EUROPEAN COMMUNITY

COMPETITIVE AND SUSTAINABLE
GROWTH PROGRAMME

SOURDINE II

D6-1
Prototyping results ATC simulator

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

Sourdine II Consortium:

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

Document Change Log

Release	Author	Affected Sections / Comments	Document Nature	Date
0.1	NLR	All, Creation	Confidential	27/11/03
0.2	NLR	-	Confidential	30/01/04
0.3	NLR	-	Confidential	25/08/04
0.4	NLR	Version available for review	Confidential	13/10/04
0.5	NLR	Comments from SICTA and AENA incorporated	Confidential	22/11/04
0.6	NLR	Internal review	Confidential	04/03/05
1.0	NLR	Final version	Confidential	17/05/05
2.0	NLR	Inclusion of EC approval	Public	01/09/05

Document Distribution

Partner	Distribution list
AENA	Pablo Sánchez Escalonilla Alfredo Gomez de Segura
Airbus France	Michel van Boven
Eurocontrol Experimental Centre	Peter Hullah Laurent Cavadini
Ineco	Peter Lubrani
Isdefe	Marcos Esteban Medina
NLR	Ruud Den Boer Collin Beers
SICTA	Mariacarmela Supino

Review and Approval of the Document

Organisation Responsible for Review	Reference of comment documents	Date
AENA	E-mail	19/11/04
Organisation Responsible for Approval	**Name of person approving the document**	**Date**
Project Manager	Ruud den Boer	June 2005
Work Package Leader	Collin Beers	June 2005
EC Official	Morten Jensen	July 2005

Document Information	
Document title	Prototyping results ATC simulator
Version	V2.0
Date	01/09/05
Classification	Public
Work package	WP6.1
Document identification	SII_D6-1_ATC_prototype_results_v20.doc

Contributing Partners	Authors
NLR	E.S. Hartlieb, hartlieb@nlr.nl, +31-20-5113119 C.S. Beers, csbeers@nlr.nl, +31-20-5113173

Contact Information
National Aerospace Laboratory, NLR
Attn. Mr. C.S. Beers
Anthony Fokkerweg 2
1059 CM Amsterdam
The Netherlands
Tel.: +31-20-5113173
Fax: +31-20-5113210 e-mail: csbeers@nlr.nl

Summary

In the preparation phase for the Sourdine II experiments, a number of prototyping sessions have been conducted. During these sessions, a number of ATC Approach controllers and pseudo-pilots participated. The objective of these prototyping sessions was to gain feedback on the following aspects of the experiment:

1. Procedures and controller tasks: Is the controller able to work with the procedures as provided, or are some (minor) adjustments required in order to make them more workable?
2. Controller support tools: Do the support tools help the controller in executing his task, and how can they be improved?
3. Simulation set-up: Does the simulation environment represent the real life working environment of an controller?

During the prototyping sessions, the controller was participating in a small scale experiment, where the controller was actually applying the Sourdine II procedures and using the system as developed.

After each prototyping session, the results were discussed and some system adaptations were incorporated into the simulator. During the next prototyping session these changes were evaluated by a different controller. Although some modifications to the Sourdine II procedures were incorporated in order to create a better working environment for the controller, the basic ideas behind the Sourdine II procedures was kept as originally designed.

Table of Contents

Figures

1 Introduction

1.1 Purpose

In the preparation phase, prior to the ATC simulations, a number of prototyping sessions were conducted. The objectives of these sessions were to gather an early insight in the functioning of the simulation in the Sourdine II set-up, as well as to get some controller feedback concerning the Sourdine II procedures. From these prototyping sessions, the set-up of the simulator has been improved, ironing out any wrinkles that may distract the controller from doing his task.

1.2 Background

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

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

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

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

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

1.3 Document Structure

This document contains seven sections and two appendixes that includes additional information and specifications:

- Section 1 presents a brief introduction that includes the document purpose, the project background, the document structure, as well as the definition of the terms and the description of the referenced documents used in this document.
- Section 2 discusses the objectives of the prototyping sessions and the questions that need to be answered during these sessions.
- Section 3 describes the environment in which the prototyping sessions have been conducted.
- Section 4 describes the choices made during preparation phase, as well as a detailed description of the various elements of the simulator.
- Section 5 describes the various measurements that will be taken during the prototyping sessions.
- Section 6 describes the results of the prototyping sessions and the adaptations to the system due to these results. In addition, this section shows the schedule of the prototyping sessions.

- Section 7 contains the main conclusions and recommendations derived from the prototyping sessions.

Finally, the appendixes include the procedures used during the prototyping sessions and the changes made to NARSIM simulator during SOURDINE II

1.4 Glossary

Term	Description
AAA	Amsterdam Advanced ATC system
ACC	Area Control Centre
ACL	ATC clearances
AMAN	Arrival Manager
APP	Approach Control
ARR	Arrival Control
ATC	Air Traffic Control
ATCo	Air Traffic Controller
ATIS	Automated Terminal Information Services
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Service / Air Traffic Server
CDA	Continuous Descent Approach
CM	Context Management
DCL	Departure Clearance
DLIC	Datalink Initiation Capability
EFL	Executive Flight Level
ETO	Estimated Time Over
FAF	Final Approach Fix
FAP	Final Approach Point
FAS	Final Approach Speed
FIR	Flight Information Region
FL	Flight Level
FLIPCY	Flight Plan Consistency check
FPA	Flight Path Angle
FPM	Flight Path Monitoring
IAF	Initial Approach Fix
IAS	Indicated Airspeed
ICD	Increase drag coefficient
IFP	Initial Flight Plan
ILS	Instrument Landing System
ISA	Instantaneous Self Assessment
KTS	Knots
LNAV	Lateral Navigation
LVNL	Luchtverkeersleiding Nederland ATC The Netherlands
MONA	Monitoring Aid
NAP	Noise Abatement Procedure
NARSIM	NLR ATC Research Simulator
NDLS	NARSIM Datalink Server
NLR	Nationaal Lucht- en Ruimtevaartlaboratorium National Aerospace Laboratory
NM	Nautical Mile

Term	Description
NTZ	No Transgression Zone
PTC	Pre-Taxi Co-ordination
PVD	Primary View Display
RNAV	Area Navigation
R/T	Radio Telephony
RWY	Runway
SID	Standard Instrument Departure
SOURDINE	Study of optimisation procedures for decreasing the impact of noise
STCA	Short Term Conflict Alert
TMA	Terminal Control Area
TOD	Top Of Descent
TOGA	Take-off / Go-around
VNAV	Vertical Navigation
VOR	Very High Frequency Omni-directional Range
WPT	Way point

1.5 Reference documents

Short Reference	Description
[TA]	SII Technical Annex.
[D2-1]	D2-1: Validation Methodology Report, version 0.9
[D3-1-2]	Updated Definition of New Noise Abatement Procedures
[D3-2]	Requirements document for the pilot and controller tools
[D6-2]	D6-2: Prototyping results flight simulator
[D6-6]	D6-6: Concept of operation for Schiphol airport simulations

2 Objectives of the prototyping

The main objective of the prototyping sessions was to gain controller feedback on the SII operational concept, the ATC support tools and to validate the preparation of the NLR ATC Research Simulator (NARSIM). Using the results of these prototyping sessions, the set-up of NARSIM itself, as well as the experiment were gradually improved, in order to prepare for a realistic full-scale experiment.

The following questions should be answered during the prototyping sessions:

Procedures and controller tasks:

- Is the controller able to work with the Sourdine II procedures, without compromising safety?
- What (minor) adaptations to the procedures would make them more eligible for future implementation?
- Are the designed R/T communications workable in these procedures?

Controller support tools

- Are the tools developed in the project helpful to the controller need in order to maintain the maximum level of safety? How can they be improved? Are there any additional tools required/desired?
- What modifications to the ATCO display (e.g., additional markers) are required in order to assist the controller in getting a clear picture of the traffic situation and the intentions of the aircraft?

Simulator set-up

- Does the designed simulation set-up provide the optimal working environment for controllers and pseudo-pilots in order to get the best results from the full experiments?
- As it is assumed that the controllers will have a system, which is very similar to the present-day operational ATC system, the NARSIM displays and functionality must also match that of the operational AAA system as much as possible. During these prototyping sessions this is also verified.
- Is the traffic flow realistic for the timeframe under investigation, regarding number of aircraft and distribution in time and space?
- Is the aircraft behaviour representative for real-life traffic?
- Is the pseudo-pilot able to handle the amount of traffic? What additional tools would he/she require?

During the prototyping sessions, the controller is participating in a small scale experiments, where he is actually using the system as developed, and is working according to the Sourdine II procedures.

After each prototyping session, the results will be discussed, and some comments will be incorporated into the simulation set-up. During the next prototyping session different controllers will evaluate these updates.

3 Prototype environment

This section describes the overall set-up of the NARSIM ATC simulator for the Sourdine II prototyping sessions.

3.1 Controller working positions

The SII exercises will always contain two arrival runways, one of which will be actively controlled and one which will be used for automatic landing aircraft. This allows for the investigation of parallel approaches on the workload of the arrival controller, without the use of a second arrival controller. Traffic on the adjacent runway will not be controlled by an arrival controller, but will be fully scripted.
In line with current practices by Dutch ATC, each arrival runway requires one arrival controller. During peak hours (which SII will focus on) each arrival controller is paired with a feeder/departure controller. The feeder/DCO controller is responsible for the merging of the two inbound traffic flows as well as the departures, and the arrival controller will be responsible for sequencing the aircraft onto the ILS glideslope, where he/she will hand over control to the tower controllers.

It is foreseen that the inbound traffic will be initiated just outside the TMA, and is handed over to the TMA controller conflict-free and in a realistic manner to the feeder/departure controller. Traffic-flow will be such, that it will not be required to have any aircraft enter the holding at the IAF.

The arrival and feeder/departure controller will both have a radar display (2k x 2k) Controller Working Position (CWP). Consequently, two NARSIM CWPs are used for one controlled runway. Additionally, Area Control Centre (ACC) controllers and stack controllers can be included. The prototyping sessions will indicate if this will improve realism of the simulation.

Figure 1 shows the display layout of the radar screen. In reality, the colour schematic of the radar display is green on a black background.

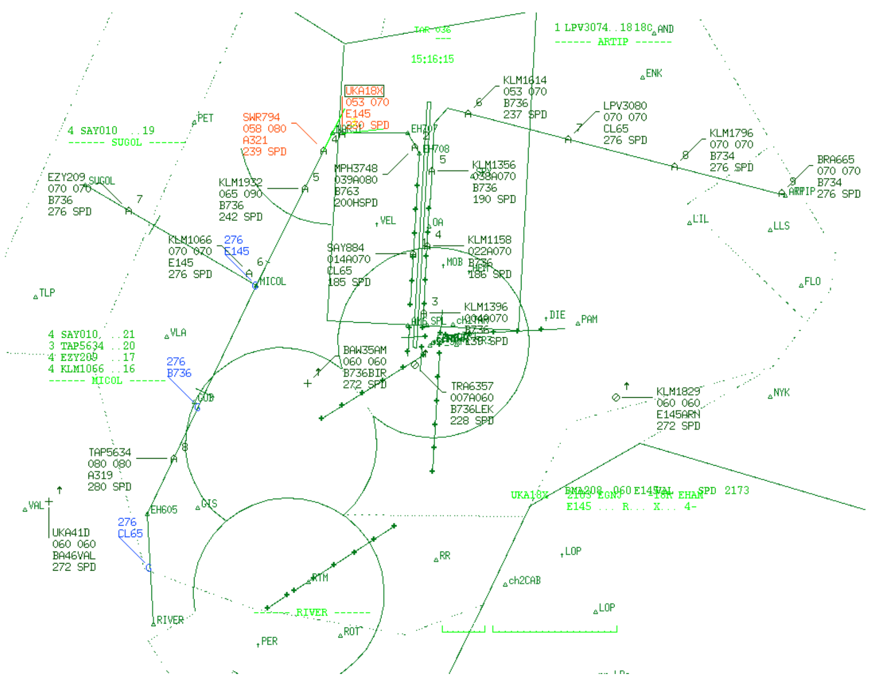

Figure 1: Radar display

Due to the pseudo-pilot's workload and aircraft frequencies each arrival and feeder controller will be communicating with at least one pseudo-pilot. As the ACC and stack controllers are not under investigation in the Sourdine II project, they will not make use pseudo-pilots. The aircraft are controlled by means of automated scripts, guiding the aircraft until taken under control of a controller. Hence, two pseudo pilots are needed. Each pseudo-pilot will be using dual 1K monitor position.

During the prototyping sessions, only feeder/DCO and arrival controller positions will be used. The inbound aircraft stream will be defined off-line, prior to the experiments. During the prototyping sessions it needs to be identified whether this traffic-flow is realistic, or ACC and stack controllers are required.

3.2 Pseudo-pilot working positions

As stated earlier, a pseudo-pilot is responsible for all traffic on a single frequency and therefore handles a specific section of the airspace. In case of a heavy traffic load, an additional position can be added to that frequency. In the Sourdine II experiment set-up, both the arrival and Feeder/DCO controller will each have one pseudo-pilot.

A pseudo-pilot is equipped with two 18" LCD displays: one showing a radar display, similar to the one of the controller, and one providing a means to enter clearances and retrieve information concerning the actual state of the aircraft. An example of this display is shown below (figure 2).

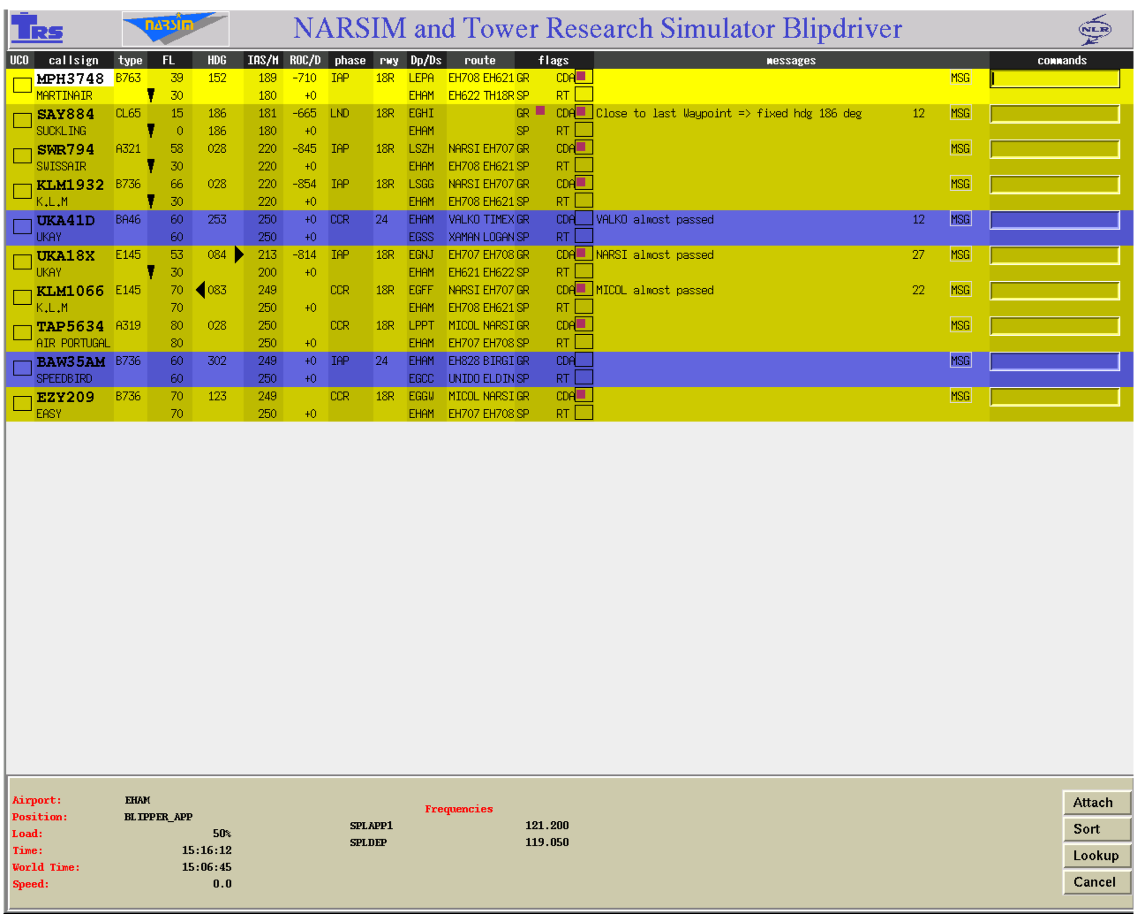

Figure 2: Pseudo-pilot working position

3.3 Room layout

During a simulation, every tactical controller will communicate using his own R/T frequency.
For every frequency in use during a simulation, one or more pseudo-pilots are required. A pilot cannot handle multiple frequencies simultaneously. For the Sourdine II experiments, it is envisaged to have two approach controllers: one arrival and one feeder/departure controller and one arrival and one feeder/departure pseudo-pilot. Additionally two pseudo-pilot positions can be added in case of heavy traffic load. Finally a supervisor position is available, from which the experiment leader can control the experiment (see figure 3).

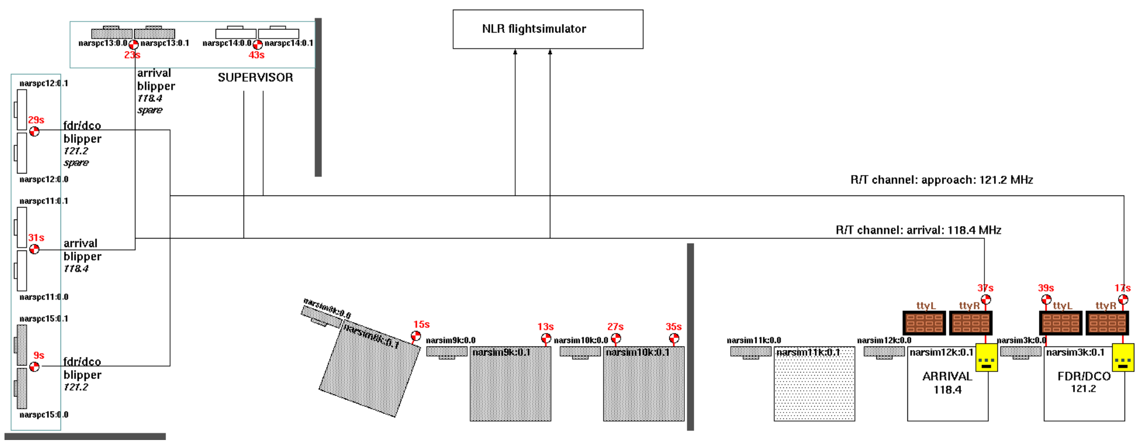

Figure 3: NARSIM room layout

4 Simulator Set Up

This section describes the system set-up of the NARSIM simulator. First the rationales behind some decisions will be discussed in section 4.1. The standard components, which are always required in a simulation, will be described in section 4.2. The required adaptations will also be described which have been done in order to meet the Sourdine II requirements. The next section (4.3) describes new components developed for the Sourdine II project.

4.1 Procedural choices/rationales

This section describes the choices that have been made at the start of the preparations for the full Sourdine II experiments.

Procedures to be validated during Real Time simulation

By the Sourdine II project the following low noise approach procedures have been developed:

Procedure I - Baseline: conform present day operations, level interception of ILS at 3000ft.

Procedure II - CDA, with 2^o flight path angle, idle thrust, until ILS capture at 3000ft. Follow ILS glidepath of 3^o

Procedure III - CDA, with 2^o flight path angle, idle thrust, until ILS capture at 3000ft. Follow ILS glidepath of 4^o

Procedure IV - CDA, with variable flight path angle. Start descent with full flaps, gear down, final approach speed, idle thrust. Intercept ILS at 3000ft; Follow ILS glidepath of 3^o

Procedure V - CDA, with variable flight path angle. Start descent with intermediate flaps, gear up, intermediate approach speed, idle thrust. Intercept ILS at 3000ft; Follow ILS glidepath of 3^o

During the real time simulation, a number of variables will need to be evaluated. These variables include: approach procedure, tools available, controller role, speed constraints. In order to evaluate each variable individually, a large number of experiment runs are required, each taking about 1 hour 15 minutes. (see Sourdine II validation plan D6-4). As there is only a limited number of experiment runs which can be conducted, not all procedures can be evaluated.

procedure I. This reference procedure is required for the gathering of reference data.

procedure II. This procedure can be flown by a large range of aircraft and is therefore of particular interest. This procedure will be evaluated in the real time simulations.

procedure III. The 4^o ILS glideslope requires new certification of all autoland systems. It is anticipated that this will not be the case for the SII timeframe (not foreseen within the first 20-30 years). This procedure will therefore not be evaluated in the real time simulations.

procedure IV. This procedure is likely to provide most benefit regarding noise abatement due to highest flight path angle. It is therefore an interesting candidate for evaluation during the RTS.

procedure V. This procedure is very similar to procedure IV. Although flight path angle is not as steep as for procedure IV, the noise component from gear and flaps are also less for this procedure. This procedure is also an interesting candidate for the RTS.

Procedures IV and V are very similar. The prototyping sessions, both in the flight and ATC simulator, will decide which procedure will be evaluated during the RTS trials.

Approach procedures I, II, IV and V will be evaluated during the various prototype sessions.

During the validation of approach procedure I, the present-day departure procedure (ICAO-A) will be used. During approach procedures II and IV, the ICAO-A and the Sourdine II close-in departure procedure will be used.

Other choices and rationales

- Initial altitude at the RIVER IAF has been moved from FL70 to FL80. The arrivals from both RIVER and SUGOL follow an arrival route with a common merging point at MICOL. It resulted from a safety assessment that in case of communication failure, this could pose a serious thread when both aircraft would enter the TMA at the same flight level. Also it was noted that due to the fixed arrival routes, the pilots do not have the absolute need to receive route-instructions from the controller, and therefore it could happen that a pilot would just follow the arrival-route, whilst not focussing primarily on getting in contact with the controller. By moving the entry level of one of the arrival route to a different level, a safety net is introduced covering this problem.
- The concept of operation defines for procedure IV a variable path, at which the aircraft will descend with final approach speed, full flaps, gear down. The aircraft performance simulations for an A340 and an A320 resulted in a maximum descend-angle of 5.2 degrees. From this, the aircraft in the simulation will descend at a fixed 4.5 degrees angle.
- Although currently STCA is not in use in the TMA, it is felt that the task of a controller shifts slightly from controlling to monitoring, especially in the final part of the approach. As this may reduce the situational awareness of the controllers, an additional safety net is required. The use of STCA might be a candidate. As separation requirements in the TMA are different from those in ACC, the STCA algorithm needs to be updated.
- In order to assist the controller with the merging of the two arrival flows, a ghosting functionality can be helpful. A ghostplot of an aircraft provides position-information of that aircraft on a different route, called ghost-route. In the Sourdine II case, ghost plots are created for the aircraft from the SUGOL IAF and will be projected on the RIVER approach route. This ghostplot gives the controller information about the position of an aircraft from SUGOL, relative to the stream of aircraft from RIVER, in which it should merge. There are two ways of presenting a ghostplot to the controller: based on distance to go, or on time to go (see also Figure 4).
  - The distance-to-go algorithm, the distance of the aircraft until the merging point is determined. Then this distance is backtracked along the ghost route, in order to find the position of the ghostplot. The distance to fly is the same for the aircraft itself, as for an aircraft flying at the location of the ghostplot. The ghostplot will fly at the same speed as the aircraft itself.
  - Another method of projecting the ghost plot is to use the time-to-go. In this case, the flying-time to the merging point is the same for the aircraft, as it is for an aircraft flying at the location of the ghostplot. The ghostplot will fly at a speed the aircraft would fly if it would be using this route. This method requires a known speed-profile for the aircraft itself, as well as a speed-profile along the ghost-route.

  The two methods will only make a difference when wind is take into account. For instance: an aircraft is flying at a speed of V_2, at an distance to merging point *d*[nm], and facing a headwind of V_w kts. Using the distance-to-go algorithm, its ghostplot would fly at a speed of V_2 kts at a distance *d* from the merging point. Using the time-to-go algorithm, the ghost would be flying at a speed of $V_2 + V_w$ at a distance $d+x$, where *x* is the additional distance covered due to the higher speed (see figure 4).

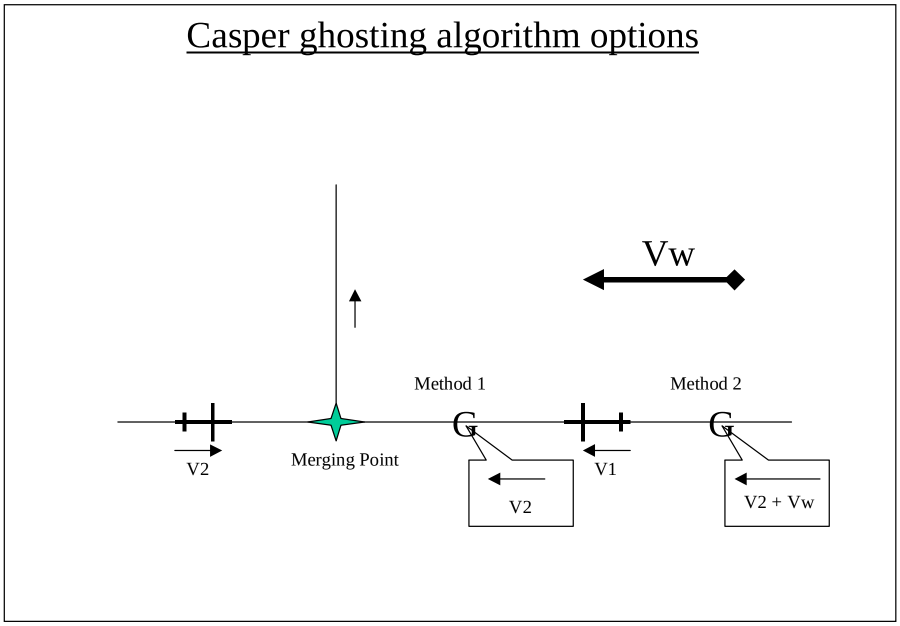

Figure 4: Ghosting projection methods

– During parallel approaches, it is of vital importance to notify a controller at the moment an aircraft does not intercept the ILS correctly and comes too close to the parallel approach. A Non Transgression Zone has been defined between the two final-approaches. The radar-tracks of the aircraft are monitored continuously. When an aircraft enters this zone, the controller is notified immediately by the label turning red. Figure 5 shows the radar display with the two approach routes for runways 18R and 18C, with the Non Transgression Zone in between the extended centrelines.

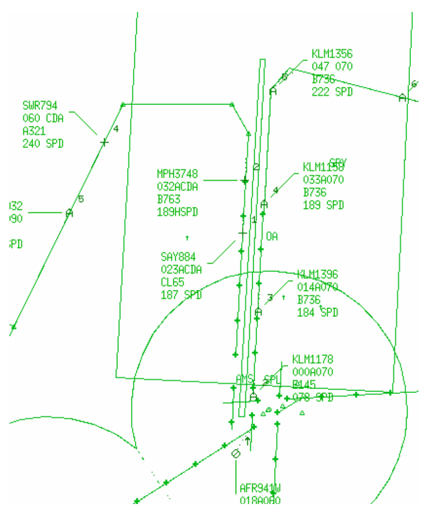

Figure 5: Final approach runway 18R and 18C

- It was found that the original approach route to Runway 18R via NIRSI - EH607 - EH608 – ILS would interfere with the approach route to 18C. This was resolved by moving the downwind leg about 1NM to the north, resulting in NARSI – EH707 – EH708 - ILS. As the merging point (EH606) will be used during R/T communications, it was renamed to MICOL.
- In order to assist the controller with the merging task, the radar-display will present a sequence number in the label of all inbound aircraft, indicating the optimal sequence of the aircraft for lining up for the final approach.
- In order to assist the controller even further with the merging, as well as maintaining separation a list is shown on the radar-display, showing *target-time-over* the merging point MICOL. An example is shown in Figure 6. When an aircraft passes the merging point at this target-time, the aircraft will arrive at the runway at the correct distance from its preceding aircraft. During the calculation of the target-time, the aircraft-type, approach-procedure, wake-vortex category and the wake-vortex category of preceding aircraft are taken into account. Currently, the units at which the TTO is presented, are minutes. It needs to be decided whether or not this accuracy needs to be increased. Although MICOL is the merging point for the Sourdine II route structure, the SUGOL arrivals can be given a shortcut to NARSI, skipping MICOL. In such a situation, NARSI is the common point for all inbound aircraft, so one could suggest a NARSI-list would be more appropriate. However, the objective of this table is to assist the controller in building a sequence during peak hours. A direct NARSI will only be given when the traffic load is still very low. During such traffic density, the controller is very well capable in making a sequence without the list.

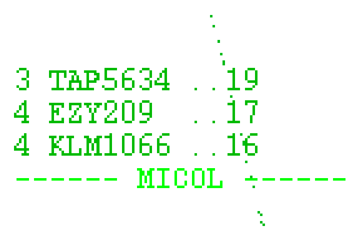

Figure 6: MICOL-list

- In general, in a continuous descend approach the descend will start at some time after the controller issued a CDA clearance, unlike a normal descend, where the descend starts immediately after the controller issues the clearance. The pseudo-pilot requires an indicator, providing information whether the CDA function of the aircraft is armed and the aircraft will start its descend at own discretion. Clearly the CDA functionality shall be armed manually upon receiving a CDA-clearance from the controller.
- A controller may ask the pilot about the distance to fly until descend. The pseudo-pilot must be given the means to provide this information: distance to descend.
- Departure routes (BERGI & VALKO SIDs) will initially remain unchanged, although problems are foreseen for the departing aircraft crossing the SUGOL/RIVER approach routes.

4.2 Basic Simulator Functionality

This section describes the existing basic functionality of the NARSIM simulator, which is required for any type of simulation. Also the adaptations required for Sourdine II to these components are described here. Figure 7 gives a brief overview of the various servers required for the Sourdine II experiments.

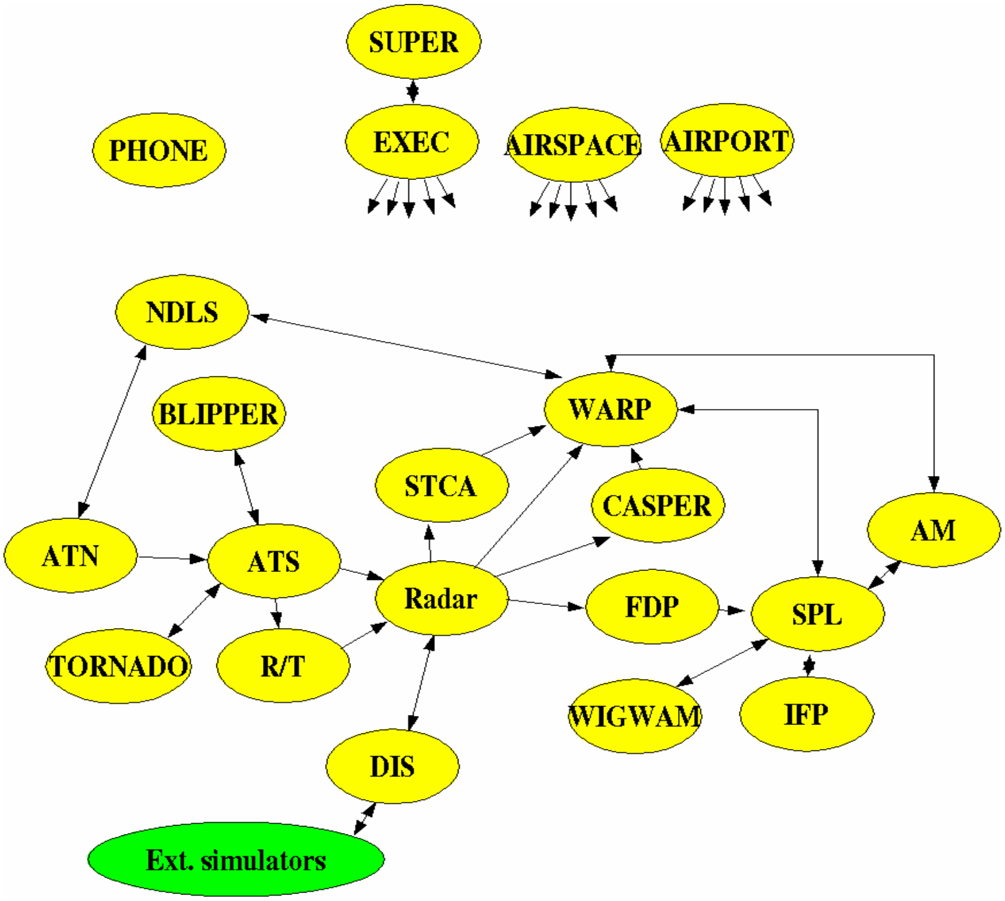

Figure 7: NARSIM system architecture

4.2.1 WARP Server

The WARP server provides radar displays to the air traffic controllers. For all simulations, the approach display set up will be used. These will be used for the 2K as well as the 1K monitors. The ACC controllers taking part will be using a 2K ACC set up, together with feeder options. Besides the controllers, also the pseudo-pilots will be equipped with such a display, in order to have situational awareness concerning the aircraft they control.

The server has been adapted to show STCAs in the TMA, as well as a warning when an aircraft enters the Non Transgression Zone between the two runways 18R and 18C. This warning turns the label of the concerned aircraft red. Also WARP has been adapted to display ghost plots. The ghost plots show the aircraft's ground speed and aircraft type. In order to minimise probability of confusing the ghostplot for a radarplot, the colour of the ghostplot will be different.

Furthermore the WARP server have been adapted to show the Sourdine II RNAV routes, as well as a table providing scheduled times of the aircraft over the merging point MICOL. Figure 8 shows a part of the controller radar-display.

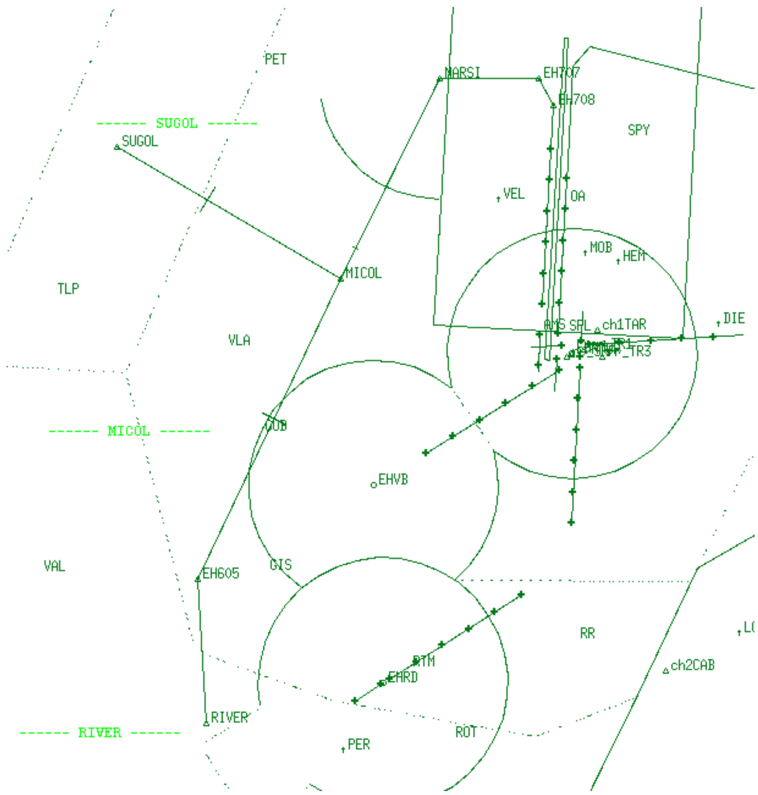

Figure 8: Radar display

4.2.2 Air Traffic Server

The Air Traffic Server (ATS) handles all aircraft in the simulation. It ensures that the aircraft fly the provided routes, taking into account their flight characteristics. For these characteristics, the ATS makes use of BADA version 2.5. The data in this version of BADA is rather limited for the approach phase, resulting in unrealistic flight characteristics. It was necessary to update the aircraft behaviour during this flight-phase, in order to solve this problem. During the prototyping phase the ATS is upgraded to the most current version of BADA: 3.5. Also Sourdine II approach procedures I, II, IV and V have been implemented in the scripts, controlling the aircraft. The lateral route is automatically set in the aircraft's flight management system. The pseudo-pilot will enter the vertical path, once instructed by the controller.

4.2.3 Airspace server

The airspace server maintains all information concerning the airspace definition: waypoint locations, routes, airfields, frequencies, sectors, etc. This information is available to any server. The Airspace server has not been modified.

4.2.4 Airport servers

The airport server maintains all information concerning an airport: runways, taxiways, gates, etc. This information is available to any server. The Airport server has not been modified.

4.2.5 System Flight Plan Server

The System Plan Server (SPL) is responsible for maintaining a consistent database containing all relevant flight information. This info is available to all ground based ATC systems. The System Flight Plan Server has been modified to be able to handle scheduled times over the MICOL merging point.

4.2.6 Initial Flight Plan Server

The Initial Flight Plan (IFP) Server initiates new flightplans into the system, at predefined times. This will initiate the Air Traffic Server to create a new flight, and the System Flight Plan Server to generate a new system plan. The Initial Flight Plan Server has been modified in order to be able to define scheduled times over the MICOL merging point at scenario definition.

4.2.7 Radar Server

The radar server provides radar tracks of all aircraft in the simulation, which are within line of sight of a radar station. The radar server is able to simulate long-distance rotating radar, TMA radar, as well as direction finders, providing directional information of an aircraft transmitting using their R/T. For the rotation radar, also the specific rotation speed of the aerial of the radar is taken into account. The radar server is, besides datalink, the only interface between the aircraft on the one side and the ATC ground systems on the other. The radar server has not been modified.

4.2.8 Executive Server

The executive server's task is to manage the simulation. It provides server and service information to the interested servers and controls time during the simulation by providing the time services. The executive server has not been modified.

4.2.9 Supervisor Server

The Supervisor server provides a user interface for supervision of the simulation to the supervisor / experiment leader. It provides the means to start and stop the simulator as also facilities to control the simulation speed. It also has facilities for on-line system monitoring. The supervisor server has not been modified.

4.2.10 Flight Data Processing Server

The Flight Data Processing (FDP) server handles correlation of radar tracks and system plans, using the SSR squawk. The FDP server provides a few functions to make sure the System Flightplans remain consistent with the rest of the simulation. The FDP server has not been modified.

4.2.11 Flight Progress Monitoring Server

The Flight Progress Monitor (FPM) will monitor the radar tracks of all aircraft and monitor if the track deviates from the expected track. It will take into account the route in the SPL, as well as the RNAV approach-route (if applicable) which the aircraft normally follow. Also controller clearances are taken into account. If an aircraft is deviating from its route, an alarm is shown in the label saying “LAT DEV”. If an aircraft uses the standard non-RNAV approach (e.g. From RIVER IAF direct SPL) while it is expected to follow the RIVER RNAV route, the alarm is shown, or when an aircraft does not make the turn to baseleg.

Also the altitude of the aircraft is monitored. If an aircraft descends without clearance, also an alarm is shown in the label, saying “FL BUST”. This applies for the “normal” level instructions, as well as for the case where an aircraft starts its CDA, while its not yet cleared to do so.

Also the aircraft departing are monitored. The Flight Progress Monitoring server has not been modified.

Figure 9: Vertical and lateral deviation warning

4.2.12 Blipper Server

The blipper server provides the pseudo-pilot with the means to control his aircraft. For each frequency (or sector) that is used in a simulation, one or more pseudo-pilot positions are required. For each aircraft, a strip is created, providing the pseudo-pilot with actual state data of the aircraft, and a command interface at which various commands can be given to the aircraft: heading commands, altitude commands, frequency commands, etc. Using the function keys, predefined commands are available. Figure 2 gives an example of the pseudo-pilot HMI. The blipper server has not been modified, only the function keys have been updated, in order to contain the specific Sourdine II route clearances and CDA clearances.

4.2.13 Radio Telephony

The Radio Telephony (R/T) server is used for controlling the communication between the controllers and the pilots. Using their push-to-talk buttons, the users can transmit on a channel. All users of a channel always listen to that channel. A user cannot disconnect from a channel. Only the supervisor can connect and disconnect users from channels. The R/T server controls the R/T system, which provides the actual connection between the various players. The R/T server just defines which communication lines can be connected and how it is connected: point-to-point connection, party-line, always on, Push-to-talk, dial-in service. Some adjustments to the configuration files have been made, in order to be able to establish the correct connections.

4.2.14 Phone

The phone server enables co-ordination between centres. This will be used for co-ordination between feeder controllers and area controllers. The phone server uses the same R/T system as the R/T server. Unlike the R/T server, the phone-server allows the user to select its communications partner from a list. This list can be provided on a touch-input device, or as a separate window on the user display. For the prototyping sessions, no inter-center communications have been used.

4.2.15 Trajectory Predictor Server[1]

The Trajectory Predictor (WIGWAM) predicts the flight-progress of a flight. Using the radar tracks, and system plan, it predicts time and altitude over the waypoints in the route. In the TMA, the TP uses a table containing information about aircraft type, IAF and its flight duration in the TMA when determining ETAs. A number of tables have been created containing the different flight times within the TMA for the different S2 routes, vertical profiles and aircraft types.

4.2.16 Arrival Management Server

The arrival management (AMAN) sequencer is responsible for optimising the sequence of arriving aircraft and to distribute arrival slots and runway assignments. No changes to the AMAN were necessary.

[1] If data link is to be used it might not be necessary to use the trajectory predictor. Whether data link or the TP will be used depends on the accuracy with which the times over waypoints are calculated. This will be determined during early accuracy trials.

4.2.17 Copilot

The copilot server can be used to control certain sectors without the use of pseudo-pilots for that sector. This server is usually used for feeder positions, adjacent to the measured sectors. The controller responsible for the feeder sector can control the aircraft by means of entering the clearances into the system using the Touch input devices, the same way as they “normally“ enter their clearances into their administration. These clearances are stored in the system plan. The copilot server detects a clearance has been given for an aircraft in an automated sector, and transmits the clearance directly to the aircraft. One can also see this service as a sector, which uses some sort of datalink for all communications. The copilot server has not been modified.

4.2.18 Weather server

The weather server (TORNADO) provides weather information to all components in the simulation.
For the prototyping sessions, the wind was not taken into account. This allowed for the weather server not to be included in the simulations.
It is foreseen that the weather will play an important role during the full-scale experiments. An adaptation to the current weather server is foreseen, in order to meet the following requirements:

- Availability of a 3D grid, at which the wind speeds and direction can be defined.
- Dynamical time-dependent changes in weather.
- Weather info as is available to the ground system, as distributed by a “met-office”, shall be different from the weather the aircraft experiences.

4.2.19 Short Term Conflict Alert Server

The Short-term conflict alert (STCA) provides a alert to the controller when a conflict can occur between two aircraft within the next minute. Currently STCA is only used by area control, and not by the approach controllers. The STCA server has been adapted and now also gives alerts within the TMA, albeit with different margins. Basically, alerts are given when lateral separation becomes less than 3 NM or when vertical separation becomes less than 1000 feet. The area where the aircraft turn onto the ILS has been excluded from the STCA working area. This is due to the fact that the two parallel runways are so close to each other that STCA will always give an alert during parallel approaches.

4.2.20 DIS Light Server

The DIS server provides a means to connect external simulation facilities to the NARSIM simulator by means of the DIS protocol. This server can be used for connecting with the NLR flight simulator. Using this server, position information from the flight simulator is received, including the flight-simulator in the NARSIM environment. Also position information of all other flights is send to the flight-simulator enabling the flight-simulator to “see” their surrounding traffic. For the prototyping sessions, the flight-simulator has not been participating in the NARSIM simulations.

4.2.21 NARSIM Data Link Server

The NARSIM Datalink Server (NDLS) provides air-ground datalink services to the various ATC tools. The NDLS can connect to a real Aeronautical Telecommunications Network (ATN), enabling real-life aircraft to participate in a NARSIM simulation. Also can the NDLS be connected to an ATN server, acting as an intermediate with the simulated traffic, as controlled by the Air-Traffic Server.

A large number of air-ground datalink services have been developed during previous projects: Datalink Initiation Capability (DLIC), Context Management (CM), Pre-Taxi Co-ordination (PTC), Departure Clearance (DCL), Flightplan consistency check (FLIPCY), ATC clearances (ACL). For Sourdine II, mainly the FLIPCY service is of interest; in order to get a detailed, reliable prediction from the aircraft containing its 4D route.

Depending on the Concept of Operations, it might be required to downlink an aircraft’s ETA and time over IAF. Once this information is available on the ground, the ground systems can perform scheduling calculations. No datalink functionality has been used during the prototyping sessions.

4.2.22 Aeronautical Telecommunication Network (ATN) Server

The Aeronautical Telecommunication Network server, provides a means to exchange datalink messages with the simulated aircraft, as controlled by the Air Traffic Server. As no datalink has been used during the prototyping sessions, the ATN server has not been used as well.

4.3 New Components

This section describes the new components, as have been developed in the Sourdine II project.

4.3.1 Ghosting Tool

A ghosting tool can project the position of an aircraft onto another plane. The tool can be used by the controller in case of converging runways as well as where aircraft on fixed lateral/vertical tracks need to be merged. For the Sourdine II prototyping sessions, the inbound aircraft from the SUGOL IAF were projected onto the RIVER arrival route. This provides the controller with information about the relative positions of the aircraft on the two inbound routes, prior to merging into a single stream. The current version of the tool used a basic ghosting algorithm that determines the distance to go (along track) to a projection-point on the route. This distance is then backtracked across a given path in order to determine the location of the ghostplot. This path can either be a straight line or a predefined route (e.g. RIVER arrival route). For the projection point the NIRSI position was configured, as all arrivals will have to be merged at this location, even those aircraft that were cleared to proceed direct from SUGOL to NIRSI, skipping the MICOL merging point. Figure 10 shows examples (blue labels on the radar display) of a ghostplot.

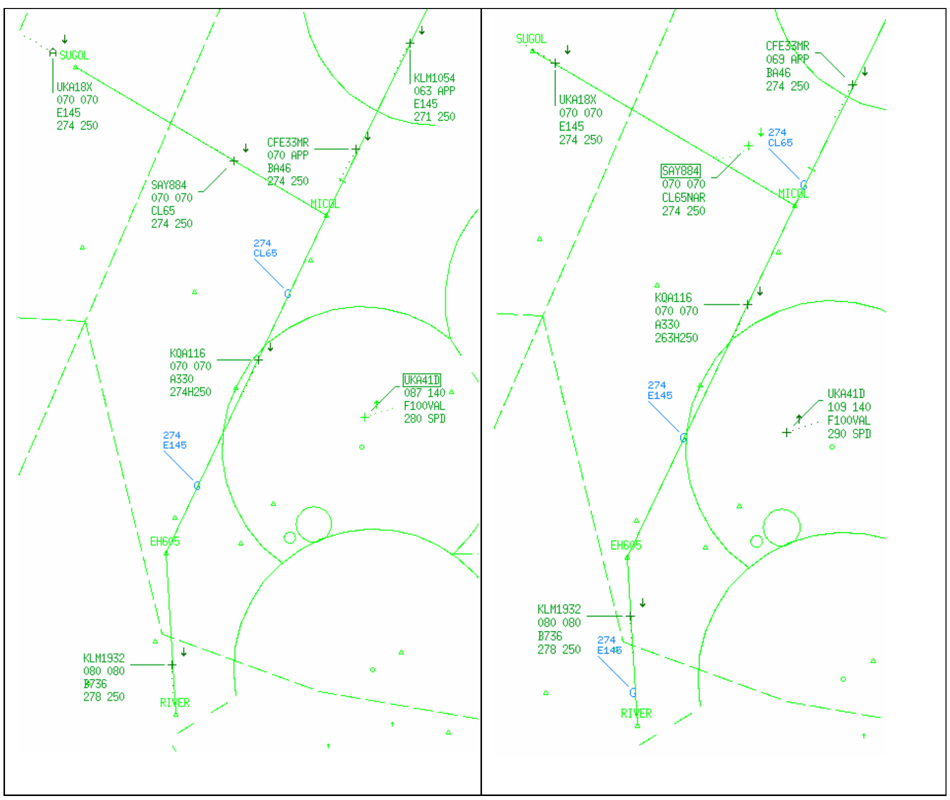

Figure 10: Ghost plot for merging traffic flows

For all the changes made to NARSIM see also Appendix B.

5 Measurements

This section describes the different measurements that were taken during the prototyping sessions. The metrics related to these measurements can be found in the document [D2-1] (D2-1: Validation Methodology Report, version 0.9).

During the prototyping sessions the following measurements are foreseen:

- ATS (flight) recording
  - All the flight parameters will be recorded, including time, position (latitude, longitude, altitude, ground speed, indicated airspeed, flightpath angle, rate of climb/descent, R/T frequency, etc.
  - Data recording at NIRSI of all aircraft including aircraft type, IAS and ETO will provide some insight in the quality of the sequence.

- R/T recording
  - The amount and duration of the R/T calls will be recorded
  - The contents of the R/T calls will not be recorded

- WARP recording
  - All inputs made by the controller on the Radar Display will be recorded

- Blipper recording
  - All inputs made by the blipper will be recorded

- ISA recordings
  - The controllers are asked to indicate their workload every 3 minutes via the Instantaneous Self Assessment (ISA) method.

- Questionnaires
  - Questionnaires with specific SII questions will be prepared

From these recording, an exact replay of an experiment can be shown, allowing the detailed analysis of an event.

6 Prototyping sessions

During the preparation phase for the experiments, a number of prototyping sessions were conducted. During these sessions, an experiment was conducted in which the controller was subjected to a system set-up as envisaged for the full-scale experiments.

The objective of these experiments was to gain feedback on the system set-up as a whole as well as the Sourdine II procedures. From each prototyping session the results were incorporated into the system, and were evaluated during the next session.

6.1 Prototyping session 1: 12 December 2003

The first prototyping session was conducted on the 12th of December 2003. During this session, one Approach controller was present as well as one pseudo-pilot.

6.1.1 Schedule

During the prototyping session following schedule was followed:

Start	Event
9.00	Welcome, overview of the day
9.15	Explanation of the Sourdine II concept and the various ATC tools
9.45	Approach Procedure IV: RIVER only, low traffic density
10.30	Debrief
10.45	Break
11.00	Approach Procedure II: RIVER , high traffic density
11.30	Debrief
11.45	Approach Procedure IV: RIVER, high traffic density
12.15	Debrief
12.30	Lunch
13.30	Approach Procedure II: RIVER + SUGOL, high traffic density
14.00	Debrief
14.15	Approach Procedure II: RIVER + SUGOL + ARTIP , high traffic density
14.45	Debrief
15.00	Discussion on tasks, responsibilities, R/T phraseology, etc.

6.1.2 Initial set-up

During these prototyping sessions, the controller was presented with the system, as has been described in chapter 4. At this point, no distortions due to wind were available.

The flight monitoring aid (FPM) was not used during these sessions.

6.1.3 Results

Procedures

- Significant problems were encountered in procedure IV, where the aircraft reduces at its own discretion to its final approach speed. As the differences in speed are significant (~ 100kts), slower aircraft are overtaken by faster ones. As the controller does not have any means of speed control in these procedures, additional separation is required in order to deal with these uncertainties.

- When an aircraft flying at FL70 behind an aircraft at FL80, the first one (at FL80) will start its deceleration and descend earlier than the other one. This way the separation between the two aircraft reduces significantly.

R/T

- R/T phraseology needs to be verified.
- The initial message of the approach controller is very long: "Aircraft callsign, after passing MICOL, continue RIVER 1B transition to NARSI and prepare for CDA ILS 18R, independent parallel approaches in force, ILS frequency is 110.1”. As it is foreseen that D-ATIS will be available at the timeframe under investigation, the information messages will be uplinked to the aircraft. ATC clearances will be given via R/T.
- Controller needs information from the aircraft when it will start its descend. It will be investigated if this can be done using the downlink of flightplan information via datalink, or that the controller will be notified by the pilot about 4NM before its descend: e.g. “Amsterdam Arrival, KLM123 will descend in 4NM”
- Same applies to speed reductions. Especially in procedure IV it is important for the controller to know when an aircraft will decelerate.

Radar display

- Ghosting did not take shortcuts into account. Aircraft arriving from the SUGOL IAF were often instructed to go directly to NARSI. As the ghost still assumed the aircraft was maintaining its original route, the location of the ghostplot did not represent an equal distance to the merging point.
- When the ghostplot of an aircraft is within a close distance of its radar plot, it should not be displayed any more.
- A Ghostplot needs to be presented in a different colour than the radar plots. A blue colour is proposed.
- Tick marks are required on the extended runway centreline at 2NM interval.
- A distance marker is required 10NM before the MICOL merging point. The separation of two merging aircraft needs to be completed at 10 NM before this merging point.
- In the MICOL list, showing the scheduled time over MICOL for all aircraft, contained some incorrect sector information regarding originating sector.
- An aircraft shall be removed from the MICOL list, when released to approach or when it has passed MICOL.
- An additional arc is required indicating the position at which aircraft will start their CDA. A large arc will be shown for CDA's from FL70 and a small indicator for the FL80 CDAs.
- The various lists (stacklists and MICOL list) need to have a different default position.
- SUGOL stacklist remains empty, although there are aircraft arriving from SUGOL.
- Landing aircraft must be removed from the display a bit more early.
- When an aircraft enters the Non-Transgression Zone between the parallel runways, the controller is warned by means of a NTZ entry warning, colouring the label red. When this warning was turned off, the label was turned yellow, instead of its normal green colour.

Touch Input Devices:

- Outbound traffic needs a different altitude clearance page than the inbound traffic: including FL70, FL90 and FL140.
- “direct NARSI” must be as a short key in the heading page.
- Departures need to have a direct to their sector-exit points.
- The controller must be able to get the coastline on the radar display, by means of a button on the TIDs.

Pseudo pilot

- Flightstrips need to be sorted in time: a new flight must be appended at the bottom of the list.
- A speed-instruction of the pseudo-pilot must not be overruled by the speed commands in the scripts.
- Pseudo-pilot has the same radar display as the controllers. This does not include waypoint names. For the pseudo-pilot it is helpful to have this information.
- On a few occasions, the controller asked the pilot about his distance to the outer marker. As this information was not presented, the pseudo-pilot was unable to provide this information. The outer marker shall be shown on the radar display as well.
- Pseudo-pilot requires the option to get the final approach speed of an aircraft.
- For departing aircraft, the pseudo-pilot got some irrelevant CDA information messages. This is somewhat disturbing.
- When a clearance for CDA is given to the aircraft when it has already passed its top of descend, a warning must be provided to the pilot that the CDA cannot be executed, and the aircraft must be descended manually.

Aircraft behaviour

- All inbound traffic was descending too soon, forcing a level section at 3000ft. A more accurate top-of-descend calculation algorithm must be implemented, allowing the aircraft to descend at the correct location allowing for a continuous descend.
- Once established on the ILS, the aircraft did not respond to any pseudo-pilot instructions like speed, abort ILS.

Simulation set-up

- For the experiments, an additional pseudo-pilot position will be set-up, with which some aircraft can be controlled that have some kind of problem: a pilot not listening very well, technical difficulty, etc.

Others

- Traffic samples need to be a somewhat increased. Post processing shows the landing interval of 106 seconds, as used during scenario preparation was also the same as the traffic flow as offered to the controller. The controllers allowed the first few aircraft to follow a shortcut to the runway. This provided for some more space for the other aircraft. Combined with the fact that the prototyping sessions were rather short in time, the total experienced traffic load early in the simulations was somewhat lower than expected. It is foreseen that with a landing interval of 100 seconds, as well as a long simulation time, this issue is dealt with.

- All BERGI departures were in conflict with the inbound traffic on the downwind leg. It is proposed to move the BERGI departures more south-west, keeping a 5NM distance with the downwind leg. This will be investigated further during a next prototyping session.
- The controller experienced uncertainty weather or not an aircraft would intercept the ILS. When the NTZ warning would be active, there was very little time to respond. Additional tool would be desired to increase the confidence of the controller that the aircraft will intercept the ILS.

6.1.4 System Adaptation

From the results of this session, following modifications to the system have been incorporated:

Procedures

- An additional procedure has been developed, identical to procedure IV, but with speed-constraints at MICOL (220 KTS) and with a fixed speed during descent of 170 KTS.

R/T

- Digital ATIS message is available, alleviating the R/T load of the controller.

Radar display

- Ghosting has been improved to take a “direct to” into account, as well as the removal of the ghostplot when it is within 1NM of the radarplot.
- Ghostplot is presented in blue on the radar display.
- Radar display is completed with tickmarks on the extended runway centreline, 10NM markers from MICOL, arcs indicating descent positions, NTZ warning fixed.
- Sector info in the MICOL list has been corrected.
- Stacklists have been fixed, and repositioned on the radar display.
- Aircraft are removed 5 sec. earlier.

Touch input devices

- Altitude clearance page for departing aircraft has been adapted to include FL 70, FL90 and FL140
- “NARSI” added to heading page (inbound aircraft) and exit points (outbound aircraft)
- Coastline can be shown on the radar display by means of a TID-button.

Pseudo pilot

- New flightstrips are added at the bottom of the list of the available strips. Empty spaces are not used. Removing empty strips can be done manually by means of a “sort” button.
- Speed instructions as entered by the Pseudo pilot are not overruled by speed-instructions of the automatic scripts.
- The outer maker is not specifically available to the pseudo-pilot, however, the third tickmark of the extended centreline can be used for this purpose.
- Pseudo-pilot can request the final approach speed of an aircraft.

– A CDA command cannot be given, once the aircraft has passed its top of descent.

Aircraft behaviour

– Top of descent calculation has been revised, eliminating any horizontal segment.

– Aircraft behaviour while established on the ILS has been corrected.

Simulation set-up

– Additional pseudo-pilot positions have been set-up for "difficult cases"

Others

– Landing interval has been reduced to 100 seconds.

BERGI SID for runway 24 has been replaced by the BIRGI departure, which is located more to the south-west than the BERGI SID.

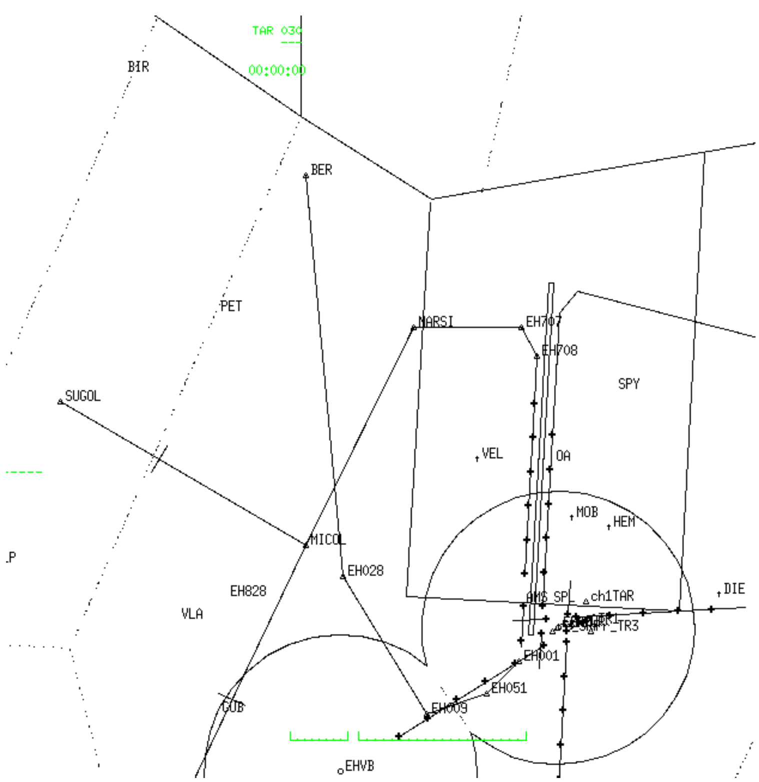

Figure 11: Original BERGI departure

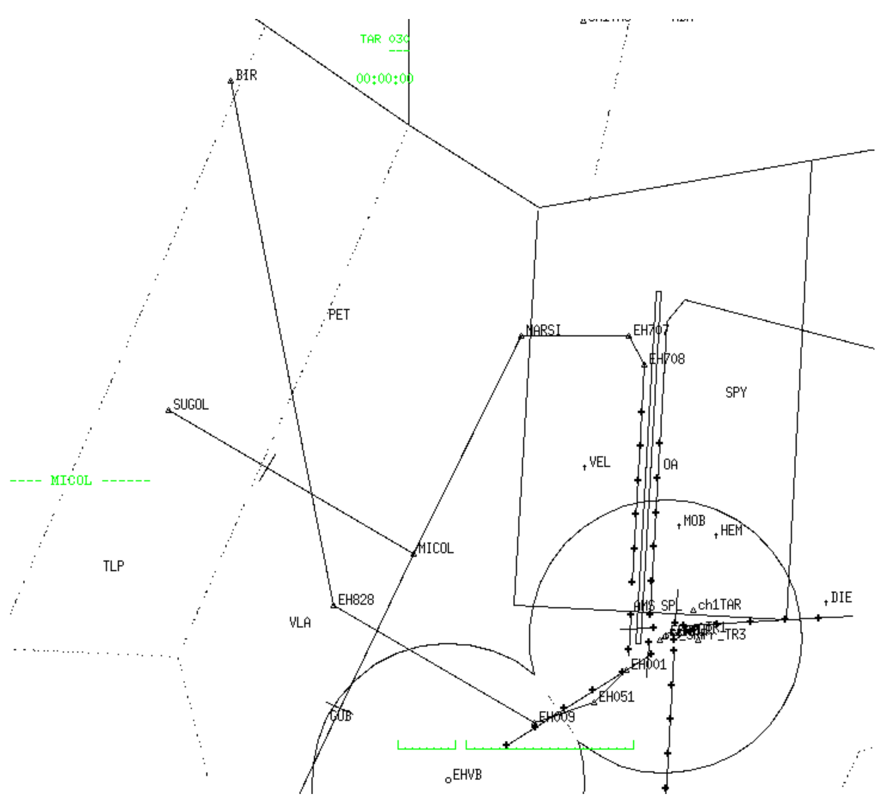

Figure 12: New BIRGI departure

6.2 Prototyping session 2: 19 February 2004

The second prototyping session was conducted on the 19th of February 2004. During this session one Approach controller was present as well as one pseudo-pilot.

6.2.1 Schedule

During the prototyping session following schedule was followed:

Start	Event
10.00	Welcome, overview of the day
10.15	Explanation of the Sourdine II concept and the various ATC tools
10.30	Procedure II: RIVER + SUGOL , high traffic density
11.00	Debrief
11.15	Procedure IV, with speed constraints: RIVER+SUGOL , high traffic density
11.45	Debrief
12.00	Discussion on tasks, responsibilities, R/T phraseology, etc.

6.2.2 Initial set-up

During the prototyping session, the controller was presented with the simulation set-up, as resulted from the first prototyping session. The flight monitoring aid (FPM) was not used during these sessions.

6.2.3 Results

Following the results of the first prototyping session, a large number of items have been addressed. The resulting system has been presented to a approach controller and pseudo-pilot. The objective of this session was to validate the changes to the system and procedures. During this session, two short simulation runs were conducted for procedure II and IV.

Procedures

- FMS is not intended for use during ILS interception, since at this point there is a transfer between a calculated position to a absolute position relative to the ILS glideslope. Boeing does not allow interception of the ILS in RNAV mode!
- FMS at this moment in time is not suited for complex CDA approaches. The combination of a fixed descent-angle and speed constraint can be difficult.
- Traffic from RIVER-IAF can cross the IAF at a much higher altitude: between FL100 and FL150. Aircraft want to stay at high altitude as long as possible. A long stretch between IAF and Top-of-descent at FL80 is not preferred.
- When intercepting the ILS from above (procedure IV and V), the possibility of intercepting a false glideslope is identified as a hazard.
- What are the effects to the impact of wake-turbulence with procedure IV (low speed)? Can wake turbulence separation standards be reduced in this case?
- The new BIRGI SID, replacing the “old” BERGI, was very helpful. The controller did not have any trouble separating outbound from the inbound aircraft.

R/T

- The R/T clearances are still somewhat unclear. Difference unclear between “Cleared approach” and “cleared CDA”.

From the NL-AIP:

When cleared NIRSI/NARIX approach RWY18R:

- *continue via transition*
- *descent at pilot discretion*
- *respect min altitudes*
- *published speeds mandatory*
- *execute ILS approach 18R*

Something similar shall be defined for Sourdine II. Very clear R/T messages need to be developed.

- R/T is fairly easy. Calls are fairly short and not too frequently. Much improved since first prototyping sessions.
- QNH must still be mentioned via R/T, although this information is also available via the ATIS.

Radar display

- The ghosting functionality was highly appreciated. The two options for determining a ghost position were discussed. The controller did not have a preference for either one, as long as the choice is clear.
- For aircraft, which are fixed on a heading, parallel to the MICOL-NARSI leg, it is difficult to determine the position at which they should be directed back to NARSI. An additional line at extended baseleg, could be helpful here. The controller must be able to switch this line on and off using a button on the touch-input device.
- For procedure 4 also an indication of the aircraft top of descent point shall be available, as implemented for procedure 2.

Touch input devices

- Controller has not made use of the Touch input device. No administrative inputs have been made.

Pseudo pilot

- Modifications to the pseudo pilot interface make life a lot easier than before.
- Function keys shall be changed a bit: a report button must be placed as a *shift-Fx* above the command key *Fx.* At high workload the Fx-key could be mistakenly pressed instead of the shift Fx key.

Aircraft behaviour

- Aircraft behaviour is good. Nothing strange noticed.
- Pilots follow speed reductions very quickly, while in real life they want to maintain at high speed much longer, so wait a bit before reducing.
- When an aircraft is cleared for CDA after reaching its top of descent, it is unable to follow its descent profile, and an error message is presented to the pilot. At this moment, the aircraft needs to be guided manually. The error message needs some clarification.
- Wind influence shall be taken into account.

Simulation set-up

- Number of departing aircraft is very low early in the scenario.

Other

- It is unclear to the controller what the aircraft is going to do, until it has actually done so. The downlink of aircraft short-term intent information (e.g. 2 minutes ahead) would be very welcome.
- Traffic-flow from ACC over the IAF is better than it is in real life. Following distortions to the traffic flow are suggested:
  - Speeds over the IAF must be varied a bit. (about 10% enters the TMA with a speed of 330kts)
  - Altitude of the aircraft entering the TMA shall be varied. (some entering at FL180 even from SUGOL)
  - Some aircraft do not enter the TMA via the IAF, but enter the TMA from the north.

- LEKKO departures automatically came onto the departure frequency, which should not have, and the VALKO departures did not come onto the departure frequency.

6.2.4 System Adaptation

Following adaptations to the simulation environment were implemented:

Procedures

No adaptation to any of the procedures is incorporated. It is foreseen that in a high traffic load environment, the ACC controllers will require all aircraft to enter the TMA via the IAFs. In such a case also the altitude will be closely monitored by ACC, not allowing for too much variation.

R/T

When cleared for approach RWY18R, the pilot is allowed the following:

- continue via transition
- descent at pilot discretion
- respect min altitudes
- published speeds mandatory
- execute ILS approach 18R

Radar display

- An additional line is added extending the baseleg. This line can be switched on and off by the controller using the TIDs.
- Added Top-of-descend markers on baseleg (NARSI – EH707) for FL70 and FL80.

Figure 13 shows the modified radar display for procedure IV.

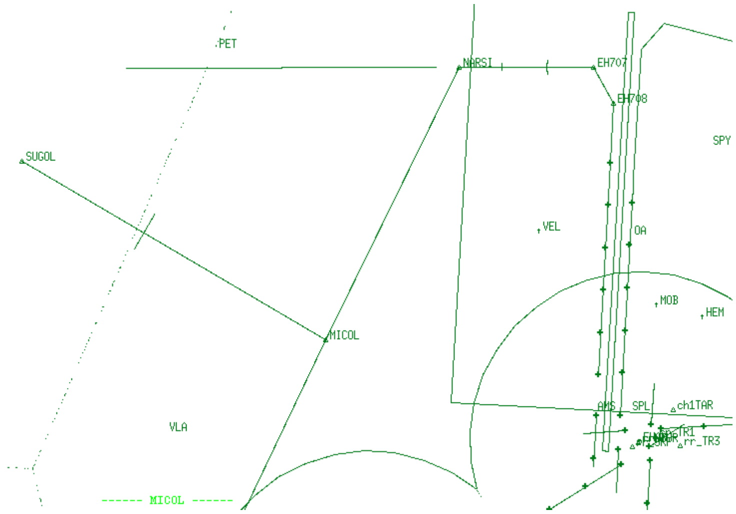

Figure 13: Updated radar display with NARSI aiding line

Touch input devices

– No adaptations to the touch input devices were incorporated.

Pseudo pilot

– Function keys have been changed in order to group “report” functions under a single button.

Aircraft behaviour

– No adaptations to the aircraft performance figures were incorporated.

Simulation set-up

– Number of departures at the start of the simulation has been increased.

Other

– Only departing aircraft via VALKO and BERGI now call on this R/T frequency.

6.3 Prototyping session 3: 22 September 2004

The third prototyping session has been conducted on 22nd of September 2004. The objective of this prototyping session was to investigate the controller tasks using CDAs. For this prototyping session, both a Feeder/DCO and Arrival controller participated in the experiment.

Prior to these ATC prototyping sessions, a prototyping session with the flight simulator was conducted. During these flight simulator experiments, it was found that procedure IV poses significant problems in the aircraft. This procedure requires the aircraft to reduce to final approach speed, fully extend flaps and lower its gear, before starting the CDA. As the differences in speed between different aircraft can be significant (as has been shown by the previous sessions as well), it is believed that the controller will be forced to give speed instructions during the CDA in some occasions. Due to the fact that the speed of the aircraft during the CDA is very low, flaps fully extended, and gear down, the aircraft has no means to reduce speed if required. This leaves the controller with only the option to have other aircraft increase speed, or abort the approach. This reduction in flexibility is found to be highly undesirable.

Furthermore it is believed that the early deployment of full flaps and gear greatly increases the wear of the aircraft.

From these findings, it has been concluded that procedure IV is not likely to be implemented in the future. Procedure V (also with a fixed speed and a variable vertical profile) will be a better candidate for implementation. The procedure V, which requires the aircraft to use an intermediate flap setting, with gear up, and thrust idle during descent will result in an intermediate approach speed of approximately 40kts above the final approach speed. This also leaves the aircraft with options for speed reductions if required. In procedure V, the descent angle is not as steep as for procedure IV, resulting in less optimised noise profiles. On the other hand noise contribution due to gear and flaps is less than for procedure IV. It is found to be a good compromise between workable procedures and noise abatement. Starting with prototyping session 3, procedure IV has been replaced by procedure V.

In procedure V, the aircraft reduces from about 250 kts to their descend speed only shortly before the CDA initiation point. This was also the case for procedure IV, which caused a lot of problems due to the large speed differences. It is foreseen that this will also be the case for procedure V. Therefore also a variant of the procedure has been implemented, with additional speed constraints along the RNAV route.

For this prototyping sessions also the Sourdine II departure procedures will be used.

6.3.1 Schedule

Start	Event
13.00	Explanation of the Sourdine II concept and the various ATC tools
13.15	Procedure II, SUGOL+RIVER +ARTIP high traffic density
14.00	Debrief
14.15	Break
14.30	Procedure V: SUGOL+RIVER+RIVER , high traffic density
15.00	Debrief
15.15	Break
15.30	Procedure V with speed constraints: SUGOL+RIVER+ARTIP, high traffic density
16.00	Debrief
16.15	Discussion on tasks, responsibilities, R/T phraseology, etc.

6.3.2 Initial set-up

From prototyping session 2, the following new functionality has been added:

- weather services have been added: there is now a strong south-western wind
- BADA 2.5 has been replaced by BADA 3.5.
- The flight monitoring aid (FPM) was available during these sessions, providing FL_bust and LAT_DEV warnings.
- Sourdine II low-noise departure procedure:
- Replacement of procedure IV by procedure V.

6.3.3 Results

- Significant problems were encountered between outbounds and inbounds (mainly crossing of BERGI outbounds and RIVER inbounds). As outbounds are climbing with reduced thrust between 3000 and 5000ft, it was found to be very difficult to have the outbounds continue their climb and cross overhead the inbounds. Instead, the departures were kept at FL60, until clear of inbound traffic and cleared for further climb. Only occasionally the departures could climb through a gap in the inbound traffic stream (RIVER). Alternatively, an early descend instruction to the inbound aircraft could enable a departure to continue its climb and cross the inbound stream overhead the inbound aircraft. However this can cause significant problems between two consecutive departures, with a faster one behind a slower one. Two aircraft on the same SID may need to be started at a larger spacing than the current 2 minutes. The use of the BIRGI SID (south of the original BERGI SID) did alleviate the problem.
- Slow climb procedures would require the RNAV routes to be moved close to the airfield in order to have the departures cross these routes quickly and start their climb, whilst fast climb procedures require RNAV routes further from the airfield in order to climb above inbound traffic flow before crossing.
- As the options for route-stretching and shortening is far more limited compared to vectoring, the inbound planning must be much better and aircraft must be delivered to approach more accurately.
- Ghosting aid is found to be very helpful in the merging of traffic from SUGOL and RIVER. The 10NM markers before MICOL were of little use, when compared to ghosting.
- Flight monitoring warnings were not considered very useful. When the “FL_BUST” warning was shown, this was usually due to the controller being a bit late updating his administration. “LAT_DEV” messages were not required, as aircraft not on the RNAV route already caught the attention of the controllers. Usually the intentions of the aircraft were clear (shortcut). The STCA safety net shall be sufficient.
- Besides the merging of the RIVER and SUGOL traffic stream, the Feeder/DCO also needs to build the sequence for approach, as the arrival controller has very little time and means to optimise the sequence.
- Workload for feeder/DCO shifted significantly from controlling to monitoring. Workload for arrival controllers became significantly higher due to differences in speed, dealing with uncertainty and limited controlling options. The R/T load reduced significantly for both controller roles.
- A point of discussion during the trials was the exact meaning of the transition clearance, as given by the Feeder/DCO controller. Does it also clear the aircraft for the CDA, although the CDA will be executed under control of the Arrival controller? During the experiments, it was assumed the transition clearance also implies an approach clearance.
- It is found that controllers tend to wait longer before intervening in the aircraft's speed profile.
- For all procedures, the controlling options during the descend are significantly less than with radar vectoring.
- No problems with R/T were encountered.
- Aborting CDA did not work properly
- Some aircraft accelerated at ILS interception.
- Weight category of some aircraft were apparently not shown in the label.
- Deceleration-rate of aircraft was considered to high.

Procedure II specific results

- The exact procedure concerning speed constraints is unclear: is the aircraft supposed to be at the specified speed over the waypoint, or shall it start reducing when passed the waypoint. In the simulation the aircraft start decelerating just before the waypoint, in order to pass the waypoint with the prescribed speed. Some pilots will reduce very early, while others maintain high speed very long, and reduce at the last minute. This causes uncertainty regarding speed profiles of the aircraft resulting in uncertainty concerning separation and accurate sequencing.
- Controllers found the amount of traffic to be less than a busy inbound peak at Schiphol.
- Too much bunching of inbound traffic. Current traffic scenario represents present-day operations. But this is not sufficient for CDAs. During CDA approaches, ACC needs to deliver the traffic more accurately to approach.

Procedure V specific results

- In this procedure the aircraft will decelerate from 250 kts to their CDA initiation speed (about FAS+40kts) just before starting their CDA. This creates large differences in speed just before the CDA initiation point. What seems to be a large separation at one moment, proved to be only small separation distance the next moment.

- During CDA, all aircraft descend at their intermediate flap speed, which creates significant differences in speed between the aircraft. There is no margin for dealing with these differences. Speed instructions were given frequently. If no intervention is desired/allowed, additional spare capacity must be claimed, reducing the available capacity. It is felt that a maximum capacity of 28-30 is feasible for this procedure.
- Traffic load in this experiment was better than in procedure II.

Procedure V -with speed constraints- specific results

- Arrival controller was much better able to anticipate separation between aircraft, as speed reductions just before CDA initiation point were much less. Feeder/DCO did not experience much difference in workload.
- Speed constraint of MICOL (200kts IAS) was felt to be too low for pilot's convenience, 220Kts would be more appropriate.

7 Conclusions and recommendations

From the prototyping sessions it can be concluded that prototyping sessions are very helpful in getting early controller feedback concerning the Sourdine II procedures as well as the verification of the simulation set-up. A number of simulator issues have been identified, which could have distracted the controllers during the experiments, distorting the results. During the prototyping phase, these issues have been resolved. The result of these prototyping sessions is a technically validated simulation environment which provides the controllers and pseudo-pilots with an optimal working environment for the operational validation of the Sourdine II procedures.

The prototyping sessions were kept relatively short, in order to be able to evaluate a large number of experiment set-ups and procedures, but just long enough for the controller to get a good feel about the handling capabilities of the various procedures. This allowed for a lot of discussion about the procedures and simulation-set-up.

7.1 Procedures

Procedure II in general did not pose significant difficulty to the controller, although the moment of deceleration was still uncertain and controllers needed to close monitor this. Even with the introduction of speed constraints this uncertainty remained, because some pilot will maintain high speed and reduce just before the speed constraint while others reduce in an early stage.

Main problems for procedure IV – where the aircraft decelerate to final approach speed before starting the CDA - has been the unpredictability of the aircraft intentions, as well as large speed differences between the aircraft in the CDA and the large sudden speed reduction from 250 kts to Final approach speed.

To the controller it was not clear when an aircraft would reduce and at what point it would start its descend. This uncertainty required the controller to have a larger safety margin between two aircraft in trail, and though reducing capacity significantly. As the differences in speed between different aircraft can be significant (as has been shown by the previous sessions as well), it is believed that the controller will be forced to give speed instructions during the CDA in some occasions. Due to the fact that the speed of the aircraft during the CDA is very low, flaps fully extended, and gear down, the aircraft has no means to reduce speed if required. This leaves the controller with only the option to have other aircraft increase speed, or abort the approach. This reduction in flexibility is found to be highly undesirable.

During the ATC prototyping sessions, a prototyping session with the flight simulator was also conducted. During these flight simulator experiments, it was found that procedure IV poses significant problems in the aircraft. The procedure required the aircraft to reduce to final approach speed, fully extend flaps and lower its gear, before starting the CDA.

From these findings, it has been concluded that procedure IV is not likely to be implemented in the future. Procedure V (also with a fixed speed and a variable vertical profile) will be a better candidate for implementation. The procedure V, which requires the aircraft to use an intermediate flap setting, with gear up, and thrust idle during descent will result in an intermediate approach speed of approximately 40kts above the final approach speed. This also leaves the aircraft with options for speed reductions if required. In procedure V, the descent angle is not as steep as for procedure IV, resulting in less optimised noise profiles. On the other hand noise contribution due to gear and flaps is less than for procedure IV. It is found to be a good compromise between workable procedures and noise abatement.

The use of a speed constraint on the merging point MICOL of 220kts seemed workable for the controllers. This solved the problems of the large speed reductions just before the CDA initiation point.

With the results of the prototyping sessions it is decided to use, besides the reference procedure I, procedure II (with and without speed constraints) as well as procedure V (with only the 220kts speed constraint on the merging point MICOL).

During the prototyping sessions, also the Sourdine II low noise departure procedure has been tried out. In this procedure, the aircraft will initially climb at take-off thrust up to 1000 ft, then reduce thrust, and slowly climb to 3000ft. At 3000ft set thrust to climb thrust, and start acceleration and cleanup after reaching 500ft. As this procedure uses a low thrust setting between 1000 and 3000 ft, the climb profile of the aircraft is much shallower. This results in a shift of the location at which the aircraft reaches an altitude of FL60 much further from the runway. In the simulations, where the departures would cross the inbound stream (at FL70/80), it was experienced this causes significant difficulties. As a result, the controller was forced to keep the departures stay at FL60 until clear of inbounds, before continuing their climb. Alternatively the controller could instruct inbound aircraft to descend earlier, however this would reduce flight efficiency and significantly increase the number of R/T instructions.

With conventional departures, where the point of reaching FL60 is much closer to the airfield, the controller has enough separation to allow for the departures to continue their climb overhead the inbound stream.

7.2 Tools

The Ghosting aid was found to be very helpful in the merging of traffic from SUGOL and RIVER. The 10NM markers before MICOL were of little use, when compared to ghosting. The representation of the ghost plots was also accepted and remains unchanged for the trials.

Not all participants considered flight monitoring warnings useful. When the “FL_BUST” warning was shown, this was usually due to the controller being a bit late updating his administration. “LAT_DEV” messages were not required, as aircraft not on the RNAV route already caught the attention of the controllers. Since the warnings did not disturb the participants either and their work shifts from controlling to more a monitoring task, it was decided to keep the monitoring tool during the trials.

The STCA functionality was considered helpful. The tool will act as a safety net and shall be part of the set-up for the trials.

7.3 HMI issues

Initially, a list was shown containing scheduled times for the aircraft to cross Micol. When the aircraft would cross Micol at that time, the separation between the aircraft was ensured. However it was found that just this list was not sufficient for the controller to anticipate the aircraft was late and what speed instruction would be required in order to meet the time constraint. It was concluded that this would require a tool, which would be able to provide the controller with a required speed for each aircraft. However as this currently is also done by the controller manually, and he/she is very capable in determining the speed profile of the aircraft and anticipate on speed differences between aircraft, it was felt this tool would not aid the controllers in doing their work.

For arrival procedure II, an arc has been shown on the radar display, showing the location at which the aircraft would start their CDA from FL70.

7.4 R/T and ATIS

As during the approach-phase, there are a lot of clearances given to the pilots, the user interface of the pseudo-pilot have been extensively evaluated, and improved where possible for use in the TMA.

During the Sourdine II procedures, there is a lot of informative R/T, stating the localizer frequencies, approach procedures, parallel runways in use, etc. It found that this amount of information could better be covered by the ATIS. Due to the maximum length of the ATIS (30 sec) maybe Digital ATIS is an option. For the experiments it is foreseen to include D-ATIS to reduce this R/T load.

The prototyping sessions have shown that the incoming traffic flow is representative for the traffic flow in real life. It is not required to set-up an additional feeder position for ACC. In order for the CDA procedures to work, it is required that the quality of the inbound planning is improved and ACC and stack controllers will be able to deliver the traffic flow according to this planning.

Appendix A: Procedures

During Mode 2 the following RNAV transitions and approaches are available:

- RIVER 1B TRANSITION (TO RWY 18R)
- SUGOL 1B TRANSITION (TO RWY 18R)
- REGSU 1 APPROACH (TO RWY 18C)

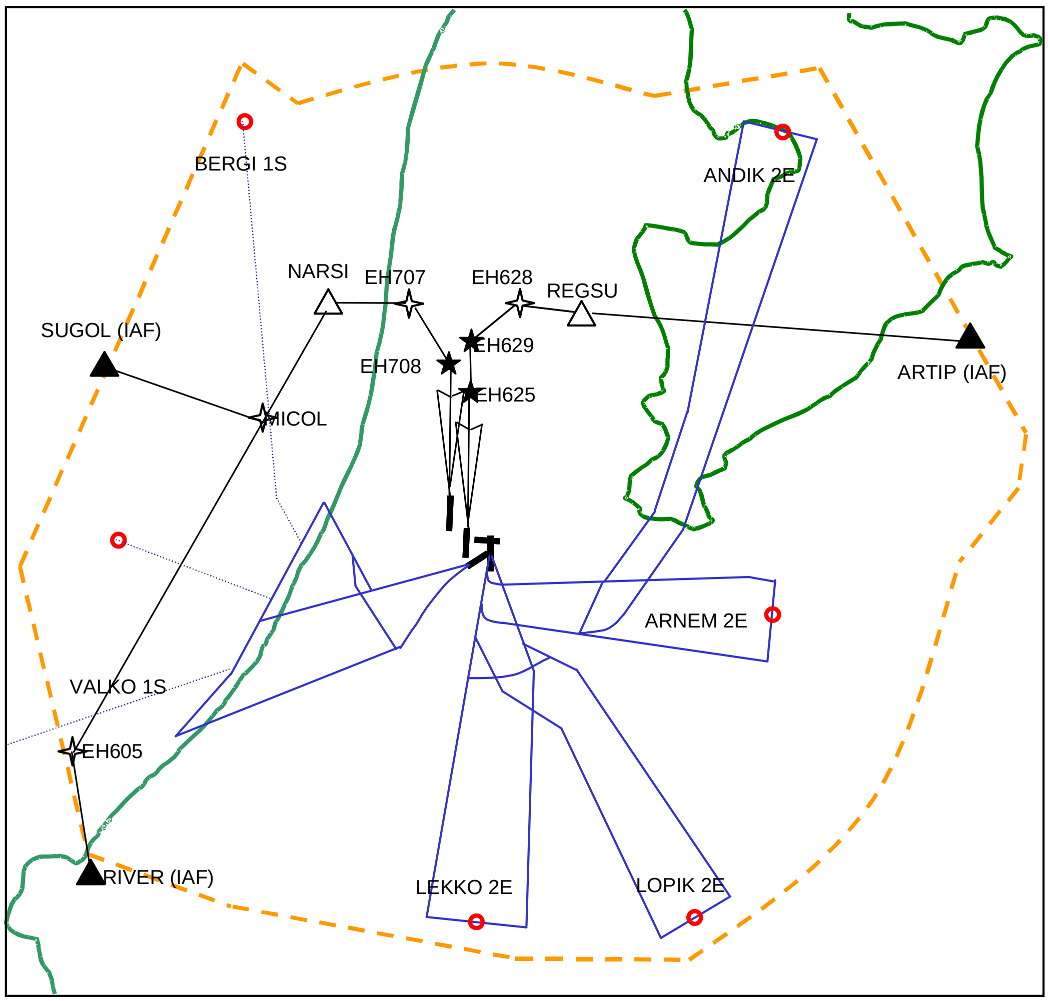

Figure A.1: RNAV transitions, approaches and SIDs during Mode 2

During Mode 2 the following SIDs are available:

- ANDIK 2E (RWY 18L)
- ARNEM 2E (RWY 18L)
- LEKKO 2E (RWY 18L)
- LOPIK 2E (RWY 18L)
- BERGI 1S (RWY 24)
- VALKO 1S (RWY 24)

The vertical procedures used during the prototyping sessions are:

Approach Procedure II: Basic CDA with 2° initial FP A

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

(++) Minimum allowable flap deployment

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

Approach procedure II: Basic CDA with 2° initial FP A and speed constraints

- Same as procedure II, but now with the following speed constraints
- At MICOL, speed 220 KTS.
- When passing NARSI, speed 200 KTS.
- When passing EH707, speed 180 KTS.
- When passing the Outer Marker, speed FAS.

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

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

Approach procedure IV: CDA with constant speed, variable FPA segment at landing configuration and speed constraints

- Same as procedure IV, but now with the following speed constraints:
- At MICOL, speed 200 KTS.
- 4NM before NARSI, speed 170 KTS, full flaps, landing gear down

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

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

Departure procedure 1: Reference (ICAO-A)

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

Remark: The airspeed of 250 KTS IAS is an ATC constraint for altitudes below 10000ft in the Schiphol TMA.

Departure procedure 2: Sourdine optimised close-in

Condition	Parameter values
0 ft	– TOGA (Take-off Go Around) thrust – Brake release and acceleration to rotation speed (*) – Rotation and lift-off
	– Retraction of undercarriage – Climb out at a speed of V2 + 10-20 KTS IAS (**)
At an altitude not lower than 800ft [1]	– Reduce thrust to OEI climb gradient (***) or max climb, whichever is lowest – Maintain V2 + 10-20 KTS IAS
3000 ft	– If OEI climb gradient thrust was selected: gradually change thrust to climb thrust – Maintain V2 + 10-20 KTS IAS
5000 ft****	– Accelerate and retract flaps/slats on schedule to clean configuration – Continue acceleration to 250KTS – Climb to 15000ft

(*) cleanest possible takeoff configuration

(**) V2+10 where possible

(***) 1.7% for 4 engines jet, 1.2% for twinjet

(****) alternatively, to allow for more aircraft/weight specific optimisation: replace “5000ft” by “between 3000 and 5000ft AFE, upon attaining climb thrust”

[1] Strictly dependant on local airport

Appendix B: Changes made to NARSIM simulator

This appendix describes the changes made to the NARSIM simulator during SOURDINE II.

ATS

- added function (ICD) to increase CD of an individual aircraft. The increase is an increment, i.e. the value specified is added to the CD value. To decrease the CD a negative value can be specified. -> this function was necessary for the implementation of procedure 4, where the aircraft decelerates to FAS at a certain (high) altitude and then starts a steep descent. The ATS had no means of increasing CD, and the a/c accelerated dramatically (some 100 knots) on the way down.
- The ILS command has been corrected. There were two obvious bugs. First, the GS angle specified in the configuration file was not used during the actual flight mechanics function. Second, the interception altitude, given in WGS84, was transformed to RDNAP resulting in an incorrect interception height (too high).
- The ILS command has been improved, so that is now accepts speed changes until the outer maker (altitude above 1200 feet). Once outer marker is reached, the a/c decelerates to FAS.
- ATS scripts have been written to simulate the SII procedures (arrivals: 2 and 4, departures: ICAO-A). Graphs created by Airbus (for an A340) were used to fine-tune the a/c behaviour resulting from the scripts. These scripts make use of the function and changes mentioned above.
- Thrust commands were added, allowing a pilot to select a certain amount of thrust (as percentage of maximum thrust) resulting in a corresponding speed, instead of selecting a speed, resulting in a corresponding thrust.
- BADA 3.5 has been integrated and validated. Some BADA figures have been changed for better conformance to the real aircraft performance.

wARP

- Added STCA warnings in APP mode
- Added FPM warnings
- Added table for merging point (MICOL)
- Added warning when a/c flies into NTZ, via FPM server
- Added ghost plots
- Display of RNAV routes and aiding lines

Touch input device

- Added aircraft dependent altitude menus: departing aircraft has a different altitude clearance menu than arriving aircraft.
- Some information on the radar display can be switched on/off by the controller using the TIDs.

Scheduler

- No updates to the scheduler have been incorporated.

Casper

- Ghosting functionality has been implemented.
- Set up of algorithm via configuration file.
- Works on distance to go algorithm, recalculated on each track update.
- Can also be used for converging runways.

STCA

- Adapted for working in the TMA.
- Possible to use different configuration files.
- Values in configuration file changed for TMA (lateral 3 NM, vertical still 1000 ft).
- During procedure 2, STCA is switched off under flight level 47. At this point, if aircraft are following a CDA, they are about to turn in for runway line up, and if parallel approaches are in force, multiple STCA warnings will appear.
- Currently, STCA is not included in runs where procedure 4 is simulated. As aircraft stay at a high altitude, the filter built in to switch it off at flight level 47, doesn't work, this would need to be flight level 70, more or less. This would mean that basically no STCA warnings would show. It was therefore decided to not include STCA.

FPM

- Added flight level monitoring, giving an alarm when the aircraft is starting its CDA without proper clearance.
- Added Lateral deviation monitoring, giving an alarm if the aircraft is not following the expected RNAV route.
- Added NTZ warning, where a warning occurs when aircraft flies into NTZ.
- NTZ is configurable in the servers configuration file.
- The NTZ is currently the only warning that wARP shows. This was due to a number of issues:
    1. for lateral deviations, the next route point calculations, by the FDP server, does not work correctly. Due to the confined airspace and tight turns the algorithm often skips route points. This causes the lateral deviations to show, even though the aircraft is not deviating.
    2. for vertical deviations (AAA: EFL Monitoring) the problem is the CDA. A solution would be to alert the ATCo if the aircraft hasn't started its descent, after passing TOD point. To achieve this, the TOD point would need to be known by the system, which is currently not the case.

Blipper

- Strips sorted in time.
- Added a flag to show whether a/c is flying CDA.
- New key definitions.
- Time stamp in recording.

R/T

- Configuration files changed.
- Changed recording: time stamp.

SPL

- Added TTO, which can be added in the IFP file, which can then be used by wARP in an ETO table.

TORNADO

- Added 4D grid defining the weather at a certain location, at a certain time.
- Predicted weather is different from the actual weather.

Appendix C: ATIS message and R/T

Example of Digital ATIS message

ATIS information:	ALPHA
Arrival runways:	18R (ILS, “cda”), 18C (ILS, “cda”)
Departure runways:	24
Surface Wind	speed: 30 KTS, direction 200º (degrees)
Visibility	10 NM
Cloud	overcast
Air Temperature	15º (degrees Celsius)
Dew point temperature	5º (degrees Celsius)
Altimeter settings	QNH 1013
Specific ATIS instructions:	Parallel independent runways in use
Other operation info	RWY18R ILS 110.1 MHz
RWY18C ILS 109.5 MHz	
Transition level	FL040
Trend type landing forecast	NOSIG

Example of SOURDINE II R/T Procedures

ACC	"Aircraft callsign, HELEN arrival, expect runway 18R, expected approach time is TT [min]"
ACC	"Aircraft callsign, descend to FL70 and speed 250KTS "
ACC	"Aircraft callsign, after RIVER, proceed on RIVER 1B transition to NARSI"
ACC	"Aircraft callsign, contact Schiphol approach on 121.2 (West) / 119.05 (East)”
a/c	“Aircraft callsign, on the RIVER 1B transition to NARSI at FL80”
FDR	"Aircraft callsign, continue RIVER 1B transition to NARSI and prepare for CDA ILS runway 18R, information Alpha, independent parallel approaches in force”
FDR	"Aircraft callsign, contact arrival on 118.4 (West) / 131.150 (East)”
a/c	“Aircraft callsign, on the RIVER 1B transition to NARSI at FL80, speed 220 kts”
ARR	"Aircraft callsign, cleared approach runway 18R, localiser frequency is 110.1”
FDR	"Aircraft callsign, contact Tower on 119.225 (West) ”