SOURDINE–II: SOME ASPECTS OF THE ASSESSMENT OF NOISE ABATEMENT PROCEDURES

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Abstract

The Sourdine-II (Study of optimisation procedures for decreasing the impact of noise) project is a 5th framework RTD project of the European Union focusing on the development and assessment of Noise Abatement Procedures (NAPs). It started November 2001 and will be finished August 2005. Four parts can be distinguished in the study:

1. Procedure definition (approach and departure)
2. Further development of assessment tools
3. Procedure assessment
4. Procedure implementation

In this paper, the project organization and applied methodology, as well as the first two topics mentioned above, are discussed very briefly. However, the main emphasis in this paper is on parts of the procedure assessment work.

In the Sourdine-II project a selection of approach and departure procedure is assessed with respect to safety, environmental impact (noise and emissions), capacity, Costs/Benefits, and acceptance by end-users (pilots and air-traffic controllers). This paper presents an overview of the initial results of the assessment work, with emphasis on the real-time simulations which were executed to determine the acceptance by end-users. Also, a brief overview of a part of the safety study is presented.

The work on the procedures implementation plan has just started and is not included in this paper.

Both in the real-time simulations as well as in the safety analysis bottlenecks for the implementation of the concept are identified. These bottlenecks will help the operational concept developers to find improvements for the operation before a successive assessment is done.

1. Introduction

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

1. Source noise reduction
2. Regulation and land-use planning
3. Noise Abatement Procedures.

Many efforts are already being undertaken (and are still continuing) to reduce the source noise itself by the introduction of more silent aircraft and engines. Also, regulations are nowadays applied at many airports in the form of restrictions to older airframe/engines, curfews and noise charges. At the planning of new urban areas it is pursued more and more to avoid areas which will be affected by aircraft noise. A third way of improving the situation is the development and implementation of new approach and departures procedures to provide increased air-transport capacity while maintaining a high level of safety and complying with ever-stricter environmental constraints.

This topic is adressed in the Sourdine-II project. The main objectives of the project are:

- Definition of new noise abatement procedures (both approach & departure)
- Further development of assessment tools
- Assessment of a selected set of procedures with respect to the following parameters:
  - Environmental impact
  - Safety
  - Capacity
  - Acceptance by end-users (pilots & air-traffic controllers)
  - Cost /Benefit
- Define implementation plan for selected procedures and define requirements for tools needed by pilot and air-traffic controllers.

2. Overview of SOURDINE-II

2.1 Organization

The topic adressed in Sourdine-II requires a multidisciplinary approach. Therefore a consortium is formed with partners who can contribute in different expertise areas. The consortium consists of:

AENA
Airbus – France
Eurocontrol Experimental Centre
INECO
Isdefe
NLR (Co-ordinator)
Sicta.

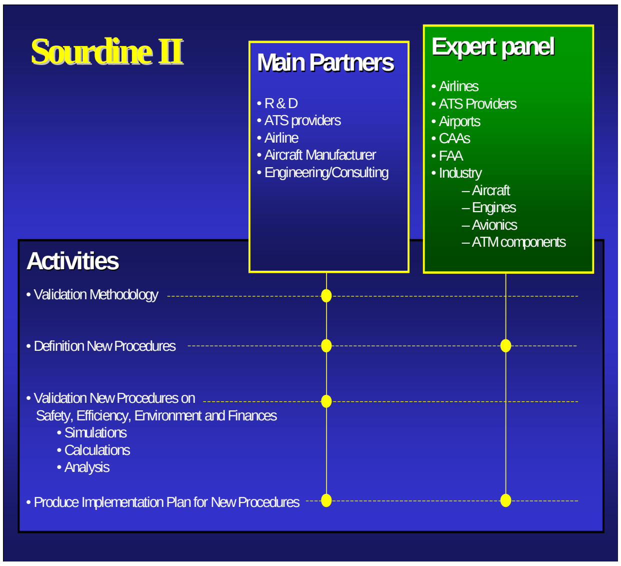

Figure 1: Organization of SOURDINE-II

Although many expertise areas are covered by consortium, also an expert panel is formed to cover additional expertise areas (for instance expertise of engines, small business jets, airport management, regulation issues) needed for the procedure definition. For the development and acceptance of an implementation plan for the new procedures, the support of many different type of organizations (Airlines, ATS – service providers, airports, CAAs, Industry etc.) is required. Both aspects were covered by the Sourdine-II expert panel at the same time: coverage of additional expertise areas and commitment to the implementation plan. Figure 1 presents the involvement of the expert panel in the project.

2.2 Methodology

In Sourdine-II, many (dozens) approach and departure procedures have been defined (see reference 1). For all these procedures, single event simulations have been performed for the A320 and A340 aircraft (see reference 2 and section 4). Based on these simulations and the inputs of sessions with

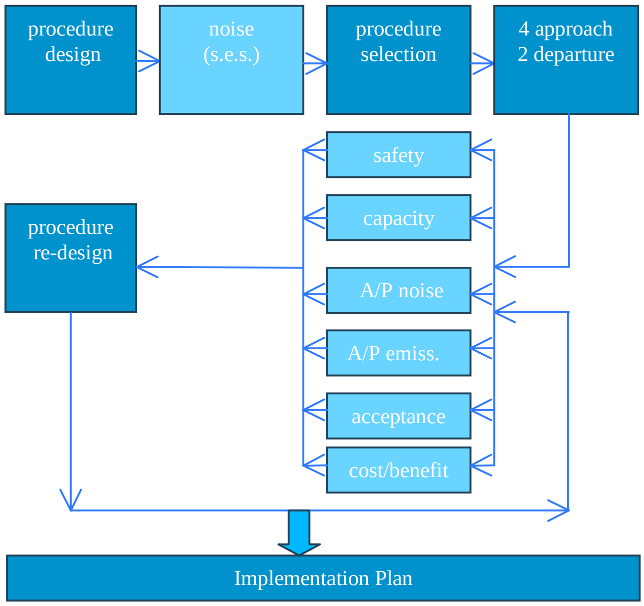

Figure2: Working methodology

the expert panel, 4 approach and 2 departure procedures have been selected, as well as an approach reference procedure and a departure reference procedure (see reference 3 and section 5).

So far, the procedures are defined in a generic way, i.e. a vertical profile, speed, thrust and configuration development. For (most of) the assessment with respect to the parameters mentioned in section 1 (see also figure 2), the procedures have to be embedded in an operational concept. Safety assessments have been done partly based on a Madrid (Barajas) based concept and on a Amsterdam (Schiphol) – based concept (see section 6). The same Amsterdam (Schiphol) concept was used during real-time simulations to assess the acceptance by pilots and air-traffic controllers. Airport noise and Emissions, as well as Capacity and Cost benefit assessments, have been done for Madrid (Barajas), Paris (Charles de Gaulle), Naples (Capodichino) and Amsterdam (Schiphol).

The next step after all the assessments, is the feed back to the procedure designers and the refinement of the procedures. After some iteration, the procedure will be fixed and an implementation plan will be made.

3. Scope of this paper

This paper only presents a small part of the Sourdine-II work. For the procedure definition and the Single Event Simulations, the reader is referred to the Sourdine-II website: www.sourdine.org. The study of the CBA and the implementation plan are at the very end of the project and were not finalised at the paper submission date. The further development of the INM – tool for the airport noise calculations and the use of multi-configuration and multi-speed NPD-curves will be presented in 2005 at another conference (paper has been submitted. Results of the capacity assessment and the Airpoirt noise and emissions study will be presented at the AIAA/AAAF Aircraft Noise and Emissions Reduction Sympoium (see reference 4). The main focus of this paper is on the assessment of the acceptance of the noise abatement procedures by Pilot and Air traffic controller (section 8). Also, a brief overview of a part of the safety study is presented (section 7).

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4. Single event simulation (example)

The objective of the single event noise calculations was to identify approach and landing procedures that are efficient in terms of noise exposure reduction. All procedures defined in the "procedure design"- work package were evaluated in this way. Note that the single event simulations were done on basis of manufacturers performance tools and resulting trajectories reflect performance characteristics of the aircraft. However, other operational, regulatory and pilot perception aspects were NOT subject of the single event simulations study. The single event simulations produced results in the form of graphs of the vertical, speed and thrust profile. As an example, for some of the selected procedures (see section 5), the vertical path and maximum noise profile is presented in figure 3.

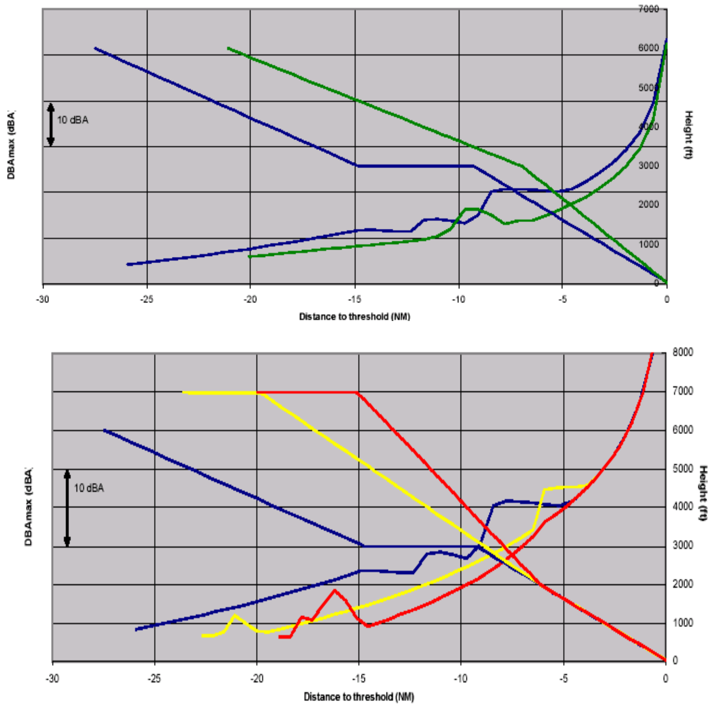

Figure 3: Vertical profile and maximum noise level for the procedure I (reference approach,blue), procedure III (green), procedure IV (red) and V (yellow).

5. Selected procedures

Based on the results of the Single Event Simulations and the results of the expert panel meetings, the following procedures were selected for further, detailed assessment:

Approach Procedures (4+1 reference)

- Procedure I: Reference with level deceleration at 3000ft
- Procedure II: Basic CDA with 2° initial FPA
- Procedure III: CDA with 2° initial FPA and increased final glide slope (4º)
- Procedure IV: CDA with constant speed, variable FPA segment at landing configuration
- Procedure V: CDA with constant speed, variable FPA segment at intermediate configuration

Departure Procedures (2+1 reference)

- Procedure 1: ICAO A
- Procedure 2: SII Optimised Close-in
- Procedure 3: SII Optimised Distant

For the evaluation with respect to safety and user acceptance, first all six selected procedures were evaluated on an intermediate level. Next, two procedures (II and V) were selected for detailed analysis with respect to safety and user-acceptance. In the user acceptance study, also the effect of adding speed constraints to procedure II was investigated. The procedure II with speed constraints is notified as procedure II-A.

6. Concept of Operation

The Sourdine-II operational concept for the Schiphol related assessment work is based on the current night transition procedures. Only the position of some of the waypoints has been slightly changed and therefore some of the according names were changed as well. The runway combination used is based on the Mode 2 configuration (wind coming from the South): inbound runway 18C and 18R, outbound runway 24 and 18L. Figure 4 shows the fixed arrival routes from the initial approach fixes (IAFs) River and Sugol to runway 18R and from ARTIP to 18C. Traffic from River and Sugol will be merged between Micol and Narsi. If required, controllers can instruct directs to Narsi for aircraft flying between Sugol and Micol. These so-called RNAV shortcuts can be used to optimise the traffic sequence.

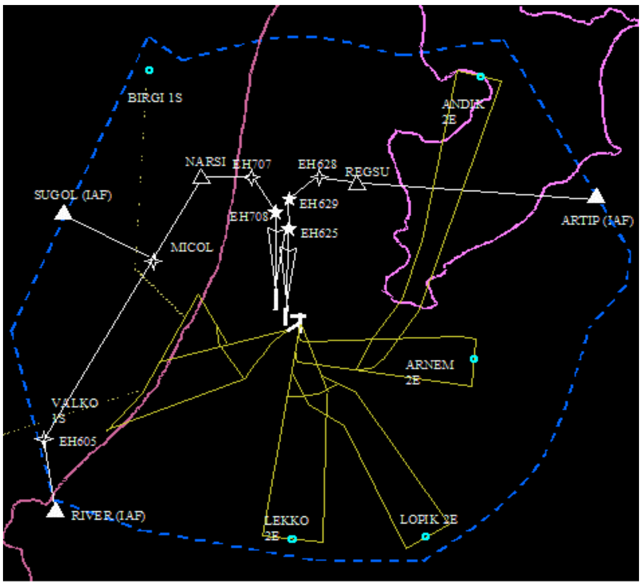

Figure 4: Operational concept

7. Safety risk assessment

The approach adopted for the safety risk assessment is the stepwise, iterative approach of the TOPAZ methodology [Ref. 5]. This approach allows for the use of Monte Carlo simulations for selected safety aspects [Ref. 6].

First the exact objective and scope of the safety risk assessment was identified, including determination of an initial target level of safety. As part of the scoping, an operational identification of the safety issues of the 6 procedures (four approach and two departure) was made from a pilot's point of view. The safety issues identified during this process are given in short.

For approach procedures II and especially III it was identified that possible excess speed at glide slope intercept may cause an unstabilised approach. Furthermore, the steep final glide slope of procedure III potentially increases workload, and this non-standard operation requires special analysis of acceptance and of obstacle clearance surfaces. To overcome some of these issues, the operational concept developers decided to define a variant of procedure II, named procedure II-A, in which speed constraints are of force.

In procedure IV a possibly steep intermediate approach segment could result in glideslope interception from above, with the potential consequences of glide slope undershoot and unstabilised approach. Also, potential flight path control problems could occur, which could lead to increased workload and an unstabilised approach in case the path is too shallow. For procedure V the same issues are identified, though all less severe.

The main issue identified for the departure procedures was speed control problems at low powersetting at the OEI climb thrust. This is expected to be more severe for procedure 2 than for 3.

Because of constraints, it was unrealistic to perform an in-depth safety risk assessment for all procedures. Based on the operational safety issues above and other arguments (on capacity, cost-benefit, acceptability, etc.), the 'most promising' procedures were selected for the scope of the safety risk assessment: approach procedures II-A and V and departure procedure 2.

In the following we illustrate the safety risk assessment cycle performed for approach procedure II-A. For this procedure an operation on Schiphol airport was determined by the operational concept developers. Safety experts verified this on completeness and consistence regarding the systems, human roles, procedures, and environment, and all interactions.

As many and as diverse hazards as possible were identified for this operation. This was done by means of hazard brainstorms with operational experts aiming to identify 'functionally unimaginable' hazards [Ref. 7], and by means of search in the TOPAZ hazard database. The hazards were structured into five conflict scenarios, describing all plausible ways in which they can lead to or affect a conflict situation:

1. Conflict between merging aircraft
2. Conflict between aircraft flying in trail
3. Conflict between aircraft on parallel localizers
4. Conflict at localizer intercept
5. Wake vortex encounter

The location of the conflict scenarios in the context of the operation is illustrated in figure 5:

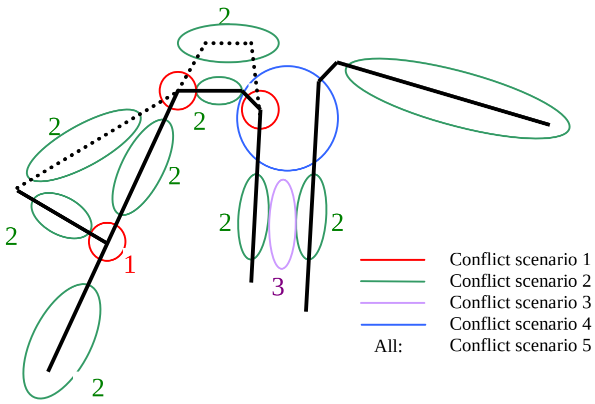

Figure 5: Locations of the conflict scenarios.

For each conflict scenario it was assessed how often the conflict occurs and how often it ends in a specific severity class. For conflict scenarios 1, 2, 3, and 5, an argumentation-based approach was used, and for conflict scenario 4 a simulation-based approach. Both these approaches rely on structuring of inputs retrieved from experts and statistics. In the argumentation-based approach this information is evaluated directly via argumentations. In the simulation-based approach this information is used to develop a Monte Carlo simulation model, to assess the accident risk for this model, and to assess bias and uncertainty [ref. 8]. This way, an expected accident risk value and a 95% uncertainty area for realistic accident risk is retrieved.

The risks were classified by combining severity and frequency estimates and comparing to the target level of safety. For conflict scenarios 1 and 3, the risk was assessed to be better than the initial target risk. For conflict scenarios 2, 4, and 5 it could not be ruled out that the risk was worse than the initial target. For these conflict scenarios safety bottlenecks were identified, which can help operational concept developers to find improvements for the operation. It is considered most logical to do a new cycle of the safety risk assessment once the operation has been improved. It is recommended that then also a simulation-based approach is adopted for conflict scenarios 2 and 5. It is also recommended to improve the derivation of the target level of safety.

8. Acceptance by pilot and air-traffic controller

8.1 RTS experiment set-up

The real-time simulations (RTS) were performed at the NLR and were divided in a prototyping part and an experiment part. These simulations mainly focus on the usability and the acceptance by the users of the proposed procedures and tools.

The prototyping was performed with APERO (Advanced Prototyping & Evaluation for Research & Operations) and NARSIM (the NLR Air Traffic Control Research Simulator). APERO (figure 6) is an easy to configure single pilot cockpit. APERO is used for prototyping of the new cockpit displays and tools used by designers in combination with test pilots or technical pilots.

Figure 6: APERO

NARSIM (figure 7) is a high fidelity ATC simulator, which is used for prototyping and final simulations. NARSIM is used to get initial feedback on tools and procedures as well as to evaluate controller workload and acceptance.

Figure 7: NARSIM

For the experiments both NARSIM and the GRACE (Generic Research Aircraft Cockpit Environment) flight simulator were used. GRACE (figure 8) is used to evaluate crew interaction and workload as well as to gain feedback on acceptability of new displays, tools and SII procedures.

Figure 8: GRACE

8.2 RTS Prototyping results

From the prototyping sessions it can be first of all concluded that these sessions are very helpful in getting early controller and pilot feedback concerning the developed procedures and tools as well as the verification of the simulation set-up. The result of these prototyping sessions is a technically validated simulation environment, which provides the controllers and pilots with an optimal working environment for the operational validation of the Sourdine-II procedures.

For the ATC part of the prototyping the controller provided feedback on the Sourdine-II procedures, proposed tools, human machine interface (HMI) and the content of the Digital – Automatic Terminal Information Service (D-ATIS) and Radio Telephony (R/T).

Several adaptations to the controller working position (CWP) were prototyped during these sessions. These adaptations consisted of a ghosting and a monitoring tool, Short Term Conflict Alert (SCTA) functionality within the TMA and changes to the radar display. Especially the ghosting functionality was considered very helpful in assisting the controller with the merging of two traffic streams.

A ghost plot of an aircraft provides position-information of that aircraft on a different route, called ghost-route (figure 9). In the Sourdine-II case, ghost plots are created for the aircraft from the SUGOL IAF and are projected on the RIVER approach route. This ghost plot 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 (figure 9).

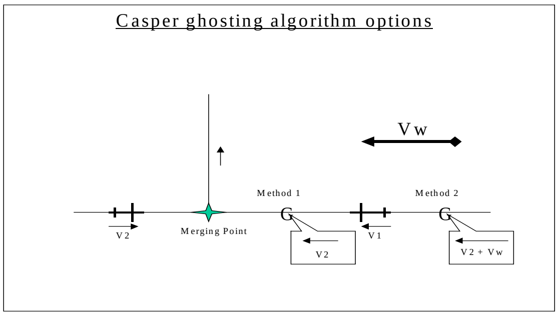

Figure 9: Ghosting algorithm options

In 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 ghost plot. The distance to fly is the same for the aircraft itself, as for an aircraft flying at the location of the ghost plot. The ghost plot will fly at the same speed as the aircraft itself.

In the time-to-go algorithm, 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 ghost plot. The ghost plot will fly at a speed the aircraft would fly if it would be using this route.

The main difference between the two methods is how the effect of wind is taken into account. For instance: an aircraft is flying at a speed of V2, at an distance to merging point d[nm], and facing a headwind of Vw kts. Using the distance-to-go algorithm, its ghost plot would fly at a speed of V2 kts at a distance d from the merging point. Using the time-to-go algorithm, the ghost would be flying at a speed of V2 + Vw at a distance d+x, where x is the additional distance covered due to the higher speed (figure 9).

Other functionalities that were added to assist the approach (APP) controllers in their tasks were:

- Introduction of STCA in the TMA
- 10 NM tick marks before the merging point and other small adaptations to the radar display.
- Monitoring functionality that warns the controller by deviations from the expected lateral and vertical profile.

For the pilot point of view two important tools were introduced on the navigation display: a vertical view and a flap/gear deployment cue on the ND.

8.3 Results of the real-time flight simulation

The general aim of the real-time simulation for the airborne side was:

- To present pilots with the new noise abatement procedures (NAPs) and pilot tools,
- To investigate flyability of the proposed NAPs,
- To investigate the usability and acceptance of the proposed pilot tools, and
- To assess the impact of the proposed NAPs and pilot tools on noise, perceived safety, and efficiency as well as the impact on pilot workload and situational awareness.

Five crews of each two airline pilots participated in the experiment and conducted several experimental runs. In these runs, three NAPs (procedure I, II and V, see section 5) were flown under different experimental conditions (for example, with different wind conditions, with and without the use of pilot tools, etc.). Subjective data were collected by means of questionnaires. The participants completed a post-run questionnaire after each experimental run, which asked for the participants' experiences during that specific run.

A debriefing questionnaire after the experiment asked for participants' overall opinion on the procedures, the tools used, and the experiment.

Pilots were asked, by means of a rating scale, to rate the flight efficiency, noise friendliness and safety. It should be noted that these are subjective ratings and should be seen as expert judgement feedback of the experiment and not as objective results.

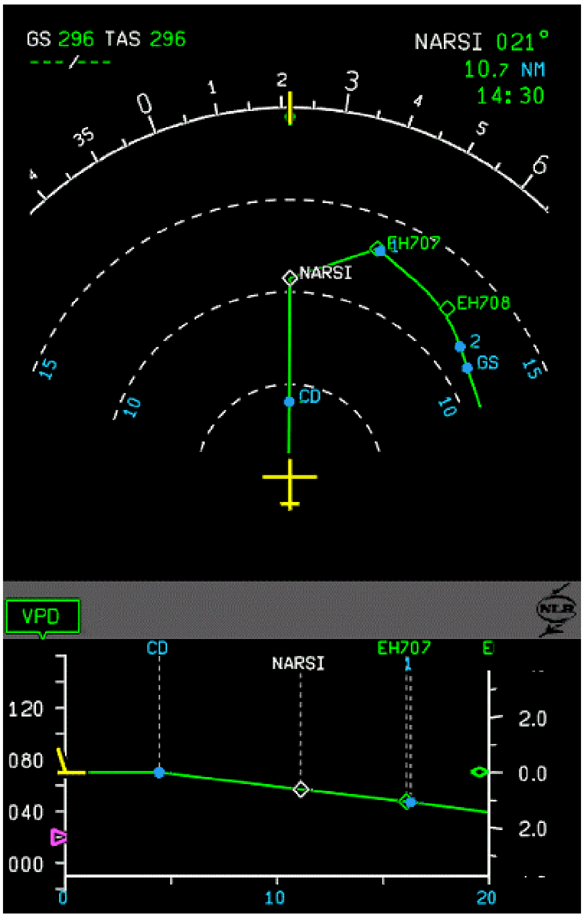

Figure 10: ND with flap/gear deployment cues and vertical view

Efficiency

Efficiency ratings by the participants (see figure 11) showed that procedure I (baseline) was rated less efficient than procedure II ($p < .005$ for the post-run, this was a tendency of $p < .10$ for the debriefing) and also rated less efficient than procedure V ($p < .01$ for the post-run, and a tendency of $p < .10$ for the debriefing). Altogether, that the proposed noise-abatement procedures II and V are rated to be more efficient than the current approach procedure.

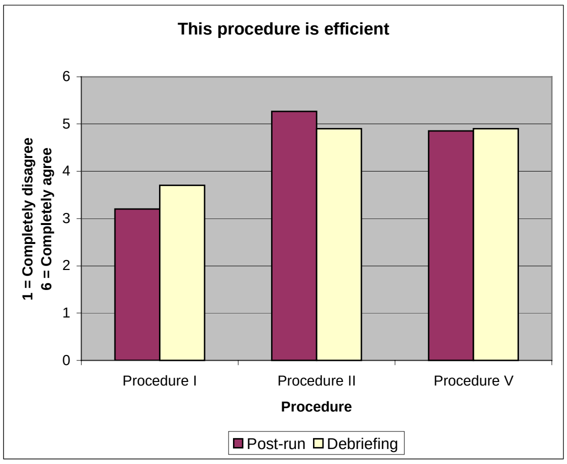

Figure 11: Efficiency ratings for NAPs

Perceived safety

Safety ratings were made by the participants and presented in figure 12.

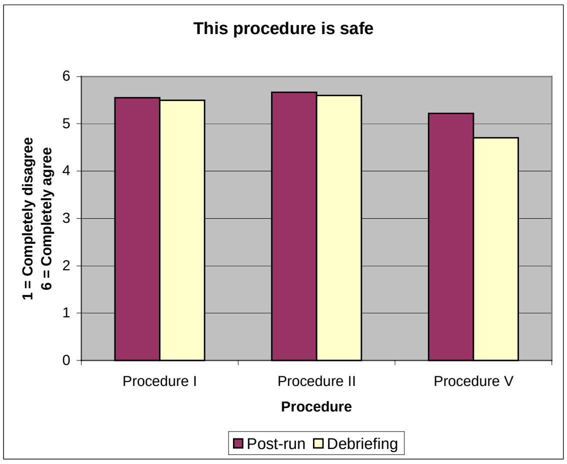

Figure 12: Safety ratings for NAPs

Ratings from the debriefing questionnaire showed tendency that procedure I is rated safer than procedure V ($p < .10$) and a significant effect that II is rated safer than procedure V ($p < .05$). Procedure V is rated less safe because of the smaller room for error.

Additional findings

In addition to efficiency and perceived safety, also some pilot-related measurements were performed. First, workload measurements (measured by NASA-TLX and RSME) were performed. These measurements showed no significant differences in workload ratings for procedures I, II, and V.

Secondly regarding the Sourdine-II specific tools on the flight deck it was found that the configuration change points are clear and that these are evaluated as very helpful for the pilots. This is especially true for the initial points CD (CDA initiation point) and 1 (flaps 1) and 2 (flaps 2) and the GS point (glide slope intercept) to enhance situation awareness and manage their energy level. The latter points, 3 (flaps 3) and FULL (full flaps), etc. were considered as current practice and therefore less beneficial. The vertical navigation display in the lay-out as presented in figure 10 is useful, but it is not required. If more information could be included in the vertical display it will be much more attractive to use according to the participating pilots. This additional information could be:

– Extra information about (speed) constraints
– Vertical speed
– Vertical trend of aircraft
– TCAS warning
– Significant weather information

And finally, situational awareness – especially the aspects “navigational awareness” and “energy awareness” – was investigated. The ratings for both aspects of awareness show to be always between high and very high.

8.4 Results of the real-time ATC simulation

The general aim of the real-time simulation for the ground side was:

– To present controllers with the new noise abatement procedures (NAPs) and controller tools,
– To investigate the feasibility and acceptance of the proposed NAPs,
– To investigate the usability and acceptance of the proposed controller tools, and
– To assess the impact of the proposed NAPs and controller tools on noise, perceived safety, capacity, airline costs as well as on controller workload and situational awareness.

Two trials with duration of two days have been executed at this moment. At least one and probably two more trails are foreseen before the end of the project. During the trials two controller roles in the Schiphol TMA (figure 4) were realised:

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

Like the flight trials, subjective data was collected by means of questionnaires. The participants completed a post-run questionnaire after each two runs of a specific procedure, which asked for the controllers’ experiences during that procedure acting both as a

FDR/DCO and an ARR controller. A general debrief was held at the end of the two-day experiment.

Perceived safety

In general, participants considered the impression that Sourdine-II procedures are safe. This holds especially for procedure II and II-A. Most importantly, the use of fixed lateral routes was experienced as safer than radar vectoring.

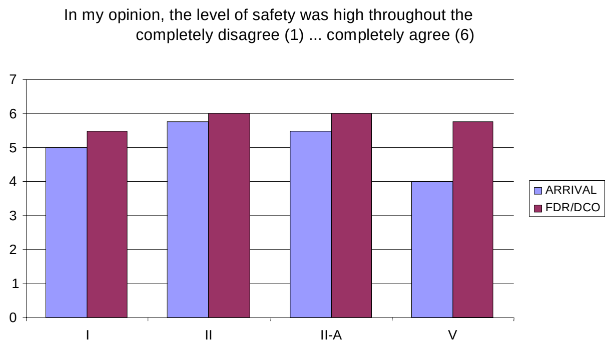

Figure 13: Safety ratings by controllers

The only procedure that was assessed less safe than the baseline procedure was procedure V. Here, participants indicated that they ‘did not experience the situation as fully under control’, and that the separation on final approach was in some cases less than 3 NM.

Workload

Controllers reported that there was less R/T load in the Sourdine-II procedures than in the baseline procedure (figure 14 and 15, in these figures “PP” indicates the corresponding pseudo-pilot R/T load). R/T is often taken as an indicator of task load (i.e., the objective task demands), which would indicate that the task demands were less with the Sourdine-II procedure than the baseline procedure.

However, participants also indicated that there was a shift from active control tasks (such as issuing instructions) to monitoring tasks. This was especially true for procedures II-A and V, and for the role of the ARR.

These monitoring tasks, although not accompanied by other behaviour such as R/T, were often experienced as demanding and stressful. One reason is that if the ARR controller actively builds the sequence (by turning the aircraft at a specific time on final approach, by issuing a speed instruction, etc), he or she can predict the resulting position of an aircraft, and only needs to watch the aircraft as part of the standard monitoring process.

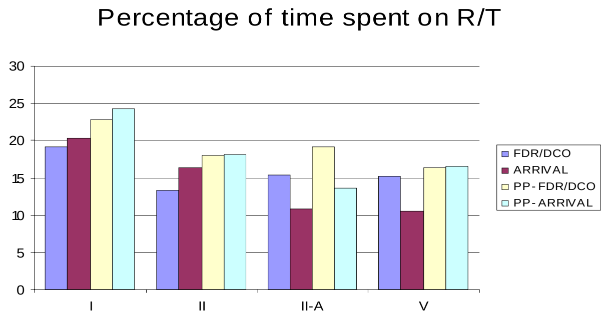

Figure 14: Time spent on R/T

With procedures II and V, in which the development of the traffic situation bears more uncertainty, the monitoring process becomes more intense (i.e., the controller spends more time observing the aircraft).

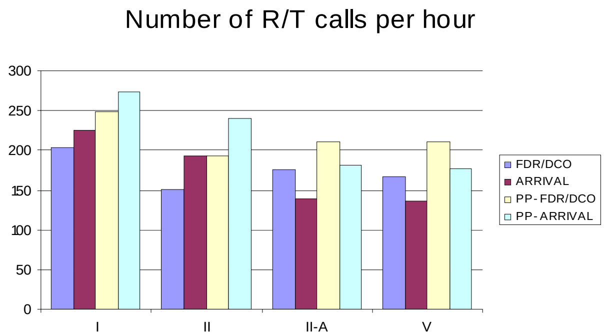

Figure 15: R/T calls per hour

For the role of the FDR/DCO, participants stated that in all of the three Sourdine-II procedures (II, II-A and V) the FDR plays a more central role in building of the sequence.

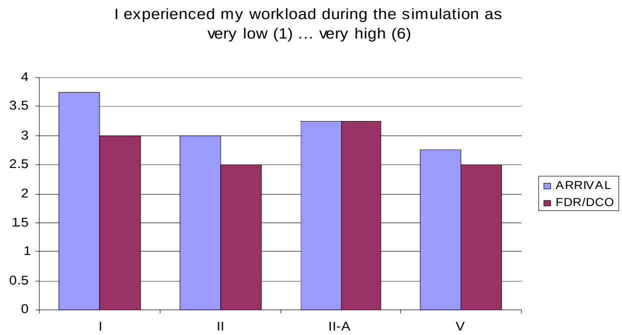

Figure 16: Workload ratings

The reason is that the instruments for building the sequence (i.e. short-cuts and extensions of the lateral route) are available to the FDR/DCO, but not to the ARR.

Thus, there is a shift from ARR tasks to the FDR/DCO. In line with this, the rated level of workload (measured on the basis of the post-run questionnaire) shows a numerical decrease for the role of the ARR and a numerical increase for the FDR/DCO.
However, the Sourdine-II procedures do not just imply a shift in task components from one controller role to the other. Rather, some task components change. These task components, for instance, refer to radar vectoring of aircraft or to the issuing of altitude instructions that is used for building the sequence / merging inbound streams in current procedures.

Controller tools

Ghosting
Ghosting was experienced as very helpful. It facilitates the merging of inbound streams from RIVER and SUGOL, which is done by the FDR/DCO. Some of the participants considered it would be advantageous to display the ghost plot on the basis of time rather than distance (as it is currently done). If ghosting was based on time, the information could also be provided to ACC. The advantage of displaying ghost plots based on distance is the easy correlation between the actual plot and the ghost plot.

Monitoring Aids
Participants appreciated the general idea of providing monitoring aids to the controller. Nevertheless, they were not fully satisfied with the chosen implementation. It was indicated that if the ARR and FDR/DCO's tasks primarily consist in monitoring, then there would be a broader set of monitoring alerts. For instance, controllers could be warned in case of insufficient separation between a heavy and the subsequent aircraft.

Conclusions on real-time ATC simulations

Procedure II is seen as an efficient and noise-friendly approach. Pilots indicated that procedure II could have been made steeper than the 2 degrees descent path. Noisewise it was rated as improved compared to the baseline. It was regarded having more margins for error (energy corrections) than procedure V and therefore safer.

According to the controllers both procedure II and II-A could be used in real operation, given that the following requirements are met:

– Pilots need to strictly follow the procedure
– ATCos need to accept the procedure: they need to understand why it is important to apply the procedure (because it yields a substantial reduction in noise)
– Very good planning of flights: Aircraft need to enter the TMA at a specific time and altitude.
– Controllers should be able to overrule the speed constraints in the procedure (II-A). This of course should still be within the performance envelope of the aircraft flying a continuous descent procedure.

Procedure V is seen as very noise friendly and fuel efficient, but there is not much room for error for the pilots. There is an increased risk of being too high and/or too fast in order to perform a stabilised approach.

The controllers experienced procedure V as a drastic change from current working procedure: "this procedure is really taking it to the extremes". Nevertheless it was stated that some of the felt uncertainty involved in the procedure might decrease with practice: "the different speeds are a question of getting used to: after a while you know how fast aircraft are flying."

As mentioned in the results the developed controller tools (ghosting and monitoring functionality) and pilot flap/gear deployment cue and vertical navigation display were well appreciated. Though the functionality of the monitoring tools and the vertical navigation display should be further extended to optimally support the users in their tasks.

9. Conclusions

Potentially, noise abatement procedures can contribute to a large noise reduction around airports. However, implementation is only possible when the new procedures satisfy the requirements with respect to safety, capacity, emissions, cost/benefit and acceptance by the pilot and the air traffic controller. In this paper, results of a part of the Sourdine-II safety study and user-acceptance study have been presented.

From the safety study, it could not be ruled out that the risk was worse than the initial target for three conflict scenarios. For these conflict scenarios safety bottlenecks were identified, which can help operational concept developers to find improvements for the operation.

The results of the study on user acceptance of the Sourdine-II procedures is presented in section 8. Both from a pilot viewpoint as well as from the air traffic controllers' viewpoint, there are some bottlenecks identified. It was identified that introduction of the procedures could be facilitated by:

- For the pilot:
  - The ND should display the CDA initiation point and configuration change points
- For the air traffic controller:
  - provide early sequencing of the aircraft
  - provide extended monitoring tool (speed deviations and required wake vortex separation) for APP, or even replace by ASAS Spacing functionality on baseleg and final.

For airports which use two parallel runways for arriving aircraft, a continuous descent of two aircraft could cause a violation of the separation minima (1000ft/3nm). Additional research is required to investigate further technical or a procedural solutions (e.g., flying curved approaches using GPS or MLS) to use continuous descent approaches on parallel runways.

For more information: see www.sourdine.org

10. References

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11. Abbreviations

A/P	Airport
APP	Approach
ARR	Arrival
CBA	Cost Benefit Analysis
CWP	Controller Working Position
DCO	Departure Controller
FDR	Feeder
FPA	Flight Path Angle
GRACE	Generic Research Aircraft Cockpit Environment
GS	Glide Slope
HMI	Human Machine Interface
IAF	Initial Approach Fix
INM	Integrated Noise Model
NAP	Noise Abatement Procedure
NARSIM	NLR ATM Research SIMulator
ND	Navigation Display
NPD	Noise Power Distance
OEI	One Engine Inoperative
RSME	Rating Scale Mental Effort
R/T	Radio/Telephony
RTD	Reasearch Technology and Demonstration
RTS	Real-Time Simulation
SES	Single Event Simulation
Sourdine	Study of optimisation procedures for decreasing the impact of noise
STCA	Short Term Conflict Alert
TLX	Task Load Index
TMA	Terminal Manoeuvering Area

TOPAZ	Traffic Organization and Perturbation AnalyZer

12. Authors' biographies

Ruud den Boer received his M.Sc. in Aerospace Engineering at the TU Delft in 1981. From 1981 to 1996 he worked at the Aero-elasticity department of NLR. He was the leader of several projects executed by NLR for General Dynamics/Lockheed and was heading the experimental unsteady aerodynamics group. In 1996 he joined the ATM department at NLR, he headed the ATM – real-time simulations group (NARSIM) from 1999-2002 and currently he is the co-ordinator of the Sourdine-II consortium.

Collin Beers received his M.Sc. in Aerospace Engineering at the TU Delft in 1998. Since then he is working as an aerospace engineer at the ATM department of the National Aerospace Laboratory (NLR) the Netherlands. He was previously involved in MTCD related projects such as the MTCD shadow mode trials at Malmö and Rome ATCC and the evaluation of MTCD at Riga ACC contracted by Eurocontrol. Currently he is involved in the Sourdine-II project and Dutch government projects. These latter projects are focusing on airspace capacity and the development of concept of operations for the future.

Hans Huisman started working for the NLR in 1991 in the avionics group. After specialising in user interface aspects of flight deck design a.o. for Fokker aircraft and european projects and gaining experience in running human in the loop experiments with the flight simulators of the NLR he moved to the Human factors department in 1993. Currently he is senior R&D manager within the Training, Human Factors

Mariska Roerdink has a degree in cognitive psychology and specialised in Human factors. She started working for the NLR in 2002 in the Human factors department. Currently she is R&D engineer within the Training, Human Factors and Cockpit Operations department. She has been involved in preparing and running human in the loop experiments, for example Sourdine-II.

Jelmer Scholte has worked as R&D engineer in air transport safety at NLR since 2000. He received his M.Sc. degree in Applied Mathematics from Twente University. His current research interests include safety risk asessment and safety risk criteria. He has performed many qualitative and quantitative safety risk assessments for various customers.