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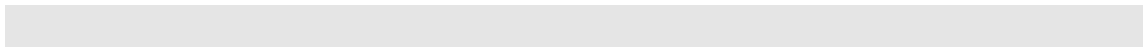
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Summary

This document describes the fast time simulation results of the Sourdine II noise abatement approach procedures. Four arrival procedures were conducted for this simulation and compared with a conventional 3000ft arrival procedure defined within the baseline scenario. The Sourdine II procedures are based on provided Airbus data and were simulated for the Schiphol situation in 2015 based on RNAV trajectories. Procedure II has a 2 degrees continuous descent approach with a 3 degrees ILS path and a variable speed profiles. Procedure II-A is based on procedure II but then with several speed constraints involved. Procedure IV can be considered as a quite ambitious approach procedure as it consists of a steep two-segment approach with a constant speed profile. Procedure V consists of a 3 degrees glidepath with a constant speed approach profile.

The timetable used contains 5 aircraft types: A320, A330, A340, F50 and MD11. The speed profiles used for the F50 and the MD11 were deduced from respectively the A320 and the A340. In addition, a quick scan study was performed taking into account the effect of the A319 and the A321 inside the timetable.

The emphasis of the study was put on the approach procedures only, and the effect of the proposed Sourdine II procedures with respect to arrival delay and capacity.

Due to the significant speed differences between the speed profiles of the proposed Sourdine II procedures, extended separation was needed in order to comply with the separation criteria within the TMA. The extended separation was calculated during the pre-processing of the simulation. The results show a consistent increasing of arrival delay for proposed procedures. The more speed differences between aircraft types during the approach segment, the higher the arrival delay due to extended separation used.

The Sourdine II procedures II and V are affected by an increased arrival delay. This increasing of arrival delay is mainly caused by the extended separation required to compensate the speed differences between aircraft. Procedure II-A consists of arrival procedures, which includes generic speed constraints. The speed constraints were selected in such way that all aircraft were able to fly the profile (deduced from a generic CDA). Procedure II-A is for that reason quite similar to the baseline scenario. Procedure IV shows a significant reduction of performance and capacity. Within this procedure aircraft have to fly the final approach speed (FAS) over the last 15NM.

It should be emphasized that the increased flying time with various procedures is not part of the calculated delay.

The study has shown that the distribution of a fleet mix will influence the performance of the ATM system considerably. A consistent fleet mix does provide positive performance effects of the ATM system, the less the aircraft type consistency (and therefore speed profile consistency as well), the more capacity problems will occur.

The reduction in capacity is a loss of peakhour capacity and therefore only of interest during peakhour operations (when demand exceeds the capacity).

Referring to the Sourdine II procedures it can be stated that capacity can be maintained at a certain level by introducing speed constraints along the approach segment. However, the problem of different speed profiles related to different aircraft types should still be considered as a major problem. Airborne Separation Assurance System (ASAS) spacing functionality (also called Station Keeping) could also be a potential enabler to maintain capacity, but this needs further investigation and is outside the scope of this study. The same counts for the downlink of aircraft performance data (e.g. 4D constraint points like EAT and ETA) using datalink applications.

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1. Introduction

1.1. Purpose

Within Sourdine II several assessments are conducted to gain feedback and results on the proposed procedures and tools. These assessments are:

- Expert judgement
- Single Event Simulations, SES
- Fast time simulations, FTS (capacity assessment as well as noise and emission calculations)
- Safety assessment
- Cost Benefit Analysis, CBA
- Real time simulations, RTS

This report describes the results of the fast time simulation exercises for Schiphol airport performed by NLR.

1.2. Background

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

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

1.3. Glossary

ACC	Area Control Centre
AMSL	Above Mean Sea Level
APP	Approach Control
ATC	Air Traffic Control
ATM	Air Traffic Management
CAS	Calibrated Airspeed
CBA	Cost Benefit Analysis
CF	Course to a Fix
CTA	Control Area
DF	Direct to a Fix
EAT	Expected Approach Time
ETA	Estimated Time of Arrival
FA	Fix to an Altitude

FAF	Final Approach Fix
FAS	Final Approach Speed
FM	Fix to a Manual
FMS	Flight Management System
FPA	Flight Path Angle
FTS	Fats Time Simulation
GS	Glide Slope
IAF	Initial Approach Fix
IAS	Indicated Airspeed
IF	Initial Fix
L	Left
MAPt	Missed Approach Point
NM	Nautical Mile
OEI	One Engine Inoperative
OIM	Operation Instruction Manual
R	Right
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
RTS	Real Time Simulation
RTD	Research, Technology Development
SES	Single Event Simulation
SID	Standard Instrument Departure
STAR	Standard Arrival Route
TAAM	Total Airport and Airspace Modeller
TF	Track to Fix
THR	Threshold
TMA	Terminal Control Area
TOGA	Take-off / Go-around
TWR	Tower
WPT	Waypoint

1.4. References

Short Reference	Author / Organisation, Title, Edition, Date and Reference
[AIP]	Aeronautical Information Publication the Netherlands
[VDV-1]	Voorschriften Dienst Verkeersleiding part 1, Amsterdam ACC (Dutch, not public)
[VDV-2]	Voorschriften Dienst Verkeersleiding part 2, Schiphol TWR/APP (Dutch, not public)
[OIM]	Operational Instruction Manual, LVNL
[DOC4444]	Procedures for Air Navigation Services -Air Traffic Management, ICAO Doc-4444
[D2-1]	D2-1: Validation Methodology Report, version 0.9
[D3-1-2]	Updated Definition of New Noise Abatement Procedures
[APPPr]	APPROVE project 5 th framework, fast time simulation RNAV effects, M.P. Storm
[D6-6]	D6-6: Concept of operation for Schiphol airport simulations

2. Overview of the study

2.1. Objective

The main question for this study that should be answered is: ***how does the proposed Sourdine II procedures affect 'efficiency'?***

The phrase "efficiency" will be considered as the amount of arrival delay and the runway capacity of the procedure. Note that possible additional flying time will not be part of the calculated arrival delay.

This study aims to investigate the ***Sourdine II*** proposed procedures based on RNAV transitions only. The comparison between vectoring based transitions and RNAV based transitions has already been explored in detail level within APPROVE – (5th frame work European projects). Therefore this study could partly be considered as following work of the APPROVE project.

2.2. Scope

2.2.1. Location and Geographical extent

Airport

Schiphol's tangential runway configuration requires complex ATM operations. Five main runways are available for operations under different weather and wind conditions. Schiphol airport uses a yearly set up of 'Usage Plan' (Gebruiksplan) which comes into effect 1st of November each year and is applicable until October 31st of the following year. It describes how much traffic is expected and will be permitted during day and night, with wind/ weather conditions and environmental measures involved. Normally, a list of main runway combinations based on wind and noise controlling directions has been determined for operations. Because of the uncertainty with respect to noise control within 2015, the runway usage is undefined yet.

At Schiphol several modes can be distinguished. Most of these combinations correspond with different runway preferential combinations. The most common runway combination is mode 1, this runway combination has the right balance between noise and efficiency. The direction of this mode is to the North, (wind coming from the North, inbound runway 06 and 36R, outbound runway 36L and 36C). Mode 2 operates to the south (wind coming from the South, inbound runway 18C and 18R, outbound runway 24 and 18L) operations. Schiphol uses two main runways and two secondary runways, so departure and arrival operations of runway depend on the in-and outbound periods. For Mode 2, the main runways are 18R arrival / 24 departure, and secondary runways 18C arrival / 18R departure. Mode 1 main runways are 06 arrival / 36L departure, and secondary 36R arrival / 36C departure.

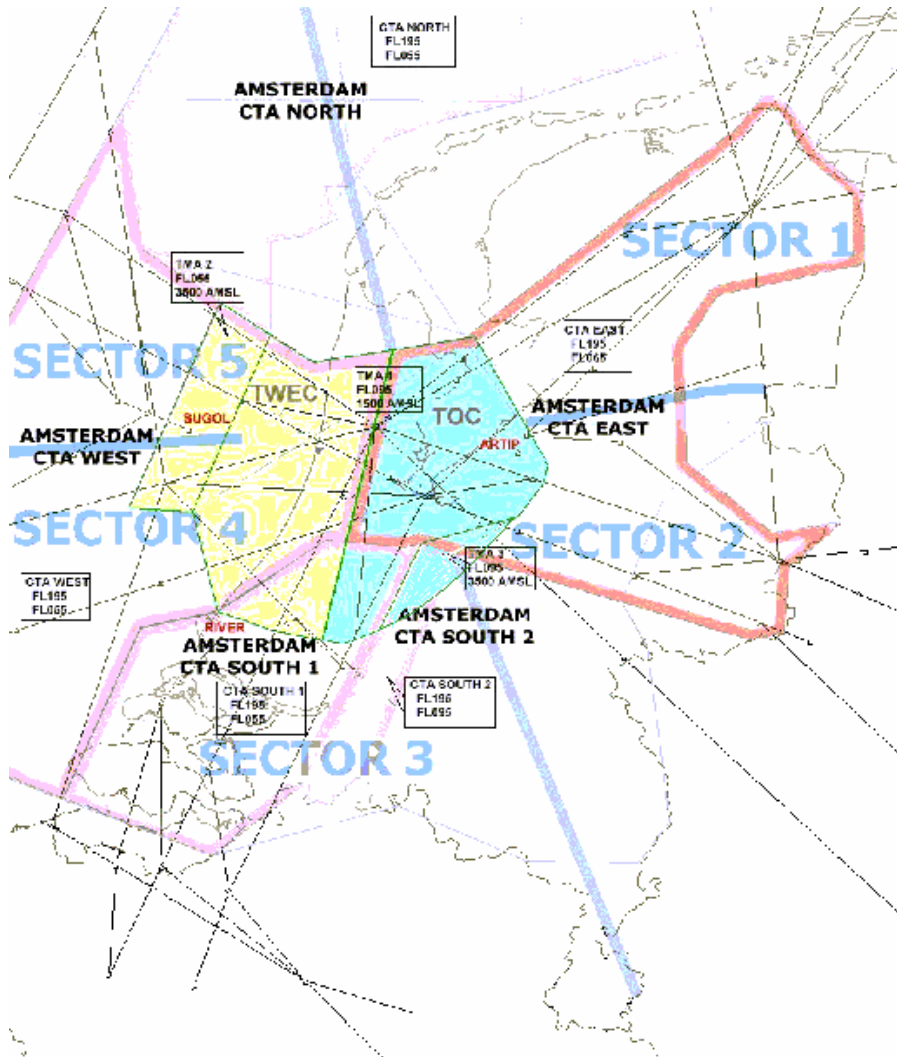


Figure 2-2: Dutch airspace

2.2.2. Timeframe

The simulation will be carried out within the scenario 2015. It should be noted that due to flight technical reasons and procedure complexity, some of the proposed *Sourdine II* procedures might not be implemented yet for the year 2015.

2.2.3. Traffic sample

Schiphol Airport has lots of uncertainties with respect to the traffic growth for the (near) future. The traffic scenario used for this simulation is based on extrapolation of market expectations for the years 2005 - 2012 (source: STATFOR). No uncertainties have been taken into consideration. Figure 2-3 shows the way in which the traffic sample was determined. The two blue trend lines represent the low and high expected traffic grow for Schiphol. The black line represents the average of both trend lines. This average line was used for the simulation. The number of traffic expected for Schiphol in 2015 is

based on 1800 movements. A traffic sample within 2015 was chosen and agreed within the consortium and will be used by all partners.

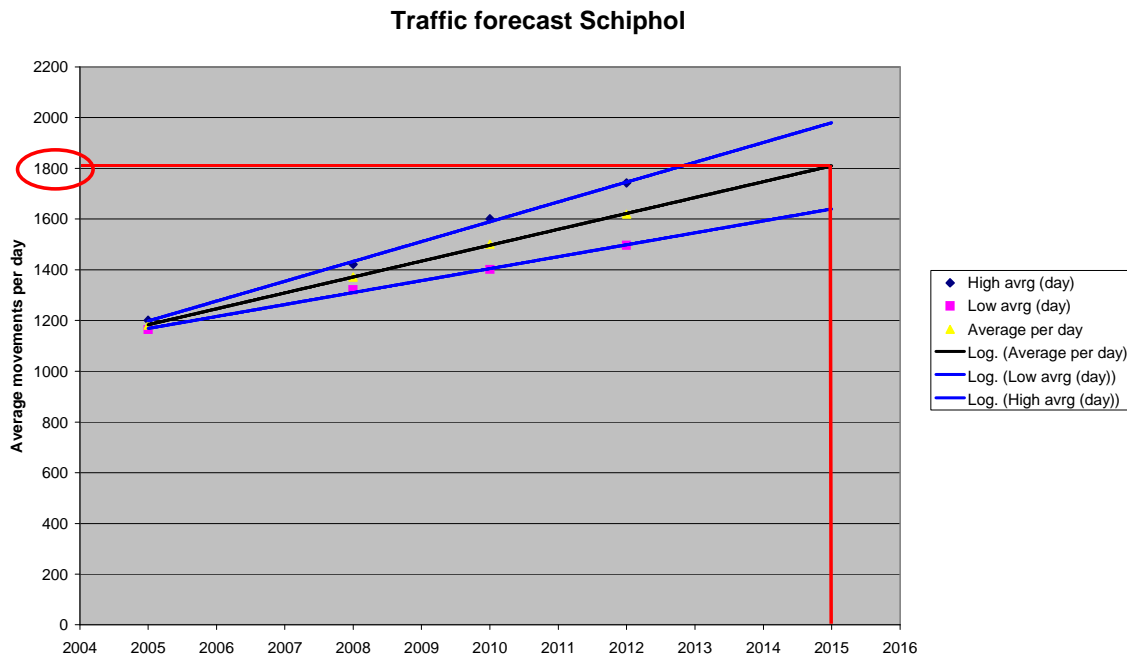


Figure 2-3: Traffic forecast Schiphol based on STATFOR data

2.3. Outline of the study

Phases or experimental design

The Fast Time Simulation activities within *Sourdine II* can be divided in the following sub-phases:

- Pre-calibration phase
- Calibration phase
- Baseline vs Sourdine II simulation phase

Pre-calibration:

- Within the Sourdine II project, this pre-calibration was performed by AENA, EEC and SICTA and these results have also been used for this document. Since NLR uses the same platform as AENA and EEC it was sufficient to use the outcome of this pre-calibration and not to actively participate.

Calibration:

- Definition of the baseline scenario for Schiphol
- Preparation of data to be input to the simulation
- Definition of baseline timetable (corresponding to scenario 2015),

- Testing & calibration of baseline scenario & verify input data to reach the objective of the simulation.
- Execution of baseline simulation
- Testing and calibrating **Sourdine II** profiles
- Testing TAAM integrity with respect to the scope of the simulation
- Verification of baseline results, which will be compared with the following simulations.

Baseline vs Sourdine II simulation:

- Running the simulations: baseline and alternative scenarios with proposed noise abatement approach procedures.
- Compare results with baseline scenario
- If necessary several reiterations to tune parameters.
- Analysis of results of the different runs
- Writing of the report

2.4. Tools and Methods

2.4.1. Simulation tools

At NLR's ATM & Airport department the Total Airport and Airspace Modeller (TAAM) from Preston Aviation Solutions, has been used as an evaluation tool of generic Sourdine II procedures at Schiphol. TAAM is a microscopic Fast Time Simulation (FTS) tool that can be used as a planning tool or to conduct analysis and feasibility studies of ATM concepts. TAAM can simulate most ATM functions in detail and can provide scenario generation for real-time ATC simulators. The simulations cover the entire gate to gate ATM process, generally in more detail than competing models.

FTS tools are powerful for large scale scenario's with a long time span compared to real time simulation, but directly hold the restriction of the inability of interaction during the simulation (human-in-the-loop). In order to enhance the modulation of the procedures inside TAAM, additional tools such as Excel calculation sheets will be used as well. The calculation inside Excel will be used in order to calculate the arrival separation between aircraft. This will be explained in the calibration phase.

ATC-Playback will be used in order to illustrate the results in a more professional way. ATC Play back is a powerful tool, which can be used to assess and analyse, obtained TAAM results in visual matters.

2.4.2. Hypothesis

Proposed **Sourdine II** procedure will be compared with the baseline scenario, which represents the situation at Schiphol including RNAV procedures during day-time operations. The baseline scenario will be further explained in the calibration phase. The current flown CDAs needs additional separation between aircraft because of the unique speed profiles. Each aircraft types flies a unique speed profile in order to follow a pre defined x/ y/ z- trajectory. Different aircraft types lead to different speed profiles, and could also (small, medium, heavy) result in different separation criteria between aircraft.


Based on above mentioned description the following hypotheses can be stated:

- All Sourdine II procedures will expect to show a reduced performance as the arrival separation will increase.

-
- Procedure II and II-A consist of minor speed differences between aircraft types. This procedure will be expected to have the best performance of the Sourdine II procedures.
 - Procedure IV consists of significant speed differences between aircraft types. This procedure will be expected to have the worst performance of the Sourdine II procedures.

2.4.3. Simulation and analysis methods

The simulation will be carried out by TAAM. During the pre-defined phases of the project the results will be analysed in an iterative way. Consequently, new runs will be carried out as a necessary subset of **Sourdine II** simulations; all results will be compared with the baseline. Chapter 5 provides an overview of the simulation.



3. Pre-calibration

3.1. Background

Procedures in TAAM are defined through flexible logical rules (e.g., when crossing X radial X VOR, turn left heading X). TAAM randomises automatically aircraft performances to obtain the trajectory for each aircraft depending on its performances.

The way of defining the procedures determines the possibility to represent them in TAAM and even conditions the achievable accuracy.

When the procedures are defined in terms of thrust or configuration setting, additional pre-processing work is required to model them in TAAM since the tool does not consider these parameters. In this case, it is needed that the procedures are translated into parameters understandable by TAAM (rate of climb and descent, climb speed etc, ...) specified in Level Bands.

When the procedures are defined in terms of geometry and speed, they can be modelled in TAAM with a degree of realism that depends on the specific procedure and on the intrinsic limitations of the tool. These limitations were discussed in the WP4-WP5 meeting held by NLR in Amsterdam in July 2002.

In general, for all the sites, sequencing problems are envisioned when implementing the continuous descent approaches into the models. The procedures defined so far, start at 6000-7000ft whereas the TMAs of Charles de Gaulle and Madrid-Barajas airports start at levels close to FL250.

Due to constraints pointed out above, it is fundamental to be completely sure that the selected platforms are able to simulate, accurately enough, the new procedures designed in Sourdine II considering new concepts as Advanced CDA, etc.

Within the Sourdine II project, this pre-calibration was performed by AENA, EEC and SICTA and these results have also been used for this document. Since NLR uses the same platform as AENA and EEC it was sufficient to use the outcome (in the form of the TAAM settings, see appendix 3) of this pre-calibration and not to actively participate.

3.2. Objectives

The main objectives of the Pre-calibration phase are the following:

1. Solve the uncertainty about the suitability of the selected FTS platform.
2. Find out whether the simulation platforms selected – TAAM Enhance INM on the one hand and SIMMOD INM on the other hand- are able to simulate, accurately enough, the new procedures designed in Sourdine II considering new concepts as Advance CDA, etc providing accurate and reliable results. The Pre-calibration phase has tried to answer these questions:
 - o Is it possible to represent the new SII procedures with an acceptable level of accuracy?
 - o Is possible to model a certain degree of both vertical and horizontal track randomisation?
 - o Is it possible to solve the envisioned sequencing problems of the tools when implementing CDAs in a satisfactory way?
3. Explore the capabilities of the tools to provide, accurately enough, the outputs demanded by the validation methodology regarding capacity, noise, safety and cost-benefit indicators.
4. Harmonise working methodologies with the tools, i.e. the method for translating the SII concept into the models for the three sites involved in the Pre-calibration phase (AENA, EEC and SICTA) to avoid airport specific results instead of comparable and extensible results.

3.3. Pre-calibration Method

For a description of the Experimental design of the pre-calibration method and the assumptions made, reference is made to section 3.3 ('Pre-calibration Method') of Document D4-1-3a ('Capacity Results Madrid-Barajas').

3.4. Description of the pre-calibration scenario

For a description of the pre-calibration scenario, reference is made to section 3.4 ('Description of the pre-calibration scenario') of Document D4-1-3a ('Capacity Results Madrid-Barajas').

3.5. Problems encountered and corrective actions

For a description of the problems and limitations of representing CDAs with TAAM and SIMMOD, as well as a description of the corrective actions taken into account to solve these problems, reference is made to section 3.5 ('Problems encountered and corrective actions') of Document D4-1-3a ('Capacity Results Madrid-Barajas').

3.6. Pre-calibration results and conclusions

The purpose of the pre-calibration phase was to solve the uncertainty about the suitability of the selected FTS platform. By carrying out this part of the study, it was possible to evaluate whether the simulation platforms selected- TAAM Enhance INM on one hand and SIMMOD INM on the other hand- were able to simulate the new procedures designed in SourDine II providing accurate and reliable results. For this, new concepts such as Advance CDA, etc had to be considered.

The capabilities of the mentioned tools are to be explored to decide if they provide acceptable accuracy in the outputs required by the validation methodology. These outputs allow to evaluate capacity, noise, safety and cost-benefit indicators.

Certain limitations of the simulation tools used were found and problems were encountered during the process. Corrective actions considered necessary to solve or lessen the limitations were carried out.

One of the most important objectives of the pre-calibration tests is to determine whether or not the TAAM output is realistic and detailed enough to feed directly in INM. Concerning the vertical profiles provided by TAAM, these were discarded for the noise assessment. Even though after making a fine tuning of the aircraft performance file in TAAM, AENA was able to reproduce a very realistic CDA (vertical and speed profile) for A340s and A320s, the amount of work needed to reach that objective was too much. After the pre-calibration phase, the consortium decided not to consider them for the noise assessment. On the other hand, TAAM ground tracks are accurate enough to feed INM (noise study).

4. Calibration

4.1. Objective

Proposed Sourdine II procedures will be simulated and finally compared with the baseline scenario. The aim of the calibration phase is to gather all appropriate data for the simulation and to check whether input data will affect the simulation. In addition, it will check the integrity of the fast time simulation model as a follow-up of the (pre-)calibration study performed in an early stage of the project by different partners.

In order to reach a close approximation of reality of the Sourdine II procedures, verification and calibration is needed for various input files, taking into account the limitations of TAAM. This chapter describes the approach of how Sourdine II procedures were developed in order to reach similarity between the simulation environment and the desired situation. A work around of the separation behaviour problem will be explained in this chapter. The aim is to define a reliable representation of the scenarios to be tested.

4.2. Calibration method

Determining the performance of a new ATM concept is only of value when modelling was performed with a great level of detail. The emphasis of this study is put on the difference between scenarios with respect to delay, performance and capacity. In order to ensure reliable results, constraints should be kept to the minimum, and unnecessary elements should be discarded. The main reason to discard elements is to ensure transparency among results and minimise negative influences on the procedures. Elements such as ground movements, weather & wind will not be taken into account during the simulation. Appendix 3 provides the TAAM model settings which were used for all the simulations.

Verification of the simulation set-up was carried out based on the Airbus profiles. The emphasis was put on the workaround of the separation model and the speed profiles with the correlated speed differences between profiles. In fact, the separation extension due to speed differences between aircraft should be considered as the main metric in this simulation. During this phase, the additional separation required for each aircraft type will be determined in order to analyse the effect of the proposed Sourdine II arrival procedures.

4.3. Description of the calibration scenario

4.3.1. Assumptions

The following assumptions have been taken into consideration within the simulation. Each assumption will be described in more detail within the following section:

- Runway usage combination for Schiphol airport with two arrival- and departure runways, All active runways will be continuous open for either arrivals or departures (no peaks or no mix mode ops) At present, Schiphol uses a 2+1 runway combination (2 runways will be open for inbound movements and one for out bound, or the other way around). The transition of in-and outbound peaks will definitely cause operational disturbances of the schedule, which might affect the final obtained results. In order to obtain transparent results of the implemented Sourdine II procedures, constraints have been kept to the minimum and a permanently open runway combination was chosen. This means that two inbound runways and two outbound runways will be used permanently during the simulation.

- All runways used as independent

The runway combination used within the simulation allows independent operation.

- Normal weather operations, no extended separation
The simulation will be carried out with nominal weather condition, with standard separation criteria (3 NM separation within the TMA and 5 NM separation within the CTA).
- Number of traffic based on 1800 flights
This amount of traffic corresponds to the market scenario of 2015 (see to paragraph 2.2.3.).
- Traffic will be simulated for one average day
The schedule is based on an average day in 2015, for FTS only one day for simulation is used in practice and provides a good representation of operational effects.
- Arrival segregation based on “stack segregation”
Aircraft will be separated by stack segregation. Aircraft flying from holding stack ARTIP will have to land on 18C, Aircraft flying from holding stacks RIVER and SUGOL will proceed to land on runway 18R.
- Departure direction based on east - west direction
For safety reasons, crossing SIDs are not allowed. Departing aircraft will be separated by using one runway for westbound and one for eastbound traffic.
- No ground movements,
Simulated aircraft will be “terminated” at the end of the runway, departing aircraft will appear on runway entry.
- All aircraft are supposed to be RNAV equipped, Simulations will be carried out under P-RNAV circumstances.
In 2015 Schiphol expects to operate within a full RNAV environment. Vectoring based approaches within the baseline scenario would be more close to current practise, but in order to maintain consistency among the simulations all simulations will be carried out under P-RNAV conditions. This will result in less lateral track deviation as well.
- Conflict resolution off (TAAM specific)
Scenarios will be modelled with conflict detection on, and resolution off.
- Aircraft configuration
It should be noted that TAAM does not distinct aircraft by different gear or flap settings during the simulation. However, aircraft configuration, such as flap setting and gear has been taken into account within the TAAM performance file. The performance data used inside TAAM is quite detailed and encompasses the essential performance characteristics of aircraft such as speed changes, rate of climb, rate of descent, turning rates, max take off factors, and fuel burn data.

4.3.1.1. Input

An analysis of new ATM procedures and concepts is only of value when data was validated and the modelling was performed to a great level of detail. Data used for this simulation has been gathered from the APPROVE project (5th Framework E.U. Project which has been completed recently). Operational experts such as air traffic controllers were involved during the validation.

4.3.1.2. Metrics

Within the Sourdine II capacity analyses several metrics were used to conduct the study. The metrics have been deduced from the available data from TAAM. The following metrics can be take into consideration during the simulations.

- glide path
- speed
- aircraft configuration/thrust (already integrated within the TAAM performance data)
- Speed variation between aircraft

Arrival procedures can be based on fixed speed, -configuration & thrust or vertical trajectory. However, TAAM enables the user only to develop procedures based on speed profiles or lateral / vertical profiles. Therefore, no thrust and configuration settings were taken into account for the selected procedures. In fact the thrust and configurations are already integrated inside the TAAM performance data.

4.3.2. Definition of procedures

4.3.2.1. Approach Procedure

The simulation contains several proposed Sourdine II procedures. The main differences between procedures are the speed profiles. The emphasis of the study is to analyse the speed profiles of the proposed approach procedures.

The following procedures will be taken into consideration during the simulation.

1. Baseline
2. Procedure II
3. Procedure II-A (identical to procedure II, but now also including some speed constraints)
4. Procedure IV
5. Procedure V

For an overview of the procedures see appendix 5 as well as reference D3-1-2.

4.3.2.2. SIDs and STARs

SIDs

Traffic departing from Schiphol Airport will be separated into east or west directions. Departures with an eastbound trajectory will use runway 18L and traffic with a westbound trajectory, will use runway 18C. This measure will be used to prevent crossing SIDs within the TMA. South and Northbound traffic will use both runways.

STARs

The STARs used within the simulation are based on the existing RNAV routes. The routes are currently in use during the night period (during low traffic density). The main difference between the RNAV route and the current vectoring routes is the location. The RNAV routes are located above sea and the vectoring routes, currently used during daytime, are located above the Dutch coast.

Figure 4-1 shows the lateral trajectories of the STARs in case of RNAV trajectory. This situation was used within the simulation.

SUGOL encompasses several short cuts in order to optimise the traffic flow. The traffic distribution over the short cuts is shown in figure 4-1. The yellow trajectories represent the approach segments used within the simulation. Within the illustrated approach segments aircraft will fly a specific speed profile as defined within the Sourdine II procedures.

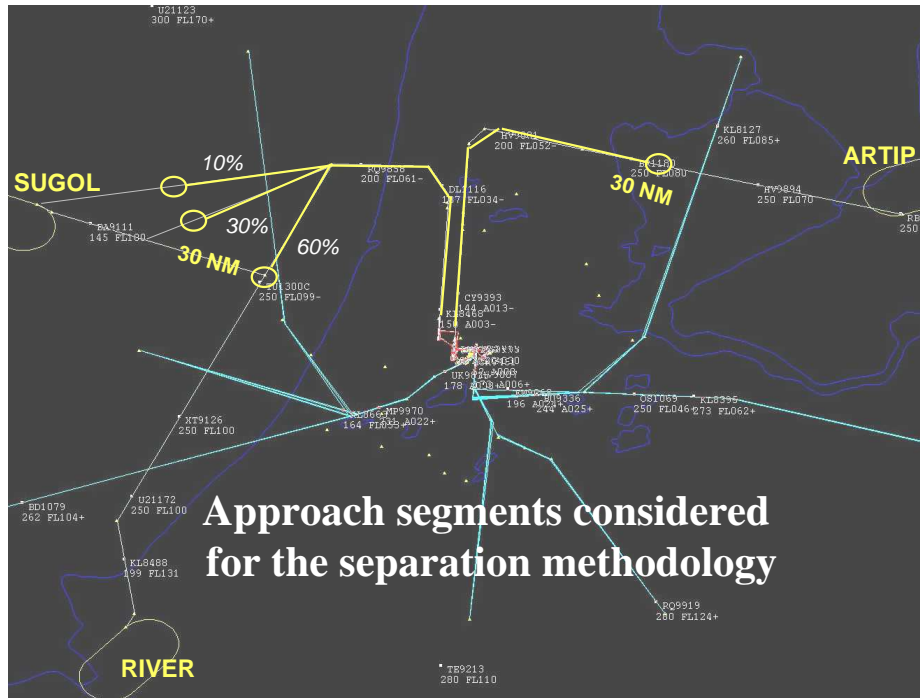


Figure 4-1: RNAV – trajectories at Schiphol airport

4.3.2.3. Modelling RNAV approaches

The trajectory shown in figure 4-1 is currently in use at Schiphol during night-time as RNAV transition. This study put the emphasis on noise abatement routes in 2015. Within this context we expect to have all aircraft being RNAV equipped. The TAAM STARs will be fixed and all aircraft involved will fly the same lateral trajectory, no dispersion, tromboning or vectoring tracks will be used.

It should be noted that APPROVE (EU project which have been carried within the 5th framework) has already investigated the impact of implementing RNAV transitions within the TMA. Additionally, the emphasis of the simulations conducted within this study was put on the differences between vectoring and RNAV transitions within the TMA. The main results and conclusions will be taken into consideration within this report (see also chapter 6).

The simulation contains two RNAV shortcuts from SUGOL. The short cuts are used in order to optimise the merging and sequencing along the West inbound trajectory segment. The Sourdine II profiles and the separation calculation inside the simulation are modelled inside the shortcuts as well.

The locations where the procedures start are 30 track miles before touch down. TAAM distributes inbound traffic from SUGOL over 60% nominal track, 30% shortcut track, and 10% direct track. The ‘shortcut’ and ‘direct’ track ensures an optimised sequencing for the inbound movements, even taking into account the distribution percentages.

4.3.2.4. Departure procedure

Within this simulation the emphasis was put on the arrivals only. The departures will therefore fly standard departure procedures based on the SID's published within the AIP. The profiles involved are based on an ICAO-A procedure.

Each scenario includes departure procedures based on SIDs published within the AIP.

- Each aircraft involved will fly a standard departure profile based on the standard performance settings within TAAM. The profiles are similar to the ICAO-A profiles.

4.3.2.5. Traffic Sample

Traffic sample used for the simulation is deduced from the traffic scenario to be expected in 2015. This sample contains several aircraft types which need to be substituted to the aircraft performance types available for the project. The available aircraft types for this study are:

- A319
- A321
- A320
- A330
- A340

A timetable that only represents airbus aircraft would not be realistic for Schiphol. Therefore, the F50 and MD11 were added in order to create a more realistic timetable. F50 represented 10% and the MD11 for 5%. In fact, Schiphol will have to cope with light-medium aircraft (such as turboprops) in the future. So, in order to obtain realistic data, it is important to include turboprops within the timetable as well. It should be noted that turboprop aircraft would have significant difference performance behaviour in comparison with Airbus aircraft. The simulation results should therefore be interpreted in context with assumptions made. Adding F50 within the timetable should be considered as an important assumption for the simulation. Table 4-1 below shows the substitution of the aircraft types involved for arrivals. The table shows a column with 2002 data. The number of aircraft shown in this column represents the original timetable. The numbers of aircraft within the column '2015' are cloned numbers. The 'cloning' principle inside TAAM was used in order to scale-up the original timetable of 750 movements to the traffic scenario expected in 2015 (the cloning percentage used is 18%). The total inbound movements are scaled-up to 902 inbound movements.

Table 4-1: Overview of the substitution made to simulate the 2015 traffic

Aircraft types 2015 EHAM	Substitute	2002	2015	%
F100	A320	66	79	8,8
A319	A320	40	48	5,3
A320	A320	49	59	6,5
A321	A320	20	24	2,7
A333	A330	55	66	7,3
A343	A340	20	24	2,7
B733	A320	65	78	8,6
B734/5	A320	27	32	3,6
B738	A320	86	103	11,4
B739	A320	28	34	3,7
B73G	A320	5	6	0,7
B744	A340	39	47	5,2
B74 E/F/Y	A340	7	8	0,9
B752	A330	28	34	3,7
B763	A330	18	22	2,4
B772	MD11	30	36	4,0
ATR4	F50	28	34	3,7
D328	F50	26	31	3,5
EM4	F50	22	26	2,9
F70	A320	74	89	9,8
MD11	MD11	10	12	1,3
MD80	A320	9	11	1,2

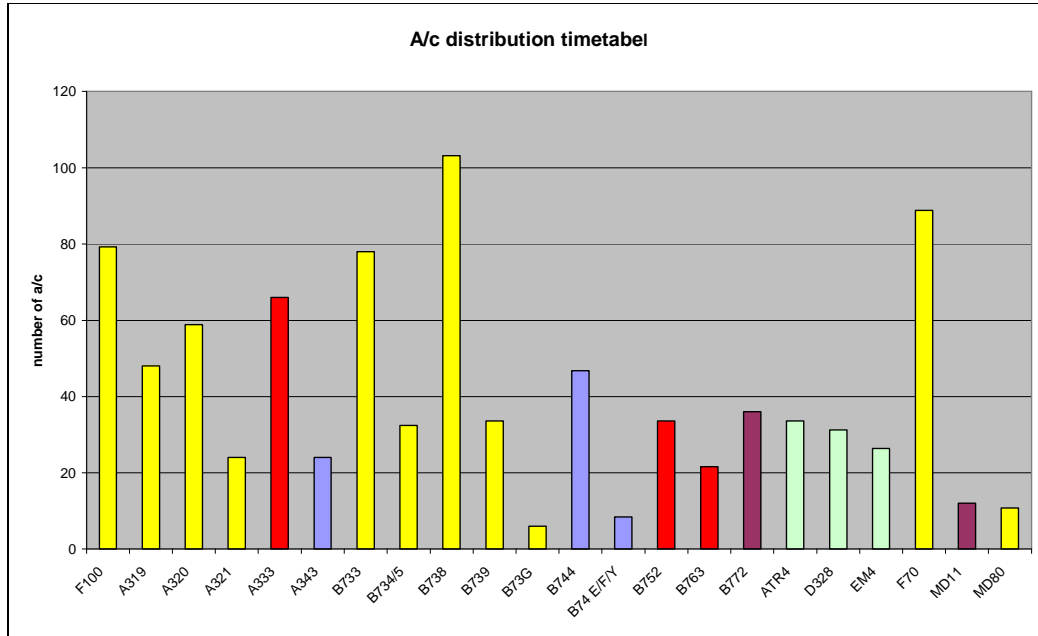


Figure 4-2: Aircraft distribution

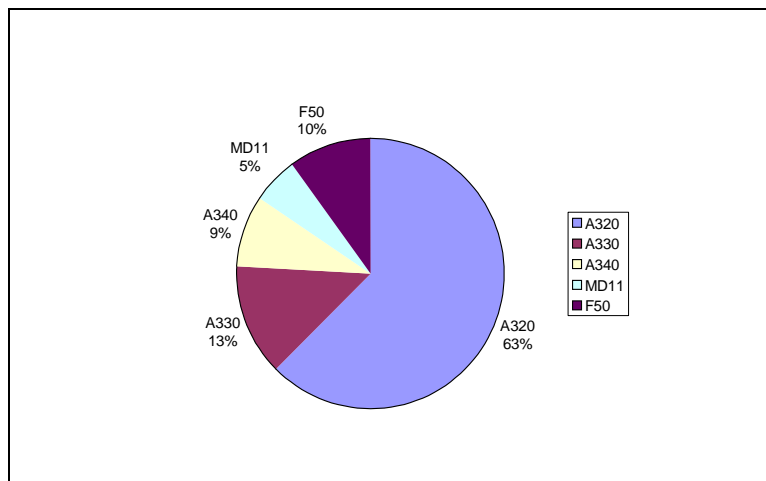


Figure 4-3: Aircraft distribution during the simulation

4.3.2.6. Aircraft performance

As mentioned earlier, only three aircraft approach profiles were available during the initial phase of the project. The aircraft performances used during the simulations are based on the A320, A330 and the A340 performance data. Although the A319 and A321 were not taken into consideration during the FT-simulation, the effect of the A319 and the 321 within the context of fleet mix and the Sourdine II approach procedures were analysed. In accordance with the already obtained simulation result, and

the known aircraft type distribution, as mentioned within the previous section, an analysis was made with the A319 and A321 as well. The F100 and F70 were substituted to the A319. The obtained results are described in chapter 6.

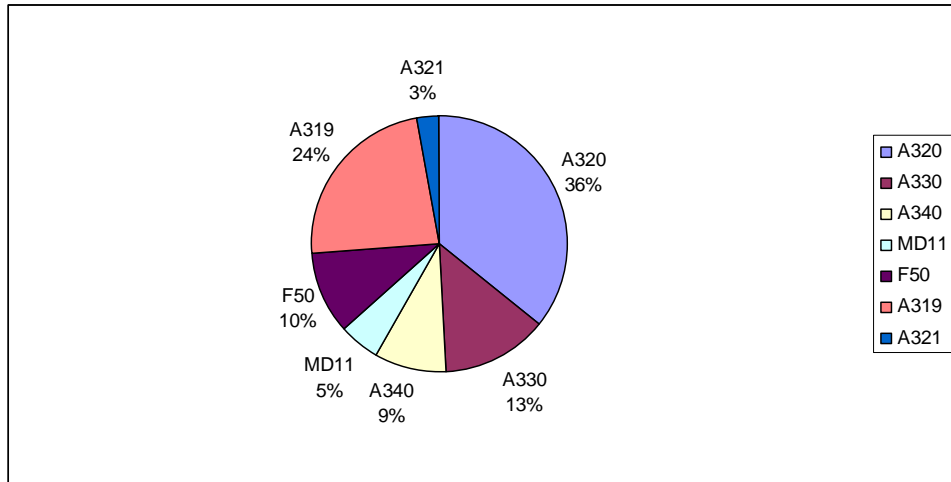


Figure 4-4: Aircraft distribution during the second iteration

4.3.2.7. Traffic distribution

The following figures provide some information with respect to the number, distribution and types of traffic used for this simulation. The total number of movements will be 1800 flight (which corresponds to the market scenario for 2015). For this simulation no uncertainties have been taken into consideration. This simulation was carried out with the early mentioned five aircraft types:

- A320, A330,-A340, F50, MD11

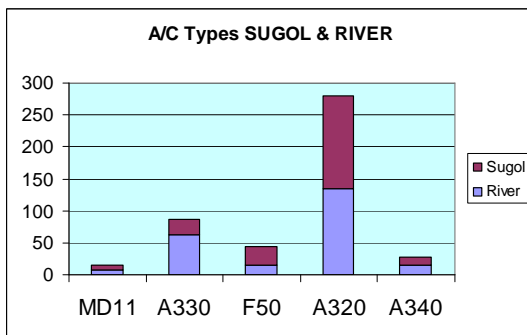


Figure 4-5: A/c distribution SUGOL and RIVE

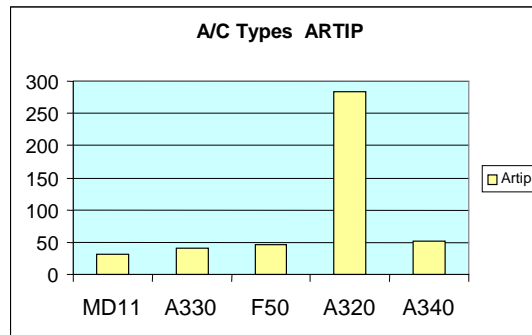


Figure 4-6: A/c distribution ARTIP

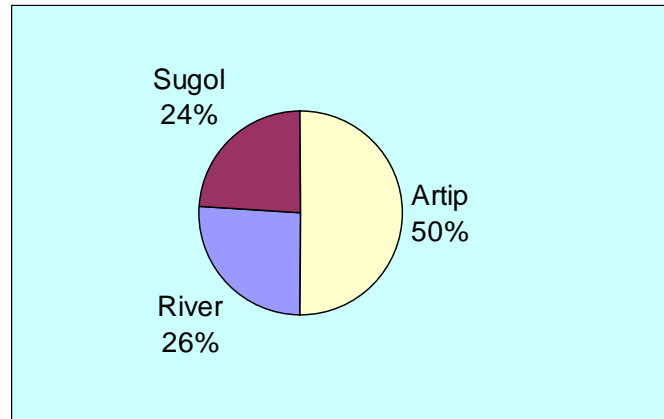


Figure 4-7: Traffic distribution over the stacks

Within the simulation only the Terminal Manoeuvring Area (TMA) will be taken into consideration. As described in the assumptions, aircraft flying from RIVER and SUGOL will use runway 18R. Aircraft flying from ARTIP will proceed to runway 18C. However, this operation requires a balanced arrival flow for both landing runways. The distribution will be 26% RIVER - 24% SUGOL and 50% ARTIP.

4.3.2.8. Vertical adherence to nominal trajectories and speed profiles

The Airbus speed & altitude profiles available for the simulation were converted into TAAM data. For each procedure a STAR was generated with speed constraint involved. The speed constraints were set each 2 NM. The constraints ensure that aircraft types will follow their assigned speed and altitude during the approach segment. Within the simulation five different STARs were generated with each their own speed and altitude profiles, deduced from Airbus data.

4.3.2.9. Limitations

Fast time simulation includes several limitations with respect to the modelling of the proposed procedures. Vertical trajectory of the STARs might result in unexpected results, because of the TAAM modelling methodology. TAAM uses performance files based on level band, where each level band corresponds to a specific altitude where speed and rate of climb are defined. The Baseline approach consist of a 7 NM 3000 ft level flight segment, within this procedure aircraft will fly the assigned speed within the 3000 ft level band only. Sourdine II Procedure II aims to descent gradually to 3000 ft without any level flight segment, in this situation the aircraft will pass more level bands with more speed variations. This will result in a higher average descending speed for procedure II. In order to prevent any differences with respect to the speed profiles for both scenario's and to maintain a level of consistency, the baseline performance data was edited in such a way that average speed mentioned in the level band of 3000ft will correspond to the average speed of the Sourdine II procedures.

In addition, the way TAAM calculates the separation at final approach seems not useful for this study. This should be considered as a major problem since the separation criteria are of great importance of the study. TAAM calculates the desired separation at final approach only (based ICAO wake-vortex separation standards). If two succeeding aircraft will have different speed profiles, the separation will be violated at 30NM before landing. TAAM calculates the separation backwards, and takes the final approach segment as a starting point. This problem and the "workaround" to solve this problem are described in detail in Appendix 2: 'Encountered problems during calibration'.

4.3.2.10. Airspace area considered for simulation

The figure below shows the area considered for simulation. The procedures used within the simulation were simulated in assigned area. The considered airspace includes the stacks (RIVER, SUGOL and ARTIP) and the two TMA sectors (TMA west and TMA East).

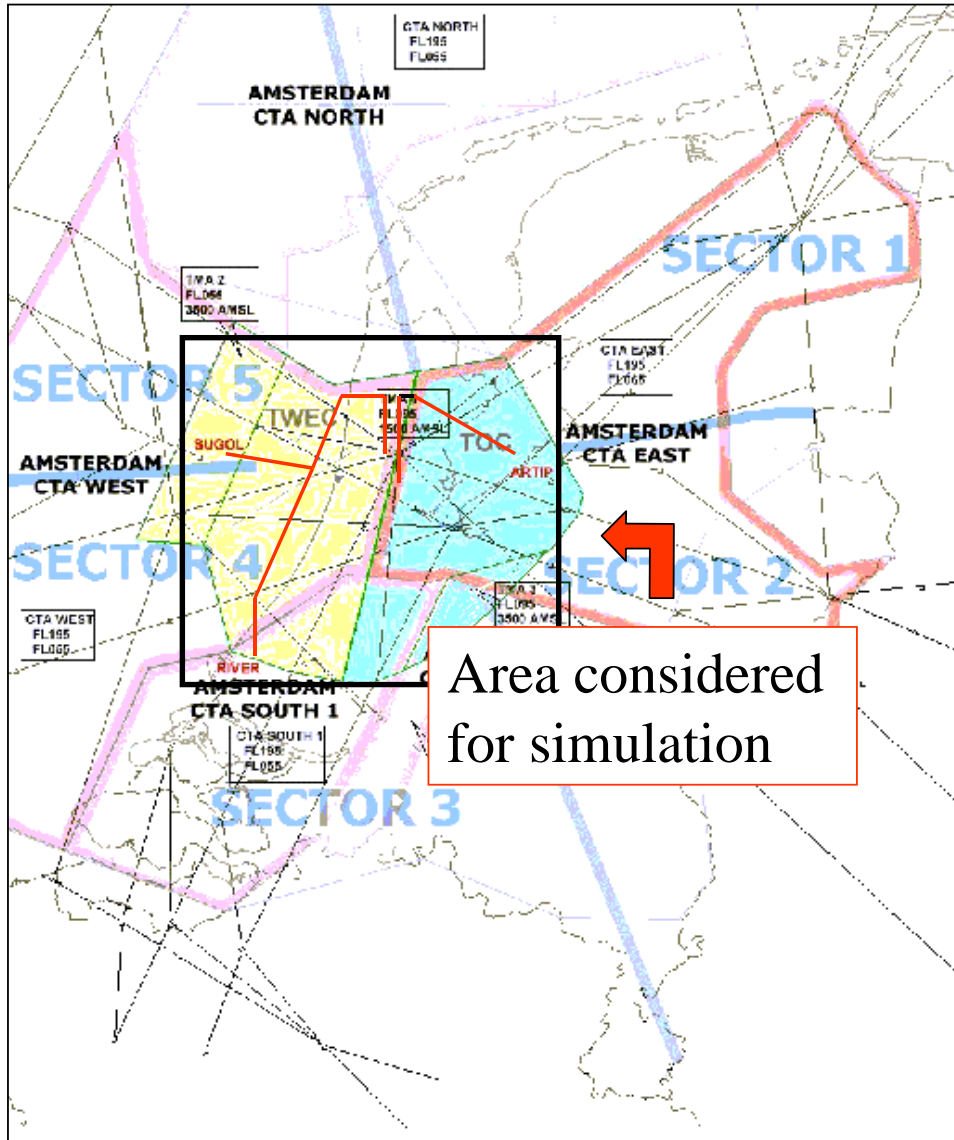


Figure 4-8: Simulation Area

4.3.2.11. Randomisation

No randomisation was used in this simulation.

4.3.2.12. Sequencing

Sequencing will be based on standard TAAM sequencing functionality. After passing a sequencing threshold distance of 80 NM before touch down, the sequencing list will be fixed. NOTE: the setting inside TAAM are agreed within the consortium. For the TAAM settings see appendix 3.

4.3.3. Speed Differences

The definition process of the Sourdine II procedures contains different phases. The profiles used within the simulation were compared and the average speed differences between the profiles were used for separation calculation. The separations were finally implemented inside TAAM. This section describes the profiles and the speed differences between the speed profiles.

The following aircraft types were used within the simulation. The speed profiles of the F50 and MD11 were substituted by the respectively the A320 and A340. From the outer marker the original FAS of the F50 and MD11 were kept during the simulation.

4.3.3.1. Speed profile Baseline

The figures 4-1, 4-2 show the speed profiles used within the baseline scenario. The profiles contain 5 different aircraft types. The approach segment conducted for the baseline includes 4 different speed constraints.

Speed constraint # 1: 250kts at Stack and until 30 NM

Speed constraint # 2: 220kts at 30NM

Speed constraint # 3: 180kts at ILS intercept

Speed constraint # 4: 160kts at Outer Marker (OM).

The profiles show a similar speed profiles due to the constraints involved. Refer to the following figures for a lateral and vertical illustration of the speed constraints.

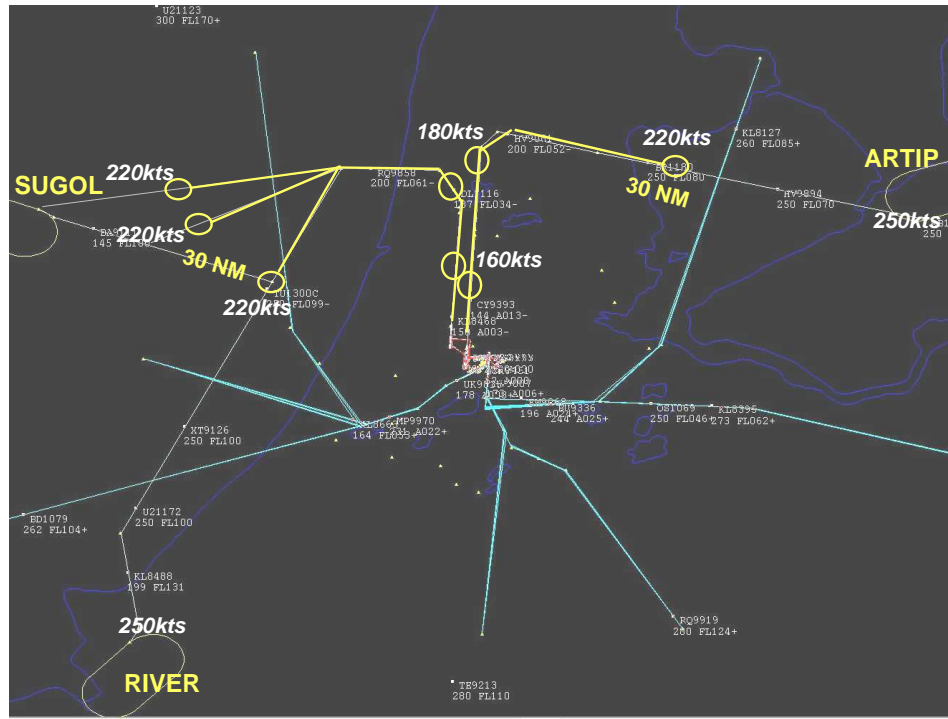


Figure 4-9: Baseline lateral speed constraints

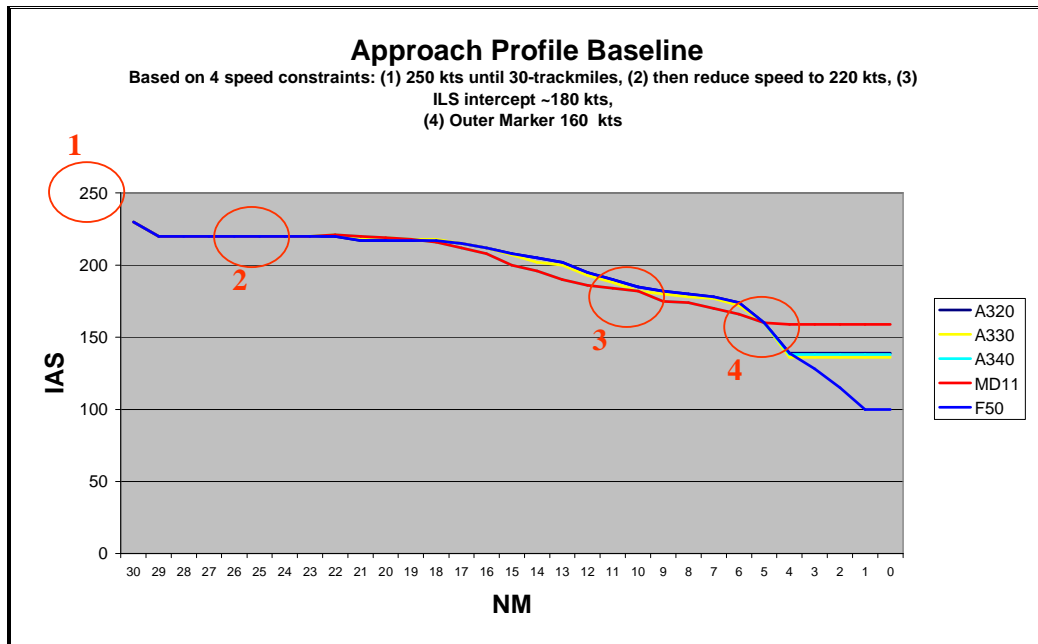


Figure 4-10: Baseline vertical speed constraints

4.3.3.2. Speed profiles of the Sourdine II procedures

The next profiles represent the Sourdine II procedures used within the simulation, two profiles were selected in order to show the speed differences between the profiles II & IV. The speed differences within the profiles are interesting for analysis within FTS. In order to compensate the speed differences within the approach segment, separation should be extended. Within this simulation it is assumed to fly fixed arrival routes, (routes that are fixed in lateral way (x, y)). Thus, no extended downwind leg will be applied in order to compensate the required separation between aircraft. With this keeping in mind, it is expected that the speed differences along the approach segment will significantly influence the overall ATM performance. Fast time simulation will be conducted for this study in order to quantify the lack of performance with the introduction of CDAs.

The FAS for the aircraft types used within the baseline are also used within the Sourdine II procedures. The FAS is reached as soon as the aircraft has passed the outer marker (approximately 4 NM before threshold). Within the Sourdine II procedure, this point is variable and depends on the aircraft type. It should be noted that because of the extended deceleration of the F50, the FAS is reached at approximately 2.5NM before threshold.

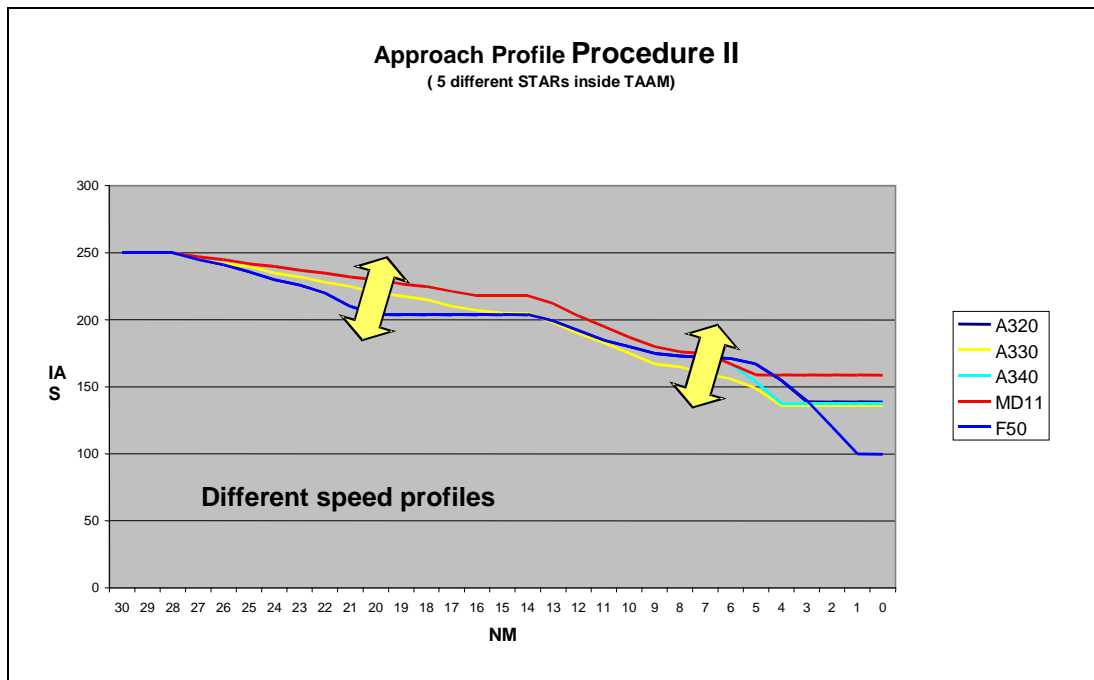


Figure 4-11: Speed profile procedure II

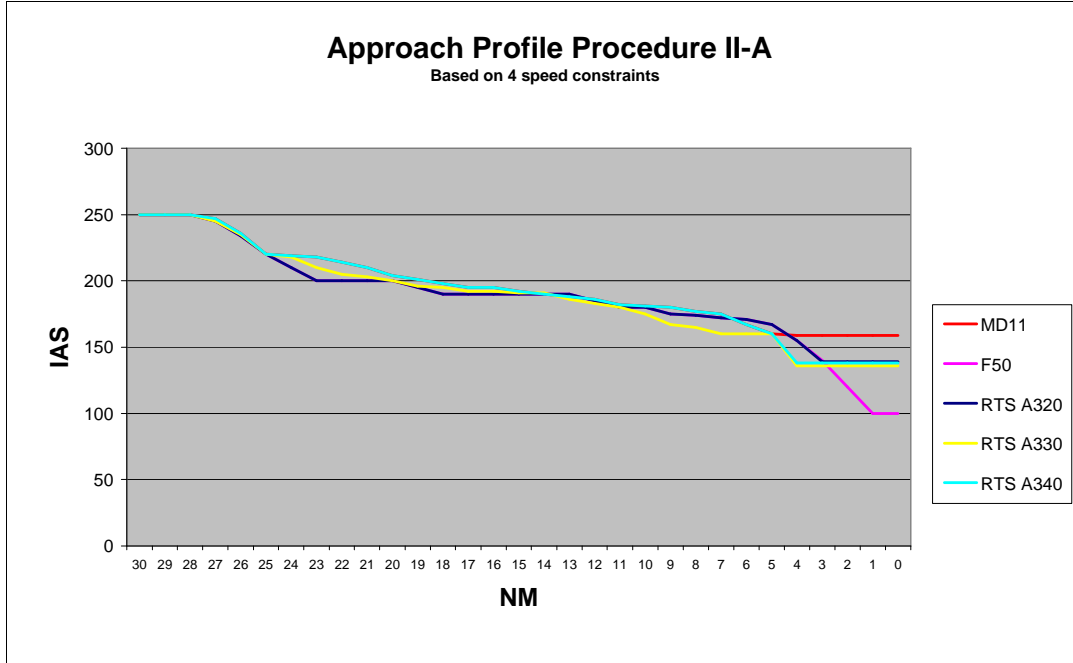


Figure 4-12: Speed profiles Procedure II-A

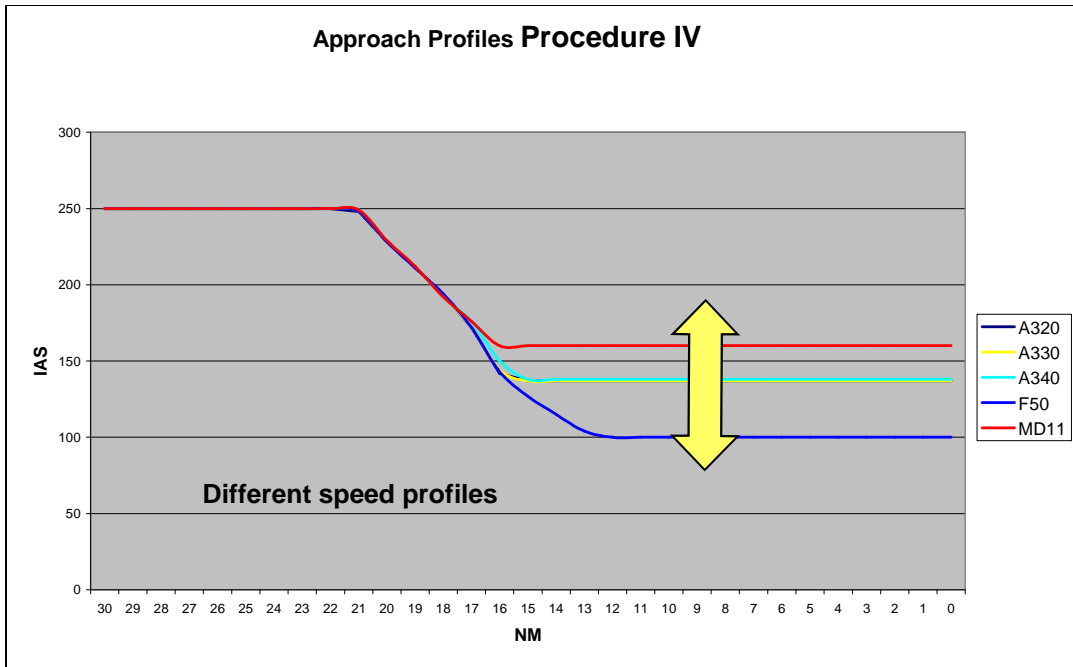


Figure 4-13: Speed profile procedure IV

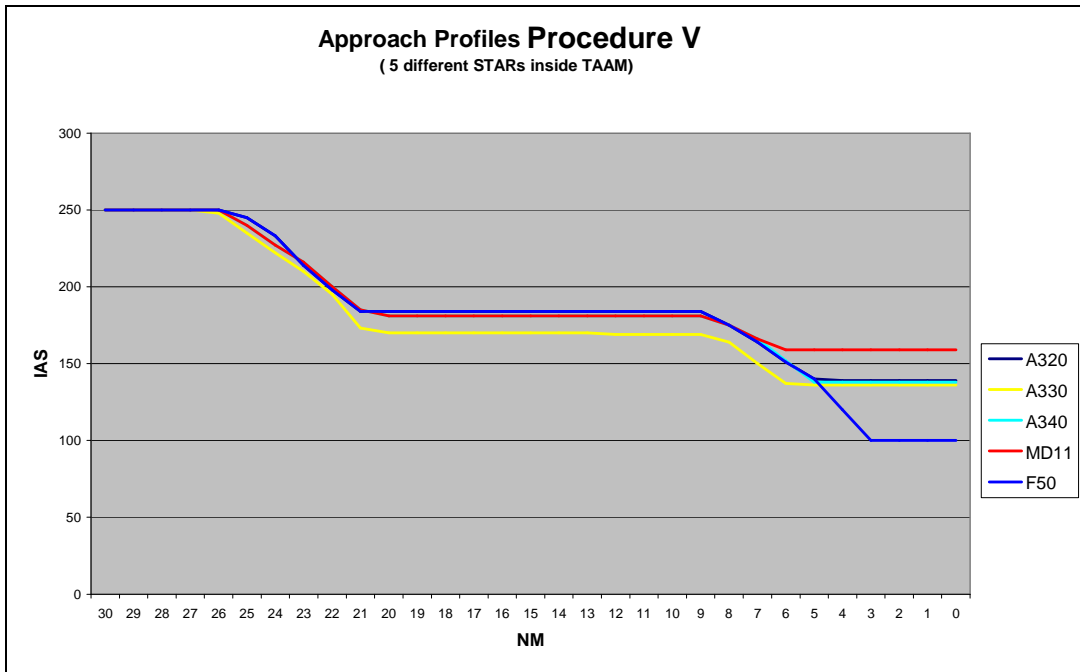


Figure 4-14: Speed Profiles Procedure V

4.4. Calibration results and conclusions

During the calibration process, several test simulations were carried out in order to check whether TAAM was able to perform the calculation. However, TAAM handles maintaining of separation different from the way it is required for Sourdine II procedures.

The Sourdine II procedures contain significant different speed profiles during the approach segment. Due to the speed differences additional separation is needed in order to compensate the separation validation between aircraft within the whole approach segment. The preliminary simulations were based without the use of the workaround. The obtained results show no significant effects between the baseline and alternatives. The main reason for this is that TAAM did not show the separation effects as they were required inside the Sourdine II study. TAAM calculates the desired separation at final approach only (based ICAO wake-vortex separation standards). If two succeeding aircraft will have different speed profiles, the separation will be violated at 30NM before landing. TAAM calculates the separation backwards, and takes the final approach segment as a starting point (see appendix 2). Unfortunately TAAM is not able to comply to the separation criteria without performing adequate workarounds. An extensive description of how TAAM performs the separation calculation and the way how the problem was fixed is described in appendix 2 “encountered problems during calibration”.

The calibration shows the importance of using the separation methodology. The methodology ensures that aircraft will use the right separation during the approach segment. The separation was calculated based on the speed differences. More speed variations between aircraft means more required separation.

The methodology (work around) used to solve the separation problem should be considered as an enhancement of TAAM which complies with the separation requirements needed to conduct the Sourdine II simulations.

5. Baseline versus Sourdine II

5.1. Objective

This chapter encompasses a description of the baseline and the Sourdine II procedure conducted by Fast Time Simulation and provides an overview of the simulations. The results obtained will be described in the next chapter.

5.2. Method

The simulations will be carried out based on the separation criteria described within the previous chapter. The separation criteria were calculated for each aircraft combination. The simulations were ran and processed individually. All Sourdine II scenarios were finally compared with the baseline.

5.3. Procedures

Within Sourdine II, TAAM is used to create an airport and airspace environment, together with a set of approach procedures affecting that environment. TAAM will be used on basis of ‘what if’ philosophy and proposed procedures will be compared against conventional procedures. TAAM enables the user to simulate an ATC environment with a close approximation of reality. It should be clearly understood that it is not reality. Although it may represent or simulate the essential features of the ATC system, the representation should be used to better understand, analyse and evaluate the specific Sourdine II procedures.

The operational description of the baseline and the Sourdine II procedures are described in the appendices.

The table below gives an overview of the simulation carried out for the Schiphol capacity study. The first column “RNAV” is based on the Sourdine II procedures within a RNAV trajectory environment. The second column “vectoring” is based on a nominal vectoring trajectory environment. This study aims to pinpoint the effect of vectoring versus RNAV approach procedures. The “fleet mix” column represents the timetables used within the simulations. “fleet mix A” was used within all simulations and is based on the A340, A330, A320, the MD11 and the F50. “fleet mix B” consists of fleet mix A but then with the A319 and A321 involved. It should be noted that the “Vectoring” and “Fleet mix B” scenarios have been carried out based on qualitative analysis.

Table 5-1: simulation overview

	<i>RNAV</i>	<i>Vectoring</i>	<i>Fleetmix A</i>	<i>Fleetmix B</i>
Baseline	X		X	
Procedure II	X		X	X ¹
Procedure II-A	X	X ¹	X	
Procedure IV	X		X	X ¹
Procedure V	X		X	X ¹

(1 analysis of qualitative bases)


5.4. Traffic sample

The traffic sample used for the simulation is deduced from the traffic scenario to be expected in 2015. This sample contains several aircraft types which need to be substituted to the aircraft performance types available for the project. The available aircraft types for this study are:

- A319
- A321
- A320
- A330
- A340

A timetable that only represents airbus aircraft would not be realistic for Schiphol. Therefore, the F50 and MD11 were added in order to create a more realistic timetable. F50 represented 10% and the MD11 for 5%. In fact, Schiphol will have to cope with light-medium aircraft (such as turboprops) in the future. So, in order to obtain realistic data, it is important to include turboprops within the timetable as well. It should be noted that turboprop aircraft would have significant difference performance behaviour in comparison with Airbus aircraft. The simulation results should therefore be interpreted in context with assumptions made. Adding F50 within the timetable should be considered as an important assumption for the simulation. In table 4-1 of section 4.3.2 ('Definition of the procedures') a description is given of the substitution of the aircraft types involved for arrivals. This table shows the 2002 data as well as the 2015 data, which was derived as described in that section. The 2015 traffic sample contains a total of 902 inbound movements and a total of 1800 movements

Details on the number, distribution and type of aircraft used for the simulation are presented in detail in section 4.3.2 ('Definition of the procedures').



6. Simulation results

6.1. Objective

The following paragraph provides the results obtained during the simulation. The results will be described and explained in context with the assumptions made. The influences of the fleet mix as well as the separation criteria used for the simulations will be described extensively. The emphasis of the study was mostly put on the Sourdine II arrival procedure. It is for that reason that the results are basically focused on the arrivals. The issues that will be described are:

- Delay (arrival & departure),
- Runway capacity (arrivals),
- Movements (arrivals)
- A qualitative analysis of RNAV and Vectoring trajectory
- Influence of A319 and A321.

The simulation results were obtained from:

- Baseline scenario
- Procedure II
- Procedure II-A
- Procedure IV
- Procedure V

6.2. Expectation with respect to the results

The proposed Sourdine II procedure will be compared with the baseline scenario, which represents the situation at Schiphol as expected in 2015. The proposed procedures can be considered as Continue Descent Approaches (CDA). As explained in chapter "*Calibration*", the CDAs needs additional separation between aircraft because of the unique speed profiles and the speed differences. Each aircraft type flies a unique speed profile in order to follow a pre defined profile trajectory. Different aircraft types (small, medium, and large), mean different speed profiles and in addition different separation between aircraft. Because of this reason it is expected that Sourdine II procedures will have a negative influence on the throughput capacity and the arrival delay.

6.3. Overview of Arrival Delay

Figure 6-1, "Percentage Delayed Arrivals" shows the number and the percentage of delayed aircraft. The distributed delay periods are 0 minutes, (aircraft arriving without delay), 0-15 minutes (aircraft arriving with ≤ 15 minutes delay), and aircraft arriving with more then 15 minutes delay.

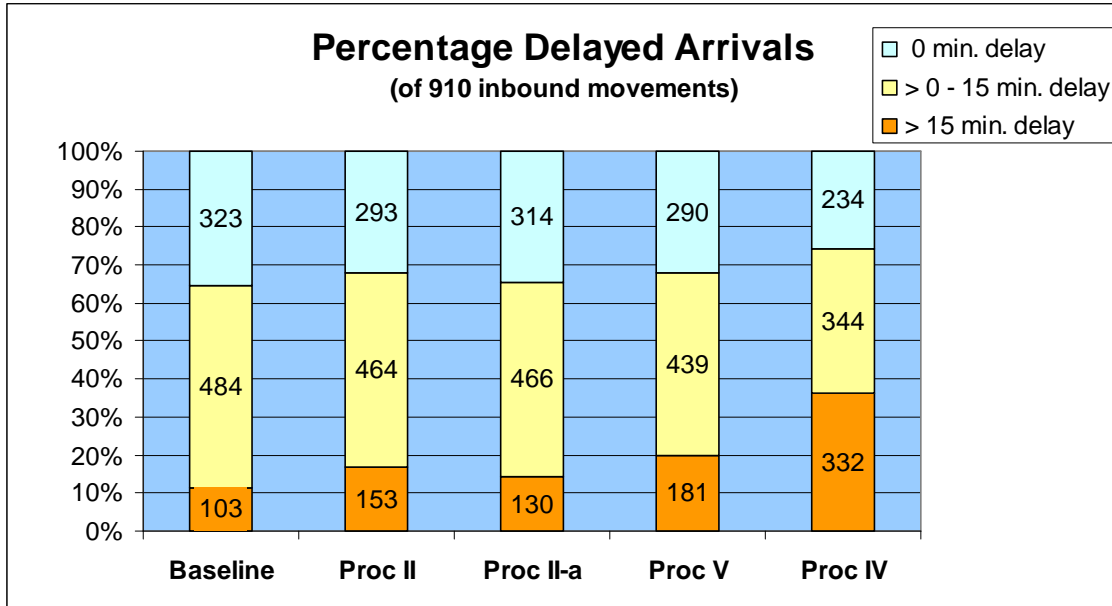


Figure 6-1: Percentage Delayed Arrivals

Figure 6-2 shows the "Average Arrival Delay" of all simulations involved. The average delay was calculated by the amount of delay divided by hourly movements.

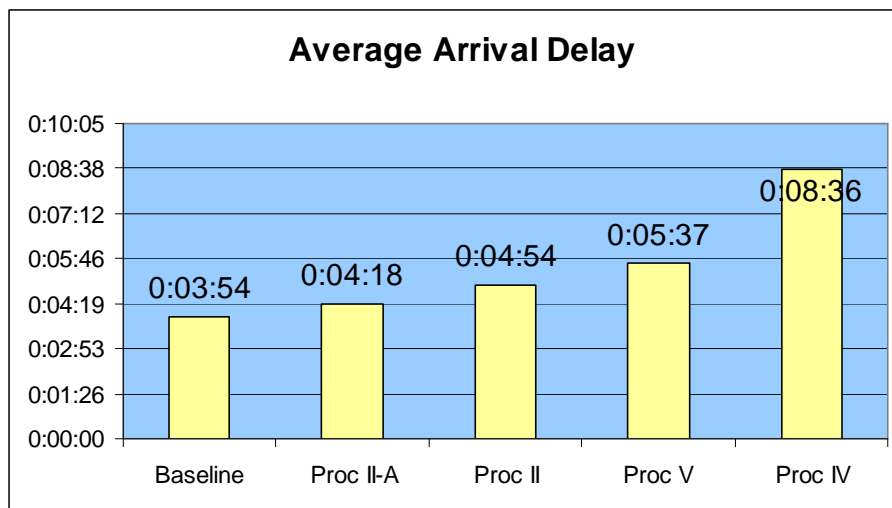


Figure 6-2: Average Arrival Delay

How delay was build up during the day

There are two reasons why arrival delay occurs within the simulation.

1. Delay caused by the overall ATM process and the traffic flow with exception of the effect of proposed Sourdine II procedures.
2. Delay caused by the proposed Sourdine II procedures

Ad 1.

The reason why arrival delay occurs within the simulation (besides the effect of the proposed Sourdine II procedures) is because of the unbalanced traffic demand. The term unbalanced traffic demand means an unsteady traffic flow from different directions during the inbound peak periods. During several inbound peaks an unbalanced traffic distribution was reported between runway 18R and 18C. For example: the traffic demand from ARTIP was significant lower than the demand from RIVER/SUGOL between 12:00-13:00 (figure 6-3).



Figure 6-3: Traffic density Schiphol airport between 1200 and 1300.

This unbalance results in an overburden and generates delay. In addition, other aspects that caused delay are sequencing problems due to simultaneous traffic demand and the lack of 'compensating' and 'fine tuning' measures such as tromboning or doglegs. In addition, the RNAV shortcut from SUGOL has a positive effect of the sequencing of aircraft and thus the delay. Although, this can not be shown by the results obtained simulation exercises in the calibration phase has shown this positive effect. An environment without RNAV shortcuts would result in more delay problems. The delay caused by the above mentioned aspects can be considered as the 'trend' of the simulation, it is also visible within each scenario output. The performance of the proposed Sourdine II profiles determines whether the trend will be deteriorated.

Ad 2.

The proposed Sourdine II procedures mainly cause the difference in delay between baseline and alternatives. This delay is caused by the extended separation needed for the arrival procedures. The more speed differences between aircraft types, the more separation were needed. Figure 6-4 shows the cumulative arrival delay. The 'bumping' lines of delay are mainly caused by the unbalanced traffic distribution during inbound peaks as mentioned within ad1.

The amount of arrival delay is also caused by the fleet mix. The fleet mix determines the performance of the ATM system by reducing disturbances within the traffic flow. The more the consistency of aircraft types within a traffic flow, the less extra separation is required due to the speed differences. Therefore, It should be clear that changes with respect to the fleet mix will also have implications to the results. It is therefore worth mentioning that results should be interpreted in context with the assumptions made. The assumptions are described within the "calibration" chapter.

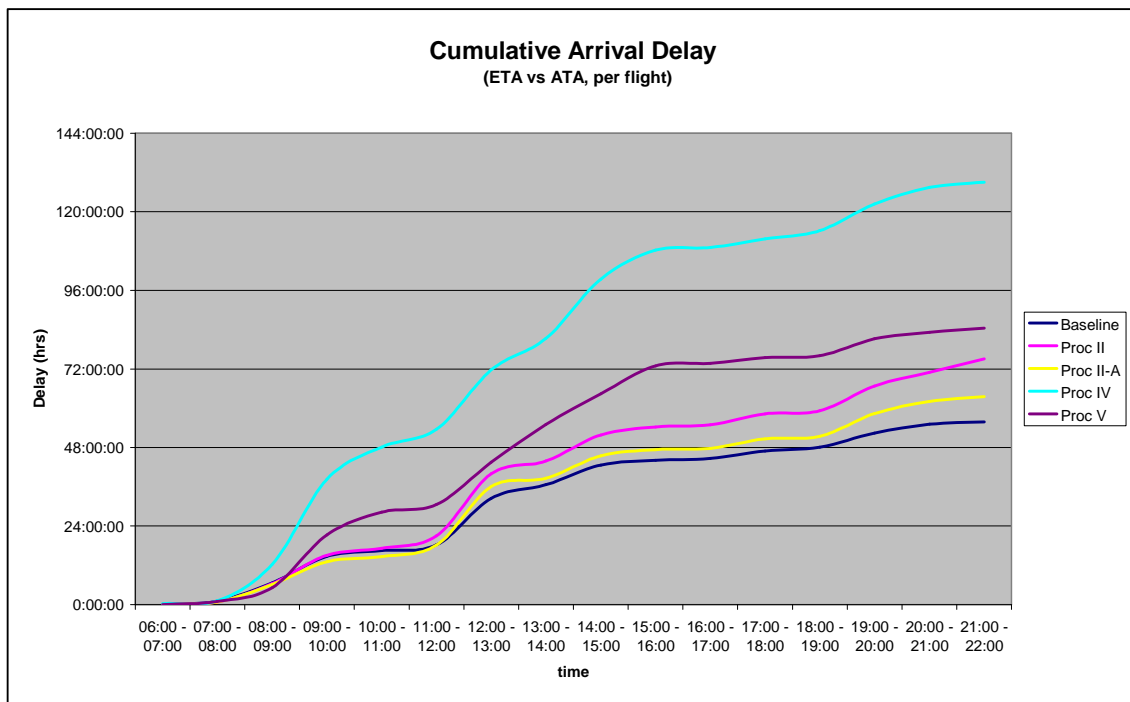


Figure 6-4: Cumulative Arrival Delay

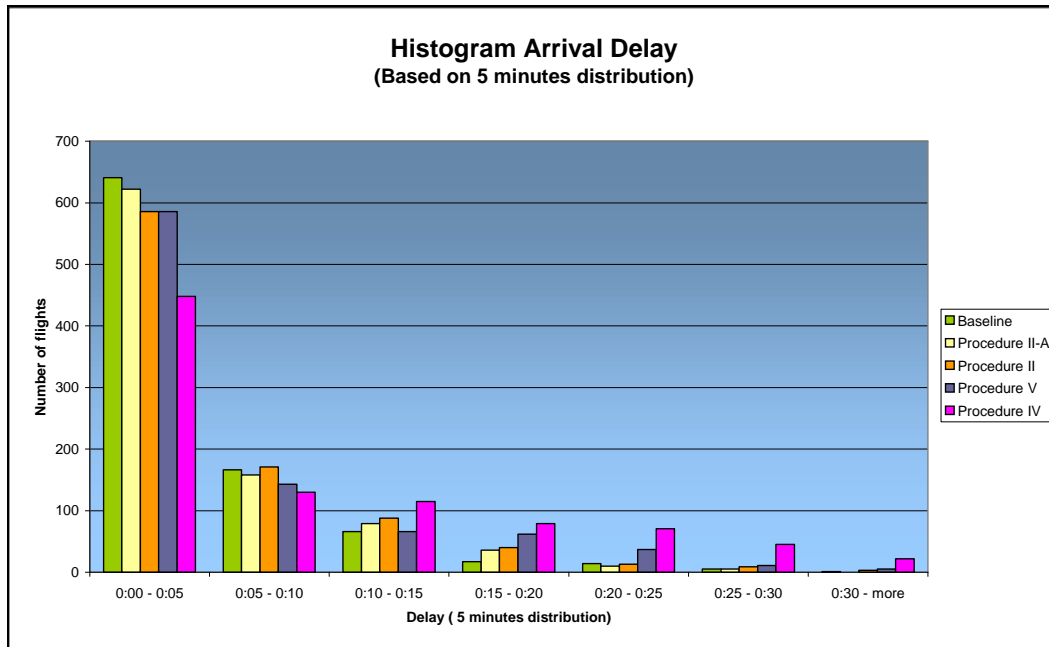


Figure 6-5: Histogram

The histogram of figure 6-5 shows the delay distribution within 5 minutes periods for all alternatives.

Most aircraft are affected by an arrival delay between 0-5 minutes. The more the delay distribution is build up, the less the number of affected aircraft. For procedure IV, however, the delay seems to increase as the delay distribution increases. This procedure has also significant high overall delays due to the additional separation needed to cope with the speed differences.

6.4. Capacity calculation

The obtained capacity figures are based on the methodology for capacity calculation, agreed within the consortium. The capacity calculation stated by SourDine II provides an exponential trend line based on the average delay per hour (dividing the total amount of delay generated during each hour between the number of operations) and the number of movements. From the baseline scenario the tolerable delay value per hour for arrivals was calculated for Schiphol airport, this value will be based on 10±1 minutes.

The correlation factor (the distribution of points and the relation of the points vs. the trend line) will be based on 50%. This value means that situations with less then 50% of the maximum realised demand will not be taken into consideration. For example: within the baseline the maximum realised hourly movements was 74 movements. 50% of 74 movements will be 37 movements. All recorded data below 37 movements will not be taken into consideration within the capacity calculation. In fact, a demand below 37 movements can be considered as a too low demand for two runways. It is therefore not necessary to include low demand figures inside the capacity calculation, as it would influence capacity in a negative way. A lower correlation factor (i.e. ~25%) would result in more realistic data, but since the correlation factor was fixed and set to 80% within the consortium during the project, a balance was made between NLRs point of few and what the consortium agreed.

Table 6-1 Capacity runway 18R & 18L

Arrival capacity runway 18C & 18R	
Baseline	72 - 74
Proc II	69 - 71
Proc II-A	71 - 73
Proc IV	59 - 61
Proc V	66 - 68

The capacity chart below (figure 6-6) shows the relation between demand and average arrival delay for two inbound runways. In order to obtain reliable capacity data for both runways (18R and 18C) it is important to gather enough recorded data. The recorded report period used inside the simulation was set to 1 hour. For capacity data however, one hour would be not enough to perform the calculation. It would definitely result in unreliable capacity results. Therefore, for capacity calculation, a “rolling hour” principle was used. This means that for each 20 min, the full next hour was reported. The period considered for capacity calculation was between 07:00 – 23:00, which corresponds to 16 hours. For each individual hour, data was recorded, and due to the rolling hour principle, 16 hrs x 3 = 48 recorded data point were taken into consideration during the capacity calculation. Based on expert judgement this can be considered as a reliable number of recorded data.

Runway Capacity (18R & 18C) Demand vs Average arrival delay

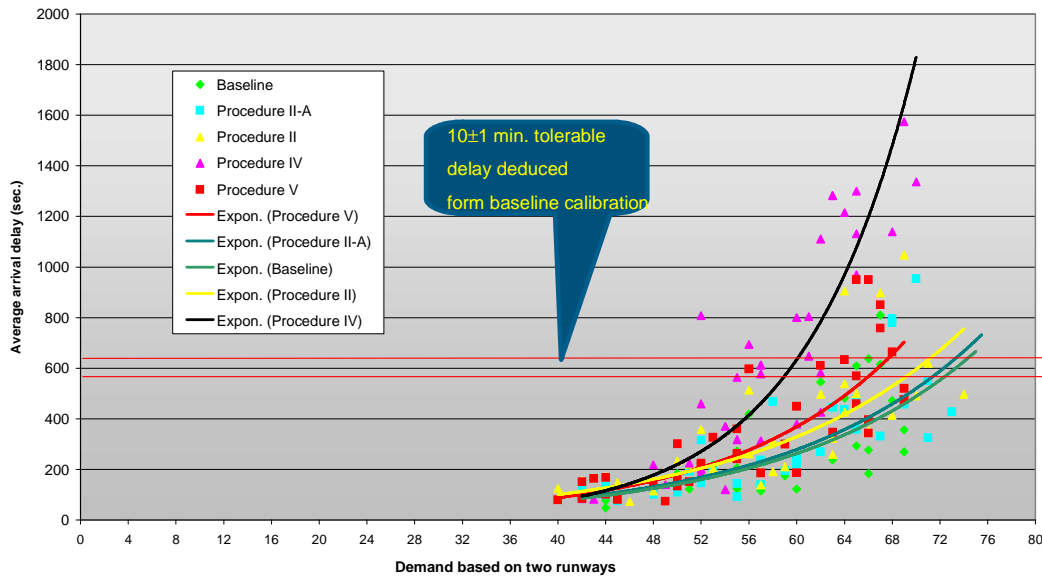


Figure 6-6: Capacity calculation chart, based on 50% correlation factor

6.5. The effect of the A319 and the A321

Previous results have shown only the effect of the fleet mix based on the F50, MD11, A320, A330 and the A340. As mentioned earlier in this report, unfortunately the A319 and the A321 were not included

within the simulation. In order to get an idea of the effect of both aircraft with respect to the already obtained results, an analysis was made based on the initial used fleet mix. The original timetable includes 24% A319 and 2.7% A321. It should be noted that the F100 and the F70 were substituted to the A319 as well. The analysis was performed on basis of the speed differences and the distribution of both aircraft types. The following steps were taken into consideration:

1. The fleet mix of the original timetable was analysed and the number of A319 and A321 were determined.
2. Based on the provided Airbus data the average speed over the entire approach segment was calculated and compared with other aircraft types.
3. As described earlier, the average approach speed related to the specific aircraft determines the required separation during the approach segment. For the A319 and the A321, this calculation was also performed and finally an overview of required separation for each aircraft type combination was obtained.
4. In accordance with the aircraft type distribution a probability calculation was made in order to determine the probability that an aircraft was suffered by the additional separation required of the A319 and the A321. This calculation was important, since the separation criteria determines the performance of the procedure. The additional separation required due to the introduction of the A319 and the A321 did increase, and so the performance of the procedures was expected to reduce.
5. The overall separation of each type of aircraft was brought into a function of the already obtained delay (from previous simulations). The relation between delay and the required separation was used to calculate the effect of the introduction of the A319 and the A321.

Based on the calculations and the methodology mentioned above the following values were determined:

- *Procedure II will have an increased arrival delay of 8 %*
- *Procedure IV will have an increased arrival delay of 5 %*
- *Procedure V will have an increased arrival delay of 2 %*

Due to lack of data for the baseline and procedure II-A, the calculation was only performed for Procedure II, IV and V.

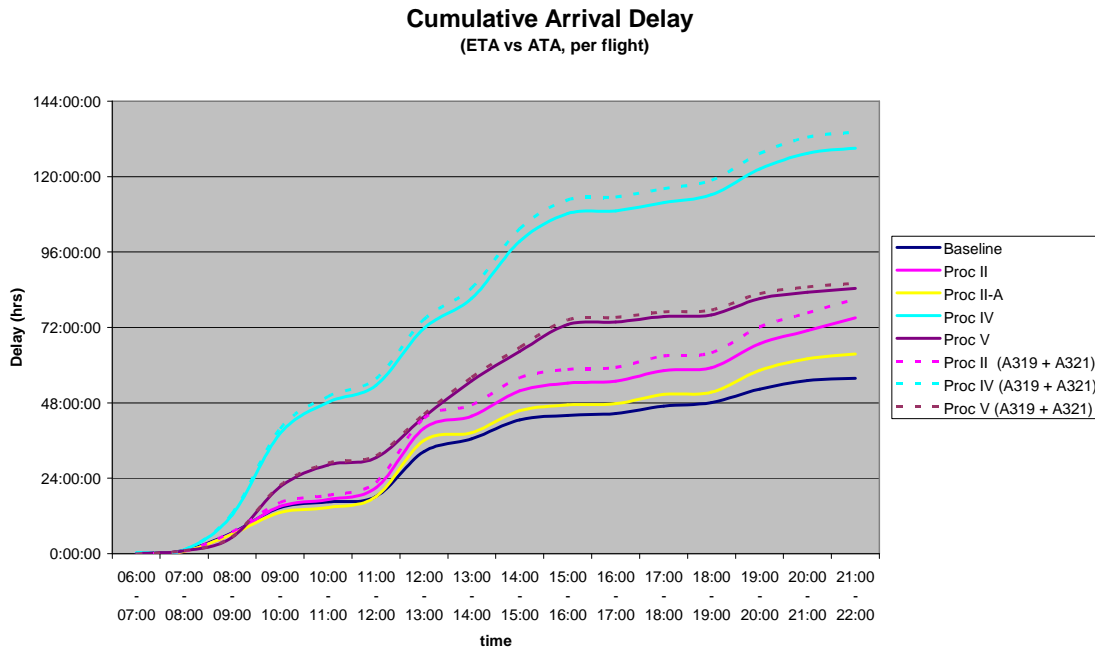


Figure 6-7: Cumulative arrival delay with predicted A319 & A321 calculation

6.6. The movements

Figure 6-8 shows the inbound movements and the arrival delay. The period was distributed by one hour. Within this chart it is important to compare results with the baseline scenario. The baseline movements can be considered as the “planned” movements, during comparison. Procedure II, II-A and procedure V seem able to cope with the traffic demand, and show more-or-less a similar behaviour as the baseline. Procedure IV shows a deviated pattern, which is caused by the lack of throughput capacity. Due to the speed differences between aircraft types, additional separation is needed within the TMA.

The following figures (6-8, 6-9 and 6-10) show the delay and the inbound movements of the scenarios. Several situations need an additional explanation, these spots are mentioned with a yellow circle.

Average Arrival Delay & Inbound Movements (incl. Proc IV)
 (arrival delay based on flow ETA vs ATA, average per hour)

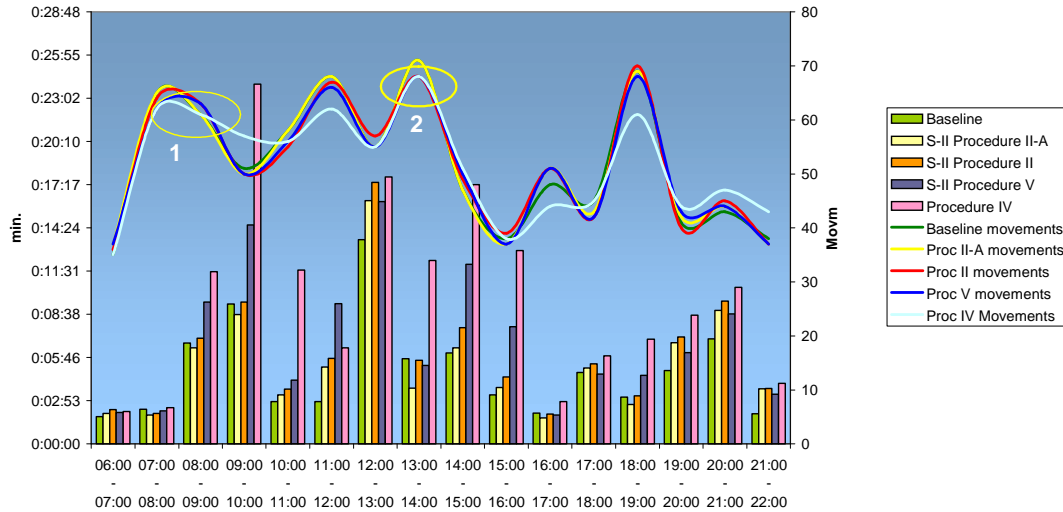


Figure 6-8: Arrival Movements vs Delay

Spot 1. A “runafter” of inbound movement for procedure IV & V

Procedure II, II-A and V seem quite similar to the baseline scenario, with exception of the morning peak, where procedure V seems to have a temporary lack of capacity. Procedure IV significantly deviates from the others. Figure 6-8 might suggest that procedure IV will have a lower demand during the day, it is therefore worth mentioning that procedure IV has the same number of inbound movements as the baseline. However, procedure IV is not able to cope with the demand and shows especially after peak periods a “runafter period”, which is caused by the lack of throughput capacity. The reason that Procedure IV is not able to cope with the demand is because of the separation criteria used within this scenario. The runafter period at 20:00 through 22:00 is extended beyond the boundaries of this chart. After 22:00 procedure IV was still struggling with the demand from previous period.

Procedure V has a runafter period during the morning peak as well. During the merging of SUGOL and RIVER traffic, two aircraft had extensive sequencing problems within the TMA. The sequencing problem is caused by the extended separation needed for one of the aircraft due to the speed difference. It should be noted that the sequencing order was not the same for all simulations. (Sequencing order means the way TAAM handles the traffic order at the final stage of the approach) For example, if TAAM manages to sequence a F50 before an A340, then TAAM will have less sequencing problems (caused by separation) then when the order will be the other way around. Simulations might vary with this sequencing order. This was certainly the case within procedure V during the morning peak. Although the simulation was carried out for several times, it was no possible to filter this effect out due to the lack of randomisation within the aircraft performance. So, the lack of capacity during this period is not related to the procedures. In fact the procedure seems to perform quite well during the rest of the day. But it should be noted that the sequencing order of aircraft has also effect on the performance of the ATM system.

Spot 2. Temporarily increase of inbound capacity for procedure IV

Procedure IV has a lack of capacity during the entire day. Within the period 13:00 - 14:00 (spot 2) the capacity seems to increase for short period. The reason for this is based on the concentration of A320 aircraft for both runways. In fact during this period only one F50 was reported. It would be clear that this will result in less disturbances of the traffic flow. The high concentration of A320 aircraft ensures the existence of consistent speed profiles which leads to minimal separations between aircraft along the approach segment. The throughput capacity will finally increase due to this temporarily benefit. This example stresses again the significant influence of the fleet mix. A consistent fleet mix does provide positive performance effects of the ATM system.

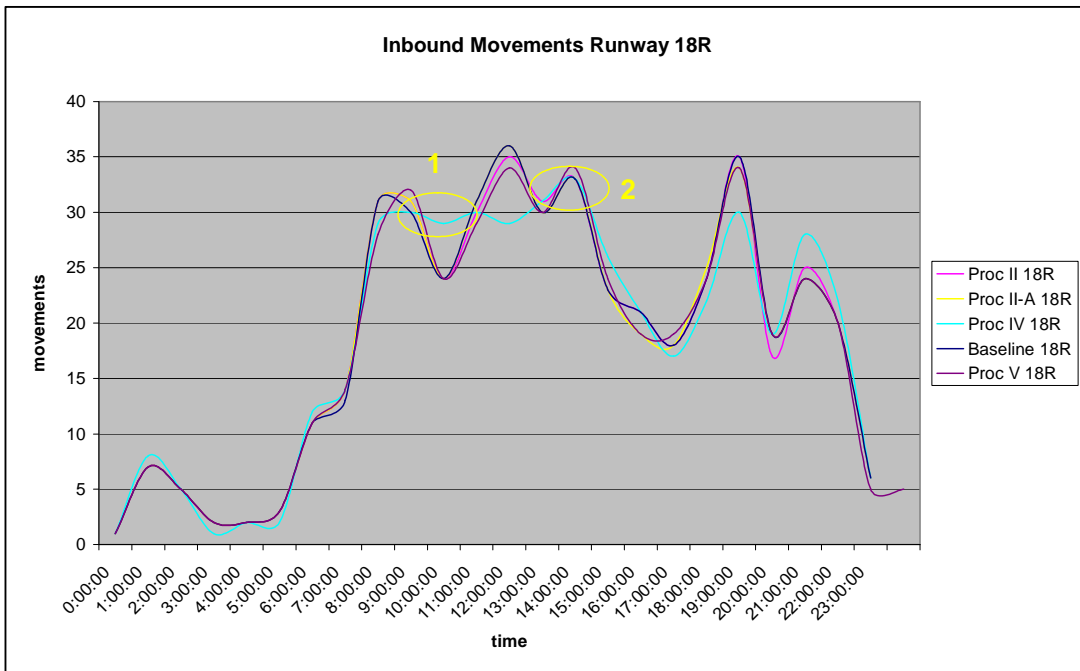


Figure 6-9: Movements 18R

Figure 6-9 and 6-10 shows the movements of the individual inbound runways. Procedure II, II-A and V seem quite similar to the baseline. The shape of procedure IV significant deviates from others.

Spot 1. Lack of capacity

Procedure IV seems to have significant capacity problems, as it is not able to manage a demand of 29 a 30 aircraft. The 'sinus shaped' behaviour of the movements stresses that the maximum performance of the procedure was reached with the given fleet mix. The fleet mix distribution changes along the day and so the separation between aircraft. This results in an unsteady 'sinus-like' shape of the inbound movements. Again, it should be underlined that procedure IV uses extensive separation criteria for the arrival approaches, which results in significant capacity drops.

Spot 2. Displacement of movements

Spot 2 shows a temporally increasing of inbound capacity. The reason for this is already explained within the previous overall movement chart (figure 6-8). Due to consistent fleet mix (A320) between 13:00 and 14:00, the traffic flow can be handled with minor separation criteria. This results in a positive effect on the runway capacity.

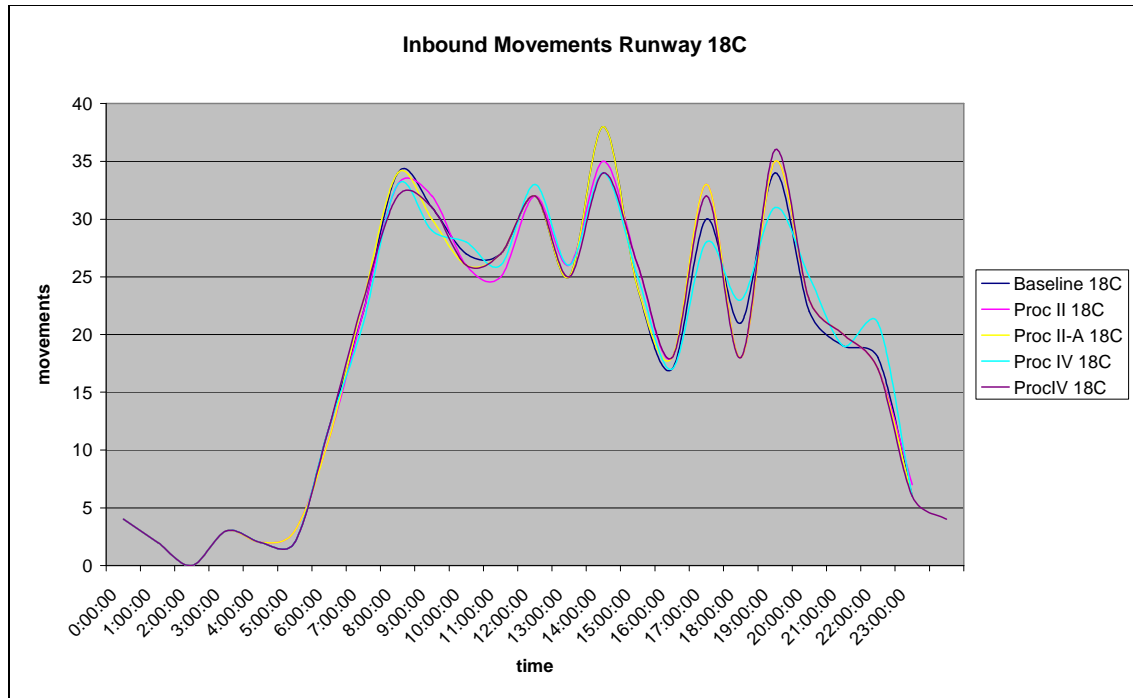


Figure 6-10: Movements 18C

Figure 6-10 shows a similar performance as figure 6-9. However, procedure IV is considerably better, as it is at least able to manage the traffic flow at a certain level. Better sequencing conditions such as one-stack-one-runway, and a favourable fleet mix are the main reasons for this.

6.7. Departures

Although the emphasis of the study was put on the arrivals, the departures are also interesting for analysis. A few comments can be made with respect to figure 6-11. The reason why a departure delay occurs is basically caused by the disturbances in traffic flow for departures. It would be clear that this affects delay. Figure 6-11 represents the traffic density for both outbound runways. The figure shows clearly an unbalance in traffic distribution for both outbound runways (runway 24 and 18L). There are more aircraft leaving Eastbound than Westbound. The bumpy shapes of figure 6-12 are caused by this problem, and all procedures seem effected by it.

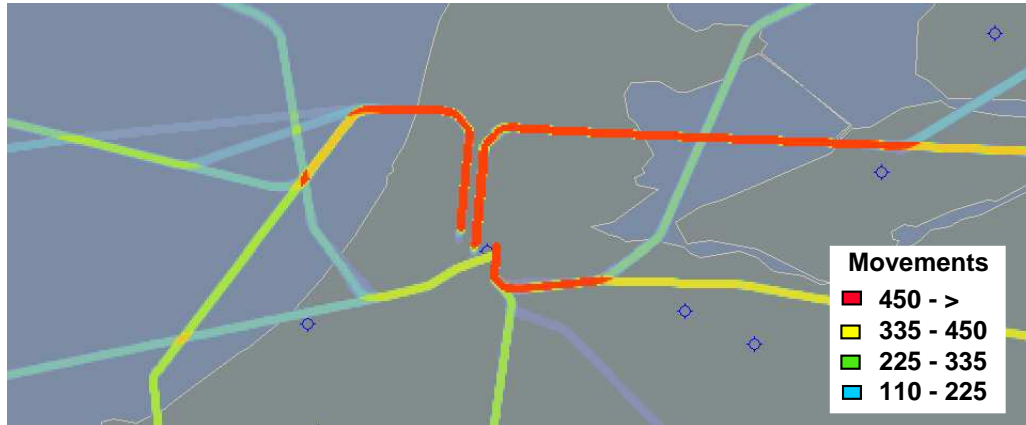


Figure 6-11: Movements during the entire simulation period (24 hours)

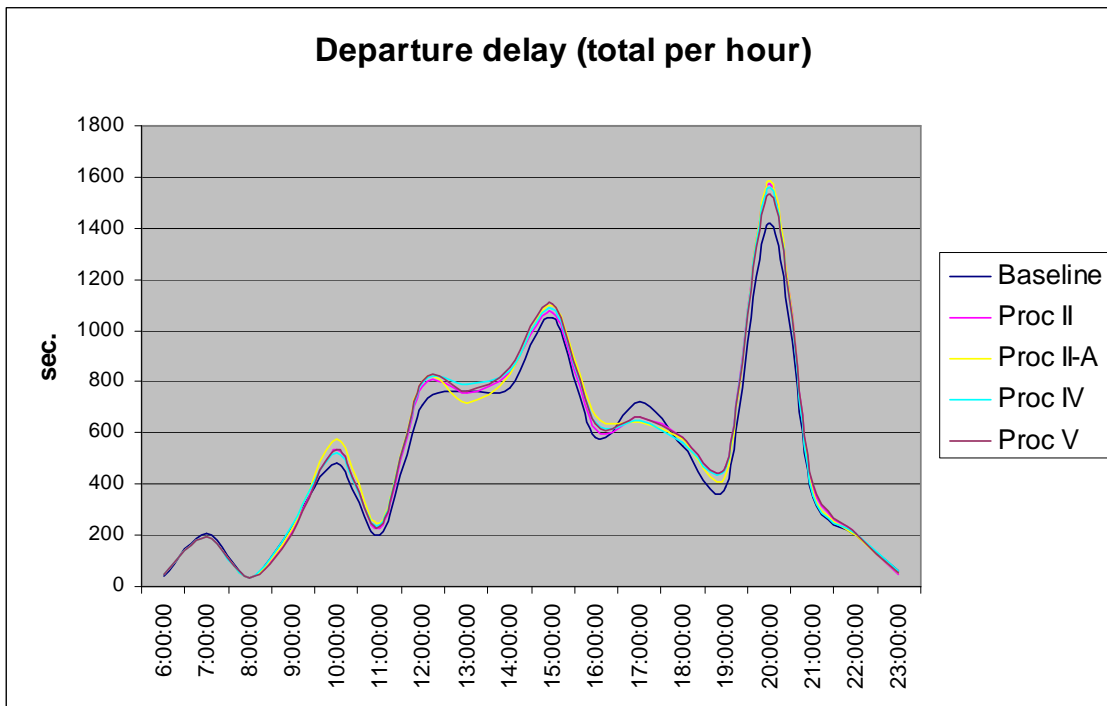


Figure 6-12: Departure delay

SID – STAR interference at Schiphol w.r.t. Procedure IV

Procedure IV significantly deviates from other approach procedures because of the unique altitude profile. This procedure prescribes that aircraft are allowed to descend at approximately 15 NM (track miles) before landing. The point where the SID crosses the STAR is located approximately 24 NM before landing. At this stage, inbound aircraft descends within the altitude segment of 7000 ft – 8500 ft. For that reason, departures from runway 18L might come into conflict with arrivals, as they will cross this point at an altitude segment of 8000 ft – 9000 ft.

The problem is shown in figure 6-13 and 6-14. In order to illustrate the number of conflicts between SIDs and STARS, the simulation was re-ran. Figure 6-13 shows several conflicts between the departures and the arrivals. The conflicts are mentioned with a yellow bullet. The size of the bullet represents the seriousness of the conflict. A small bullet shows a 100% separation violation, this means that the minimum separation was met. 50% separation violation, however, means that 50% of the minimum separation was met, which will be considered as a conflict. So, below the 100% a bullet will be considered as a conflict and the bigger the bullet, the more serious the conflict.

Other proposed Sourdine II procedures have a lower altitude profile at this location, which enables departures to cross this point with significant less conflict.

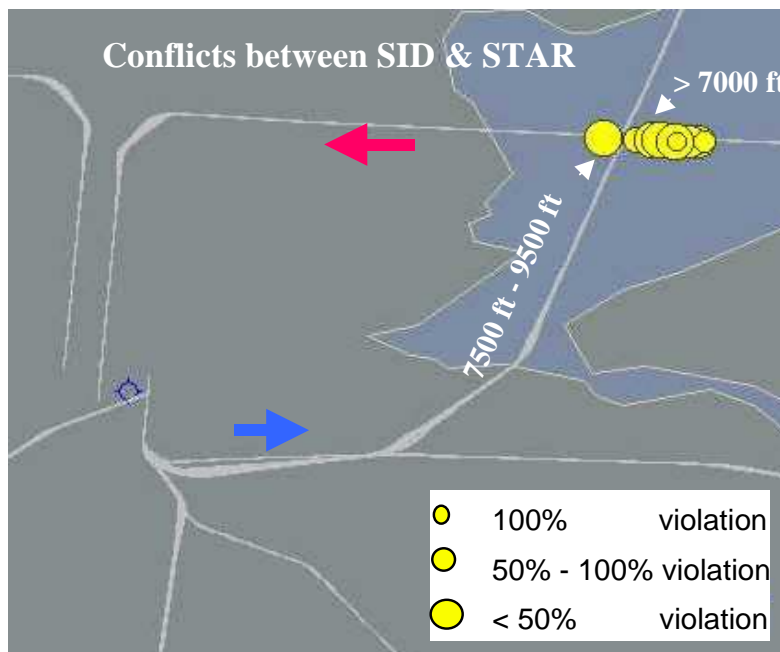


Figure 6-13: Conflict between SID and STAR at ARTIP

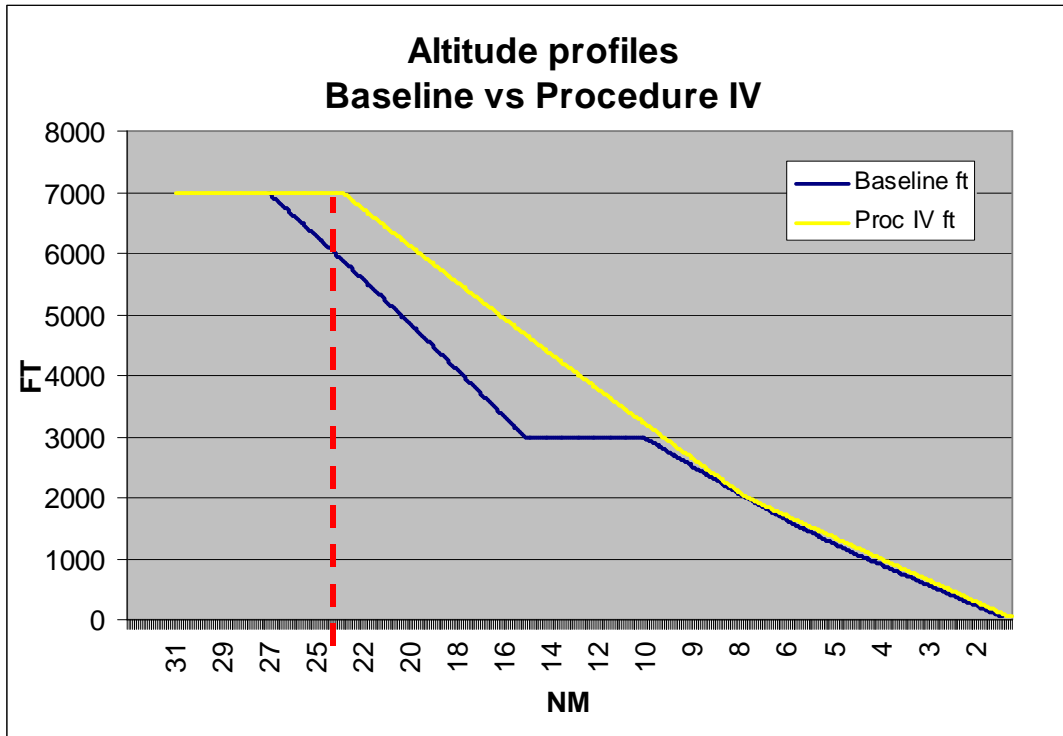


Figure 6-14: Baseline and Proc. IV altitude profiles

6.8. RNAV based vs nominal vectoring routes

The Sourdine II simulations were simulated within RNAV conditions only. In order to get a better understanding of the effect of the lateral trajectory an additional simulation was carried out based on the current average vectoring trajectory used at Schiphol. This trajectory deviates significant from the trajectories used within the Sourdine II simulation. The vectoring trajectories are located above the Dutch coast and the Sourdine II trajectories are located above the North sea (see figure 6-15 and 6-6). The trajectory from ARTIP stack was not changed. With "Luciad Play back" a comparative analysis was made between both trajectory locations. The emphasis was put on the number of conflict point between Westbound SIDs and STARs from RIVER and SUGOL. Normally, at Schiphol, arrivals are allowed to descend to 7000 ft unless they are instructed by ATC, however departures are not allowed to climb above 6000 ft. This rule is based to avoid conflict between departures and arrivals (also called "60/70 rule")

For analysis purposes, It should be noted that this rule was skipped during the simulation. In order to analyse the actual number of conflicts between the SIDs and STARs for each scenario the conflict avoidance was managed by the simulation and aircraft itself. Therefore, to avoid conflicts between SIDs and STARs during the simulations, departures should reach a minimum altitude of 8000 ft (or higher) at the conflict points A,B,C (see figure 6-15 and 6-16), as arrivals should descent to 7000 ft (or below). The arrival procedure used for this analysis was procedure II-A. In fact, the arrival procedure used does not affect the analysis, as the altitude of all procedures involved will be 7000 ft at the SID/STAR crossing point.

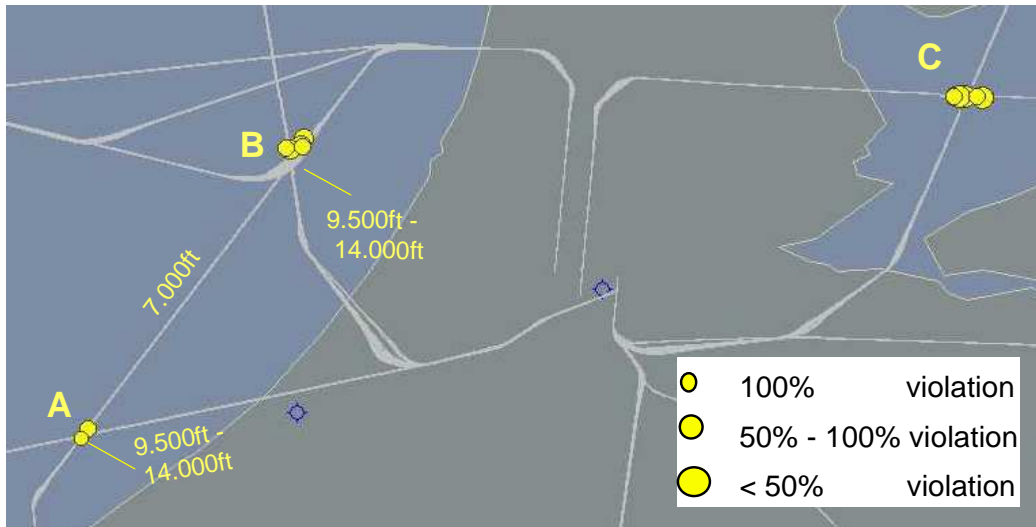


Figure 6-15: RNAV trajectories

Figure 6-15 shows the lateral RNAV trajectories and the SIDs. The conflict points between Westbound SIDs and STARs are taken into consideration only. For what concerns the SIDs from Schiphol: the average altitude in which aircraft passes the conflict points is between 9,500 ft and 14,000 ft. In general, the distance between Schiphol and point A and B will be enough to reach a minimum altitude of 8000 ft for departures. Within this simulation period, practically no conflicts were detected. The few conflict shown in figure 6-15 were caused by the descending aircraft, which were not able to reach the altitude of 7000 ft. In combination with a 'slow-climber' this will result in a conflict. The maximum separation violation reported was between 100%-50% violation. This means that 100%-50% of the minimum vertical separation was violated (min. vertical separation is 1000 ft).

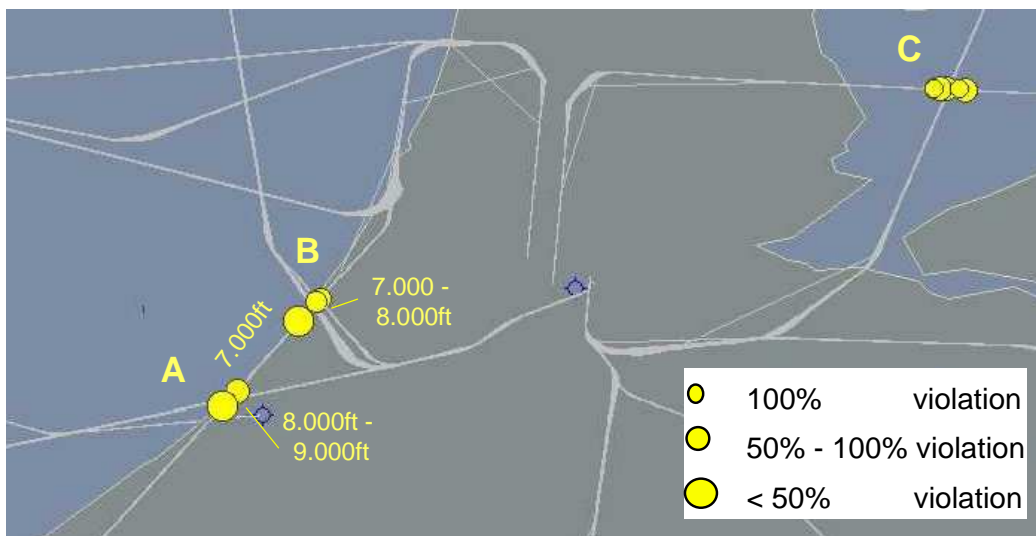


Figure 6-16: Nominal Vectoring trajectories

Figure 6-17 shows the conflicts between SIDs and STARs for the vectoring trajectory. The STARs from RIVER and SUGOL are relatively close to Schiphol. For Westbound departing aircraft, the amount of trackmiles available to reach an altitude of 8000ft will be significantly less than the RNAV trajectory. Figure 6-16 shows several more conflicts in comparison with the RNAV trajectory (figure 6-15). The situation is getting serious within the vectoring trajectory. In this case several conflicts reported a violation less than 50% of the tolerable vertical separation (vertical separation between aircraft should not exceed below 1000ft).

With the obtained results the following can be stated:

- The more the RIVER STAR is displaced to the West, the less conflicts seems to occur between the RIVER STAR and Westbound SIDs.

Therefore, in translation to Schiphols' actual situation the following can be stated:

- As the departures seems to be able to reach a safe altitude, the current "60/70 rule" might be abolished if the RIVER RNAV trajectory ensures that aircraft will reach an altitude less than 7000ft at the points A and B (refer to figure 6-15, 16). In addition, this would be more efficient for departures, as they can climb continuously.

NOTE: The five aircraft types used inside the simulation were able to climb to a safe altitude (above 8000 ft). However, to explore the possibility to abolish the "60/70 rule" it is recommended to explore this option in detail with more aircraft types involved.



7. Conclusions

7.1. Conclusions

These conclusions describe the capacity and delay results of the various SII procedures. It should be emphasized that the increased flying time with various procedures (e.g. arrival procedure IV where aircraft are flying FAS from 7000ft) is not part of the calculated delay.

7.1.1. Arrival procedure II and V

The Sourdine II procedures II, V are affected by an increased arrival delay (Proc II 25%, Proc V 43%). 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. It would be clear that this would affect the arrival delay in a negative way.

7.1.2. Arrival procedure II-A

Because of the minor speed differences between the profiles within the Procedure II-A, the performance of this procedure will be in line with the baseline. The increase of arrival delay was 10%. Procedure II-A consists of arrival procedures, which includes generic speed constraints. The speed constraints were selected in such way that all aircraft were able to fly the profile (deduced from a generic CDA). Procedure II-A is for that reason quite similar to the baseline scenario.

7.1.3. Arrival procedure IV

Procedure IV has significant speed differences between the F50 and the MD11. In this procedure aircraft have to fly the FAS over the last 15NM. Because of the significant difference in FAS along this segment between the F50 and the MD11 (160kts – 100kts = 60kts!), the performance was reduced considerably. The increase of arrival delay in comparison with the baseline was 120%!

7.2. Final Conclusion

The intention of including the MD11 and the F50 within the Sourdine II procedures was because of the importance of the effect of fleetmix with respect to the results. A timetable that contains only three types of (Airbus) aircraft would provide optimistic results, and wrong conclusions might be taken. In order to prevent any uncertainties with respect to the results, two aircraft types (F50 & MD11) were added in order to represent the timetable with more aircraft types involved (the more aircraft types involved, the more realistic the scenario).

Afterwards, it can be stated that the various aircraft types were of great importance of this study. This study has shown that the distribution of a fleet mix will influence the performance of the ATM system significantly. A consistent fleet mix does provide positive performance effects of the ATM system, the less the aircraft type consistency (and therefore speed profile consistency as well), the more capacity problems will occur. With other words: the more the consistency of aircraft types occurs within a traffic flow, the less extra separation is required due to the speed differences. This statement is also funded by the analysis made for the A319 and A321. Both aircraft types provide more speed differences and thus more disturbances.

Referring to the Sourdine II procedures it can be stated that capacity can be maintained at a certain level by introducing speed constraints along the approach segment. However, the problem of different speed profiles related to different aircraft types should still be considered as a major problem. The reduction in capacity is a loss of peakhour capacity and therefore only of interest during peakhour operations.

7.3. Recommendation

Additional study on generic CDAs might be recommended.

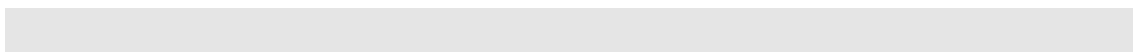
This study has shown that the introduction of CDAs results in extra arrival delay (as previously mentioned not take into account additional flying time within the various procedures) and a reduction of runway capacity (meaning loss of peakhour capacity and therefore only of interest once the demand exceeds the capacity). One of the reasons for this decrement of capacity and performance is caused by the extra separation required due to the speed differences between aircraft types. The speed differences between aircraft types can be considered as a major problem when introducing CDAs within a high traffic dense environment. The main recommendation of this study is to put effort in additional study and to find a solution for the speed differences problem between aircraft types.

Additional study might be recommended on the fleetmix variation. The study has shown that the number of aircraft types significant affect the results due to the differences between speed profiles. So, the more aircraft involved, the more speed profile differences. Within this study only a few aircraft types were involved, which does not represent the situation in realistic way. Further study might put the emphasis on a realistic fleetmix (e.g. approximately 15 aircraft types) in order to obtain more realistic results.

The lateral location of the inbound trajectories might be interesting as well for further analysis. For each aircraft speed segment, a separate STAR could be used, which ensures a consistent speed profile that results in no extra separation. For example a STAR for the turboprops, a second STAR for average speed segment aircraft types, and a third STAR for high-speed aircraft types. The *Slow* trajectory “compensates” the *Fast* trajectory due to the short amount of track miles. In this way the overall time required to fly each STAR will remain the same for each trajectory.

The three inbound STARs should be merged at the ILS if possible. It should be clear that the complexity of inbound STARs inside the TMA increases considerably.

Airborne Separation Assurance System (ASAS) spacing functionality (also called Station Keeping) could also be a potential enabler to maintain capacity, but this needs further investigation and is outside the scope of this study. The same counts for the downlink of aircraft performance data (e.g. 4D constraint points like EAT and ETA) using datalink applications.



Appendices

Appendix 1 Definitions used in the document

Airport Capacity:	The number of aircraft operations during a specified time corresponding to a tolerable level of average delay
Performance:	The number of aircraft operations during a specified time corresponding to the context in which the procedure was performed.
Arrival Delay:	Delay caused by sequencing measures inside TAAM (Holding, speed reductions) in fact this can be considered as the difference between STA and ATA.
Average Arrival delay:	Cumulative arrival delay divided by all inbound aircraft
Weighted average arrival delay:	Cumulative arrival delay divided by aircraft affect by arrival delay only
Departure delay:	Runway delay caused during the line-up process. Delay is basically caused by wake vortex separation, radar separation, SID/STAR conflicts

Appendix 2 Encountered problems during calibration

During the calibration process several problems were encountered. The problem encompasses the way TAAM calculates the arrival separation during the approach segment. TAAM calculates the approach separation based on the maximum of Wake-Vortex separation and radar separation, the radar separation is the separation set within the TMA (3 NM). So, with other words the radar separation will be met in any situation, but the separation will increase as different aircraft types are involved due to the wake vortexes. In this case the radar separation is set to 3 NM inside the TMA and 5 NM outside the TMA. The Wake-Vortex separation is different for each combination of aircraft. TAAM calculates the required wake-vortex separation at the final approach segment backwards and takes the final approach segment as a starting point. In case of all aircraft will have to comply with speed constraints along the approach segment (baseline scenario), the separation criteria can be met for all aircraft along the entire approach segment. This is because of the minor speed differences between aircraft types along the approach segment. For the proposed Sourdine II approach procedure, however, TAAM will have to cope with different speed profiles during the approach segment. In this case, TAAM does unfortunately, not meet the separation criteria at the approach segment. It is only able to comply with the separation at the final approach segment, as it was taken as starting point and was calculated backwards. It should be clear that separation should be maintained during the entire approach segment, in order to analyse the performance consequences of the proposed procedures.

Figures 8-1, 8-2 and 8-3 illustrate the problem.

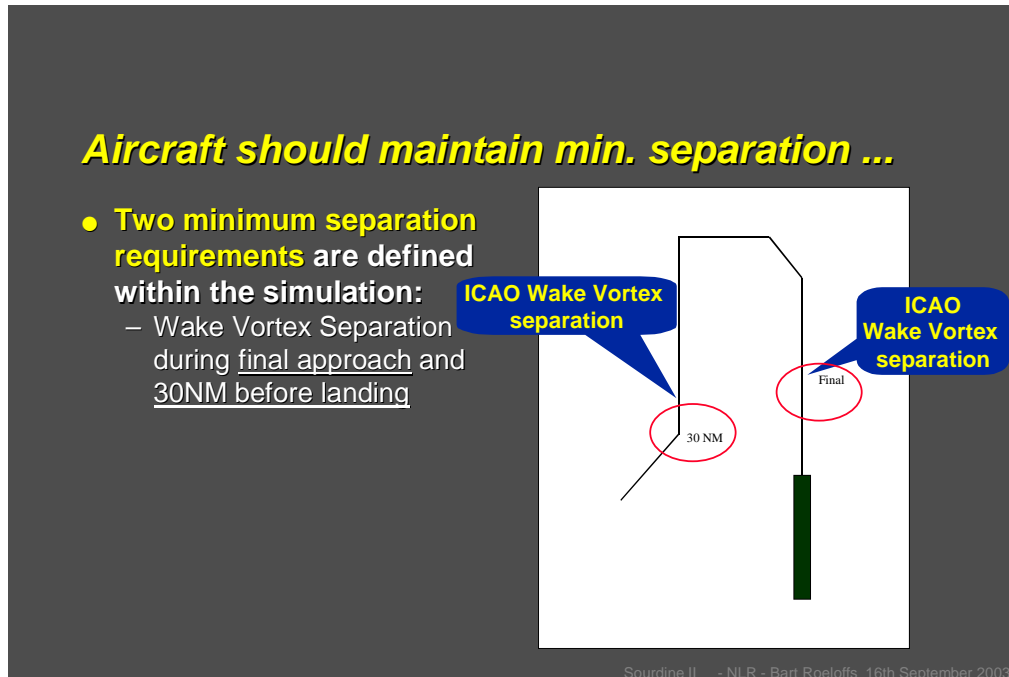


Figure 0-1: separation criteria at 30NM and final approach

Aircraft should maintain min. separation ...

- TAAAM maintains final approach separation (based on ICAO Wake Vortex) and calculates the previous desired separation (at 30nm) backwards.
- TAAAM takes the final approach separation (1) as starting point
- The separation at 30nm (2) is related to the speed differences between aircraft.

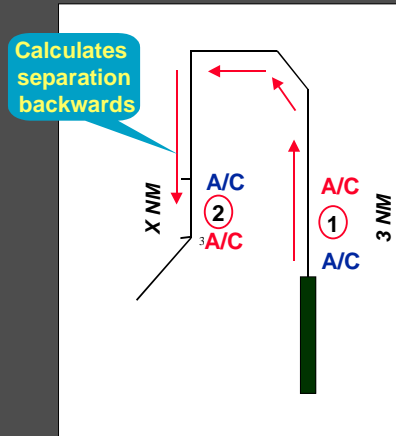
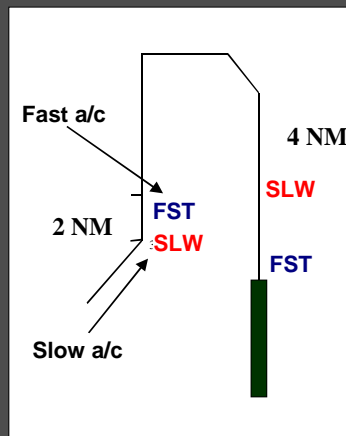


Figure 0-2: Separation methodology inside TAAAM

Separation problem ...

- Two minimum separation requirements are defined within the simulation:
 - Wake Vortex Separation during final approach and 30NM before landing
- The separation criteria is not met at 30NM when a slow aircraft follows a fast aircraft.



Sourdine II - NLR - Bart Roeloffs, 16th September 2003

Figure 0-3: Separation problem inside TAAAM

Calibrating desired separation based on the ‘work around’

In order to create a reliable environment in which the simulation can be performed, alternatives of the separation model should be found. The problem described within the previous sections can be tackled with a workaround, which will be described below.

The main question of the simulation is: how do the proposed Sourdine II procedures effect the overall ATM performance. The main requirement that encompasses this question is the separation criteria at 30NM and final approach. Due to the different speed profiles, TAAM was not able to cope with both separation criteria. The workaround will force TAAM to fly aircraft with the minimum desired separation at the entire approach segment.

By calculating the different flight time of each individual aircraft over the last 30NM, the separation differences at 30NM can be calculated. As already mentioned in the previous section, TAAM calculates the previous desired separation backwards and takes the wake-vortex separation at final approach as starting point. The figure below shows the calculation of the separation at 30NM before threshold between various aircraft combinations. The calculation is based on the flown flight time over the last 30NM.

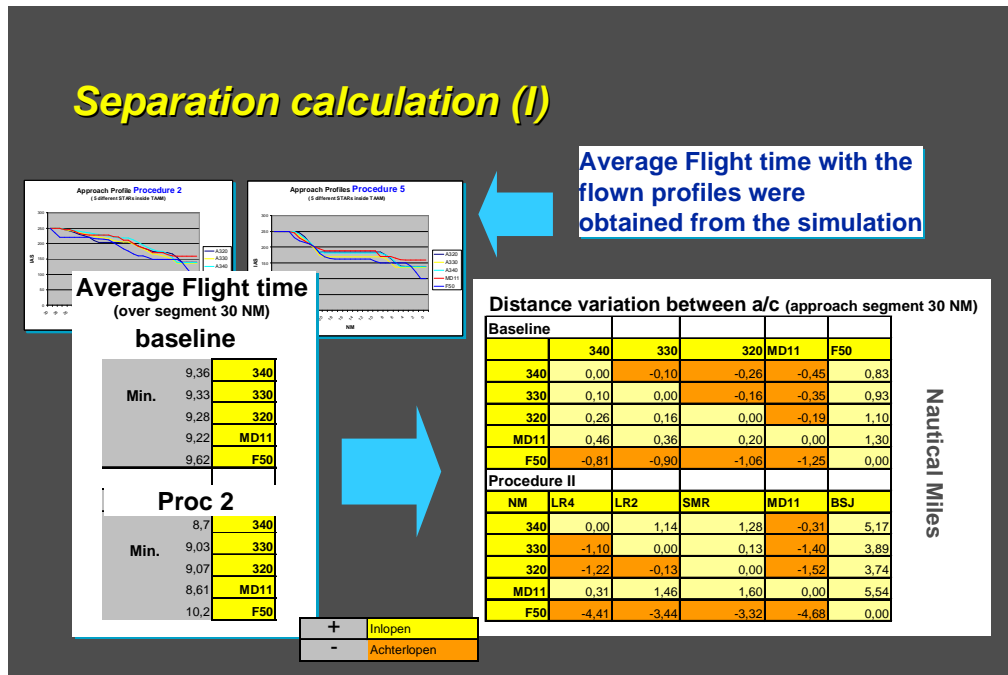


Figure 0-4: Work around Separation calculation

The next step is to determine whether aircraft are able to comply with the desired separation at 30NM. The following figure shows the calculation of the actual separation at 30NM, in fact, this is the way in which TAAM calculates the separation (backwards). The calculation takes into account the wake-vortex separation between aircraft, even at 30NM.

Based on air traffic controller’s expertise, it is assumed that wake-vortex separation will be maintained at 30NM before landing. Another option was to comply with the radar separation only (3NM).

Separation calculation (II)

ICAO W&V Sep. + Distance variation = Separation at 30 NM

ICAO Wake-Vortex Separation Min. (NM)					
NM	340	330	320	MD11	F50
340	4	4	3	4	3
330	4	4	3	4	3
320	5	5	3	5	3
MD11	4	4	3	4	3
F50	5	5	3	5	3



Distance variation between a/t (NM)					
Baseline	340	330	320	MD11	F50
340	0.00	-0.10	-0.20	-0.40	0.80
330	0.10	0.00	-0.10	-0.30	0.90
320	0.20	0.10	0.00	-0.10	1.10
MD11	0.40	0.30	0.20	0.00	1.30
F50	0.80	0.90	1.00	1.20	0.00
Procedure II					
NM	LR4	LR2	SMR	MD11	BSJ
340	0.00	1.14	1.20	-0.30	5.17
330	-1.10	0.00	0.10	-1.40	3.80
320	-1.20	-0.10	0.00	-1.50	3.70
MD11	0.90	1.40	1.60	0.00	5.50
F50	-4.40	-3.40	-3.30	-4.60	0.00

Separation at 30 NM (NM)					
Baseline	340	330	320	MD11	F50
340	4.00	3.90	2.74	3.55	3.83
330	4.10	4.00	2.84	3.65	3.93
320	5.26	5.16	3.00	4.81	4.10
MD11	4.46	4.36	3.20	4.00	4.30
F50	4.19	4.10	1.94	3.75	3.00
Procedure II					
NM	340	330	320	MD11	F50
340	4.00	5.14	4.28	3.69	8.17
330	2.90	4.00	3.13	2.60	6.89
320	3.78	4.87	3.00	3.48	6.74
MD11	4.31	5.46	4.60	4.00	8.54
F50	0.59	1.56	-0.32	0.32	3.00

Figure 0-5: Work around Separation calculation II

For each aircraft combination separation at 30NM is calculated. The table "separation at 30NM" shows a trend with respect to fast & slow aircraft and slow & fast aircraft.

Figure 8-6 shows a situation in which a *slow* aircraft follows a *fast* aircraft. The separation at final approach is met, but unfortunately at 30NM the separation is seriously been violated.

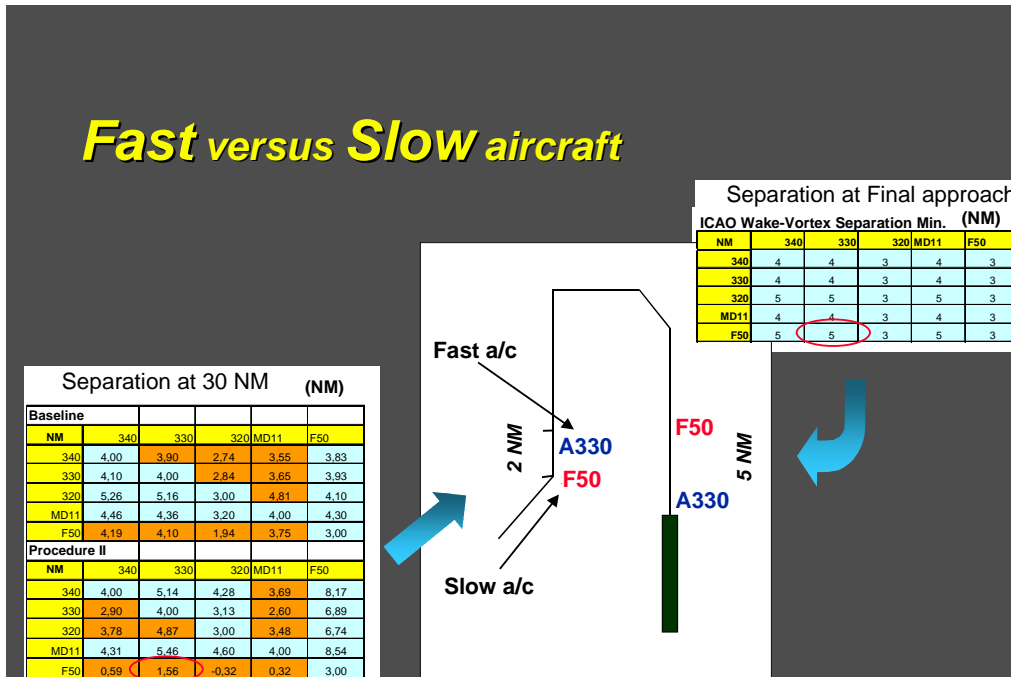


Figure 0-6: Effect Fast vs Slow aircraft

If a *fast* aircraft will lead a *slow* aircraft, the minimum separation criteria can be met. Figure 8-7 below shows this situation.

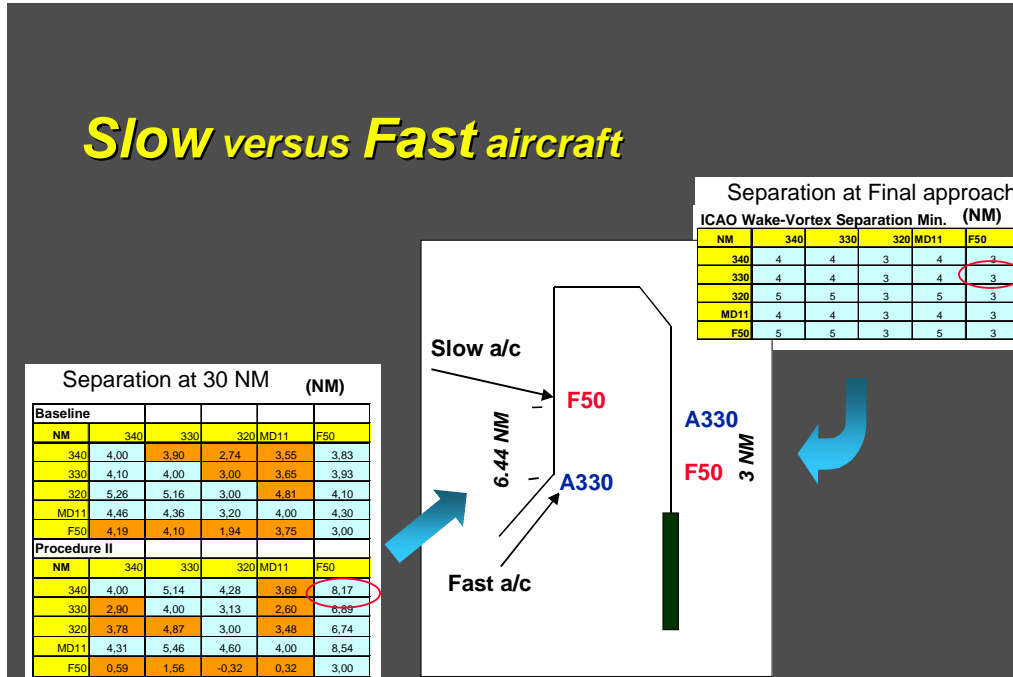


Figure 0-7: Effect Slow vs Fast aircraft

The work around which have to be generated will be based on the 'orange highlighted' separations shown in the table within figure 8-8. In order to force aircraft to fly the desired minimum separation at 30NM, the differences between the actual separation and the Wake-Vortex required separation will be determined and added to the wake-vortex separation which is valid for specific aircraft combinations. The figure below shows an example of the calculation for the A330 and the F50. The calculated arrival separations were implemented inside TAAM within the "arrival separation rules".

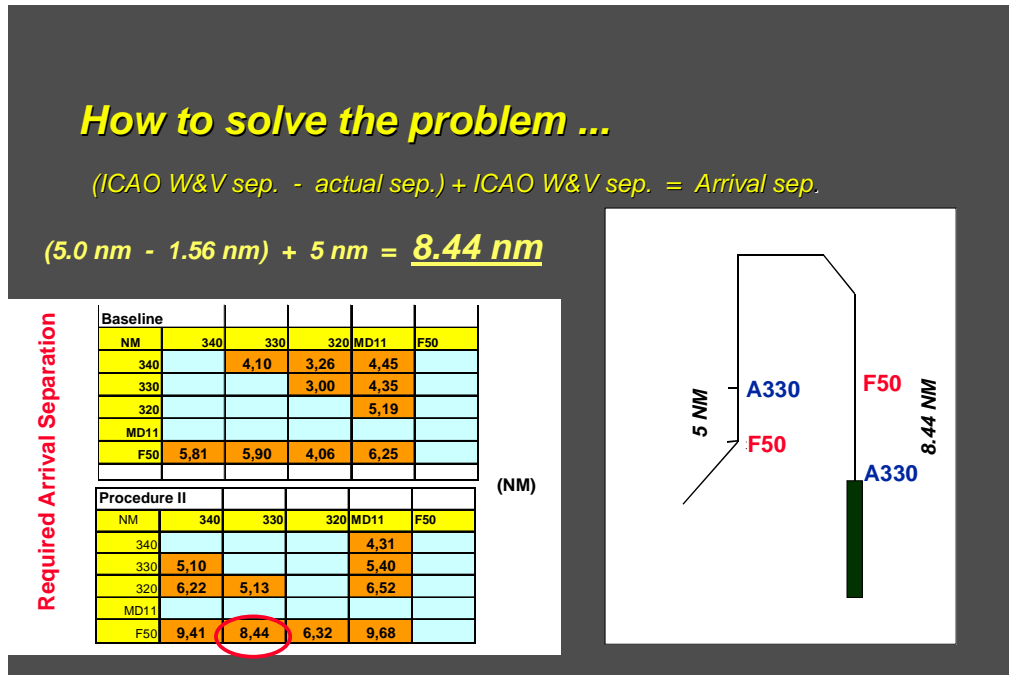


Figure 0-8: Work around

Appendix 3 TAAM model settings

TAAM model parameters

TAAM model parameters and setting were discussed during several consortium meetings. The following settings within TAAM were used:

TAAM settings

- General scenario parameters
 - Conflict detection: Enabled
 - Aircraft performance randomization: disabled
 - In trail separation: disabled
 - Airspace Rules: Disabled
 - Holding Stack Rules: Disabled
 - Flow management: Disabled
 - Conflict resolution: Disabled
 - Wind and weather modeling: Disabled
 - Radar airspace: Enabled
 - Gates and taxiways or other ground structures: Disabled

- Departure separation and sequencing
 - Holding preference: 100% airborne
 - Is Wake turbulence calculation on the basis of track distance used: Enabled
 - Airborne conflict checking on departures: Enabled; Except for overflights
 - Conflict look ahead time (ghost): Enabled
 - Delay time when an airborne conflict is detected? (30s)
 - Departure sequence optimization: limited

- Arrival Sequencing
 - Sequencing Method: Flexible ETA (Resequencing not Allowed)
 - Sequencing Thresholds:
 - i. Based on? Distance Max
 - ii. Landing Queue Threshold? (130nm)
 - iii. Sequencing Action Threshold? (80nm)
 - iv. Fixed Sequence Threshold? (10nm)
 - SIMOPS (Land and Hold Short Operations – LAHSO): Disabled
 - DOGLEGS: Disabled

- Allow Overtaking on STARS? Disabled

- Intrail and flow control
 - Intrail separation with overflights: Disabled
 - Intrail separation beyond top of descent: Enabled
 - How much is target flow rate into the airport 40 movements
 - Is Flow reassessed? NO If yes, How many time is between every reassessment?
 - Full Speed control on cruise: Enabled

- Flight trajectory parameters
 - Are Speed and altitude constraints enforced? No?
 - Is Climbing between waypoints allowed? Yes
 - Is attempted Gradual descent allowed? Yes
 - Could Descent rate be reduced below normal rate No
 - Specify percentage of minimum climb rate is in relation to normal climb rate. (75%)
 - Are speed limits ignored in level bands? No
 - Descent immediately: on

- Sector Parameters
 - Radar separation for Departures Sectors? (3 NM)
 - Radar separation for Arrival Sectors? (3 NM)
 - Radar separation for Final Approach Sectors? (3 NM)
 - Capacity of the sectors? Unlimited
 - The maximum number of aircraft holding? unlimited
 - Are conflicts checked in the sector? Yes (does not affect simulation)
 - Could the sector handle unlimited number of conflicts? Yes

Appendix 4 Operational Description of the Baseline Scenario

The baseline scenario was deduced from the actual situation at Schiphol. Procedures, which are effective during day period, were used as much as possible. In order to make the baseline comparable with the Sourdine II scenarios, RNAV routes were used in the baseline scenario as well. In reality, RNAV routes are effective during night period only. No tromboning or down wind leg extension was used during the simulation, the trajectories are all fixed.

The area that will be taken into consideration for the simulation is located inside the TMA. The approach segment in which the aircraft will have to fly the specific approach procedures will be 30 NM. From RIVER or SUGOL, the 30NM point is established at a 15NM radius from Schiphol. From this point aircraft will have to fly 220kts. This point is considered as the first speed constraint of a series of 4 constraints.

Speed constraint # 1: 250kts at Stack and until 30 NM

Speed constraint # 2: 220kts at 30NM

Speed constraint # 3: 180kts at ILS intercept

Speed constraint # 4: 160kts at Outer Marker (OM).

The vertical approach profile is based on a 3000 ft level segment which starts at approximately 5 NM before ILS intercept. Figure 8-9 shows the actual situation at Schiphol. It contains the speed constraint of 250kts at the stacks and the 220kt at 15NM radius from Schiphol. The other speed constraints were deduced from air traffic controller's experiences and approach procedures published inside AIP the Netherlands.

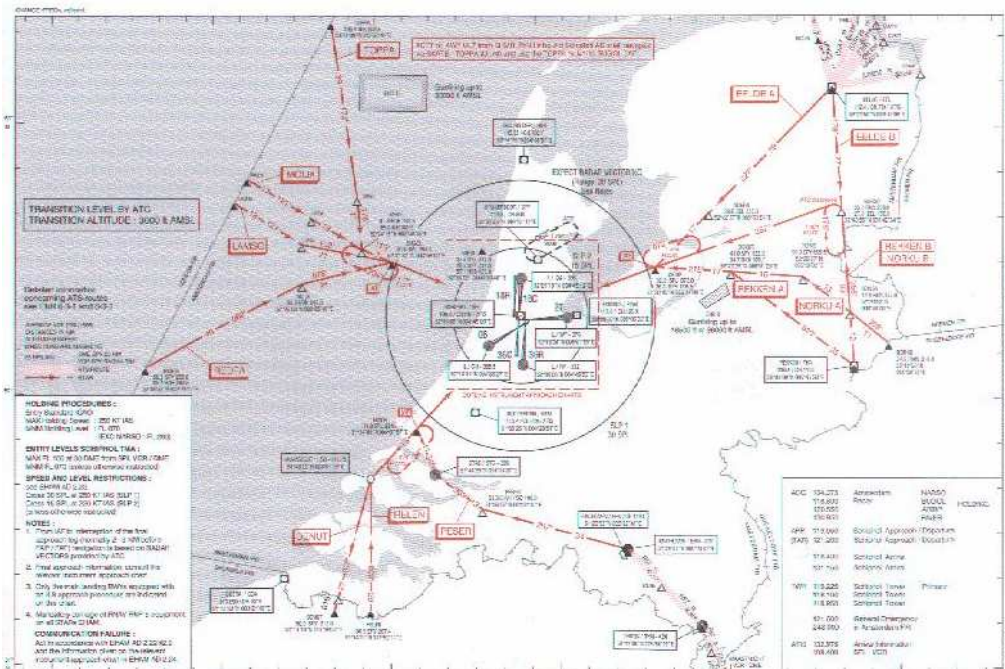


Figure 0-9: Dutch airspace

Approach procedure

The vertical approach profile is based on a 3000-ft level segment, which starts approximately 5 NM before ILS intercept.

Specification of Baseline scenario:

Condition	Parameter values
7000 ft (Fixed height)	<ul style="list-style-type: none"> - Idle thrust - Speed 250 KTS CAS - Clean Configuration - Landing Gear up - Constant CAS descent
3000 ft (Fixed height)	<ul style="list-style-type: none"> - Level flight - Decelerate to intermediate flap speed - Change to intermediate configuration
	<ul style="list-style-type: none"> - Fixed descent angle of 3°. - Change to Configuration FULL, Landing Gear down at CONF3 - Decelerate to FAS
Landing configuration and speed reached (Resulting height, minimum 1000ft)	<ul style="list-style-type: none"> - Adapted Thrust for descent at 3° - Constant speed (FAS) descent to 50ft

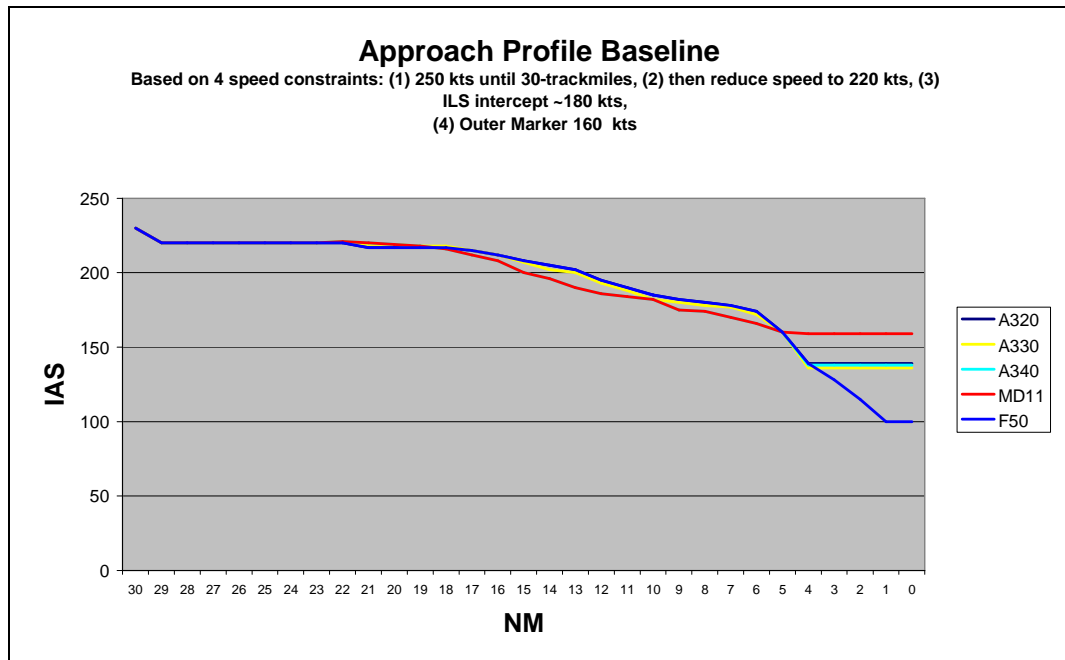


Figure 0-10: Baseline speed profiles

Appendix 5 Operational Description of S-II procedures

Sourdine II procedures will be simulated under the same conditions as the baseline. The lateral tracks, runway combination and the traffic used in the baseline will also be used in the Sourdine II scenarios. The approach procedures, however, will significantly deviate from the baseline. As mentioned in previous chapters, the Sourdine II procedures contain specific speed profiles for each aircraft type. It is expected that the speed differences between aircraft will affect the ATM performance because of the extended separation needed due to the speed differences.

The main difference between the Sourdine II scenarios and the baseline is the sub-set of proposed approach procedures and the revised calculated arrival separation between aircraft during the approach segment (refer to chapter calibration)

In addition it should be noted that the speed constraints used in the baseline are not effective within the Sourdine II procedures. This should also be considered as a main difference between baseline and Sourdine II scenario. Within the Sourdine II scenarios aircraft are “free” to select a specific approach speed during the approach segment, within the baseline all aircraft have to proceed a specific pre-determined speed profile based on 4 different speed constraints.

The following figures illustrate the different procedures used within the Sourdine II scenarios.

The procedures are deduced from SEDITEC data.

Appendix 5.1 Procedure II

Sourdine II procedure II can be considered as a basic CDA approach with a 2 degrees descent path until the ILS. The ILS intercepting altitude will be 3000 ft and the ILS path 3 degrees. The figure below shows the speed profiles of the 5 aircraft types involved. The speed profiles of the A320, A330 and the A340 are deduced from SEDITEC data. The profiles of the F50 and the MD11 were changed. The profiles are based on the A320 (F50) and the A340 (MD11), but using the F50 (100KTS) and MD11 (160KTS) FAS values.

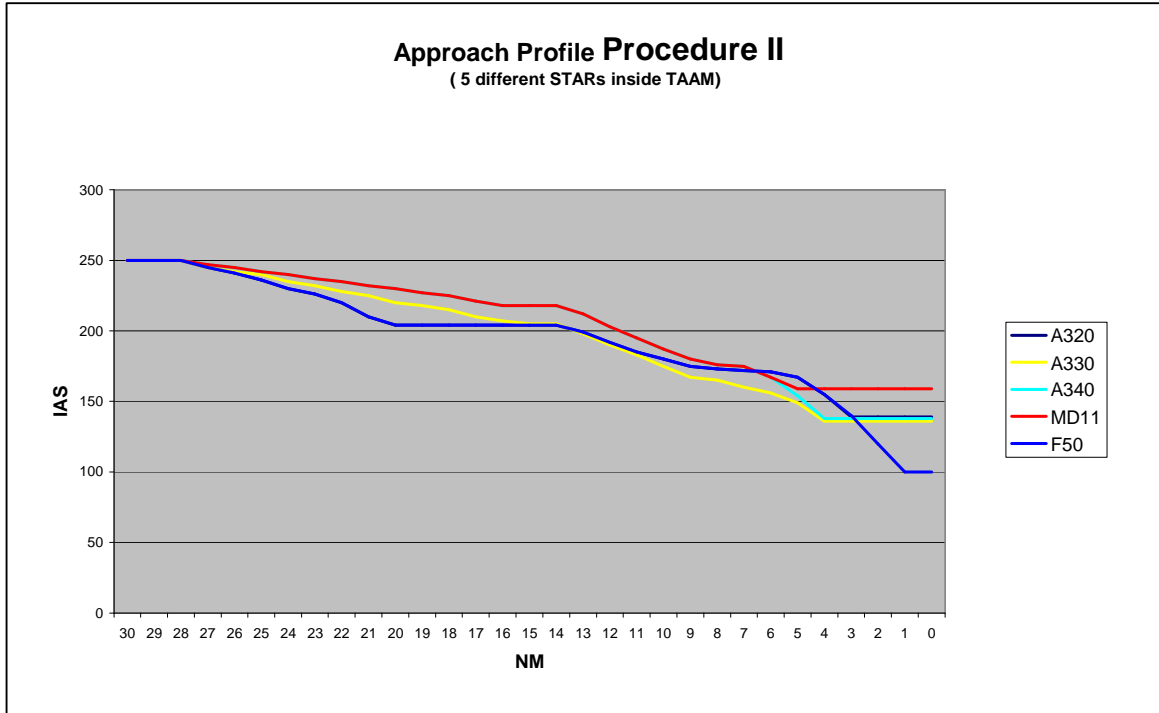


Figure 0-11: Procedure II speed profiles

Appendix 5.2 Procedure II-A

Sourdine II Procedure II-A can be considered as procedure II with several speed constraints involved. As mentioned earlier the main problem with CDAs is the speed difference between aircraft types during the approach segment and the required separation. Within procedure II-A, a consensus was reached between Sourdine II procedure II and the baseline scenario (the baseline scenario has 4 different generic speed constraints involved). The aim was to generate an 'average' speed profile that could be flown by all aircraft involved. In fact this could be considered as a generic CDA effective for all aircraft.

NOTE: due to the simplified fleetmix (5 aircraft types only), a 'generic CDA' was easy to create in this simulation. It should be clear that this would not be the case when more aircraft types will be part of the simulation due to different performances of aircraft types.

In addition, this procedure was taken into consideration during real time simulation (RTS).

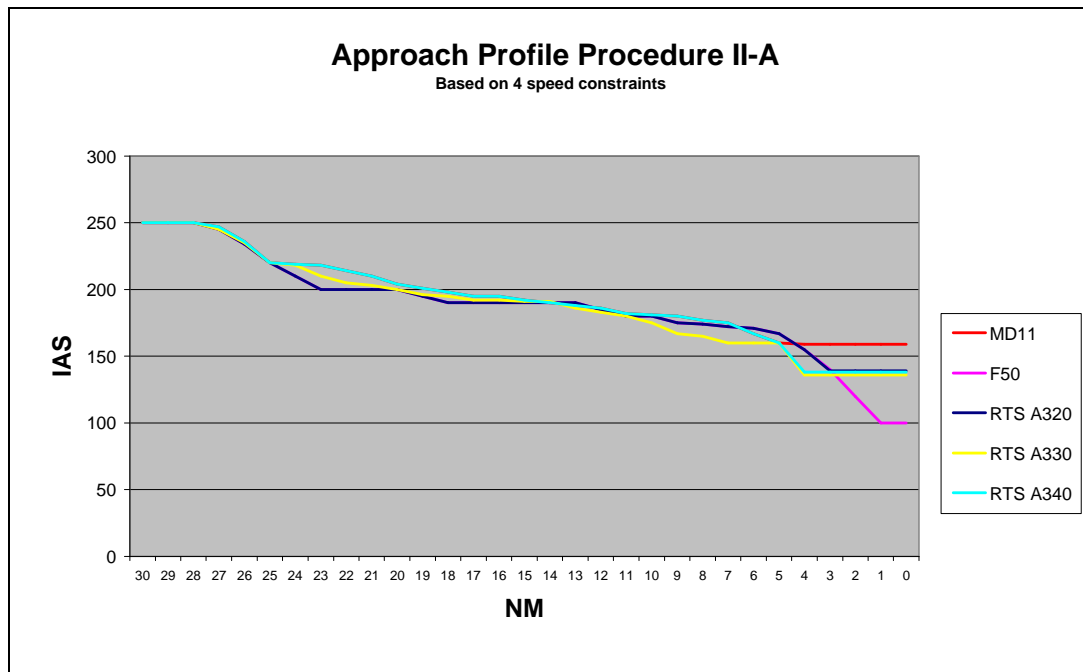


Figure 0-12: Procedure II-A speed profiles

Appendix 5.3 Procedure IV

Sourdine II Procedure IV can be considered as the most ambitious Sourdine II procedure. It is expected that the noise benefit would be significant, but the capacity and performance figures might show disappointing results. Within Procedure IV aircraft are allowed to descend with constant Vref (FAS). This speed will be reached soon after the aircraft commence to descent from 7000ft to 2000ft. The figure below shows that aircraft will have to fly the Vref along the last 15NM. It would be clear that due to the different FAS used for each aircraft type the capacity would drop significantly.

The speed profiles of the A320, A330 and the A340 are deduced from SEDITEC data. The profiles of the F50 and the MD11 were changed. The profiles are based on the A320 (F50) and the A340 (MD11), but using the F50 (100KTS) and MD11 (160KTS) FAS values. The F50 will only reach the FAS of 100kts after approximately 12NM before threshold because of the extended deceleration.

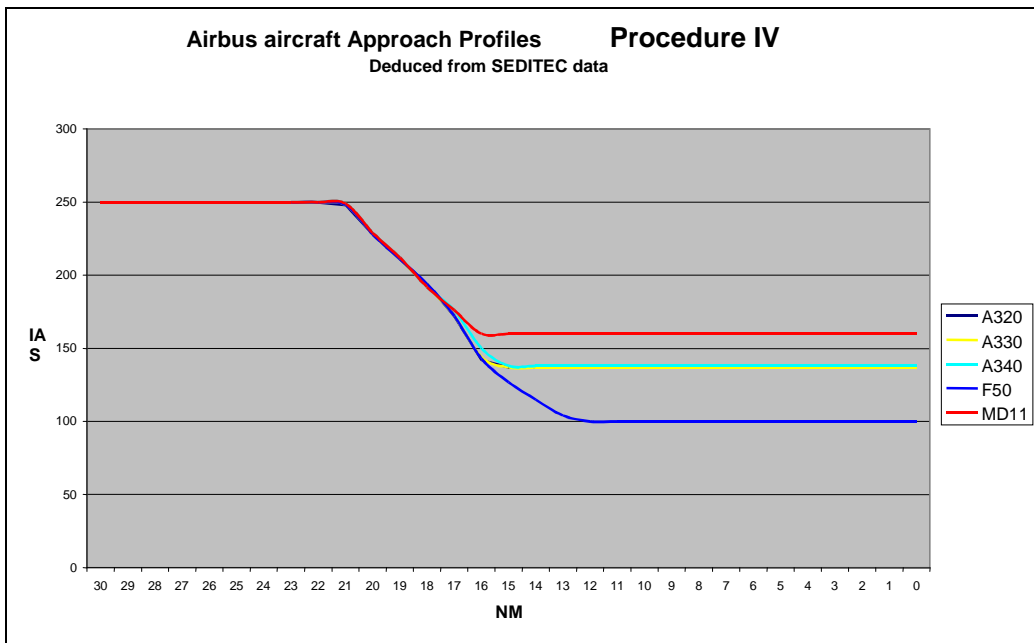


Figure 0-13: Procedure IV speed profiles

Appendix 5.4 Procedure V

Procedure V is also based on a constant speed segment during descent. The entire descending path will be 3 degrees. Also, in this simulation the speed profiles of the A320, A330 and the A340 are deduced from SEDITEC data. The profiles of the F50 and the MD11 were changed. The profiles are based on the A320 (F50) and the A340 (MD11), but using the F50 (100KTS) and MD11 (160KTS) FAS values.

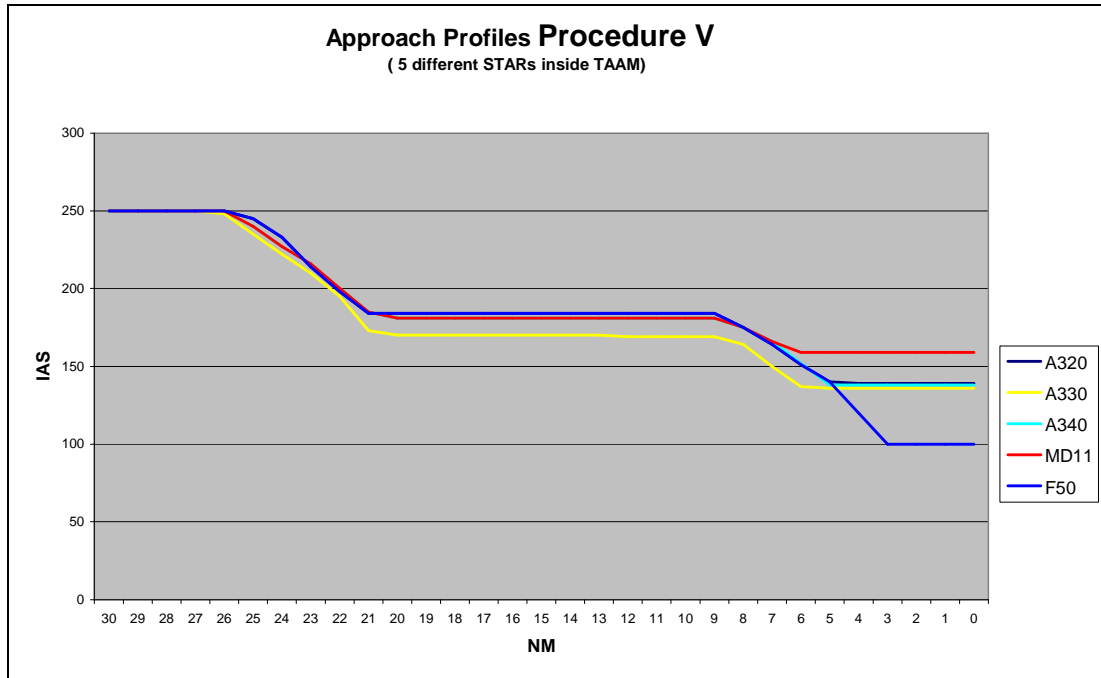


Figure 0-14: Procedure V speed profiles