendation is mainly derived from a safety point of view, increased risk on pilot error when flying many different procedures.

The SII *departure* procedures are found to be currently implementable, provided aircraft are well equiped Operation of such procedures does require appropriate engine control and flight management systems on board the aircraft.

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On the short term the SII *approach* procedures II and II-A are promoted for implementation (no parallel RW) as well as the SII reference procedure. Procedure III might be introduced in a medium/longer term timeframe.

It is recommended to perform flight trials in a low-density situation (e.g. at night) to get detailed feedback on aircraft performance as well as pilot and controller acceptability from hands-on experience. Results from these flight trials can support additional assessments like performed in this project to reach the ultimate goal: continuous descent approaches during peak-hour operations at major European airports while maintaining or even improving capacity and safety.

11.2 Overview of Sourdine II deliverables

The below mentioned Sourdine II deliverables are all available on the Sourdine II website: www.sourdine.org

SII final deliverable list

WP	Deliverable	Title
1	D1-1	Identification document
2	D2-1	Validation methodology report
3	D3-1-1	Generic definition of new noise abatement procedures
3	D3-1-2	Detailed definition of new noise abatement procedures
3	D3-2	Requirements document for the pilot and controller tools
4	D4-1	Report on the global results; compilation of D4.1-1, D4.2-1 and D4.3-1
4	D4-1-1a	Fast time simulations capacity results (Top level document)
4	D4-1-1b	Fast time simulations noise and emission results (Top level document)
4	D4-1-2a	Capacity results Schiphol
4	D4-1-2b	Noise and emission results Schiphol
4	D4-1-3a	Capacity results Barajas
4	D4-1-3b	Noise and emission results Barajas
4	D4-1-4a	Capacity results Charles de Gaulle
4	D4-1-4b	Noise and emission results Charles de Gaulle
4	D4-1-5a	Capacity results Capodichino
4	D4-1-5b	Noise and emission results Capodichino
4	D4-2	Update D4-1 with results from additional fast time simulations
4	D4.2-1	Safety assessment of Sourdine II (Top level document)
4	D4.2-2a	Safety assessment of Approach procedure II-A on Schiphol airport (Main document)
4	D4.2-2b	Safety assessment of Approach procedure II-A on Schiphol airport (Argumentation-based analysis)
4	D4.2-2c	Safety assessment of Approach procedure II-A on Schiphol airport (Simulation-based analysis)
4	D4.2-2d	Safety assessment of Approach procedure II-A on Schiphol airport (Collection of expert interviews)
4	D4.2-3	Safety assessment of Approach procedure V and Departure procedure 2 on Barajas airport

4	D4.3	Cost benefit analysis results
5	D5-1	Noise and Emission Modelling requirements.
5	D5-2	Noise and Emission Modelling Methodology applied in SOURDINE II
5	D5-3	Results of optimisation and preliminary noise impact analysis
5	D5-4	Results of noise and emission impact analysis
6	D6-1	Prototyping results ATC simulator
6	D6-2	Prototyping results Flight simulator
6	D6-3	Real Time Simulation results
6	D6-4	Experiment Design ATC simulations
6	D6-5	Experiment Design Flight simulations
6	D6-6	Concept of operation for Schiphol airport simulations
7	D7-1	Validation process control
7	D7-2	Comparative analysis of results
8	D8-1	Implementation plan
9	D9-1	Final document

11.3 Dissemination

The (in some stages intermediate) results of the SII project has been disseminated during several events. For instance:

- Expert panel #1: EUROCONTROL Experimental Centre, Brétigny, France, 28 May 2002
- Expert panel #2: Airbus Toulouse, France, 16-17 September 2002
- Thena Workshop, Brussels, Belgium, 29th April 2003
- 5th European Conference on Noise Control, Naples, Italy, 19-21 May 2003
- Expert Panel #3: Isdefe, Madrid, Spain, 30 June 2003.
- Regionales Dialog Forum Frankfurt, Germany, 19 November 2003.
- ANCAT PLANO European aviation workshop on Operational Noise Abatement Procedures, 14 - 16 December 2004.
- Expert workshop: Deloitte Rome, Italy, 27 April 2005.
- AIAA/AAAF Aircraft Noise and Emissions Reduction Symposium, Monterey, USA, 24-26 May 2005.
- Towards environmentally-friendly aircraft: Noise reduction programmes in Europe, Paris Airshow - Le Bourget, France, 16 June 2005
- 6th U.S.A. / Europe Air Traffic Management R&D Seminar, Baltimore, USA, 27-30 June 2005
- Sourdine II final meeting, NLR Amsterdam, The Netherlands, 12 July 2005
- Commission Working Group on airport noise , EC DG-Environment, Brussels, Belgium, 14 December 2005
- ICAO – CAEP workshop, Rome, Italy, 16-19 May 2006
- 5th Community Aeronautical Days 2006, Vienna, Austria, 19-21 June 2006