EUROPEAN ORGANISATION

FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

EUROCONTROL EXPERIMENTAL CENTRE

TAAM SIMULATION

OF

OSLO TMA

EEC Report N° 372

Project ATI-S-TA-OSLO

Issued : July 2002

REPORT DOCUMENTATION PAGE

Reference: EEC Report No. 372	**Security Classification:** Unclassified
Originator: EEC – ATI (ATM Implementation Business Area)	**Originator (Corporate Author) Name/Location:** EUROCONTROL Experimental Centre Centre de Bois des Bordes BP15 91222 Brétigny-sur-Orge CEDEX France Telephone : +33 (0)1 69 88 75 00
Sponsors: EATMP / DIS / STS NATAM (Norwegian ATM and Airports Management)	**Sponsor (Contract Authority) Name/Location:** EUROCONTROL Agency Rue de la Fusée, 96 B -1130 BRUXELLES Telephone : +32-(0)2-729 90 11

TITLE:

TAAM Simulation of OSLO TMA (NORSIM–MBS–OSLO)

Authors	Date	Pages	Figures	Maps	Appendix	References
François VERGNE Marianne HENRIKSEN Paul JOHANNESSEN	07/02	XII + 89	24	-	1	3

	Project	Task No. Sponsor	Period
_	**ATI-S-TA-OSLO**	_	06/01 – 05/02

Distribution Statement:

(a) Controlled by: Head of ATI

(b) Special Limitations: None

(c) Copy to NTIS: ~~YES~~ / NO

Descriptors (keywords):

Model Simulation, TAAM, Norwegian Airspace, Oslo APP, Oslo airport Gardermoen, conflicts, ATC sectors, SID, STAR, runway usage, runway movements, noise contours

Abstract:

In 1999 NATAM (Norwegian ATM and Airports Management) requested assistance from EUROCONTROL for a series of simulations to examine and analyse the current ATC sector plan and routing schemes within the Norwegian airspace.

These simulations compose the NORSIM project. Within this project, the second Model Based Simulation was named TAAM Simulation of Oslo TMA. It considered Oslo Terminal Manoeuvring Area (TMA) and was based on the findings of the Model-Based Simulation of Oslo Air Traffic Control Centre (ATCC) using RAMS, previously conducted by EUROCONTROL ‘s Experimental Centre. The process used with this study was quite innovative as a NATAM team was in charge of the run of the simulation at EEC with the help and assistance from EUROCONTROL staff. Consequently, this project was considered as a Pilot Project aiming at defining the procedures to be followed by members states wishing to use the EUROCONTROL TAAM licences for their own studies within EUROCONTROL projects.

The main objective of the TAAM Simulation of Oslo TMA study was the optimisation of the SID and STAR system that ties the Oslo Gardermoen airport to the ATS routes structure within Oslo FIR, as amended by the previous RAMS simulation. Then, the study had to evaluate various runway usage at Oslo airport. Finally, noise contours for Oslo airport were established for the various simulated scenarios and exercises.

SUMMARY

In 1999 the Norwegian *Luftfartsverket Hovedadministrasjonen / NATAM (**N**orwegian **AT**M and **A**irports **M**anagement)* requested assistance from EUROCONTROL (EATMP/DIS/STS) for a series of simulations to examine and analyse the current ATC sectorisation and routing schemes within the Norwegian airspace.

These simulations compose the NORSIM project. Within this project, the first Model Based Simulation was named NORSIM-MBS-OSLO. It considered Oslo Air Traffic Control Centre (ATCC) and was conducted in EEC Brétigny using the RAMS simulator. This simulation followed a SAAM-based analysis undertaken by EUROCONTROL ’s AMN (Airspace section).

The results found with the RAMS study gave good indication about what could be done within Oslo ATCC in view of increasing capacity within the centre taking into account the possible interactions in the neighbouring FIRs. Nevertheless, the limitation of the RAMS simulator prevented a detailed study of some aspects such as detailed runway usage or noise abatement restrictions. That is the reason why the project team recommended to complete the RAMS study by a more comprehensive simulation of the Oslo TMA aspects. This was achieved between June 2001 and April 2002 by the means of a TAAM simulation of the Oslo TMA under the project code number ATI-S-TA-OSLO.

The objectives of the study were mainly to develop proposals in view of improving the traffic flows within the TMA. This was done taking into account the proposed changes initially evaluated with the RAMS simulation. This involved the investigation, with the help of the TAAM simulator, of current and future arrival and departure route network within Oslo TMA along with the current and future possible runway usage at Gardermoen airport.

The project was conducted in EEC by a NATAM team using the TAAM simulator. The NATAM team was advised and supported by EEC staff. This project was to be considered as a Pilot Project aiming at defining the procedures to be followed by member states wishing to use the EUROCONTROL TAAM licences for their own studies within EUROCONTROL projects. By the end of the study, a review of the whole process was part of the project in order to evaluate the possibility to extend such a working method to other studies. Globally, the process set up with this study was successfully tested and validated.

The simulation evaluated seven scenarios containing a total of 15 exercises.

The most promising route structure within Oslo TMA retained a SID / STAR system largely based on the changes proposed with the previous RAMS simulation. Nevertheless, and thanks to the ability of the TAAM simulator to integrate the airport aspects along with detailed runway usage, large optimisation and fine tuning of these initial proposals, including a set additional options in view of various runway usage at Oslo airport Gardermoen, were achieved with this study. Finally, a set of noise contours, based on the TAAM trajectories was delivered to NATAM for most of the simulated exercises. As with every model-based simulation, the results and the concepts established and evaluated during the course of the study should ideally be validated through real time simulation exercises - planned for end 2002 within NATAM - prior to operational implementation.

ACKNOWLEDGEMENTS

The authors would like to thank the experts from NATAM Røyken, Einar UNDSTAD, Geir GILLEBO, Jesper KROGH, Fred NORUM (OSL, Oslo Gardermoen airport), Geir VALLE and Tor-Øivind SKOGSETH, for their assistance and co-operation during the simulation.

The authors would also like to thank the EUROCONTROL staff who worked with them on this study. In particular, Danny DEBALS (EATMP/DIS/STS), Frédérique AYACHE (EEC/DAI/TAAM support), Louis SILLARD (EEC/OPS) and Jean-Luc JANSZEN (EEC/OPS) for their help and assistance.

Finally thanks to Pierre SCHMIT (EEC/DAI) and the team of ENV Centre of Expertise at EEC for their co-operation and support.

Table of contents

Green pages: French translation of the summary, the introduction, objectives and conclusions

Pages vertes: Traduction en langue française du résumé, de l'introduction, des objectifs et des conclusions

General abbreviations and acronyms used

ACC	Area Control Centre
AIP	Aeronautical Information Publication
AMAN	Arrival manager
AMN	Airspace Management and Navigation Unit
APP	Approach
ARR	Arrival
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATI	ATM Implementation Business Area
ATM	Air Traffic Management
ATS	Air Traffic Services
CTA	Controlled Airspace
DEP	Departure
DIS	Directorate for Infrastructure, ATC systems and support
EATMP	European Air Traffic Management Program
EEC	EUROCONTROL Experimental Centre
ENGM	Oslo airport, Gardermoen
ENHANCE	European Harmonised Aircraft Noise Contour modelling Environment
Ex(s)	Exercise(s)
FIR	Flight Information Region
FL	Flight Level
LAEQ	Average Noise Level
LAMAX	Maximum Noise Level

MBS	Model Based Simulation
NAP	Noise Abatement Procedures
NATAM	Norwegian Air Traffic and Airport Management
OPS	Operational Services
PANS	Procedures for Air Navigation Services
PC	Planning controller
RAMS	Reorganised ATC Mathematical Simulator
R&D	Research and Development
RNAV	Area Navigation
RVSM	Reduced Vertical Separation Minima
RTS	Real Time Simulation
SAAM	System for Assignment and Analysis at a Macroscopic Level
SD	Standard Deviation
SID	Standard Instrument Departure
STAR	Standard arrival
STS	Support to States Unit
TAAM	Total Airspace and Airport Modeller (licensed product from Preston Aviation Solutions)
TC	Tactical controller
TC/A	Tactical Controller on charge for arrivals (within TMA)
TC/D	Tactical Controller on charge of departures (within TMA)
TMA	Terminal Control Area

References of the document

REF 1	*OSLO ATCC Project - SAAM evaluation report N°30*
REF 2	*Model Based Simulation of OSLO AIR TRAFFIC CONTROL CENTRE - EEC Report N° 364*
REF 3	*Project Management Plan - Norwegian Airspace Simulation – PMP – 30 / 09 / 2001*

1 INTRODUCTION

In 1999 the Norwegian *Luftfartsverket Hovedadministrasjonen / NATAM (**N**orwegian **AT**M and **A**irports **M**anagement)* requested assistance from EUROCONTROL (EATMP/DIS/STS) for a series of simulations to examine and analyse the current ATC sectorisation and routeing schemes within the Norwegian airspace.

These simulations compose the NORSIM project. The NORSIM project will likely contain additional Model Based and Real Time simulations for Oslo and the other Norwegian ATCCs (Stavanger, Trondheim, Bodø).

In a first step, for Oslo ATCC, a SAAM-based analysis was undertaken by EUROCONTROL ’s AMN (Airspace section). The results of this study were provided to NATAM by the end of March 2000.

Then, based on the findings of the SAAM evaluation, a second step was initiated in April 2000, through a model-based simulation (NORSIM-MBS-OSLO) for the whole Oslo airspace, including the Oslo TMA. This simulation was conducted in EEC Brétigny (ATI business area and OPS Centre of Expertise) with the EUROCONTROL RAMS simulator. The results of this study were delivered to NATAM by February 2001(see REF2).

Most of the objectives of this study were completed. Nevertheless, and in order to have a comprehensive solution to the remaining problems still pending within Oslo TMA, NATAM wished a more detailed simulation of the TMA aspects. EUROCONTROL then proposed to NATAM to conduct their own fast-time simulation, using the EUROCONTROL TAAM licences with the help and assistance of EEC model based simulations experts. This process, described in this document, was quite innovative and was considered as a Pilot Project aiming at defining the procedures to be followed by member states wishing to use the EUROCONTROL TAAM licenses for their own studies within EUROCONTROL projects. This Model Based Simulation was named TAAM Simulation of Oslo TMA and received the project code number ATI-S-TA-OSLO.

The main purpose of the TAAM Simulation of Oslo TMA was to establish optimum SID and STAR system linking the Oslo airport Gardermoen runways to the ATS route structure within Oslo FIR as set up during the RAMS study (see REF2, Scenario C19B). This was achieved considering the impact on number and severity of conflicts (and so, workload for TMA controllers) within TMA airspace, ENGM airport estimated runways capacity and, thanks to TAAM graphical capabilities, visual validation done by Oslo ATCC operational staff. This was achieved taking into account the introduction of a Departure Controller within Oslo APP, as recommended with the previous RAMS simulation.

The TAAM Simulation of Oslo TMA also helped to define where the crossing points between SIDs and STARs should ideally be located in order to optimise the aircraft flight profiles by trying to avoid intermediate levelling off during the climb and descent phases from / to Oslo airport. This location, by delivering a clear vertical separation between arrival and departure flows where they have to cross, should avoid untimely ACAS alarms for the airspace users.

The TAAM Simulation of Oslo TMA as well evaluated various runway usage at Oslo airport Gardermoen (e.g. segregated or flexible use of both runways at ENGM).

Finally, a set of noise contours, using various noise indexes and based on the TAAM trajectories was delivered to NATAM for most of the simulated exercises. This was achieved, processing the TAAM output data with the ENHANCE tool. The analysis of these noise contours was not part of this study. This will be conducted, when required, by the NATAM environment experts.

This TAAM study made a broad use of the data set up for the RAMS simulation. The findings of the RAMS evaluation were as well extensively used for the specifications of the TAAM simulation exercises.

For this study, an initial meeting took place in EUROCONTROL Experimental Centre, Brétigny on the 03 March 2001. NATAM staff (the NATAM simulation Project Leader and her Deputy) then followed a two-week TAAM training at EEC early May 2001. The kick-off meeting of the study took place in Oslo end of May 2001. The final results were presented to NATAM in March 2002.

This document is only a summary of the study. It contains :

- General comments about the way this study was completed as this simulation was the first one conducted by member state staff using EUROCONTROL TAAM licences with the assistance of EEC fast time simulation experts.
- The general description of the simulated airspace, the traffic sample and a diagram of the study.
- The description and the main results found with every simulated scenario and exercise.

Any supplementary information about the complete description of the objectives of the study, the analysis of the different scenarios and the main findings of the simulation may be obtained from NATAM, EATMP/DIS/STS – EUROCONTROL Headquarters - or Air Traffic Management Business Area (ATI) – EUROCONTROL Experimental Centre.

2 OBJECTIVES OF THE STUDY

The objectives of the study were :

- (Priority 1) Study alternative solutions to a SID and STAR system that ties up the runways at ENGM (Oslo airport Gardermoen) to the ATS route structure within Oslo FIR, as amended by RAMS simulation Scenario C19B, taking into account the introduction of a Departure Controller. The study stressed less on numbers, but more on the traffic streams with the aim to minimise number of conflict points and thereby reducing risk and total workload for TMA controllers.
- (Priority 1) Pinpoint where the crossing points between SIDs and STARs ideally should be located in space to avoid necessity for level off in climb and descend. An aim here was to avoid unwanted ACAS alarm in cockpit.

- (Priority 2) Evaluate runway utilisation, including the effects of the suppression of the noise critical altitude of 5000ft and study how today's segregated use of runways affects capacity and efficiency as compared to flexible use of both runways.
- (Priority 2) Delivery of a set of noise contours for the various proposed scenarios in view of further analysis within NATAM.

This involved the investigation of :

- The current and future airspace structures : ATS routes, SIDs/STARs for Oslo airport Gardermoen, TMA sectorisation, holding procedures…
- The current and possible future runway usage at Oslo airport Gardermoen.
- The current and future traffic levels.
- The results of the RAMS simulation of Oslo ATCC.

Nevertheless, and due to time constraints, the impact of runway usage on capacity and efficiency was not totally evaluated with the study. The same reason prevented the simulation team to evaluate in details the effects of the suppression of the noise critical altitude.

3 GENERAL PROCESS OF THE STUDY

3.1 Introduction

With this project, NATAM staff conducted the simulation (part of the EUROCONTROL NORSIM project) using the EUROCONTROL TAAM licenses at EEC with the help and assistance of EEC fast-time simulation experts.

This was the first project conducted this way. That is the reason why it was considered by all the involved parties as a Pilot Project.

The following paragraphs will review the various phases of the project, trying to find the advantages, the drawbacks and the lessons learned with such a process.

3.2 The process

This section briefly describes the process followed during the TAAM Simulation of Oslo TMA.

Initially, a meeting took place in EEC on the 03rd April 2001 between NATAM representative and EUROCONTROL model-based simulation experts in order to define the process to be followed during the study.

First, during this meeting, the objectives of the simulation along with the expected results were presented. Then, the various roles and responsibilities were defined and the set up of the project team (including the simulation working group) was initiated. Finally, a first planning for the whole simulation project was set up.

The NATAM staff in charge of executing the simulation at EEC had to follow a TAAM training which was delivered by Preston Aviation Solutions (ex TPG) at EEC from the 07th to the 18th May 2001.

After the initial meeting, the PMP established for the whole NORSIM project was updated and approved by all the appropriate authorities (REF 3).

The kick-off meeting for the project took place in Oslo on the 11th June 2001.

Then a series of six working sessions was programmed between June 2001 and March 2002. Each working session had a duration of two weeks (10 working days) and was dedicated to the use of the EUROCONTROL TAAM licenses at EEC.

Throughout the project regular meetings with the working group took place either at EEC or in Oslo.

Then, the final presentation of results for the Oslo TAAM simulation took place in Oslo on the 07th May 2002.

Finally, this report was written by both the NATAM Simulation Project Leader, in charge of the description of the study along with the presentation of the simulation results, and EEC Simulation Project Manager, responsible for the description of the process and the finalisation of the whole document.

3.3 The team

With any project, the set up of the project team has to be made carefully. With the particularities of the TAAM Simulation of Oslo TMA, the setting up of the simulation team was really a critical point.

More particularly, the choice of the persons conducting the various working sessions at EEC was a key point. Ideally, they had to be persons with a strong operational background. Then, they had to be keen on working on a simulation project using a tool and working methods, which were totally new for them. Even with the assistance from experienced staff, the core of the simulation work (e.g. data input, tuning of the various scenarios, analysis of the results, contacts to the working group, presentations of the project…) remained their task and responsibility.

In addition these persons had to work repetitively in EEC, i.e. for this project, seven times two week periods over about one year time (including the TAAM training session). The access to the TAAM simulator from a remote location (in the present case from Oslo) was considered but not achieved with this project. The main reason being that the TAAM machines were inside the "firewall" of EEC.

The first idea was to have a single operational expert from NATAM conducting the working sessions at EEC. But after discussions about the particularities of the project during the initial meeting, it was recommended to have a team of two NATAM persons (see below) to be trained on the TAAM simulator and attending the working sessions at EEC. This was mainly aiming at reducing the risks of the project.

Again, it was clear that the selection of these two persons in charge of conducting the simulation had to be done carefully. The selected persons, both operational controllers from Oslo ATCC-APP, had a strong operational background along with a strong commitment to achieve the simulation using TAAM. These two points were really key elements in view of the success of the whole project.

The two NATAM experts, Simulation Project Leader and Deputy, were supported by a team at the ECC and a simulation working group (see below).

Finally, a project Leader in NATAM and the NORSIM EUROCONTROL Project Manager in EUROCONTROL Headquarters completed the project team.

3.4 The actors and the roles

For the TAAM simulation of Oslo TMA a project team was set up (see above). The actors and their roles within the team are described below.

Besides the **EUROCONTROL Project Manager** (from DIS / STS - EUROCONTROL Headquarters) and the **NATAM Project Leader**, it was composed of the following actors :

- A **NATAM Simulation Project Leader** and one **Deputy** : these persons, Oslo APP operational controllers, conducted each working session at EEC. The NATAM Simulation Project Leader was member of the RAMS Simulation of Oslo ATCC working group previously conducted at EEC (see REF 2). Otherwise, the NATAM Simulation Project Leader and her Deputy had no experience about model-based simulation at the beginning of the project. They followed a two week training about the TAAM simulator. This training was delivered by Preston Aviation Solutions.

- A **Simulation working group** composed of representatives from Oslo ATCC (ACC and APP) and observers from Oslo airport Gardermoen.
- An **EEC Simulation Project Manager** who provided help and assistance to the NATAM Simulation Project Leader throughout the project and mainly during the working sessions at EEC.

The role of the above actors were allocated as follows :

EUROCONTROL Project Manager :

This study was part of the EUROCONTROL EATMP/DIS/STS NORSIM project. The EUROCONTROL Project Manager had to monitor and oversee the simulation and report to NATAM Steering Committee. The Project Manager had the ultimate responsibility, from EUROCONTROL point of view, for all NORSIM related project activities.

NATAM NORSIM Project Leader :

This person was in charge of co-ordination of the NORSIM project with the Steering Group. The NATAM NORSIM Project Leader was responsible for all liaisons between NATAM and EUROCONTROL for the whole study. He was following-up the simulation working group as required and took part in the simulation working group meetings.

NATAM Simulation Project Leader (assisted by the Deputy Project Leader) :

- Followed (with Deputy) a two week TAAM training course at EEC.
- Was in charge (with Deputy) of the execution of the simulation at EEC using EUROCONTROL TAAM licenses. The EUROCONTROL Simulation Project Manager largely assisted her throughout the study (see below). As already mentioned, the possibility of using a remote access to the TAAM licences (through Internet) was investigated but not retained for this project.
- Had to establish, with the help of the NATAM NORSIM Project Leader, a working group to support her (and Deputy), as required, in Oslo and at EEC throughout the project.
- The NATAM Simulation Project Leader had to report to NATAM NORSIM Project Leader.
- As previously mentioned, it was clear that the NATAM Simulation Project Leader and the Deputy in charge of conducting the simulation had to be carefully selected within NATAM staff. This was achieved with this project as the selected persons had a strong operational background along with a strong commitment to achieve the simulation using TAAM.

EUROCONTROL Simulation Project Manager :

- Was in charge of organising and monitoring the simulation project.
- Thanks to his knowledge of TAAM and fast time simulations in general, the EUROCONTROL Simulation Project Manager was also in charge of helping and assisting the Project Leader to conduct the study.
- In this regard, full assistance was provided to the Project Leader for :
  - Matching the scenarios / exercises to be simulated with the objectives of the study.
  - Conducting the whole simulation.
  - Data preparation and validation.
  - Quality control throughout the study.
  - Analysis of the results.
- The EUROCONTROL Simulation Project Manager was as well in charge of providing resources to the Project Leader for the tasks around the simulation itself such as digitising airport layout or establishing simulation maps.

The table next page summarises the tasks sharing established at EEC in order to complete the Oslo TAAM simulation. For the sake of clarity, the table retains, for the main tasks, the following actors :

- The NATAM Simulation Project Leader (PL)
- The Deputy Project Leader (DPL)
- The Simulation working group (WG)
- The EUROCONTROL Simulation Project Manager (PM)
- Other EEC staff.

N°	ACTOR	TASK
1	PM	General organisation and monitoring of the simulation project, assistance to PL and quality control
2	PL+DPL+WG	Define the objectives of the simulation
3	PL+DPL +WG	Prepare Traffic sample
4	PM+PL+DPL +WG	Define analysis required to enable the traffic sample to be considered ready for simulation (i.e. fully validated)
5	PL+DPL +WG	Run the analysis on the traffic sample
6	PM +EEC staff	Filter the traffic data into TAAM format
7	PM+PL+DPL +WG	Validate the data for the study
8	WG	Provide accurate sector definition (vertical and lateral boundaries with the co-ordinates of the sector corners)
9	WG	Provide maps with sectors, routes, SIDs, STARs, airport layout… for specifications
10	EEC staff	Digitalisation of the airport layout
11	PM+PL+DPL	Define the scenarios / exercises to simulate and structure them
12	PL+DPL	Data input
13	PM+PL+DPL + EEC staff	Provide maps with sectors and routes from the simulator for the various scenarios to simulate
14	PL+DPL	Run of the scenarios / exercises
15	PM+PL+DPL	Validate the results of the various scenarios / exercises. Identify the necessary modifications
16	PL+DPL	Make the above identified modifications and re-run the scenarios / exercises
17	PM+PL+DPL	Define the analysis to apply to the scenarios and the various comparisons to do
18	PL+DPL	Obtain the simulation results
19	PM+PL+DPL	Analysis of the results
20	PM	Delivery of noise contours for Oslo airport Gardermoen
21	PL+DPL	Produce the necessary intermediate documentation
22	PL+DPL+PM	Write the simulation report
23	PL+DPL	Prepare the required presentation material

3.5 Effort

This section will summarise the effort spent during the whole project duration.

For the **NATAM Project Leader** and her **Deputy**, the effort could be evaluated as follows :

- One man-month attending the TAAM training course.
- Five man-month executing the tasks linked to the simulation.

For the **Simulation working group**, a total of 0.5 man month was spent on the project.

For the **EUROCONTROL Simulation Project Manager**, a total effort of 3 man - month was required for this project. This effort takes into account the total time spent working for the project . It includes the initiation of the project, the effort spent to help and assist the NATAM team (see above table), along with the effort required to deliver the noise contours and to write this report.

One man-month was spent by the **EEC Model Based Simulation support staff** throughout the project.

The effort spent by **other EEC staff** for this project represented a total of 0.5 man - month. This effort mainly consisted of filtering the simulation data (from Excel format to TAAM format, or vice versa mainly for data preparation purposes), digitising the Oslo airport Gardermoen layout, establishing simulation maps and various administration tasks (organisation for NATAM staff visiting EEC, preparation of working places for NATAM experts, establishing security badges, hotel booking, etc…).

The combined effort spent by **STS Project Manager** and **NATAM Project Leader** was evaluated at one man-month for the TAAM Simulation of Oslo TMA as part of the whole NORSIM Project.

According to the above estimation, a total effort of 11 man - month was spent by both NATAM and EUROCONTROL staff in order to complete the TAAM Simulation of Oslo TMA. One additional man - month effort was spent for the TAAM training course, prior to the actual start of the project. If the training course was not really part of the project, it was nevertheless a mandatory step towards the completion of the study using this process.

As conclusion, the total effort spent for the TAAM Simulation of Oslo TMA was equivalent to the amount of effort spent for a "standard" model based simulation project (generally set between 10 and 12 man -month). This was of course achieved with a different effort distribution between EUROCONTROL and "client" staff. The only additional effort required when retaining the process described in this document, and in comparison to the "standard" way of conducting such a study, being the necessary effort spent for the TAAM training, session due to be completed prior to the start of the project.

3.6 Cost

The costs linked to the use of the TAAM simulator were covered by EUROCONTROL.

The fees for attending the 2 week TAAM training at EEC, for NATAM Simulation Project Leader and Deputy, were supported by NATAM.

During the whole project, NATAM covered all expenses for its own personnel when at EEC. The travel and daily allowances required for this project could be summarised as follows :

- Two return travels from Oslo to Paris for NATAM Project Leader for initial and final presentation preparation meetings. Each of these meetings was a one day meeting.
- Seven return travels from Oslo to Paris for NATAM Simulation Project Leader and Deputy, for the training course and the six working sessions at EEC. Each time, the NATAM staff's assignment was two weeks.
- Two return travels from Oslo to Paris for three members of the simulation working group. Each time, they attended at EEC a two day simulation working group meeting.

EUROCONTROL travel and allowances for its own staff were :

- One return travel from Brussels HQ to Paris for the EUROCONTROL NORSIM Project Manager who attended the final presentation preparation meeting at EEC. As underlined above, this was a one day meeting.
- One return travel from Brussels to Oslo for EUROCONTROL NORSIM Project Manager and one return travel from Paris to Oslo for EEC Simulation Project Manager for the final presentation of the project. These were a two day assignment.
- One return travel from Paris to Brussels along with a single day assignment for EEC Simulation Project Manager in order to have a project closure meeting between STS and EEC staff.

3.7 TAAM usage

The EUROCONTROL TAAM licences installed at EEC were used during the training and the various working sessions by the project team.

For the Simulation of Oslo TMA, the total use of TAAM could be evaluated at approximately a total of 50 working days.

Figure 1 next page shows the number of working days spent using the various TAAM modules.

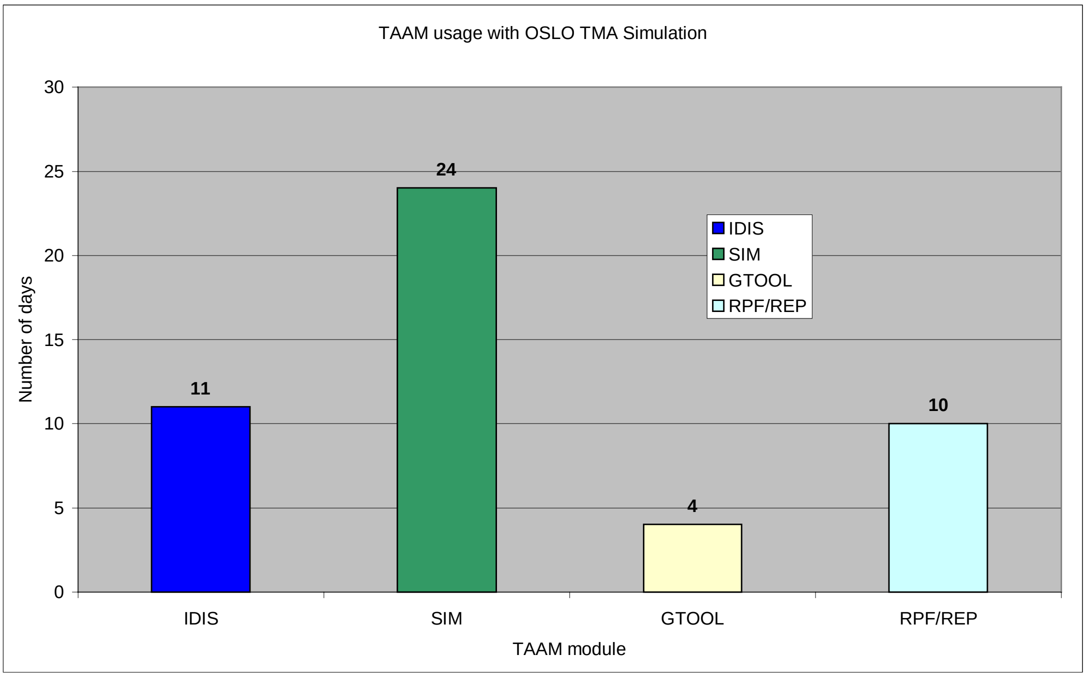


Figure 1 : TAAM usage with Oslo TMA Simulation

According to the above chart, it can be seen that mainly the Simulation module was activated during the project. Then, IDIS (preparation and amendment of data) and the TAAM Plus Reporter modules were as well used, but to a lesser extend. The use of GTOOL module (airport and sector layout drawing) was limited as few changes for these layouts were required through the study. In addition, it has to be noted that a large part of the initial data (used for the reference scenarios) came from the RAMS simulation, previously made for Oslo ATCC, via Excel and appropriate filters developed at EEC. This limited the use of the IDIS and GTOOL modules during the project.

The same filtering process (from TAAM to Excel and vice-versa) was applied for several data set modifications (mainly the ones to be achieved for the traffic data such as new runway allocation or route point sequence update).

In addition, an EEC laptop with TAAM in "Demo" mode on it (i.e. only allowing the run of previously prepared scenarios which could not be modified) was used to make presentations to the simulation working group in Oslo. With this project, the laptop computer was used for an evaluated total duration of one month.

During each working session, one TAAM licence had to be considered as blocked during the "standard" working hours. Of course, each of the various modules was used separately. But, due to the necessary tuning of the scenarios and exercises, the users had to switch from one to the other module throughout the working day. The other TAAM users at EEC had to take this into account and planned their work accordingly.

3.8 Lessons learned

As already underlined, the Oslo TAAM Simulation project was considered as a pilot project. It was the first project using the working methods and the tasks sharing described earlier in this document. With this project, a team from the authority requesting a simulation was in charge of a large part of the tasks to be achieved during the study. This was done within an EUROCONTROL project using the TAAM simulator and the EUROCONTROL TAAM licences, with help and assistance of EUROCONTROL staff. The comments included in this document should help to define the procedures to be followed by (other) EUROCONTROL Member States wishing to use the EUROCONTROL TAAM licences for their own studies within EUROCONTROL projects.

Globally, seen from both NATAM and EUROCONTROL staff point of view, the process, used for the first time at EEC, was successful. The next sections will list the main advantages / disadvantages found with the above described process.

For the NATAM team

The set up of the NATAM project team was a key point in the process. There was good relationship between the various members of the team. In addition to the fact that the various team members belonged to the same ATCC, relationship was largely based on the mutual confidence that was established through previous NORSIM sub-projects (SAAM evaluation and RAMS simulation, see REF 1 and REF 2).

The motivation of the NATAM Simulation team was outstanding. It has to be noted that it was a real challenge for operational controllers - the NATAM Simulation Project Leader and her Deputy, not familiar with large data processing tools as the TAAM simulator - to take the responsibility of the run of a whole model-based simulation project, even when help and assistance was available.

The rhythm, the length and the location of the working sessions were additional worries for the team. Nevertheless, the NATAM Simulation Project Leader and her Deputy efficiently coped with these difficulties. However, the risks linked to the "human aspects" of the process should not to be minimised. The success or the failure of such a project largely depend on the way these risks have been identified and evaluated during the initiation phase of the process and accepted by the various actors.

For the EUROCONTROL staff

The good relationship between the various members of the NATAM team (see above), between the EUROCONTROL Project Manager and the staff at EEC and between the EUROCONTROL team and the NATAM team was a key factor in the success of the process.

As previously underlined, this was largely based on the mutual confidence that was established through previous NORSIM sub-projects (SAAM evaluation, then RAMS simulation, see REF 1 and REF 2). With such good links between the various actors, it was, of course, much easier to overcome the inevitable difficulties, which appeared throughout the project.

The process used for this study allowed a more efficient employment of EEC staff, particularly for the Simulation Project Manager. With the standard way of conducting a model-based simulation, the Simulation Project Manager spends practically all of his working time (about 80-90% throughout the project duration) working for the project. It is consequently very difficult to use his (her) expertise or operational input in other projects.

With the distribution of tasks as used with the Oslo TAAM Simulation, the effort of the Simulation Project Manager was reduced to a total of 3 man - month spread over the whole duration of the project, i.e. 10 months (which is the standard duration of a detailed model-based simulation project). By his (her) action and knowledge of the fast-time simulation processes the project can remain in line with the objectives. Nevertheless, as he (she) is released of a very large part of the input of data, parameters or tuning processes, he (she) is available to participate in other simultaneous projects. The effort spent by other EEC staff remained limited (see paragraph 3.5).

The planning

The main drawback of the working method described in this document is the irregular distribution of the effort to be provided throughout the project. While this was only a question of organisation for EEC staff working in their own premises, it was more difficult for the NATAM simulation team.

The team had really to organise the work in accordance to rhythm of the working sessions. As no remote access was available (see paragraph 3.3), the TAAM simulator was only available for the NATAM team during the sessions at EEC. This obviously required a careful preparation of the working sessions in order to make the best possible use of the simulator.

For instance, the description of the new scenarios and exercises had to be completed prior to the beginning of each session. On the other end, the run of the scenarios / exercises had to be fulfilled by the end of each session, in order to allow presentation and discussions with the working group in Norway.

Consequently, the planning and the objectives of the various working sessions, along with the simulation working group meetings had to be carefully planned. They had particularly to take into account that enough time was available, between two working sessions, in order to deliver feed-back to the working group, to collect new ideas / specifications for the next steps of the project and to prepare with efficiency the next session. In addition, a long-term planning of the working sessions and working group meetings was required, particularly due to the fact that the working group was composed of operational controllers working in shift.

During this project, one re-planning of the working sessions was needed. The initial planning - established at the beginning at the project - underestimated the available time interval between two working sessions combined with the Christmas holiday period.

The time interval between two working sessions, based on the experience gained with this project, should ideally be five weeks.

The costs

In comparison to the standard way of conducting a model-based simulation, and taking into account the new (2002) EUROCONTROL STS charging policy, the process described here did not generate higher costs for the “client” asking for a simulation. Most of the costs supported by the "client" were the travel costs and the daily allowances required to attend the various working sessions.

The access to the EUROCONTROL TAAM licences was granted for the duration of the project. In addition, the high involvement of the client simulation team - including the working group - certainly made an added value to the project. For example, this would surely allow an easier implementation of the proposals established, tested and validated, under the monitoring of EUROCONTROL experts, by a team made of operational people from the relevant centre.

In comparison with the "standard" process used with model-based simulation, the cost for EUROCONTROL staff were largely reduced, mainly due to the limited time spent on the project by the Simulation Project Manager. There was as well a large reduction of the travel costs. The participation of EUROCONTROL staff to working group meetings for instance, was limited to the ones that took place at EEC. Furthermore, EUROCONTROL had not to pay for any travel cost or daily allowance for NATAM staff.

Of course, this does not take into account the cost of the TAAM licenses or maintenance, support and update fees (MSU). As a matter of fact, this is not considered here as TAAM licences were bought by the agency independently from this study and they are as well used for several other EUROCONTROL projects.

Otherwise, the cost of providing NATAM staff with working space and equipment (desk, computers, etc..) was not significant.

TAAM usage

The number of available TAAM licences being limited - as it is at any site - the planning of the various working sessions had to be made very carefully. In fact, during each of these working sessions, the NATAM simulation team had priority in the use of one TAAM licence. This had limited impact at EEC, as long as the number of simultaneous TAAM projects was limited. Otherwise, the work would have to be distributed in another way (e.g. by extended the working hours in order to accommodate, for example, one morning and one afternoon team, each of them having the full usage of one TAAM licence during its working hours). This problem would be of less importance with the planned installation of additional TAAM licence(s) at EEC.

3.9 Conclusions and Recommendations

The Oslo TAAM Simulation was the first EUROCONTROL project where an ATS provider team, composed of national ATM experts, was in charge of the execution of their own simulation using, at EEC, the EUROCONTROL TAAM licences with help and assistance of EUROCONTROL staff.

In this respect, the study was considered as a Pilot Project helping to define the procedures to be followed by (other) EUROCONTROL Member States wishing to use the EUROCONTROL TAAM licences for their own studies through EUROCONTROL projects.

Globally, the process set up with this study and described above was successfully tested and validated.

Of course, the results of such a simulation process, are widely based on the cohesion of the teams and the way the various personal affinities together.

But, if this is valid for any project, it is definitely of major importance for this kind of simulation process. Such a process could be a way to facilitate people working in different adjacent centres (e.g. APP and airport, APP, airport and ACC - as it was the case with this project - or two neighbouring ACCs…) to conduct a simulation project together, not only in the same working group, but in the same simulation team.

However, and due to the necessity to limit the size of the team in charge of executing the simulation - ideally two to three persons -, this simulation process should be recommended for projects only studying a single interface (see above) or a single airport or ATC control centre. Consequently, such a process should stick to studies of limited size. Larger simulations, and particularly the multiple centre ones, should continue to apply the standard process used up to now to conduct model-based simulations.

Nevertheless the above described process should not be limited to ATC studies, "only" looking at route modification or implementation of new sector plans for a dedicated ATS provider.

It could as well be used for R&D projects or environmental studies looking for input from model-based simulations. In that case the "client" role would be done by EUROCONTROL or contracted staff, members of the relevant project teams. The assistance provided by the EUROCONTROL model-based simulations team would be, of course, identical as the one described above. It has to be noted that such a proposed process is independent of the tool and could be used with other models available at EEC, such as RAMS, for instance.

The access to the EUROCONTROL TAAM licences, the larger involvement of the client (in comparison to "standard" model-based simulation projects), the noticeable release of EEC Simulation Project manager should largely balance the apparent drawbacks such as, for instance, the irregular rhythm of effort for the "Member State team".

Nevertheless, in case of concurrent projects of this kind and due to the fact that the number of simultaneous available TAAM licences is limited, the planning of the work would have to be modified.

Finally, it should be clear that the process proposed with the Oslo TAAM Simulation globally presented large advantages. However, the selection of the projects subject to be conducted in a similar way, the set-up of the simulation team and the planning of the whole project should be made very carefully in order to get the greatest benefits from such a process.

4 DESCRIPTION OF THE STUDY

4.1 Introduction

The results found with RAMS Oslo simulation fulfilled the objectives of the NORSIM/RAMS study. Nevertheless, as the conclusion of this study pointed out, it should ideally be completed by a more comprehensive simulation of the Oslo TMA aspects. This should mainly include routes and crossing points between SIDs (Standard Instrument Departures) and STARs (Standard Instrument Arrivals), detailed runway usage, noise abatement restrictions etc., which were not fully simulated due to the RAMS simulator limitations.

It was therefore decided to continue the NORSIM project with a TAAM simulation of Oslo TMA.

With the TAAM study, the Reference Scenario was based on the current (2002) situation within Oslo FIR, i.e. the route structure, runway usage, Noise Abatement Procedures (NAP) etc…

The proposed scenarios were based on several fixed conditions, both from the surrounding and from the underlying airspace, such as:

- The ACC route structure from the RAMS proposed scenario C19B, where both the TMA entry points for the inbound traffic and the TMA exit points for the outbound traffic were defined (see Figure 2 next page and REF 2).

- The current (2002) NAP for ENGM. The SIDs have remained unchanged inside a 6 NM circle around ENGM.

- The current (2002) runway usage, with some modifications for a limited number of exercises.

- The introduction of an AMAN tool, as proposed with the RAMS simulation, Scenario C19B.

The simulation was based on 5 NM radar separation.

A 3 NM radar separation is applicable within Oslo TMA under certain conditions only (e.g. when two conflicting aircraft are on parallel or diverging tracks). Because the separation with TAAM is limited to one separation criteria within each sector and is not linked to the situation of the conflicting aircraft, it was decided by the simulation team to use a 5 NM radar separation throughout the study.

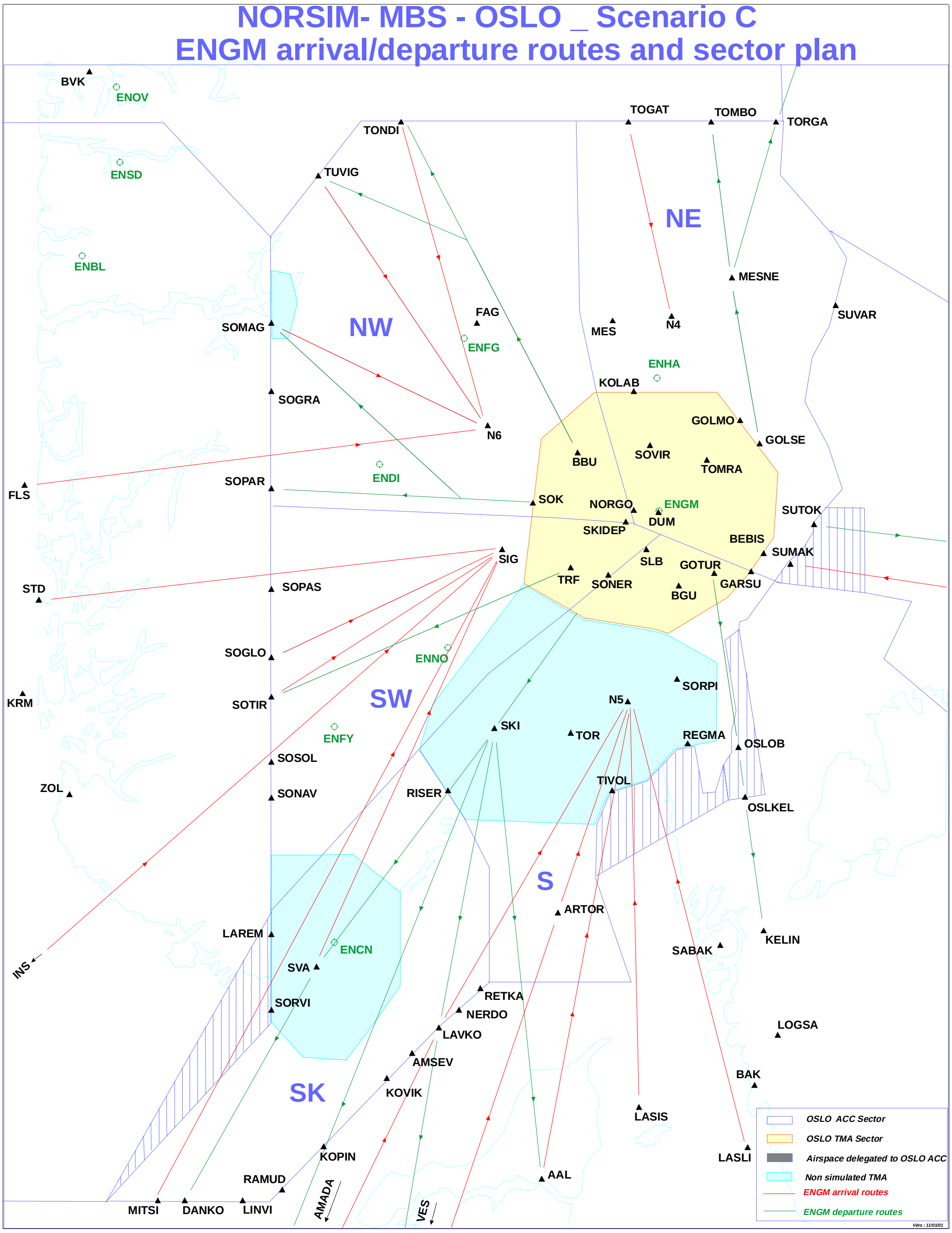


Figure 2 : Map of Oslo FIR - Proposed routes with RAMS simulation Scenario C

4.2 Simulated airspace

The TAAM study simulated the Oslo TMA airspace, with Oslo ACC sectors acting as feeder sectors only. The measured airspace was limited to the Oslo TMA.

The simulation has been strictly focused on the de-conflicting of the various proposed SID and STAR systems. The sequencing of arrivals was executed within TAAM, which may be compared, in this respect, to the functionality of an Arrival Manager tool (AMAN).

Consequently, the main results, presented below, were the total amount of conflicts found within Oslo TMA. In order to analyse and to compare the results, the different scenarios simulated the Oslo TMA as one all-including sector. However, as concluded by the RAMS simulation, it was assumed that several controller functions would be necessary for traffic handling within the Oslo TMA : one departure controller, two arrival controllers, one director controller and one planning controller, as a minimum (see REF 2). The actual sectorisation of the airspace will be subject to the RTS based on the conclusions from the RAMS and TAAM simulations.

4.3 Runway usage

ENGM airport was simulated operating independent parallel departures, and dependant parallel approaches, which are the current (2002) Oslo airport operations. The airport is designed to handle independent approaches. This has not been implemented in operational use, mainly due to the noise restrictions. However, Exercises F01PLUS and F19PLUS allowed independent parallel approaches (see paragraph 14).

No evident indication of expected future runway usage was available to the simulation team. It was therefore decided to use the current (2002) runway usage for the main scenarios of the study. The alternative runway usage introduced with scenarios D, E and F were based on assumption of what could be the most probable future changes in view of runway usage.

With **Reference Scenario and Scenarios A, B and C** the current (2002) runway usage was simulated as follows:

With Runways 01 in use at ENGM:

Runway 01R was the preferential runway for landings and Runway 01L was the preferential runway for departures. Nevertheless, some prop and turboprop aircraft, routing towards the Southeast, departed from Runway 01R. In order to accommodate these departures, some landings (again, preferably prop/turboprop aircraft) used Runway 01L.

With Runways 19 in use at ENGM :

Runway 19R was the preferential runway for landings. Both runways (19R and 19L) were used for departures according to the list of “preferred runway for departure” defined by NATAM. This list prescribes that all traffic with destinations towards the North, Northeast, East, Southeast, South and Southwest should depart from Runway 19L and all traffic with destination towards West and Northwest should depart from Runway 19R). In order to accommodate some of the Runway 19R departures, a few landings were using Runway 19L. This was preferably traffic with parking positions on the eastern side of the airport.

With **Scenario D** the runway usage was modified. With this scenario, all ENGM departures towards the East and the Southeast departed from Runway 01R. Consequently, in order to accommodate these additional departures from Runway 01R, an increased number of landings used Runway 01L.

With **Scenarios E and F**, the runway usage was further modified as the departures were divided between runways Left and Right (for both runway orientations). With these scenarios, traffic proceeding towards the Northeast, East and Southeast departed from the eastern runway (i.e. 01R or 19L), and traffic proceeding towards the Southwest, West and Northwest departed from the western runway (i.e. 01L or 19R). There was no particular runway allocated for the ENGM arrivals. Both runways (either, 19R and 19L, or, 01R and 01L) were available for landings.

4.4 SIDs and STARs

The Reference Scenario was using the current (2002) departure (SID) and arrival (STAR) routes within Oslo TMA. The proposed scenarios evaluated different SID/STAR systems.

The SID and STAR maps shown in this report were drawn for simulation purposes. For operational use, the procedures will have to be designed according to PANS-OPS rules. In addition, in view of actual operations and prior to any Real Time Simulation (RTS), it will also be necessary to consider the possible use of RNAV approach procedures, radar vectors, to review the exact location of TMA holding patterns, etc…

Various flight level restrictions along ENGM arrival routes were simulated. This was done although the behaviour of the model was to keep a steep descend down to the assigned level, to maintain, which did not reflect a realistic descent profile. Still, it gave the arriving flights a more realistic level at the actual crossing point with the SID, than if a complete "free" descent profile was to be decided by TAAM.

Speed restrictions for both arrivals and departures have also been tried. When implemented into TAAM, they disturbed the sequencing of the traffic to an unacceptable degree. This also did not have the expected impact on the climb/descent performance. It was therefore decided to do without speed restrictions throughout the study, although this added to the difference between the simulated and the actual aircraft performance.

4.5 Oslo airport (ENGM) in the simulation

The study was a TMA study, not an airport simulation. Nevertheless, in order to have realistic arrival and departure flows within the TMA, the main functionality of the ENGM airport have been simulated such as :

- The runways, and the associated runway usage.
- The basic taxiway system (with for instance limited rules for one-way taxiing, or weight limitations…).
- The basic aprons, gates and parking positions. The aim here was only to get the aircraft parked on the correct aprons (General Aviation, Military, Shengen or Non-Shengen, Domestic, etc…). Generally, the gates were defined in order to accommodate the correct aircraft type. However, there was not a strict match with real operations. For the same reasons, the flexible use of gates (e.g. between Shengen and Non-Shengen gates) was not part of the study and was not implemented in the simulation.

Within the above limits, and as far as possible, the realistic usage of aprons, gates, parking positions and turn-around of the aircraft were achieved by identifying the arriving aircraft that have a link to a departing flight (named “linked flights” in TAAM).

4.6 Holding patterns

In order to sequence the arrival traffic TAAM first uses speed adjustments then, pseudo-radar vectors through the "tromboning" function. This function, by modifying and extending the initial STAR paths, allows the simulation (though in an approximate way) of what is normally done by ATC to achieve the required spacing of the inbound traffic to an airport. Nevertheless, as with actual operations, these actions could not absorb large delays. In consequence, holding patterns were used.

To absorb the larger delays, the holding of inbound traffic was performed outside the TMA airspace. This reflects the current (2002) situation, and was also proposed with the RAMS simulation (see REF 2).

With the **Reference Scenario**, the holding patterns were located at the following points: MES, SUMAK, SORPI, TOR and SIG.

With **every proposed scenario**, the holding patterns were established at the starting points of the STARs, proposed with the RAMS simulation, located outside the TMA (see Figure 2).

In order to cope with operational implementation requirements, additional holding patterns will have to be established inside the TMA. The location of these additional holding patterns was out of the scope of this study. Nevertheless, the proposed scenarios allowed various options for the locations of such holding patterns. The exact location of the patterns will have to be defined with the help of the real time simulation.

4.7 Traffic samples

The Oslo TAAM Simulation used two traffic samples:

- One actual traffic sample, based on actual recordings (from 1999 and 2000).
- One advanced traffic sample which was obtained by cloning and duplicating flights of the actual traffic sample.

4.7.1 Actual traffic sample

The TAAM simulation of Oslo TMA used a 24-hour traffic sample. Nevertheless, this traffic sample was not the traffic of a single day, with some periods (night-time for instance) with very low traffic density.

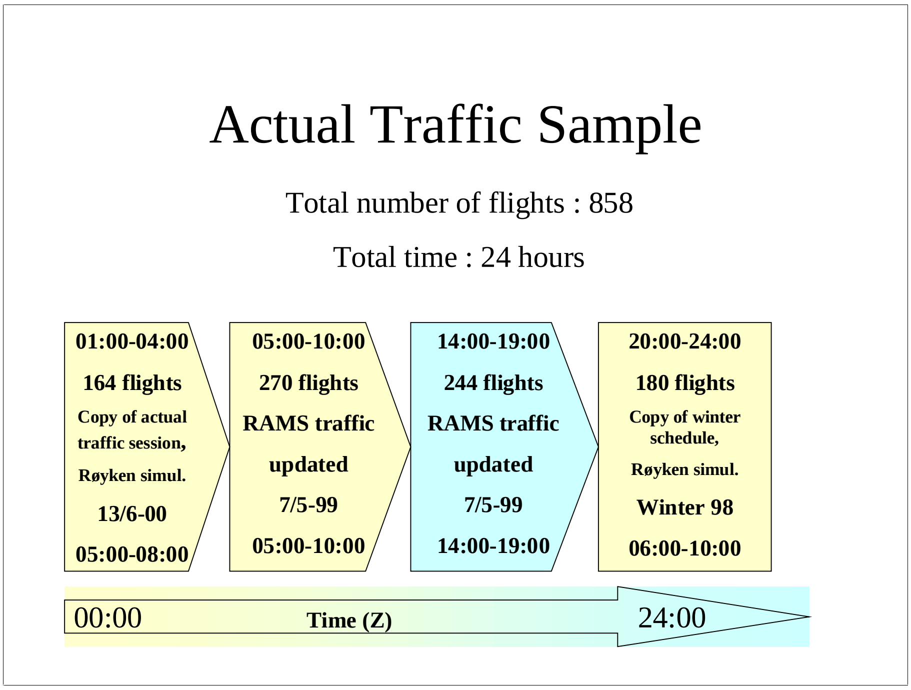


Figure 3 : Oslo TAAM Simulation - Actual traffic sample

The actual traffic sample was composed of four traffic sessions put in a sequence (see Figure 3) :

- A 3-hour traffic sample (actual time 05H00 to 08H00, containing 164 flights) coming from the Røyken real-time simulator and representing an actual traffic session from June 2000.
- A 5-hour traffic sample (actual time 05H00 to 10H00, containing 270 flights) coming from the RAMS simulation and corresponding to an actual traffic session from May 1999.

- A 5-hour traffic sample (actual time 14H00 to 19H00, containing 244 flights) coming as well from the RAMS simulation and corresponding to an actual traffic session from May 1999.

- A 3-hour traffic sample (actual time 06H00 to 09H00, 180 flights) coming from the Røyken real-time simulator and representing scheduled traffic from the winter program 1998/99.

For simulation purposes, these above traffic sessions were put in a sequence in order to make a “pseudo” 24-hour traffic sample. To achieve this, the times of the first sample were shifted to 00H00-04H00, and the times of the fourth one were shifted to 20H00-24H00. The times appearing in the second, 05H00-10H00, and in the third traffic sample, 14H00-19H00, remained unchanged. There was no traffic in the time intervals between the four traffic samples.

The third part of the traffic sample, representing afternoon traffic (14H00-19H00), was not as busy as the other three samples, representing morning traffic. However, it was considered necessary to include it into the whole traffic sample as it represented the slightly different traffic flows experienced in Oslo TMA in the afternoon. This was to ensure that the complete traffic sample contained as many different traffic situations as possible.

The actual traffic sample used with the study contained a total of 858 flights.

Figure 4 and Figure 5 below provide a brief overview of the traffic sample.

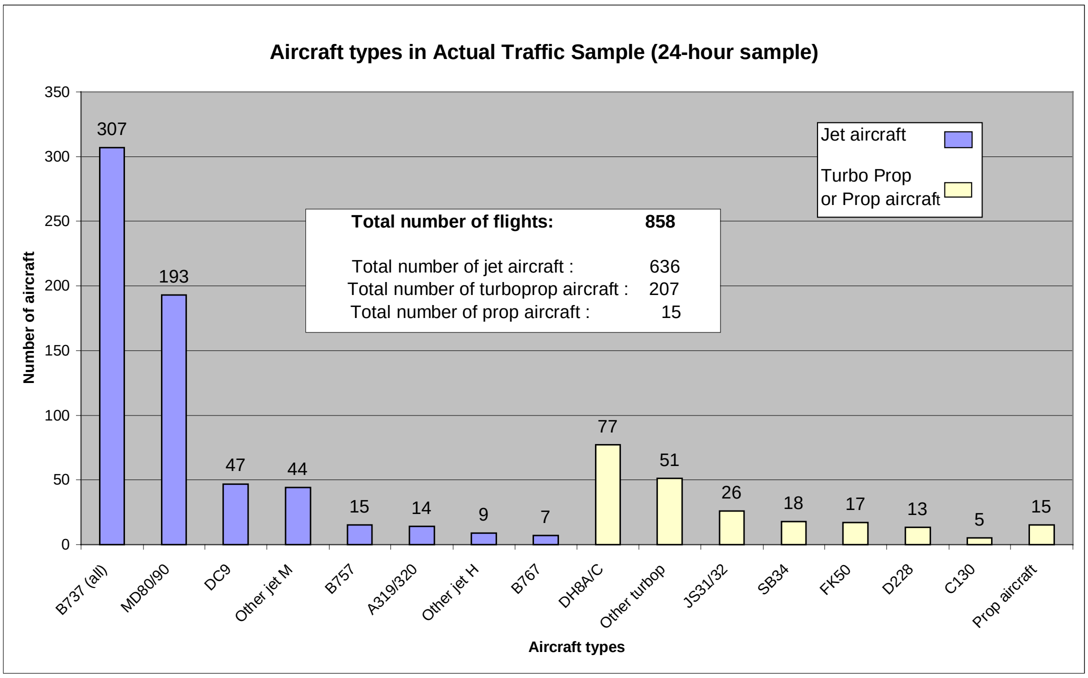
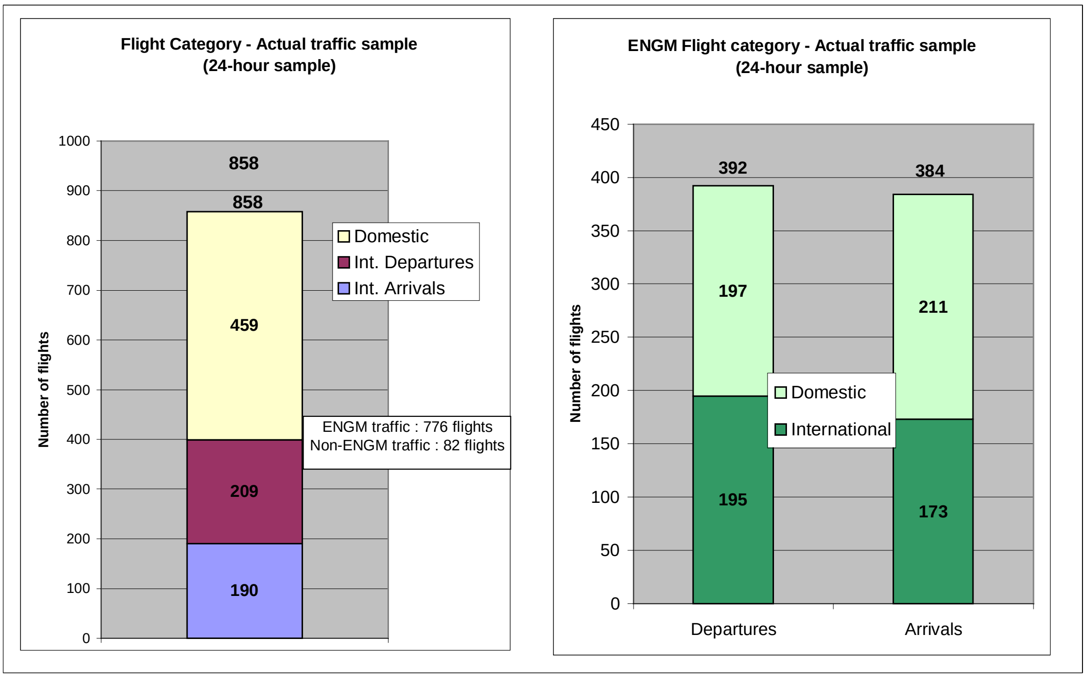


Figure 4: Aircraft types in actual traffic sample (24-hour sample)



Flight Category (whole traffic sample)	Number of flights	Percentage of the sample
International Departures	209	24.4%
International arrivals	190	22.1%
Domestic	459	53.5%
Total	858	100%

Figure 5 : Total number of flights per category - Actual traffic sample

4.7.2 Advanced traffic sample

A two-hour period of the actual traffic sample (01H30-03H30 “traffic sample time”) was chosen as basis to generate an advanced traffic sample. This sample was created by cloning and duplicating the flights contained in the original sample in order to represent increased traffic (see point 14 Exercises F01PLUS and F19PLUS).

The "Advanced" traffic sample used with Scenario F did not intend to be representative of any future planning for traffic flows development within Oslo TMA. It was only set up with the purpose of “overloading” the SID and STAR system. This allowed a better appreciation of the efficiency of the separation provided between ENGM arrival and departure flows at the various crossing points.

Consequently, the amount of traffic in the advanced traffic sample is in no way to be considered for capacity calculation purposes. It was only a mean to test the proposed route system within Oslo TMA in view of number of conflicts, not a manner to deliver capacity figures.

4.8 Transit flights

In the traffic sample, the relatively limited number of transit flights within Oslo TMA was not sufficient to produce clear, meaningful and valuable reports. During the whole study, the impact of the transit flights has been evaluated visually with every scenario. The transit flights were represented in the traffic sample by the current (2002) standard transit routes through the TMA.

From experience with the current (2002) system, the transit flights are well known to cause a large amount of conflicts. Both with the traffic proceeding on the SIDs and STARs inside the TMA, and because of the complexity of ATC sectors above the TMA. Because of this, a great deal of time was spent, throughout the study, on visually observing these flights.

This visual observation gave indications to where these routes through the TMA would generate the lowest number of conflicts in view of the various proposed SID / STAR systems. These routes will be introduced into the RTS for validation.

4.9 Diagram of the study

Part 1: Alternative solutions to a SID/STAR system - Current (2002) runway usage

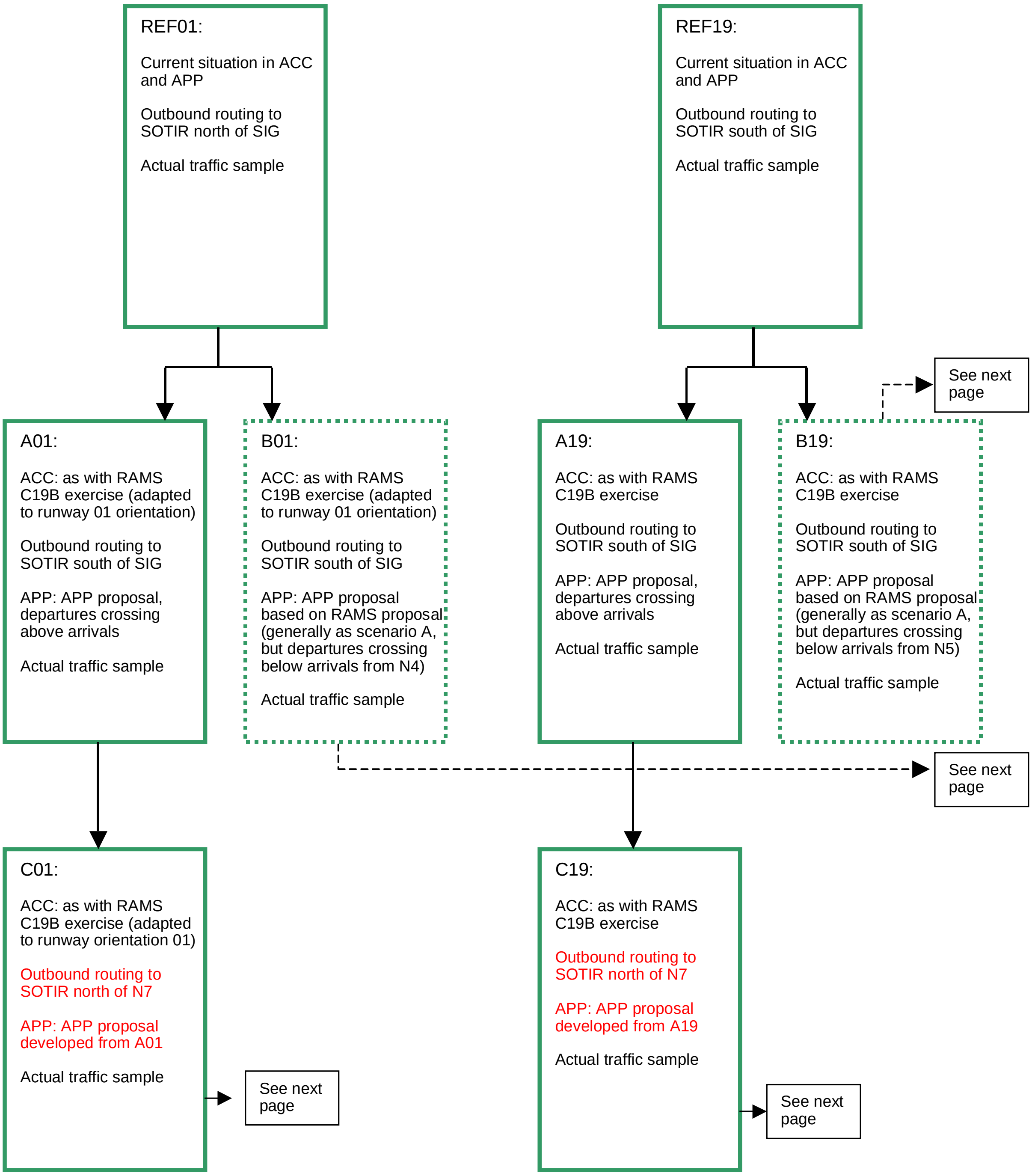


Figure 6 : Diagram of the study, Part 1

Part 2 : Alternative solutions to a SID/STAR system - Alternative runway usage

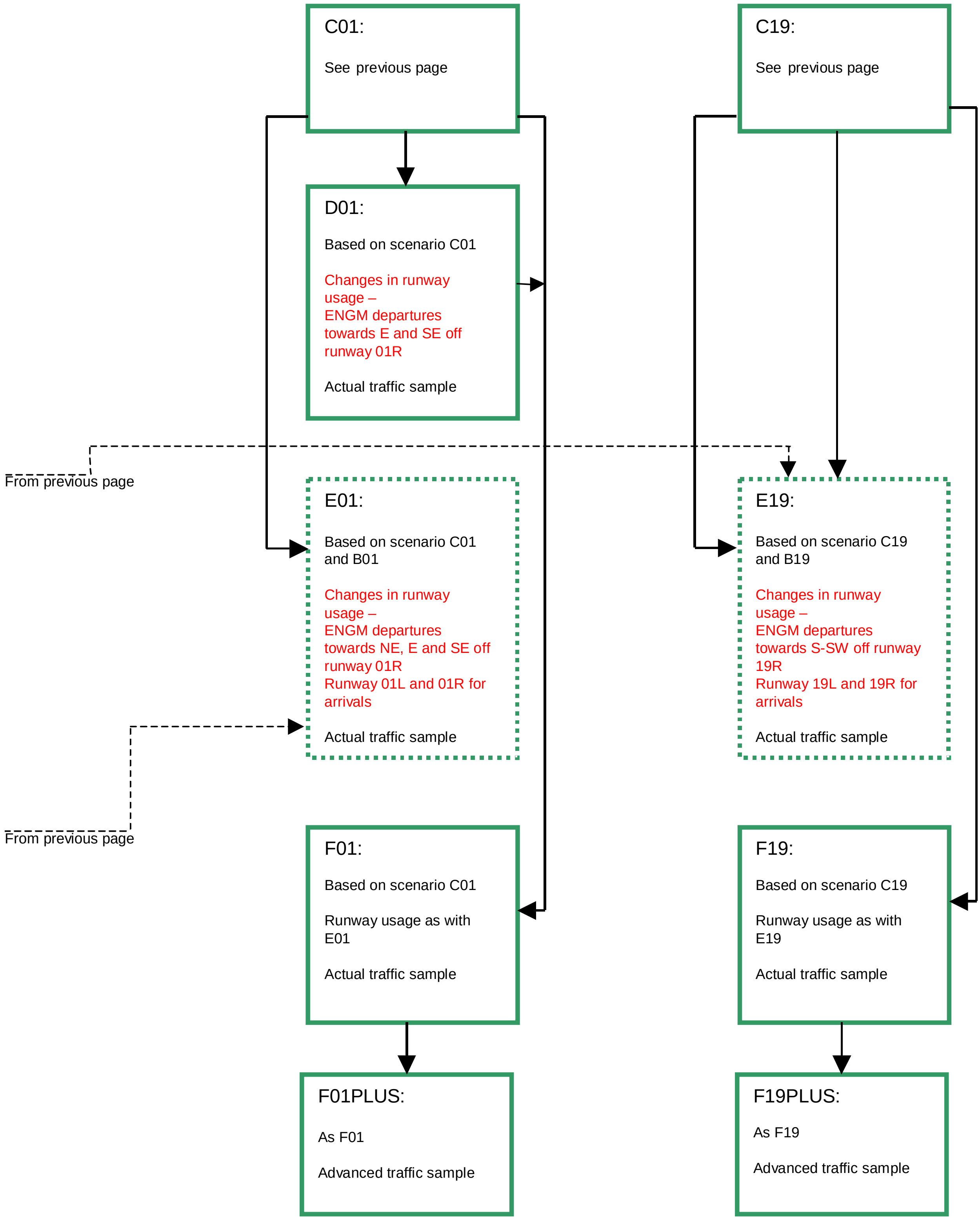


Figure 7 : Diagram of the study, Part 2

4.10 Reports

With this study the increase or decrease of the total number of conflicts within the Oslo TMA has been considered as the key indicator to evaluate the different scenarios.

One of the conclusions of the RAMS simulation (see REF 2) showed that the workload recorded for some working positions, particularly within Oslo TMA, was heavy and even severe. With the aim of reducing this high amount of workload, the various proposed scenarios simulated with the TAAM study tried to reduce the number of conflicts between arrival (along STARs) and departure (along SIDs) flights. In addition, to reducing the workload, the reduction of the number of conflicts generated by crossing traffic can also be related to safety.

The analysis of a TAAM simulation is based on a combination of analysing the reports produced by the tool and of visually analysing the situation that can be actually observed on the screen. Thanks to the TAAM graphical capabilities, the visual analysis can largely be compared to the radar monitoring task, well-known to an operational controller. This part of the analysis, conducted by watching a familiar environment, allows, in addition to the numbers delivered by the reports, to evaluate and to select the best solutions among a set of proposals.

One of the main reports generated by the TAAM Plus Reporter and used with this study was "amount of conflicts per level band" with the full details about each conflict (e.g. call sign of the involved flights, altitude, speed, etc…).

Out of this report, only the conflicts between arriving and departing traffic were considered for the purpose of the study. In addition to showing the variation of the total amount of conflicts, the report gave the possibility to pinpoint the SID/STAR crossing points in need of changes or adjustments.

As a default value within TAAM, a conflict is registered, with different severity, as soon as there is an infringement of 200% of the vertical or horizontal separation minima. For this simulation the minimum separation was set as 5nm and/or 1000 ft (see point 4.1). Consequently, every conflict in the shown reports represents two aircraft with less than 10nm and/or 2000 ft. separation.

As with every model based simulation, one of the main concerns was the simulated aircraft performance. In order to compare TAAM aircraft performance data with the “actual performance” observed in day to day operations, tests were carried out at various stages of the study. The test results varied significantly, both concerning the actual performance data and in comparison with the TAAM performance data.

Such uncertainty-factors emphasised the fact that the different results from the reports may only be employed for comparison between the different scenarios and exercises within the study. No result or number should be considered as absolute values.

In order to validate the trends obtained from the reports, as well as to double-check the input data (i.e. to be sure that the simulated traffic sample was not reflecting a particular situation but was really representative of various busy traffic situations within Oslo TMA), "multiple-run" simulations were performed with Scenarios C and F, towards the end of the study. This was achieved by randomising the various aircraft performance tables (cruise / climb / descent speed, rate of climb / descent, take-off and landing distances, etc…), in order to have a series of results, for a given exercise, showing average values along with the standard deviation (Standard Deviation indicates the variability, dispersion or spread of a set of numerical values about their arithmetic mean).

4.11 Noise contours

A set of noise contours, using various noise indexes (LAEQ and LAMAX, both over a 2 hour time period) and based on the TAAM trajectories, was delivered for most of the simulated exercises. This was achieved, processing the TAAM output data with the ENHANCE tool. The analysis of these noise contours was not part of the objectives of this study. This will be conducted, when required, by the NATAM environment experts.

A short description of the ENHANCE tool along with the Noise Contours delivered to NATAM are attached to this document as Appendix.

5 DESCRIPTION OF THE REFERENCE SCENARIO

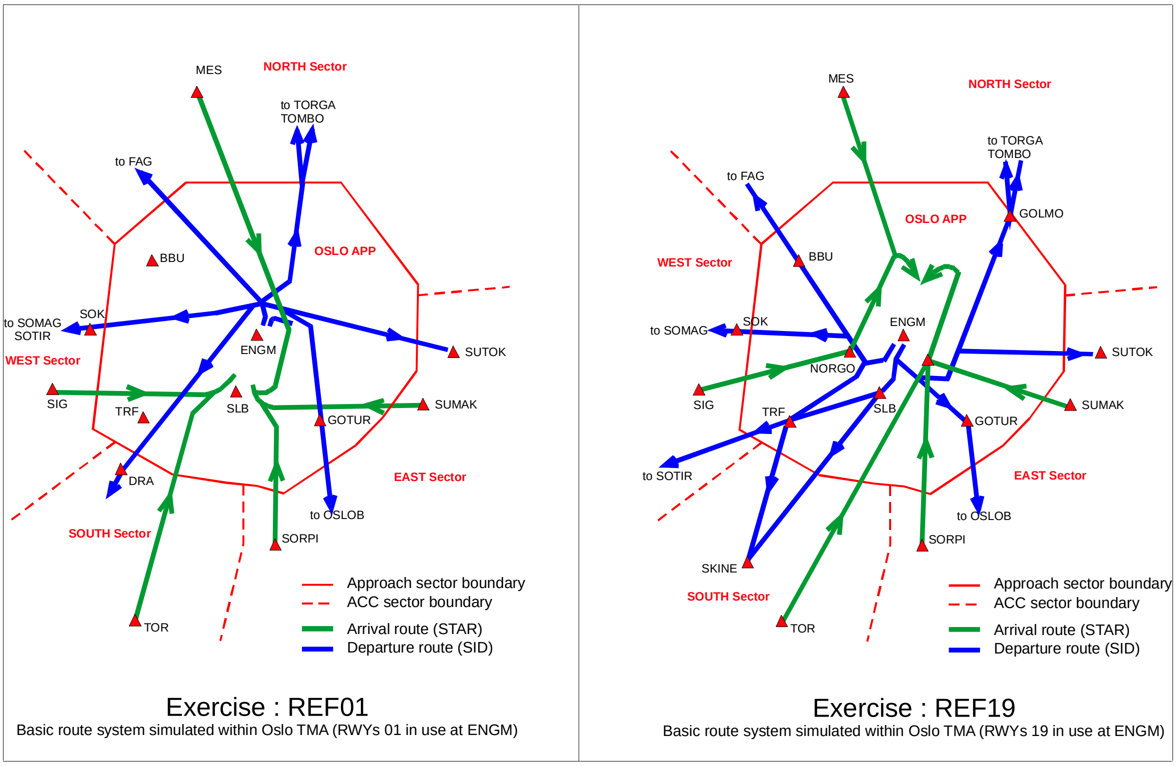
As with every model simulation, and in order to fulfil the objectives of the study, a reference scenario was simulated. The reference scenario allows the tuning of the simulator by reflecting a current known situation.

The Reference Scenario reflected the current (2002) situation at Oslo ATCC.

The Reference Scenario contained two exercises, Exercise REF01 with runways 01 in use at ENGM and Exercise REF19 with runways 19 in use at ENGM. The Reference Scenario retained the following features :

- The current (2002) runway usage along with the current (2002) NAP were simulated for ENGM airport.
- The current (2002) SIDs and STARs.
- ENGM departures towards the Southwest (SOTIR) proceeded North of SIG with Exercise REF01, and South of SIG with Exercise REF19.
- The actual traffic sample was used.
- Five nautical miles (5nm) Radar Separation was used, as well as the requirement for staggered ILS approaches at ENGM airport.

Figure 8 displays the basic route system simulated within Oslo TMA with Exercises REF01 and REF19.



Exercise : REF01
Basic route system simulated within Oslo TMA (RWYs 01 in use at ENGM)

Exercise : REF19
Basic route system simulated within Oslo TMA (RWYs 19 in use at ENGM)

Figure 8 : Reference Scenario (Exercises REF01 and REF19), simulated routes within Oslo TMA

6 DESCRIPTION OF SCENARIOS A AND B

6.1 General description

Scenario A and B both contained two exercises, Exercises A01 and A19 for Scenario A and Exercises B01 and B19 for Scenario B.

With both scenarios, the current (2002) NAP for departures was followed. In addition, the current (2002) runway-usage was followed.

A five nautical miles (5nm) Radar Separation was used, as well as the requirement for staggered ILS approaches at ENGM airport.

Generally, the RAMS proposed Scenario C19B route structure (see REF 2) was retained with Scenarios A and B. With both scenarios :

- ENGM arrivals proceeded via N4 (from North), SUMAK (from East), N5 (from South), SIG (from Southwest) and N6 (from Northwest), as defined during the RAMS study.

- The following points, located outside Oslo TMA, were used by ENGM departures:

  - TOMBO and TORGA for North and Northeast departures,

  - SUTOK for East departures,

  - OSLOB for Southeast departures,

  - SKI and SOTIR (via a route south of SIG) for South and Southwest departures,

  - SOK for West departures, and

  - FAGE for Northwest departures. FAGE was a new point located East of FAG to be used by the flights proceeding via TONDI or TUVIG (as proposed with the RAMS study).

- The outbound routing towards the Southwest (SOTIR) proceeded south of SIG for both runway orientations.

- STARs from N4 (North) and N5 (South) had two alternative routings within the Oslo TMA. One was entering the eastern part of the TMA and the other was entering the western part of the TMA. One of these routings should be defined as the main STAR, and the other as alternate. With actual operations, the choice of the STAR (main or alternate) will have to be initiated by the APP Planner, when necessary, according to the traffic situation. Making full use of this feature requires the possibility to anticipate the sequence of departing traffic.

With the traffic sample used in this study and as a result of the RAMS routing, the eastern STAR was considered as being the main STAR from both N4 and N5. This created the best distribution of traffic within the TMA.

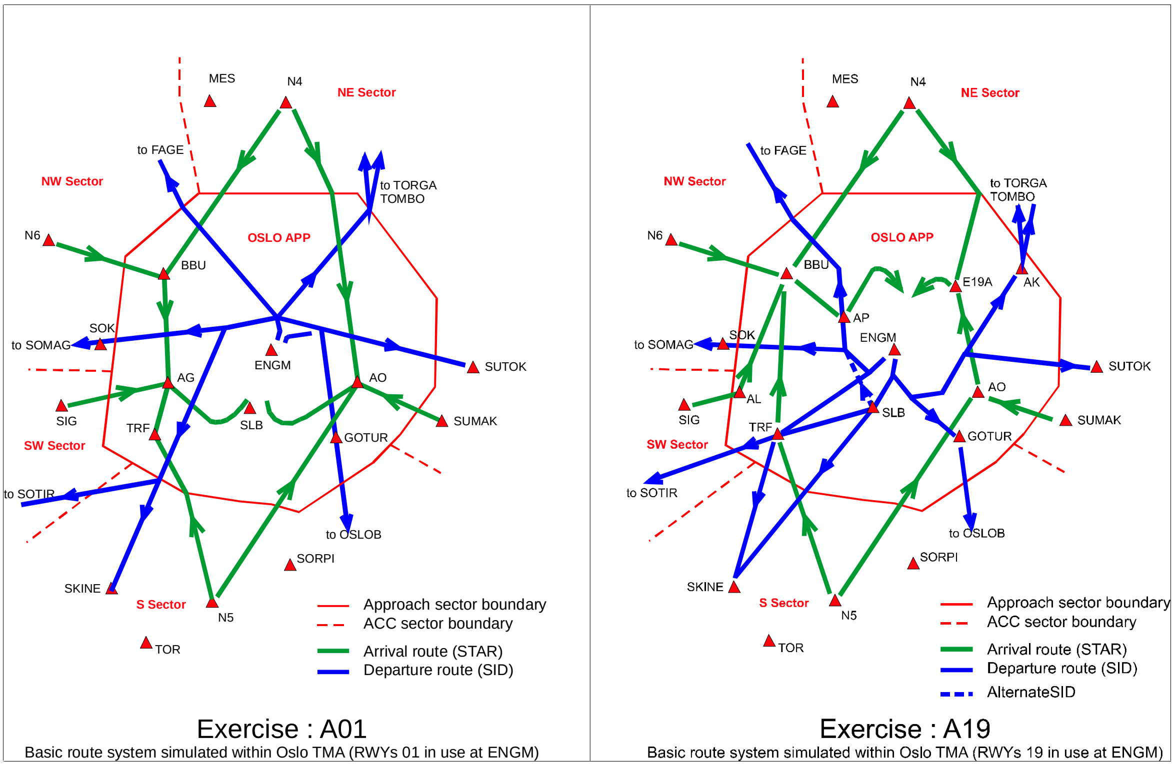
The traffic sample simulated with Scenarios A and B was the one used with the Reference Scenario. The traffic sample was, of course, updated in order to comply with Scenarios A and B routing requirements.

6.2 Scenario A particularities

The “philosophy” evaluated with Scenario A was to allow, within Oslo TMA, the ENGM departures sufficient track-miles prior to crossing the STARs in order for these flights to be clearly above the ENGM arrivals.

In addition, an alternative SID-solution was introduced with Scenario A and runway 19 in use at ENGM airport. This SID was intended for traffic departing from ENGM Runway 19L for destinations towards the West and Northwest, turning out right after SLB.

Figure 9 below shows the basic route system simulated within Oslo TMA with Scenario A, Exercises A01 and A19.



Exercise : A01
Basic route system simulated within Oslo TMA (RWYs 01 in use at ENGM)

Exercise : A19
Basic route system simulated within Oslo TMA (RWYs 19 in use at ENGM)

Figure 9 : Scenario A (Exercises A01 and A19), simulated routes within Oslo TMA

6.3 Scenario B particularities

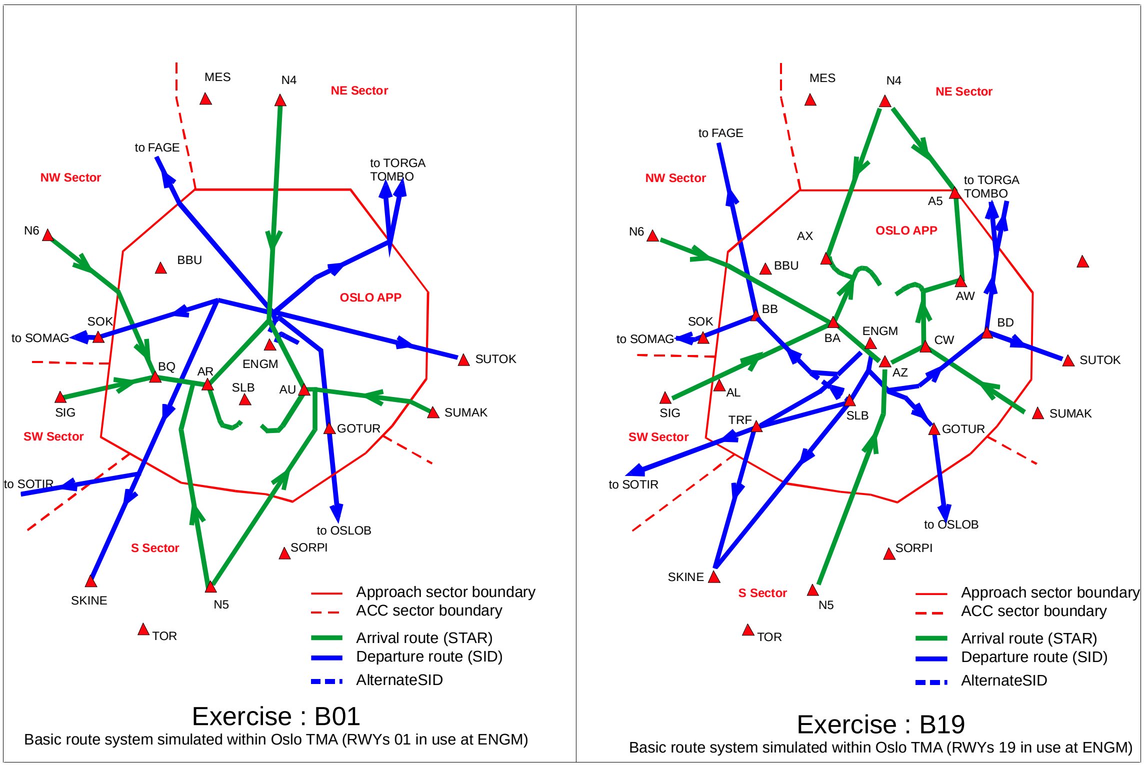
The “philosophy” evaluated with Scenario B was developed from the current (2002) philosophy. It was somehow opposite to the one tested with Scenario A.

For the STARs from N4 (North) to Runway 01, and from N5 (South) to Runway 19, the crossing point with the SIDs was located even closer to the ENGM airport than in today’s traffic regulation system.

Consequently, with Scenario B, the ENGM departures were below the ENGM arrivals coming from the North and the South (with Runways 01 or 19 in use at ENGM, respectively), before further climb to cross above the other STARs, as in Scenario A.

As with Scenario A, there was an alternative SID-solution for traffic towards the West and the Northwest from Runway 19L. This SID proceeded via a right turn out after SLB.

Figure 10 displays the basic route system simulated within Oslo TMA with Scenario B, Exercises B01 and B19.



Exercise : B01
Basic route system simulated within Oslo TMA (RWYs 01 in use at ENGM)

Exercise : B19
Basic route system simulated within Oslo TMA (RWYs 19 in use at ENGM)

Figure 10: Scenario B (Exercises B01 and B19), simulated routes within Oslo TMA

7 COMPARISON OF RESULTS : SCENARIOS REF, A AND B

7.1 Introduction

As described previously (see paragraph 4.10), the main results shown in this report will be the number of conflicts between ENGM arrivals and departures within Oslo TMA.

The number of flights per sector was unchanged throughout all the scenarios, as the TMA was seen as one all-including sector with this simulation.

The charts show all the conflicts detected between ENGM arrivals and departures, per flight level band, over the 24 hour traffic sample period. The conflicts registered in the reports were the ones involving any two aircraft closer than 200% of the 5 NM/1000ft separation minima (i.e. within 10 NM and/or 2000 ft.).

7.2 Comparison of results : Exercises REF01, A01 and B01

Figure 11 displays the number of conflicts per level band between ENGM arrivals and departures as found with Exercises REF01, A01 and B01.

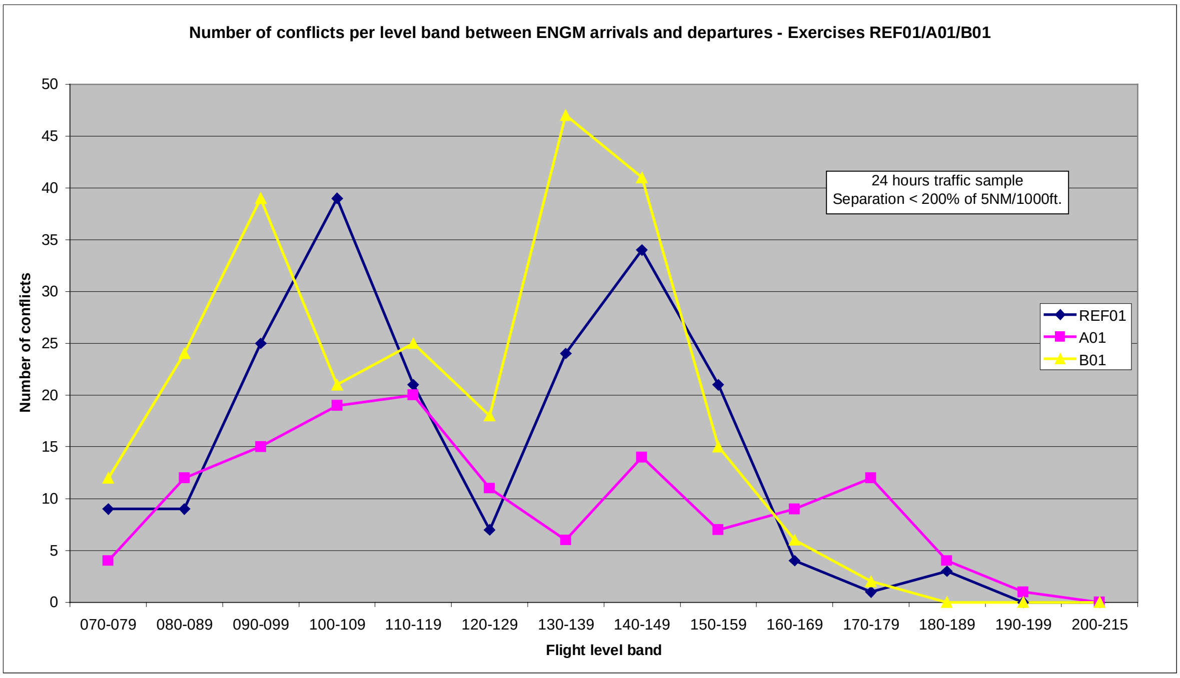


Figure 11: Number of conflicts per leve l band - Exercises REF01, A01 and B01

From the above chart, it can be seen :

- Exercise REF01 recorded a high number of conflicts between FL90 and FL110. This confirmed a known “problem area” within the Oslo TMA, in the current (2002) situation. This was the result of the SID/STAR crossing point located close to the airport where ENGM traffic (both arrivals and departures) were in the level band FL90 / FL110. According to the Simulation Request this problem had to be addressed with this simulation.

- Exercise A01 recorded the lowest total amount of conflicts between arrivals and departures.

- Exercise B01 recorded a high number of conflicts between FL80 and FL100. This was the same problem as in Reference Scenario, and showed that the "philosophy" of crossing SIDs and STARs close to the airport cannot be combined with existing NAP with Runway 01 in use at ENGM airport (see below point 7.4).

- Both Exercises REF01 and B01 recorded a high number of conflicts between FL130 and FL150.

7.3 Comparison of results : Exercises REF19, A19 and B19

Figure 12 shows the number of conflicts per level band between ENGM arrivals and departures as found with Exercises REF19, A19 and B19.

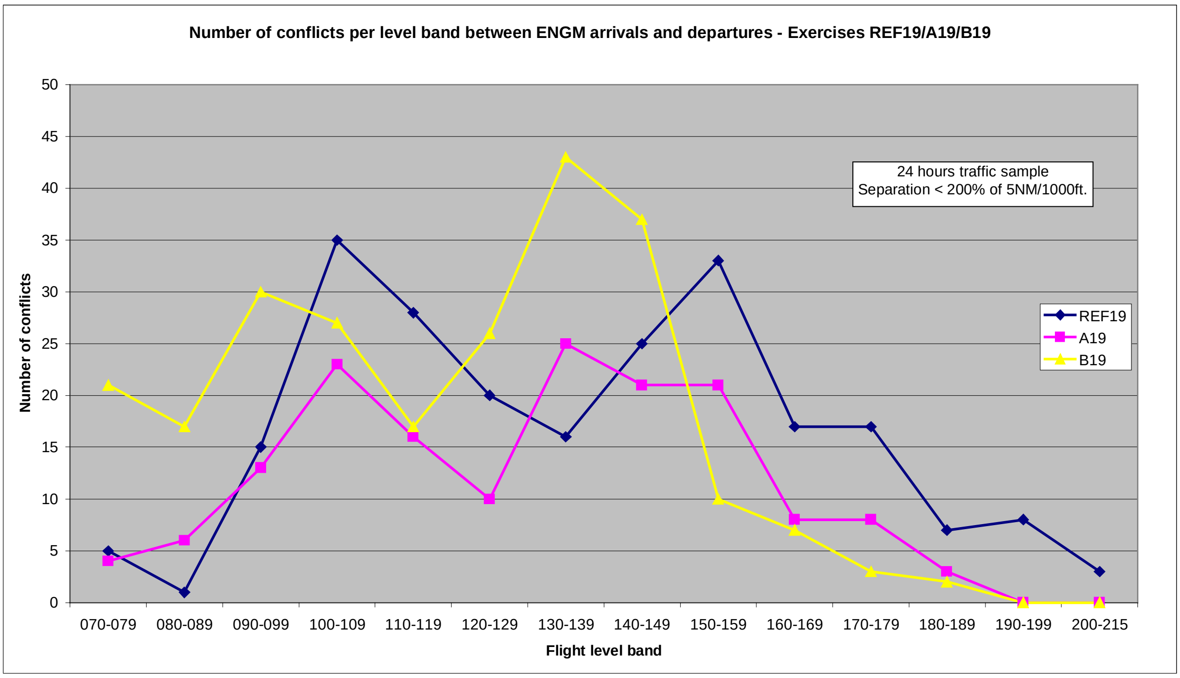


Figure 12 : Number of conflicts per level band - Exercises REF19, A19 and B19

From the above chart, the following comments can be made :

- Exercise REF19 recorded a high number of conflicts between FL90 and FL120. As with REF01, this confirmed a known "problem area" within the TMA, with the current (2002) situation. This was the result of the SID/STAR crossing point located close to the airport where ENGM traffic (both arrivals and departures) were in the level band FL90 / FL120. Again, and according to the Simulation request, this problem had to be addressed with this simulation.

- Exercise REF19 recorded a high number of conflicts between FL140 and FL160.

- Exercise A19 recorded the lowest total amount of conflicts between arrivals and departures, although not as low as the one found in Exercise A01.

- Exercise B19 recorded a high number of conflicts between FL80 and FL110. This was the same problem as the one identified with the Reference Scenario. This indicated that the “philosophy” of crossing SIDs and STARs close to the airport cannot be combined with existing NAP (see point 7.4 below). Nevertheless, with this exercise, the situation was not as severe as with Runways 01 in use at ENGM (see above, Exercise B01).

- B19 recorded a high number of conflicts between FL120 and FL150.

7.4 Conclusion

The results obtained with the **Reference Scenario**, and completed by visual validation, were coherent to what is experienced in “real life”. This indicated that the tuning of the simulator was completed and validated any further comparison between Reference Scenario and various proposed scenarios.

Scenario A clearly showed the most promising results.

In addition, the philosophy proposed with Scenario A (i.e. departures above arrivals) also gave the departure function a generous amount of airspace for conflict solving.

Scenario A was consequently considered as being the best basis for development of further scenarios and proposals.

In **Scenario B**, a fine adjustment of the level restrictions for inbound traffic could eliminate many of the conflicts around FL 120-160.

Nevertheless, both Exercises B01 and B19 also have a high number of conflicts around FL90. These conflicts (between arrivals and departures) occurred in scenario B at a slightly lower altitude than the ones, of the same type, recorded with the Reference Scenario. This cohered with the fact that, with Scenario B, the crossing of SIDs and STARs took place closer to the airport than with the Reference Scenario. These conflicts were a consequence of the existing NAP, particularly with Runway 01 in use at ENGM airport. With the current (2002) NAP, all ENGM departures from runway 01L have to maintain a common leg (heading 350°) up to 6 NM from the airport, whatever the destination. This prevents arrival routes proceeding close to the airport being de-conflicted from the departure routes.

With Scenario B, the overall conclusion was that, although some of the problems could be eliminated, others - linked to rigid NAP - were unavoidable. Therefore it was decided not to base additional scenarios on the philosophy developed with Scenario B (departures below arrivals).

Generally, the analysis of the above results clearly indicated that the “close-to-the-field-crossing” philosophy, as proposed with Scenario B, did not work out very well, although the crossing was now even closer to the airport than with the Reference Scenario. The results proved slightly better for runways 19 than for runways 01, mainly due to different layout of the NAP.

Meanwhile, Scenario A showed a definite reduction in number of conflicts between ENGM arrivals and departures, both compared to Reference Scenario and Scenario B.

Scenario A was therefore used as a basis to developed a new proposal, Scenario C.

8 DESCRIPTION OF SCENARIO C

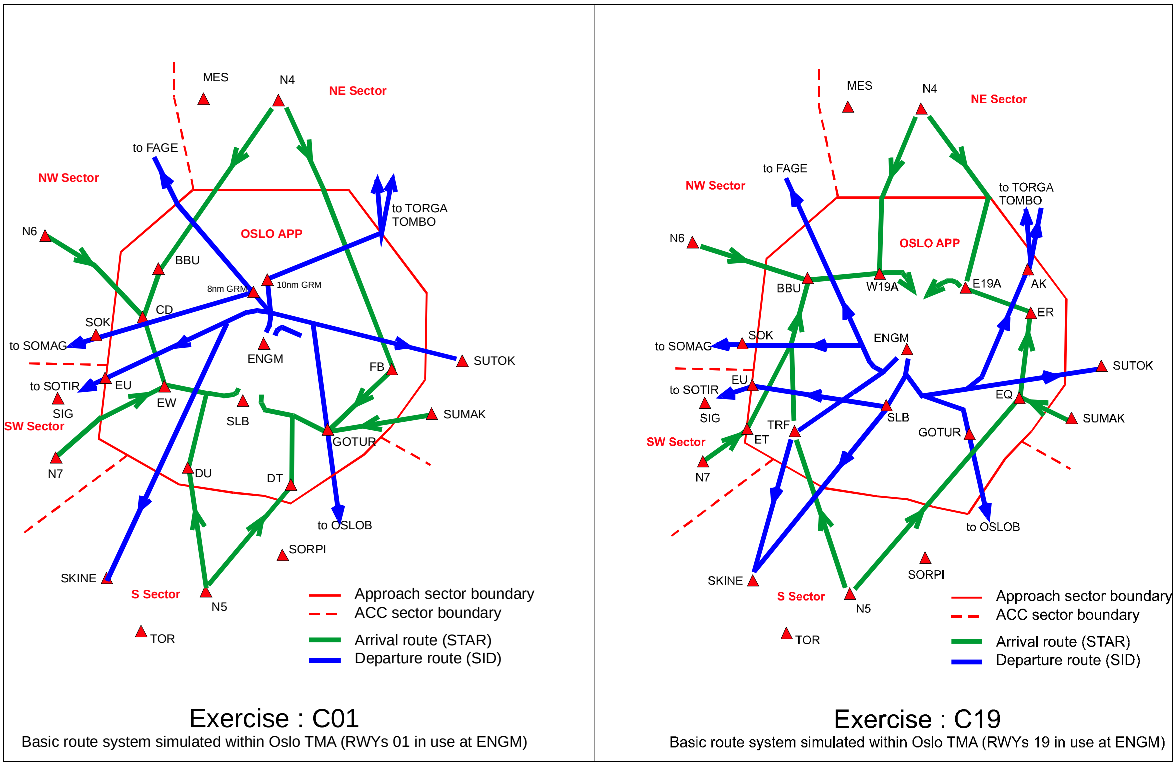
Scenario C contained two exercises, C01 (Runways 01 in use at ENGM) and C19 (Runways 19 in use at ENGM.

Generally, Scenario C was based on Scenario A with the main following changes :

- ENGM arrivals from Southwest proceeded via a new point – N7 – located S-SW of SIG.
- The ENGM departures to SOTIR were re-routed North of N7.
- The SID and STAR system within Oslo TMA was adjusted where needed, with the aim of reducing the amount of conflicts between ENGM arrivals and departures.
- The TMA has been extended in the south-eastern corner to accommodate for the wider STAR from N5 with Exercise C19.

In addition, the following particularities were simulated with Scenario C :

- The STARs simulated with Scenario C were as far away from the airport as the TMA size allowed. This was intentionally made in order to reinforce the "philosophy" proposed with Scenario A. It was assumed that the more space there is between the STARs and the airport, the more flexibility will exist to establish a SID system.
- The STARs from N4 to Runways 19 and N5 to Runways 01 were adjusted to a more direct routing to final approach, compared to Scenario A. This was based on the expectation of an AMAN tool, which functions would reduce the need for extensive upwind/downwind vectoring of the arriving flights.
- The holding pattern used for the ENGM arrival coming from Southwest and previously located at SIG was moved to a new point N7 (located S-SW of SIG, see map in Figure 13). Consequently, it was possible to have one departure route via SOK (used for traffic going West), and one departure route via new point EU to SOTIR (used for traffic going Southwest.), both proceeding north of N7. This change was made in order to ease the separation between the traffic flows during the en-route phase and it also improved the interface between Oslo APP and Oslo ACC, allowing adequate segregation between the two departure routes prior to entering the ACC NW or SW sectors.



Exercise : C01
Basic route system simulated within Oslo TMA (RWYs 01 in use at ENGM)

Exercise : C19
Basic route system simulated within Oslo TMA (RWYs 19 in use at ENGM)

Figure 13 : Scenario C (Exercises C01 and C19), simulated routes within Oslo TMA

9 COMPARISON OF RESULTS : SCENARIOS A AND C

As described above, the main results used to evaluate Scenario C, in addition to visual validation, was the number of conflicts between ENGM arrivals and departures within Oslo TMA.

The number of flights per sector was unchanged throughout all the scenarios, as the TMA was seen as one all-including sector with this simulation.

The charts displayed in this report show all the conflicts detected between arrivals and departures, per flight level band, over the 24 hours traffic sample period. The conflicts registered in the reports are any two aircraft closer than 200% of the 5 NM/1000ft' separation minima. (i.e. within 10 NM and/or 2000 ft.)

9.1 Comparison of results : Exercises A01 and C01

Figure 14 shows the number of conflicts found between ENGM arrivals and departures within Oslo TMA and with Exercises A01 and C01.

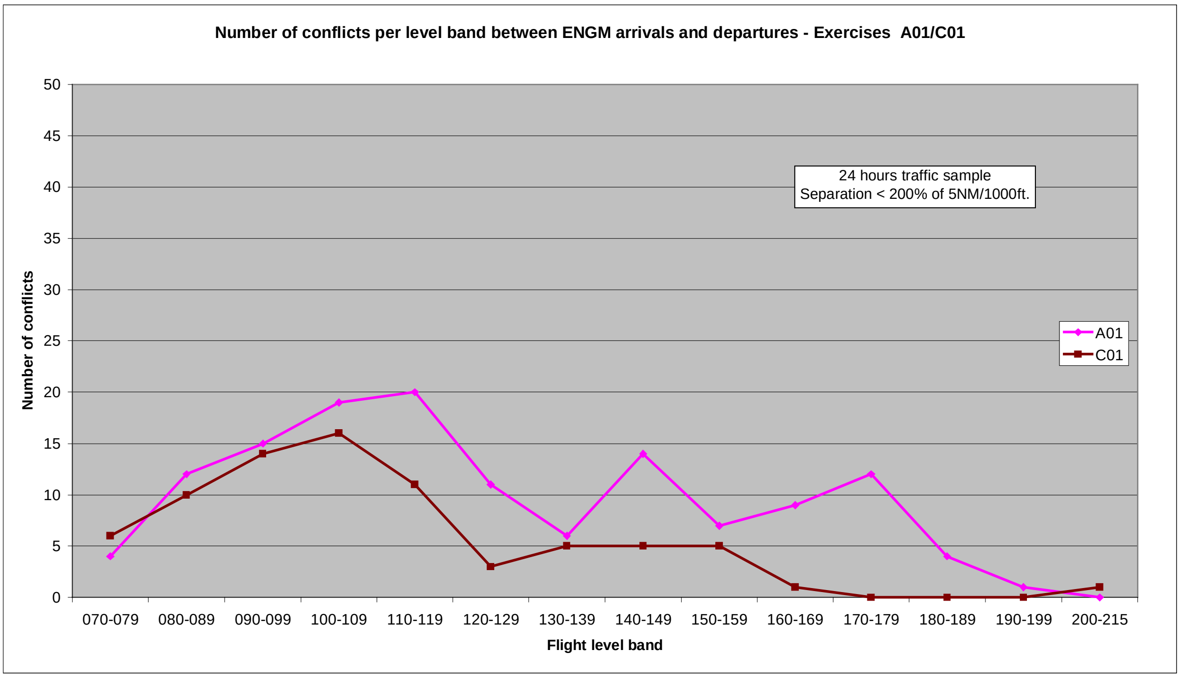


Figure 14 : Number of conflicts per level band - Exercises A01 and C01

From the above chart, it can be seen that:

- When compared to Exercise A01, Exercise C01 recorded a further reduction in the total amount of conflicts.

- There is still a relatively high number of conflicts between FL90 and FL110. Most of these conflicts were created by prop and turboprop aircraft.

9.2 Comparison of results : Exercises REF01 and C01

In order to illustrate the progress achieved up to now with the study, Figure 15 displays the comparison between Exercise REF01 and C01, as far as the total number of conflicts per level band between ENGM arrivals and departures is concerned.

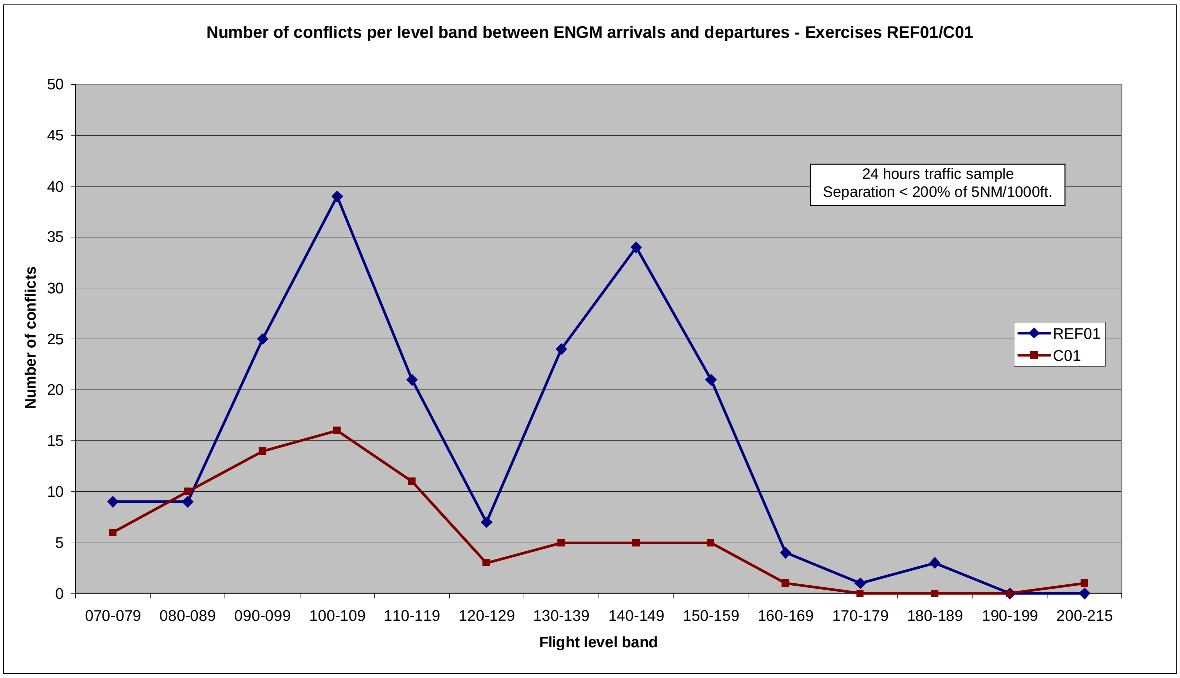


Figure 15 : Number of conflicts per lev e l band - Exercises REF01 and C01

From the above figure it was obvious that, with runways 01 in use at ENGM, the proposed Scenario C would noticeably reduce the total amount of conflicts between ENGM arrivals and departures in comparison with Reference Exercise REF01.

9.3 Comparison of results : Exercises A19 and C19

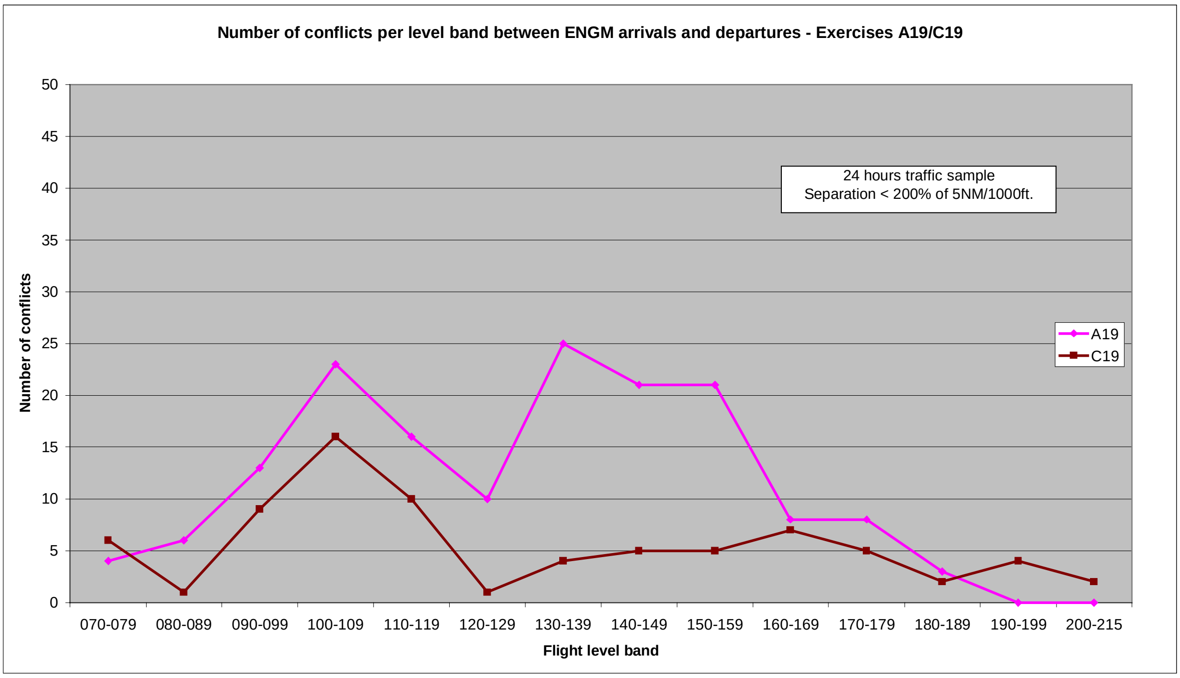


Figure 16 : Number of conflicts per level band - Exercises A19 and C19

From the above chart, the following comments can be made :

- When compared to Exercise A19, Exercise C19 recorded a further reduction in the total amount of conflicts between ENGM arrivals and departures.
- Nevertheless, there was still a relatively high number of conflicts between FL90 and FL110. Most of these conflicts were created by prop and turboprop aircraft.

9.4 Comparison of results : Exercises REF19 and C19

Again, in order to illustrate the progress achieved with the study so far, Figure 17 shows the comparison between Exercise REF19 and C19, as far as the number of conflicts per level band between ENGM arrivals and departures is concerned.

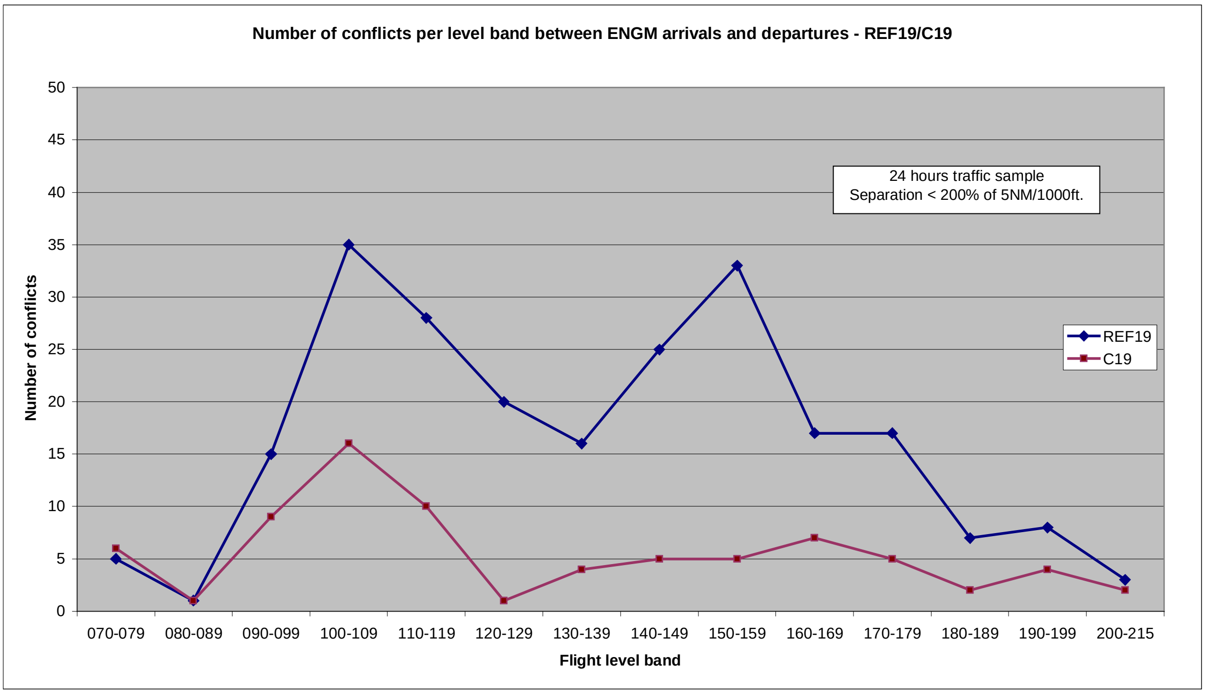


Figure 17 : Number of conflicts per lev el band - Exercises REF19 and C19

According to the above figure, it was obvious that, with runways 19 in use at ENGM, the proposed Scenario C would noticeably reduce the total amount of conflicts between ENGM arrivals and departures in comparison with Reference Exercise REF19. Same statement was made with Runways 01 in use at ENGM airport (see point 9.2).

9.5 Conclusion

According to the above presented results, the changes in the SID/STAR system as proposed with Scenario C, noticeably reduced the total amount of conflicts between ENGM arrivals and departures in comparison to Scenario A. Nevertheless, there was still a relatively high number of conflicts between FL90 and FL110. These conflicts were mainly created by turbo-prop aircraft that did not have the sufficient climb-performance required by the "philosophy" introduced with Scenario A and developed with Scenario C (i.e. departures above arrivals).

The total number of conflicts between ENGM arrivals and departures, as recorded with Scenario C, was significantly lower than the one obtained with Reference Scenario (see paragraphs 9.2 and 9.4).

Finally, the SID/STAR system proposed by the "philosophy" simulated with Scenario C presented the following advantages :

- A large optimisation of the crossing points between the arrival and departure flows with a reduction in the total number of conflicts over these points.

- The achieved segregation between the arrival and departure flows within the TMA would facilitate the introduction of a departure function as proposed with the RAMS simulation (see REF2).

- Generous space was provided for tactical actions to be made by the Departure Controller without interfering with the arrival flows.

  Moreover, this airspace structure would facilitate the re-introduction of "dependant departures" (e.g. a departure from Runway 19L interfering with the departure track from Runway 19R). This should allow flexibility for traffic to depart from the other runway (L or R) than prescribed (i.e. according to destination), when necessary, in case of snow-clearance, de-icing situations, etc…

- The crossing points between SIDs and STARs located close to the airport and generating a large number of conflicts with the Reference Scenario (as with the actual current (2002) situation), have been removed with the Scenario C proposals.

- The proposals made with Scenario C were fully compatible with the ones made for Oslo ACC during the RAMS simulation of Oslo ATCC. In addition, the "philosophy" developed with Scenario C (departures above arrivals) should give flexibility in regards to possible later changes in the surrounding (ACC en-route sectors) and underlying (e.g. runway usage) airspace.

- The split of the STARs from N4 and N5 gave the possibility to deliver the arrival flights into the one (West) or the other (East) part of the TMA, as required by the traffic situation. Again, making full use of this feature requires the possibility to anticipate the sequence of the departing traffic.

The visual observation confirmed the promising trends delivered by the results found with Scenario C. Nevertheless, in order to confirm these initial trends, a “multiple run” simulation was performed (see point 4.10). The results obtained with the "multiple run" validated the previous trends.

Finally, the simulation team, along with the simulation working group, considered that Scenario C fulfilled "Priority 1" of the objectives of the study (see paragraph 2).

Consequently, the changes proposed with Scenario C for Oslo TMA should be retained and implemented along with the ones tested for Oslo ACC with the NORSIM/RAMS proposal C19B.

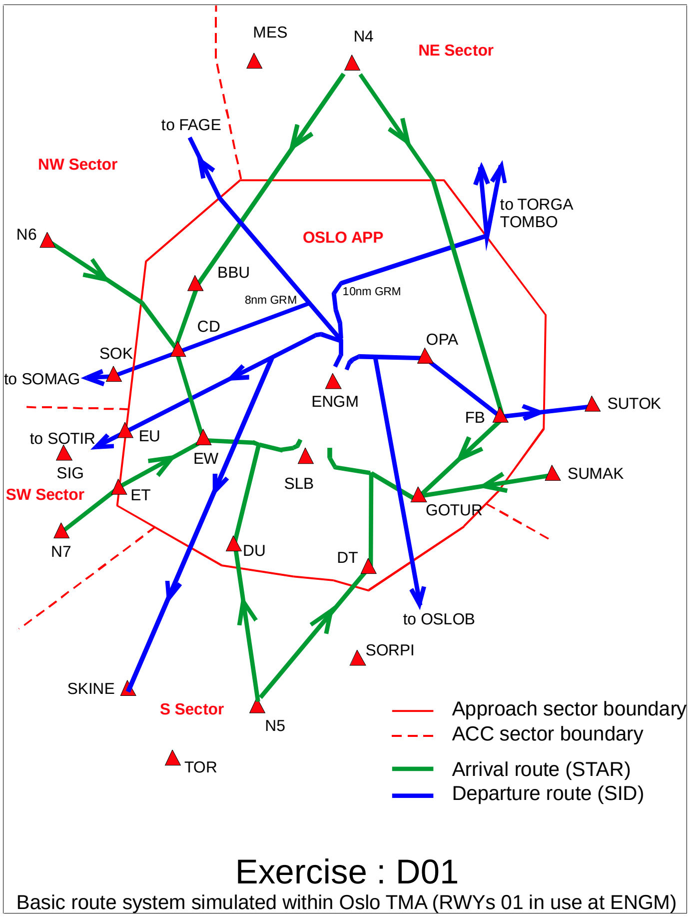
10 DESCRIPTION OF SCENARIO D

Scenario D was the first scenario to evaluate the impact of modified runway usage at ENGM. Scenario D was based on Scenario C. The changes evaluated with Scenario D only concerned the SID/STAR system in use with Runways 01 in use at ENGM airport. Consequently, Scenario D contained a single exercise, Exercise D01.

Scenario D, Exercise D01, was based on Exercise C01 with the following changes :

- All ENGM departures towards the East and the Southeast departed from Runway 01R.
- SIDs towards SUTOK and OSLOB were adjusted accordingly to accommodate the above departures from Runway 01R.
- In order to accommodate the above departures from Runway 01R, some landings were shifted to Runway 01L.

Figure 18 shows the SIDs / STARs system as simulated with Scenario D, Exercise D01.



Exercise : D01

Basic route system simulated within Oslo TMA (RWYs 01 in use at ENGM)

Figure 18 : Scenario D (Exercise D01) , simulated routes within Oslo TMA

11 DESCRIPTION OF SCENARIO E

11.1 Introduction

Scenario E was based on Scenario B, with some features retained from Scenario C.

Scenario E contained two exercises, Exercise E01 and Exercise E19.

With **Scenario E**, the runway usage at ENGM airport was further changed. ENGM departures were split between runway Left and Right as follows :

- Traffic proceeding towards the North<u>east</u>, <u>East</u> and South<u>east</u> departed from the <u>eastern</u> runway (i.e. 01R or 19L).
- Traffic proceeding towards the South<u>west</u>, <u>West</u> and North<u>west</u> departed from the <u>western</u> runway (i.e. 01L or 19R).

Finally, for each runway orientation, there was no particular runway allocated for the ENGM arrivals. Both runways, 01R and 01L with Exercise E01 or 19R and19L with Exercise E19, were available for landings.

Scenario E was based on the "philosophy" already evaluated in Scenario B (departures below arrivals), in spite of this philosophy being discarded earlier. Nevertheless, the segregation of the two main flows of departing traffic was possible, immediately after departure, thanks to the modified runway usage introduced with Scenario E (see above). This segregation allowed to locate a crossing point between the SIDs and the STARs close enough to the airport to suppress some of the conflicts between climbing (departures) and descending (arrivals) traffic. This was not achieved with Scenario B, due to the simulated (current 2002) runway usage with this scenario.

11.2 Description of Exercise E01

As explained in the previous section, Exercise E01 was based on both Exercises C01 and B01. The main changes introduced with Exercise E01 are listed below (see Figure 19) :

- ENGM arrivals from the Southwest proceeded via SIG. The new inbound routing via N7, introduced with Scenario C (see paragraph 8 Description of Scenario C) was not retained with Scenario E.
- ENGM departures proceeding to the Southeast, the East and the Northeast departed from runway 01R.
- ENGM SIDs towards TOMBO, TORGA, SUTOK and OSLOB were adjusted accordingly.
- The STARs from SUMAK, N5, SIG and N6 were based on the ones simulated with Exercise C01 and adjusted in order to accommodate the above changes.

- The STAR from N4 was based on the one simulated with Exercise B01. Nevertheless, with Exercise E01, there was no alternate route from N4. All the ENGM arrival flights proceeding via N4 had to proceed through the eastern part of Oslo TMA.

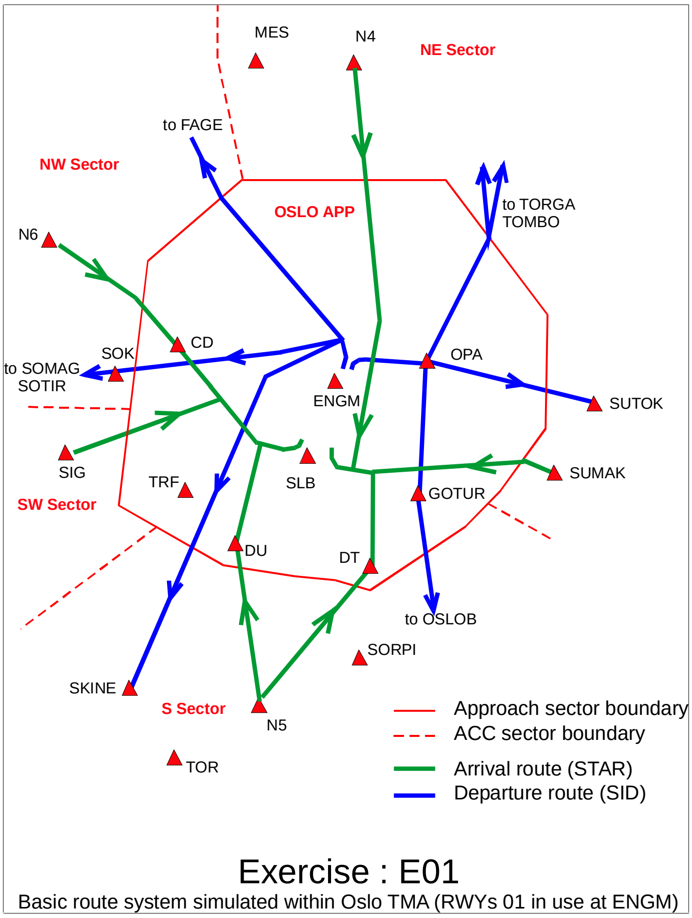


Figure 19 : Scenario E (Exercise E01) , simulated routes within Oslo TMA

11.3 Description of Exercise E19

As explained above, Exercise E19 was based on both Exercises C19 and B19 with the following changes (see Figure 20):

- ENGM arrivals from the Southwest proceeded via SIG. The new inbound routing via N7, introduced with Scenario C (see point 8 Description of Scenario C) was not retained with Scenario E.

- ENGM departures towards the South and Southwest departed from Runway 19R.

- ENGM SIDs towards SKI and SOTIR were adjusted accordingly.

- ENGM STARs from N4, SUMAK, SIG and N6 were based on the ones simulated with Exercise C19 and adjusted to accommodate the above changes.

- The STAR from N5 was based on the one simulated with Exercise B19. Nevertheless, with Exercise E19, there was no alternate route from N5. All the ENGM arrival flights proceeding via N5 had to proceed through the eastern part of Oslo TMA.

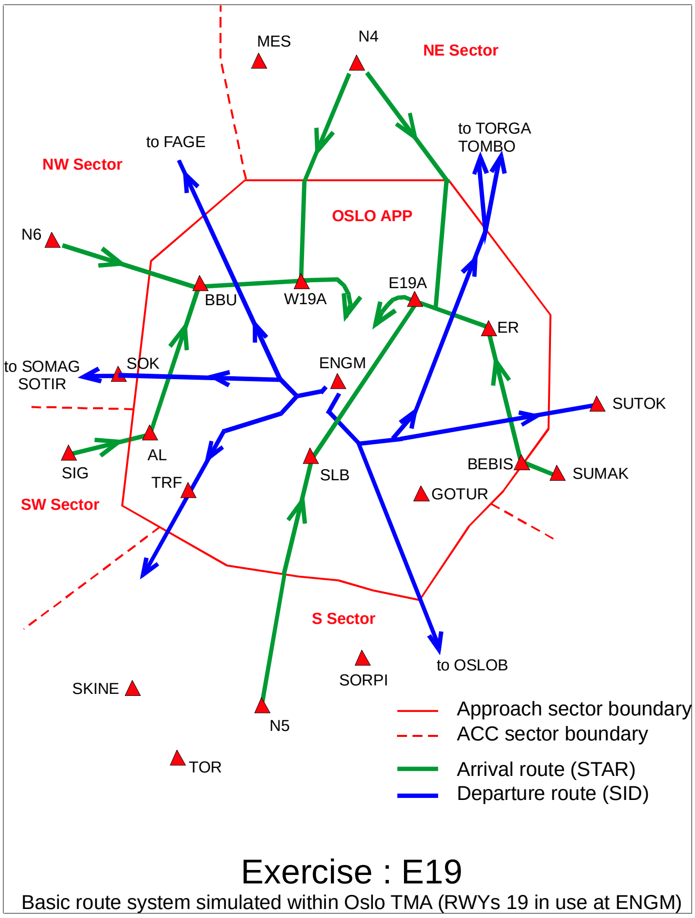


Figure 20 : Scenario E (Exercise E19) , simulated routes within Oslo TMA

12 DESCRIPTION OF SCENARIO F

Scenario F used the same runway usage than the one simulated with Scenario E. It can be summarised as follows :

- The ENGM departures were distributed between runways Left and Right.
- ENGM traffic proceeding towards the Northeast, East and Southeast departed from the eastern runway (i.e. 01R and 19L).
- ENGM traffic proceeding towards the Southwest, West and Northwest departed from the western runway (i.e. 01L and 19R).
- There was no particular runway allocated for the ENGM arrivals. Both runways, 01R and 01L with Exercise F01, or 19R and19L with Exercise F19, were available for landings.

Scenario F contained four exercises, F01, F19, F01PLUS and F19PLUS.

Exercises F01PLUS and F19PLUS simulated the same airspace / route structure as Exercises F01 and F19. The only difference was taking into account an increased amount of traffic (see paragraph 14 Exercises F01PLUS and F19PLUS).

12.1 Description of Exercise F01

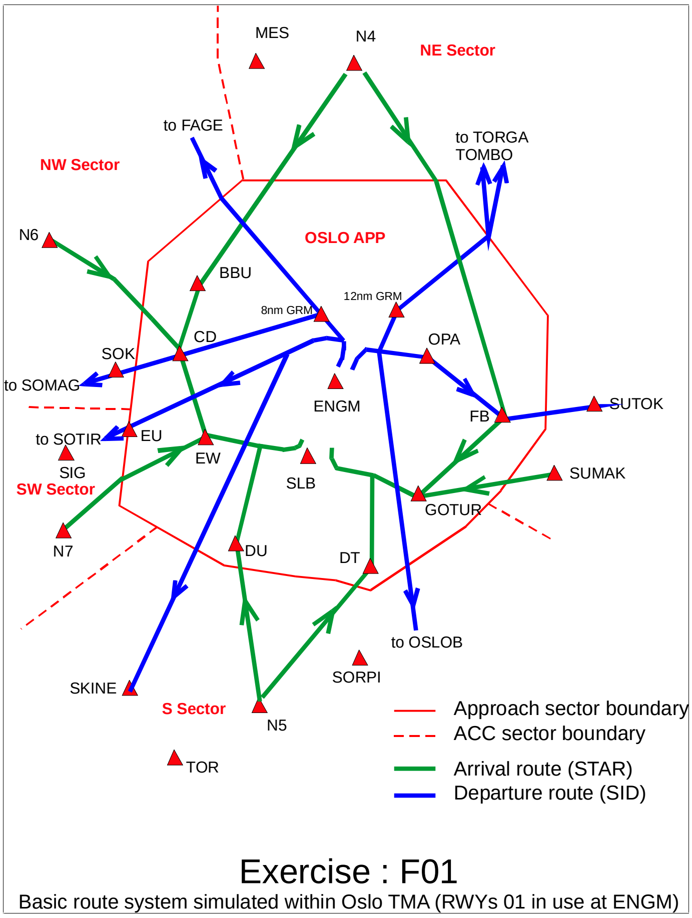


Figure 21 : Scenario F (Exercise F01), simulated routes within Oslo TMA

Exercise F01 was based on Exercise C01 with the following changes :

- ENGM departures proceeding to the Southeast, the East and the Northeast departed from runway 01R.
- SIDs towards TOMBO and TORGA were adjusted accordingly.
- SIDs towards SUTOK and OSLOB were the same as the ones simulated with Exercise D01.

Figure 21 shows the basic route system simulated with Scenario F01.

12.2 Description of Exercise F19

Exercise F19 was based on Exercise C19 with the following changes :

- ENGM departures towards the South and Southwest departed from runway 19R.
- SIDs towards SKI and SOTIR were adjusted accordingly.

Figure 22 displays the basic route system simulated within Oslo TMA with Exercise F19.

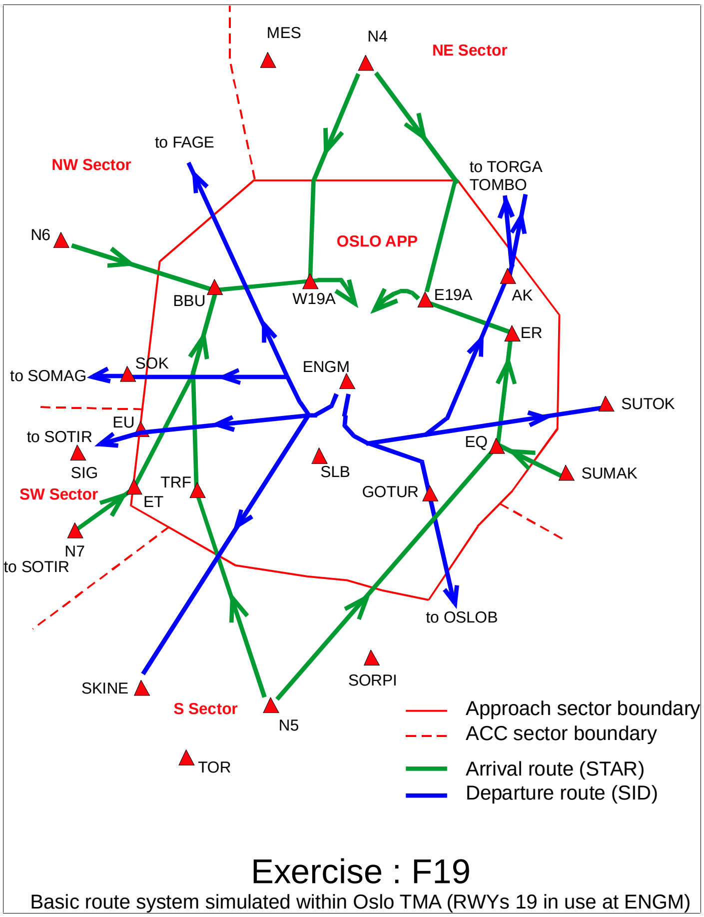


Figure 22 : Scenario F (Exercise F19), simulated routes within Oslo TMA

13 COMPARISON OF RESULTS : SCENARIOS C, D, E AND F

As described above, the main results shown in this section will be the number of conflicts between ENGM arrivals and departures within Oslo TMA.

The number of flights per sector was unchanged throughout all the scenarios (except Exercise F01PLUS and F19PLUS, see point 14), as the TMA was simulated as one all-including sector with this simulation.

The charts displayed in this section show all the conflicts detected between ENGM arrivals and departures, per flight level band, over the 24 hours traffic sample period. The conflicts registered in the reports were the ones involving any two aircraft closer than 200% of the 5 NM/1000ft' separation minima (i.e. within 10 NM and/or 2000 ft.).

The simulation team decided to show, on one chart, for each runway orientation, the combined results of Scenarios C, D, E and F. The reasons for doing so were :

- Scenario D, E and F were created to test different runway usage. Otherwise, they were all based on Scenario C. In order to illustrate the impact of the proposed different solutions, and to compare these with the current (2002) runway usage, Scenario C was used as reference.

- Scenario C, D and F were all based on the same SID/STAR system and "philosophy" (departures above arrivals, see above). The comparison of these 3 scenarios, using the same system with various runway usage, would validate the possible flexibility of the system, adapted to various airport constraints.

13.1 Comparison of results : Exercises C01, D01, E01 and F01

The chart below shows the number of conflicts per level band between ENGM arrivals and departures as found with Exercises C01, D01, E01 and F01.

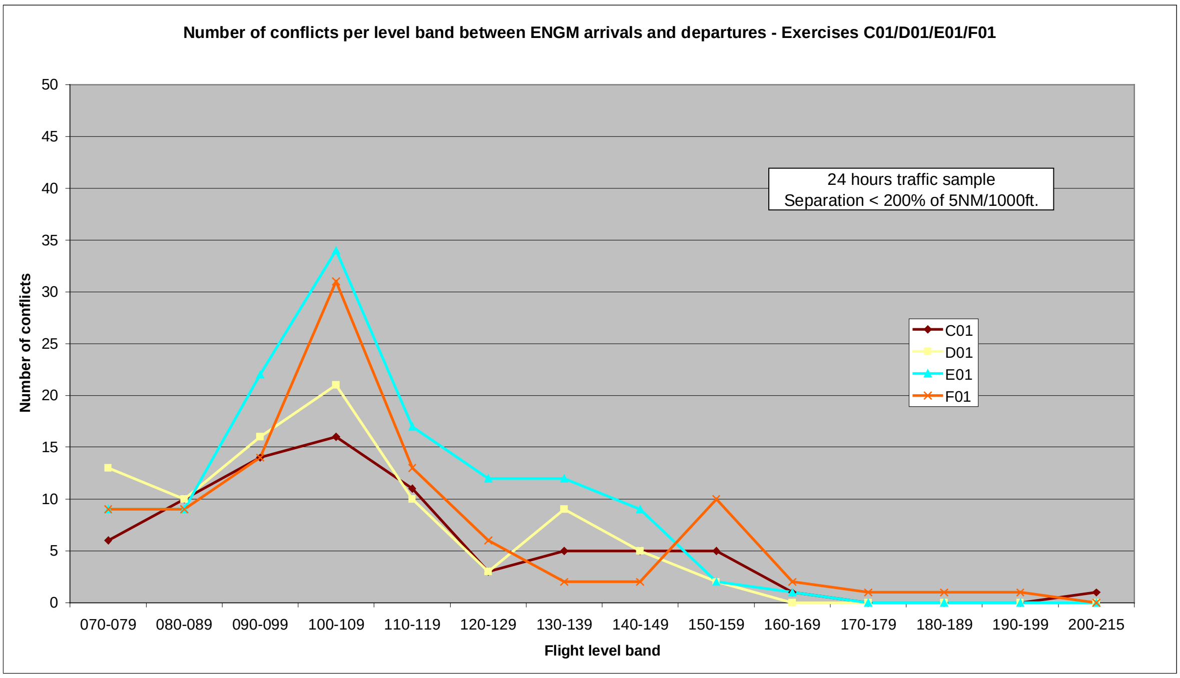


Figure 23 : Number of conflicts per level band - Exercises. C01, D01, E01 and F01

From the above chart, it can be seen that :

- Exercise D01 recorded a similar amount of conflicts as Exercise C01.
- Exercise E01 recorded the highest number of conflicts.
- Exercise F01 had relatively high number of conflicts between FL90 and FL110.
- Exercise F01 also recorded a slight increase in conflicts between FL140 and FL160. The number of conflicts within this level band was a direct consequence of the changes in the route structure in the Southwest part of the TMA.

13.2 Comparison of results : Exercises C19, E19 and F19

Figure 24 shows the number of conflicts per level band between ENGM arrivals and departures as found with Exercises C19, E19 and F19.

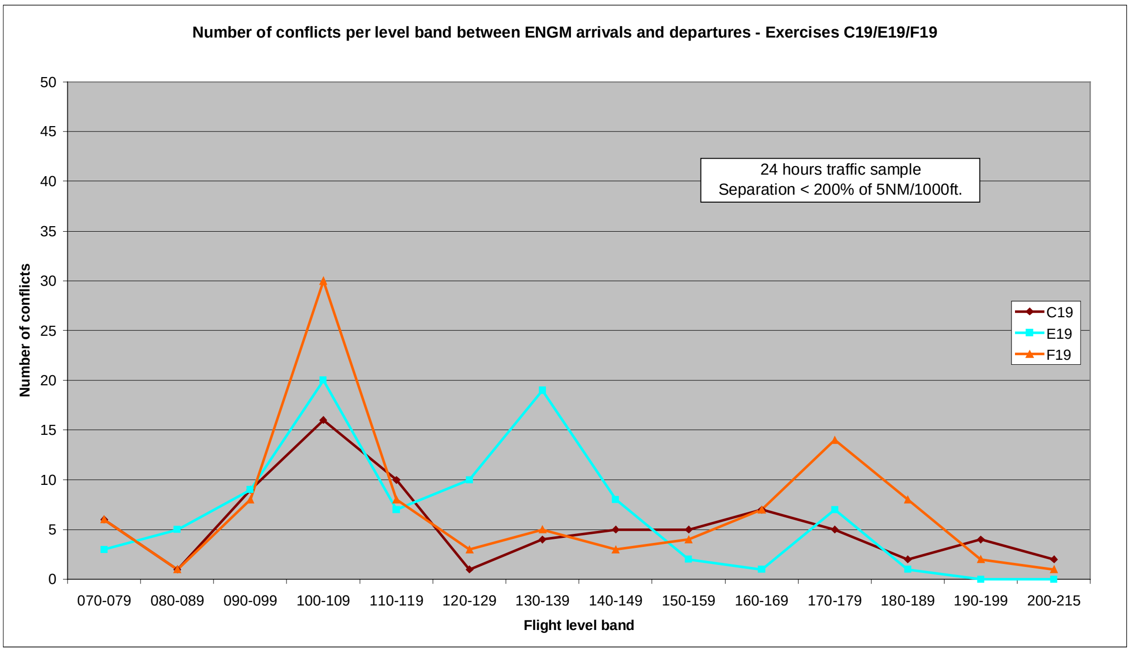


Figure 24 : Number of conflicts per lev el band - Exercises. C19, E19 and F19

From the above chart, it can be seen that :

- Exercise E19 recorded an increased number of conflicts compared to Exercise C19, especially between FL 120 and FL140.
- Generally, Exercise F19 recorded the same trend as Scenario C, with nevertheless an increased number of conflicts between FL160 and FL180. The number of conflicts within this level band was a direct consequence of the changes in the route structure in the Southwest part of the Oslo TMA.

13.3 Conclusion

Scenario D

The SID/STAR system simulated with Scenario D was the same as that proposed with Scenario C. In comparison to Scenario C, Scenario D introduced a new runway usage with Runways 01 in use at ENGM.

Scenario D generally delivered promising results, both in the reports and from the visual validation. Nevertheless, the additional ENGM departures from Runway 01R, generated by the modified runway usage simulated with Scenario D, contributed to increase the total number of conflicts (between ENGM arrivals and departures) compared to Scenario C.

Due to the proximity of the national border, the additional departures from Runway 01R had less track miles available in order to be clearly above the arrivals at the crossing point with the STAR.

Another factor limiting the amount of track-miles flown before the SID / STAR crossing point was the fact that departing traffic from Runway 01R started a right turn immediately after take-off. This is different from the departures from Runway 01L that have to climb on a common leg in the approximate direction of the runway orientation for a minimum of 6 nautical miles before they can turn on course. One of the solutions to the above problem would be the implementation of more rigid level restrictions for inbound traffic.

In spite of the above disadvantages, the results found with Scenario D (Exercise D01), based on both reports and visual observation, validated the first proposed runway usage for ENGM simulated with the study. In addition, this scenario confirmed the ability of the SID/STAR system proposed with Scenario C to cope with new requirements linked to runway usage as simulated with Scenario D.

Scenario E

Initially, the reports delivered and the visual validation conducted with Scenario E seemed to indicate that this scenario could be acceptable when compared to the other proposed scenarios.

However, deeper analysis and further validation indicated that the SID/STAR system proposed with Scenario E did not achieved the same level of flexibility, in view of possible changes in the surrounding (ACC or en-route airspace) and underlying airspace (airports aspects), as the SID/STAR system proposed with Scenarios C, D or F.

During the course of the study, it was considered that the most probable change in the current (2002) runway usage would be to allow more departures from Runway 01R at ENGM. The simulation team thought that the possible introduction of this proposed runway usage, combined with the SID / STAR system evaluated with Scenario E, would probably lead to the development of a new “problem area” (SID / STAR crossing point) close to the airport.

In addition, with Scenario E, the SIDs from Runway 01R had a common leg all the way to OPA. This would contribute to reduce the departure capacity from this runway.

Finally, when considering the above points, the simulation team decided along with the working group to reject Scenario E as a possible solution to the problems identified within Oslo TMA.

Scenario F gave, generally, promising results. Nevertheless, as underlined with Scenario D, the limited available airspace East of the airport, and the fewer track-miles available for departures from Runway 01R (see above), generated an increase in the number of conflicts between ENGM arrivals and departures within the level band FL90 / FL110.

In addition, there was as well a noticeable increase in the total number of conflicts (again, between ENGM arrivals and departures) between FL140 and FL180. This was directly related to the change in the route structure in the South-western part of the TMA. However, this increase was considered to be acceptable by the simulation team as the proposed system would ease the separation between the traffic flows during the en-route phase. Moreover, the proposed system would also improve the interface between Oslo APP and Oslo ACC, allowing clear segregation between the two departure routes (towards the West and Southwest) prior to the transfer either the ACC NW or ACC SW sectors.

Finally, according to the results based on both reports and visual observation, the simulation team along with the working group considered that Scenario F, combining a modified runway usage for Oslo airport Gardermoen and the SID/STAR system introduced with Scenario C, would present advantages enough to be retained as a possible solution for further testing (e.g. real-time simulation).

In order to verify the above statement, a "multi-run" simulation (see point 4.10) was performed with Scenario F. The results obtained with the "multi-run" confirmed the previous trends.

Generally, the SID/STAR system proposed with Scenario C was retained for Scenarios D and F (according to the results, Scenario E was not retained as a valid proposal). The only changes introduced with Scenarios D and F, in addition to minor necessary adjustments to the SIDs, were connected to the modified runway usage simulated for ENGM. According to the results, these two scenarios, first, validated the "philosophy" initially introduced with Scenario C (i.e. departures above arrivals). Then, the results also showed that the proposals made with Scenario C have flexibility enough to accommodate different runway usage such as the ones proposed with Scenarios D and F.

14 EXERCISES F01PLUS AND F19PLUS

14.1 Description

Exercises F01PLUS and F19PLUS were designed in order to test Scenario F (see above) with an increased amount of traffic.

The intention of this test was to see if the proposed SID and STAR system within Oslo TMA was really able to cope with a high amount of traffic, consisting of continuous flows to and from ENGM. This was a way to really confirm the actual de-conflicting process between SIDs and STARs engaged with this study.

The introduction of an increased amount of traffic could of course have been done with Scenario C. Nevertheless, Scenarios C and F presented large similarities. In addition, a large increase of traffic at ENGM would only be possible with an amended runway usage. Moreover, the available time left by the end of the project was limited. That was the reason why, the simulation group decided to introduce the increased amount of traffic with Scenario F only. Doing so, any validation would logically be a validation of both Scenarios C and F.

Exercises F01PLUS and F19PLUS presented the following particularities :

- The advanced traffic sample was used (see point 4.7.2 and explanations below).

- The runway usage introduced with Scenario F was retained. Nevertheless, independent parallel approaches were introduced at ENGM (see below).

- It was considered that ENGM was able to cope with an unlimited amount of traffic (this was achieved by disabling the airport functions). Again, this simulation was not an airport simulation. The effects of the introduction of advanced traffic sample was only to test the ability of the proposed SID/STAR system to cope with a high amount of flights, not to see the effects of such traffic at the airport.

The traffic increase was made for a limited period of time, the already busiest one, representing a morning traffic peak period.

In order to obtain the desired traffic load, the original traffic sample was increased by approximately 85% for the time period 01H30 to 03H30 (traffic sample time, see point 4.7.1). This time period represented morning peak traffic. The additional traffic introduced during the above time period allowed the simulator to deliver a full 1-hour measurable peak period (02H00 to 03H00).

The additional flights were created using the TAAM cloning and duplicating functions. Then, appropriate checks and adjustments were conducted prior to the run of the advanced level of traffic with Exercises F01PLUS and F19PLUS.

14.2 Results and conclusion

The "Advanced" traffic sample used with Scenario F through Exercises F01PLUS and F19PLUS did not intend to be representative of any future planning for traffic flows development within Oslo TMA. It was only set up with the aim of “overloading” the SID and STAR system proposed with Scenario F for validation purposes.

This allowed having a better appreciation of the efficiency of the separation provided with this scenario between ENGM arrival and departure flows at the various crossing points.

In addition, the amount of traffic simulated with Exercise F01PLUS and F19PLUS was in no way to be considered for capacity calculation purposes. It was only a mean to test the proposed route system, not to deliver capacity figures.

In spite of the large increase of the number of flights simulated with Exercises F01PLUS and F19PLUS, the increase of the total number of conflicts between ENGM arrivals and departures was limited. It definitely did not increase in an exponential way as it is generally the case when adding traffic to an already busy airspace. This was a clear confirmation of the previous trends and was considered as an additional validation of Scenario F. According to the similarities between Scenarios C and F (see above), these results have as well to be considered as a further validation of Scenario C.

15 GENERAL SUMMARY AND CONCLUSIONS

15.1 General review

The TAAM Simulation of Oslo TMA (ATI - S - TAAM - OSLO), part of the NORSIM project, was the follow up of the RAMS Simulation of Oslo ATCC (see EEC Report N°364) conducted in EUROCONTROL Experimental Centre between June 2000 and March 2001. The RAMS simulation of Oslo ATCC was itself a follow-up of the SAAM evaluation N°030 conducted in EUROCONTROL Headquarters during spring 2000.

The results found with the RAMS Simulation of Oslo ATCC fulfilled the objectives of the study. Nevertheless, the limitations of the RAMS simulator prevented to have a comprehensive simulation of particular Oslo TMA aspects such as interference between SIDs and STARs, detailed runway usage or noise abatement restrictions. That is the reason why the TAAM Simulation of Oslo TMA was set up. The RAMS Simulation data and results were extensively used for this TAAM simulation.

The objectives of the TAAM Simulation of Oslo TMA were mainly to develop proposals to improve the traffic flows within the TMA. This was done taking into account the proposed changes initially evaluated with the RAMS simulation. This involved the investigation, with the help of the TAAM simulator, of current and future arrival and departure route network within Oslo TMA along with the current and future possible runway usage at Gardermoen airport.

This EUROCONTROL project was conducted in EEC by a NATAM team using the TAAM simulator. The NATAM team was advised and supported by EEC staff. This project was considered as a Pilot Project aiming at defining the procedures to be followed by member states wishing to use the EUROCONTROL TAAM licences for their own studies through EUROCONTROL projects.

With this study, the main functionality of Oslo airport (ENGM) was simulated (runways, basic taxiway system, basic aprons, gates and parking positions). Nevertheless, the detailed simulation of ENGM airport was not part of the study. It was only a mean to generate a realistic behaviour of the flights entering and leaving Oslo TMA. The en-route sectors were only included in the simulation as feeder sectors. They were not measured. In addition, during the whole study, no division of the Oslo TMA was considered : the Oslo TMA airspace was considered as one entity. There was no requirement to test, within the Oslo TMA, a sector plan already validated with the previous RAMS simulation.

Finally, a set of noise contours, using various noise indexes and based on the TAAM trajectories was delivered to NATAM for most of the simulated exercises. This was achieved, processing the TAAM output data with the ENHANCE tool. The analysis of these noise contours was not part of this study. This will be conducted, when required, by the NATATM environment experts.

The TAAM Simulation of Oslo TMA contained 7 Scenarios and 15 Exercises.

Reference Scenario (2 exercises)

With this scenario, the assessment of the current situation (2002 situation) within Oslo TMA was conducted using an actual traffic sample. The Reference Scenario was also used to tune the simulator, allowing further comparison with proposed scenarios.

The Reference Scenario considered both runway orientations (01 and 19) and current (2002) runway usage at ENGM.

The Reference Scenario contained two exercises, Exercise REF01 and Exercise REF19.

Scenario A (2 exercises)

Scenario A retained the main features introduced with RAMS C19B Exercise (see REF 2) as far as the entry / exit points into / from the Oslo TMA were concerned. The SID/STAR system evaluated with Scenario A allowed the ENGM departures to be above the arrivals before reaching the crossing point.

With this scenario, each arrival route from the North and from the South had an alternative routing within the TMA. This was achieved in order to obtain a better distribution of traffic between the eastern part and the western part of the TMA.

Scenario A contained two exercises : Exercise A01 (with runways 01L and 01R in use at ENGM) and Exercise A19 (with runways 19L and 19R in use at ENGM). The runway usage simulated with Scenario A was the same as the one simulated with the Reference Exercises.

Scenario B (2 exercises)

Scenario B introduced the SID/STAR system evaluated with RAMS C19B Exercise (see REF 2). With this system, the ENGM departures were maintained below the arrivals up to their crossing points. As simulated with Scenario A, each arrival route to ENGM from the North and from the South had an alternative routing within the TMA. This was already achieved with the previous RAMS simulation in order to obtain a better distribution of traffic between the eastern part and the western part of the Oslo TMA.

Scenario B contained two exercises (Exercise B01 and Exercise B19). With Scenario B, the runway usage at ENGM was the same as the one simulated with the Reference Scenario.

Scenario C (2 exercises)

Scenario C evaluated a new proposed route network within Oslo TMA mainly based on Scenario A.

In comparison with the above scenarios, the main changes was a dual departure route to the West allowing a clear segregation of the ENGM departure traffic entering either Southwest or Northwest ACC sectors. This was possible thanks to the move to the South of the holding pattern used for ENGM arrivals coming from the Southwest (previously located at SIG).

Scenario C contained two exercises (Exercises C01 and C19). In comparison with the previous scenarios, no change was made with scenario C as far as the runway usage at ENGM was concerned.

The results found with Scenario C seemed promising (see below). That was the reason why a multi-run simulation (using randomised aircraft performances and simulation entry times) was performed with this scenario in order to prove that the initial traffic sample was generic enough and that the results were not dependant of the sample.

Scenario D (1 exercise)

Scenario D was largely based on Scenario C. The main change evaluated with Scenario D was the introduction of a new runway usage at Oslo airport Gardermoen. This change only applied when runways 01 were in used at ENGM. That was the reason why Scenario D contained a single exercise, Exercise D01.

Logically, the ENGM SIDs were modified in order to take into account the proposed runway usage (e.g. allowing ENGM departures to the East or Southeast from runway 01R). In addition, and due to the above changes, some ENGM arrivals were shifted from the right runway to the left runway in order to accommodate the additional departures from this runway.

Scenario E (2 exercises)

Scenario E was based on both Scenarios B and C. Nevertheless, the dual departure route introduced with Scenario C was not retained with Scenario E. With Scenario E, another runway usage for ENGM was introduced for both runway orientations as there was no particular runway allocated for the ENGM arrivals. In addition, the ENGM departures to the Southeast, the East and the Northeast used runway 01R when runways 01 were in use at ENGM. Alternatively, when runways 19 were in use at ENGM, the ENGM departures to the South and Southwest departed from runway 19R. The SIDs and STARs were updated accordingly.

Scenario E contained two exercises, Exercise E01 and Exercise E19.

Scenario F (4 exercises)

Scenario F was largely based on Scenario C. Nevertheless, the runway usage simulated with Scenario F was the same as the one simulated with Scenario E. For instance, and for both runway orientations, there was no particular runway allocated for the ENGM arrivals. In addition, the ENGM departures used the runway according to the part of the TMA they will have to cross. The SIDs from ENGM were modified to accommodate these changes. Then, and as with Scenario C (see above), a multi-run simulation (using randomised aircraft performances and simulation entry times) was performed with Scenario F, Exercises F01 and F19.

Finally, the simulation team decided to evaluate Scenario F with an advanced traffic sample. The purpose of the advanced traffic sample was not to make any forecast for the various traffic patterns around Oslo airport. The intention was only to see if the SID and STAR system proposed with Scenario F would be able to cope with the number of conflicts between ENGM arrivals and departures with a very high number of flights along these routes (not taking into account airport or sector capacity limits). This was achieved with two additional exercises : Exercises F01PLUS and F19PLUS.

15.2 Main results and conclusions

15.2.1 Reference Scenario

The results recorded with the Reference Scenario were confirmed by visual validation. They were coherent to what is experienced within Oslo TMA in “real life”, with actual current (2002) operations.

This confirmed that the tuning of the simulator was achieved in a proper way. After this mandatory step, to be completed with any model-based simulation, Reference Scenario was available as basis for any further comparison with the various proposed scenarios.

15.2.2 Scenario A

The first set of comparisons achieved with this study retained Reference Scenario, Scenario A and Scenario B.

Among these three scenarios, Scenario A clearly showed the most promising results.

Scenario A retained a SID/STAR system based on the "departures above arrivals philosophy". In addition, Scenario A would be able to provide generous amount of airspace (for conflict resolution) in view of the implementation of a "departure function" within Oslo TMA as proposed with previous simulations within the NORSIM project.

Scenario A was consequently considered as being the best platform for development of further scenarios to be evaluated with this study.

15.2.3 Scenario B

With Scenario B, there was a noticeable number of conflicts between ENGM arrival and departure flights. A way to eliminate most of these conflicts could be to adjust the level restrictions for arrival flights.

However, the conflicts found around FL90 between Oslo airport arrival and departure flights were a consequence of the current NAP, more particularly with Runways 01 in use at ENGM. With this airport configuration, every departure from Runway 01L have to maintain a common leg (heading 350°) up to 6 nautical miles from the airport, whatever the destination. This prevented the arrival routes located closed to the airport to be conflict-free from the departure routes.

The "philosophy" evaluated with Scenario B, considering the "departures below the arrivals" was not retained to develop further scenarios.

15.2.4 Conclusions for Reference Scenario and Scenarios A and B

With the three above scenarios, a first step in the development of the study was completed. It allowed the definition of the most suitable route structure to be proposed for Oslo TMA.

The analysis of the results obtained so far clearly indicated that the “close-to-the-field-crossing”, as evaluated with Scenario B did not work out very well, although the crossing was now even closer to the airport than in the Reference Scenario. Nevertheless, and mainly due to the different layout of the NAP, the results found with Scenario B - Exercise B19 (i.e. with runways 19 in use at ENGM) were slightly better than the ones found with Exercise B01 (considering runways 01 in use at ENGM).

On the other hand, the results obtained with Scenario A showed a definite reduction in number of conflicts between ENGM arrivals and departures, when compared to both Reference Scenario and Scenario B.

The proposals made with Scenario A were therefore largely used to develop a new proposal for a route system within Oslo TMA, Scenario C.

15.2.5 Scenario C

When compared to Scenario A, the changes in the SID/STAR system proposed with Scenario C, generated a large reduction of the total amount of conflicts between ENGM arrivals and departures.

Nevertheless, there was still a relatively high number of such conflicts between FL90 and FL110. These conflicts were mainly created by turbo-prop aircraft that did not have the sufficient climb-performance required by the proposed "philosophy" (i.e. departures above arrivals).

Globally, the SID/STAR system proposed with Scenario C present the following advantages :

- A large optimisation of the crossing points between the ENGM arrival and departure flows with a noticeable reduction in the total number of conflicts over these points.
- The achieved segregation between the arrival and departure flows within the TMA which would facilitate the introduction of a departure function as proposed with the previous RAMS simulation.
- Generous space was provided for tactical actions when required by the departure controller, without interfering with the arrival flows. Moreover, this airspace would facilitate the re-introduction of "dependant departures" (e.g. a departure from Runway 19L interfering with the departure track from Runway 19R). This should allow flexibility for traffic to depart from the other runway (L or R) than prescribed (i.e. according to destination), when necessary, in case of snow-clearance, de-icing situations, etc…
- The crossing points located close to the airport, generating a large number of conflicts as simulated with the Reference Scenario and experienced in the current (2002) situation, were removed with Scenario C.
- The "philosophy" proposed with Scenario C (i.e. departures above arrivals) should give flexibility with regards to possible further changes in the surrounding (ACC and en-route airspace) and underlying (airport aspects) airspace.

- The implementation of dual arrival routes for traffic proceeding via N4 and N5 gave the possibility to distribute the inbound traffic into either the eastern or the western part of the TMA, as necessary, according to the actual traffic situation. However, making full use of this feature requires the possibility to anticipate the sequence of departing traffic.

The initial results found with Scenario C, by combining the available reports and the visual observation, were confirmed by the results obtained with a “multiple run” simulation.

According to the above comments, Scenario C was considered to fulfil the "Priority 1" objectives of the study. The changes proposed with Scenario C for Oslo TMA should be retained and implemented along with the ones tested for Oslo ACC with the NORSIM/RAMS proposal C19B.

15.2.6 Scenario D

Scenario D generally delivered promising results, both in the reports and from the visual validation. Nevertheless, the additional ENGM departures from Runway 01R, generated by the modified runway usage simulated with Scenario D, contributed to increase the total number of conflicts (between ENGM arrivals and departures) when compared to Scenario C.

Due to the proximity of the national border, the additional departures from Runway 01R had less track miles available in order to be clearly above the arrivals at the crossing point with the STAR.

Another factor limiting the amount of track-miles flown before the SID / STAR crossing point was the fact that departing traffic from Runway 01R started a right turn immediately after take-off. This is different from the departures from Runway 01L that have to climb on a common leg in the approximate direction of the runway orientation for a minimum of 6 nautical miles before they can turn on course. One of the solutions to the above problem would be the implementation of more rigid level restrictions for inbound traffic.

In spite of the above disadvantages, the results found with Scenario D, based on both reports and visual observation, validated the first proposed runway usage for ENGM. In addition, this scenario confirmed the ability of the SID/STAR system proposed with Scenario C to cope with new requirements linked to runway usage as simulated with Scenario D.

15.2.7 Scenario E

Initially, the reports delivered and the visual validation conducted with Scenario E indicated that this scenario could be retained when compared to the other proposed scenarios.

However, deeper analysis and further validation indicated that the SID/STAR system proposed with Scenario E did not achieved the same level of flexibility, in view of possible future changes in the surrounding (ACC or en-route airspace) and underlying airspace (airports aspects), as the SID/STAR system proposed with Scenarios C, D or F.

During the course of the study, it was considered that the most probable change in the current (2002) runway usage would be to allow more departures from Runway 01R at ENGM. The simulation team thought that the possible introduction of this proposed runway usage, combined with the SID / STAR system evaluated with Scenario E, would probably lead to the development of a new “problem area” (SID/STAR crossing point) close to the airport.

In addition, with Scenario E, all the SIDs from Runway 01R had a common leg all the way to OPA. This would contribute to reduce the departure capacity from this runway.

Finally, when considering the above points, the simulation team decided along with the working group to reject Scenario E as a possible solution to the problems identified within Oslo TMA.

15.2.8 Scenario F

Generally, the results obtained with Scenario F were promising. Nevertheless, as underlined with Scenario D, the limited available airspace East of the airport, and the fewer track-miles available for departures from Runway 01R (see above), generated an increase in the number of conflicts between ENGM arrivals and departures flights.

In addition, there was as well a noticeable increase in the total number of conflicts (again, between ENGM arrivals and departures) between FL140 and FL180. This was directly related to the change in the route structure in the South-western part of the TMA. However, this increase was considered to be acceptable by the simulation team as the proposed system would ease the separation between the traffic flows during the en-route phase. Moreover, the proposed system would also improve the interface between Oslo TMA and Oslo ACC, allowing clear segregation between the two departure routes (to West and Southwest) prior to the transfer either the ACC NW or ACC SW sectors.

Finally, according to the results based on both reports and visual observation, the simulation team along with the working group considered that Scenario F, combining a modified runway usage for Oslo airport and the SID/STAR system introduced with Scenario C, would present advantages enough to be retained as a possible solution for further testing (e.g. real-time simulation).

In order to verify the above statement, a "multi-run" simulation was performed with Scenario F. The results obtained with the "multi-run" confirmed the previous trends

15.2.9 General conclusions for Scenarios C, D, E and F

The SID/STAR system proposed with Scenario C was retained for Scenarios D and F (according to the results, Scenario E was not retained as a valid proposal). The only changes introduced with Scenarios D and F, in addition to minor necessary adjustments to the SIDs, were connected to the modified runway usage simulated for ENGM.

According to the results, Scenarios D and F, first, validated the "philosophy" initially introduced with Scenario C (i.e. departures above arrivals). Then, the results also showed that the proposals made with Scenario C have flexibility enough to accommodate various runway usage such as the ones proposed with Scenarios D and F.

15.2.10 Other topics

In addition to the direct results found with the simulation, there are several other factors which should be taken into account. Mainly in view of the preparation of the planned real-time simulation (to take place in Oslo within the NORSIM project) and as well, of course, in view of operational implementation.

In order to be able to make full use of the introduction of dual arrival routes for equal distribution of traffic to both sides of the TMA, the possibility to **anticipate the sequence of departing traffic** is required. This information is not available in the TMA sectors today.

The introduction of **prop-lanes** has been discussed in the working group during the study. One of the main reasons for these discussions was triggered by the "philosophy" (i.e. departures above arrivals) chosen in most of the simulated scenarios. In order to perform well, this "philosophy" requires minimum climb performance from the departing aircraft in order to be above the arrivals at the SID / STAR crossing points. It was generally admitted that most prop and turboprop aircraft might not be able to cope with this requirement.

However, the total number of conflicts between ENGM arrival and departure flights generated by turboprop aircraft was limited. In addition, the proposed SID/STAR system took into account the implementation of a departure controller position, as initially proposed with the previous RAMS simulation. According to the relatively large airspace available in the proposed SID / STAR system, the departure controller should be able to handle these conflicts tactically, without a major impact on the capacity.

If, during a RTS or at a later stage, the introduction of prop lanes should be considered as a necessity, the available airspace should allow for this.

The various uncertainty-factors necessarily linked to a fast time simulation emphasised the fact that the different results from the reports are only to be used for **comparison** purposes between the different scenarios, within the study. The numbers should not be considered as absolute values.

It is also important to underline that there was no defined **criteria** to decide which values were "acceptable" or not (i.e. what amount of conflicts would give an acceptable workload for one controller etc…).

The **vertical interface between Oslo APP and Oslo ACC** was not part of the objectives of the study. This will have to be evaluated during the planned Real - Time simulation to take place in Oslo within the NORSIM project.

The ways to achieve the **sequencing** of the arrival flows to Oslo airport has not been evaluated by this study. This was based on the functions of an AMAN tool, simulated by TAAM in a basic way. The “straight-in” procedures introduced with the proposed SID/STAR system evaluated with Scenario C was also based on the expectations of this tool.

15.2.11 The simulation process

Globally, the process set up with this study and described above was successfully tested and validated.

Of course, the results of such a simulation process are widely based on the cohesion of the teams along with the way the various personal affinities could match together. But, if this is valid for any project, it is definitely of major importance for this kind of simulation process. Such a process could be a way to facilitate people working in different adjacent centres (e.g. APP and airport, APP, airport and ACC - as it was the case with this project - or two neighbouring ACCs…) to conduct a simulation project together, not only in the same working group, but in the same simulation team.

However, and due to the necessity to limit the size of the team in charge of executing the simulation - ideally two to three persons -, this simulation process should be recommended for projects studying only a single interface (see above) or a single airport or ATC control centre. Consequently, such a process is appropriate for studies of limited size. Larger simulations, and particularly the multiple centre ones, should continue to apply the standard process used up to now to conduct model-based simulations.

More generally, the above described process could as well be used for R&D projects or environmental studies looking for input from model-based simulations. In that case the "client" role would be done by EUROCONTROL or contracted staff, members of the relevant project teams. The assistance provided by the EUROCONTROL model-based simulations team would be, of course, identical as the one described above. It has to be noted that such a proposed process is independent of the tool and could be used with other models available at EEC, such as RAMS, for instance.

Finally, it should be clear that the process proposed with the Oslo TAAM Simulation globally presented significant advantages. However, the selection of the projects subject to be conducted in a similar way, the set-up of the simulation team and the planning of the whole project should be made very carefully in order to get the greatest benefits from such a process.

15.3 General conclusions

The Oslo TAAM Simulation was the first EUROCONTROL project where an ATS provider team, composed of national ATM experts, was in charge of the execution of their own simulation using, at EEC, the EUROCONTROL TAAM licences with help and assistance of EUROCONTROL staff. In this respect, the study was considered as a Pilot Project helping to define the procedures to be followed by (other) EUROCONTROL Member States wishing to use the EUROCONTROL TAAM licences for their own studies through EUROCONTROL projects.

Globally, the process set up with this study was successfully tested and validated.

For the various actors who participated in this project, it was clear that the process proposed with the Oslo TAAM Simulation globally presented significant advantages such as the access to the EUROCONTROL TAAM licences, the greater involvement of the operational people directly concerned by the project and the more efficient use of human resource. However, the selection of the projects subject to be conducted in a similar way, the set-up of the simulation team and the planning of the whole project should be made very carefully in order to get the greatest benefits from such a process.

The results found with the TAAM Simulation of Oslo TMA fulfilled most of the objectives of the study.

The results and the validation of the various scenarios simulated with this study were based on both simulation reports and, thanks to TAAM graphical capabilities, visual observation.

The main findings and conclusions can be summarised as follows:

The first part of the TAAM Simulation of Oslo TMA defined a SID and STAR system that tied up the runways at ENGM to the ATS route structure within Oslo FIR proposed by the RAMS simulation Scenario C19B. This was achieved taking into account the introduction of a Departure Controller and based on the current (2002) ENGM runway usage. The first part of the study was completed with the run of the third proposed scenario, **Scenario C**.

With Scenario C,

- The ENGM departing flights along SIDs were above the ENGM arrival flights along STARs at their crossing points. To achieve this, the path of the various STARs was generally located far from the airport. This system noticeably reduced the number of conflicts between arrival and departure flights in comparison with the current (2002) situation simulated with the Reference Scenario.
- The segregation between the arrival and departure flows within the Oslo TMA, would facilitate the introduction of a departure function as previously proposed with the RAMS Simulation of Oslo ATCC.
- In addition, Scenario C provided generous space for tactical actions, when required by the Departure Controller, without interfering with the arrival flows. This would as well allow flexibility, either in the usage of the departing runways or, with

the introduction of "dependant departures" from Oslo airport. Moreover, Scenario C gave flexibility with regards to possible further changes in the surrounding (ACC) and underlying (airports aspects) airspace.

- Finally, the SID/STAR system proposed with Scenario C introduced a dual arrival route for ENGM arrivals coming from the North or the South. This would allow a distribution of the related inbound traffic into either the eastern or the western part of the TMA, according to the traffic situation. Making use of this feature requires the possibility to anticipate the sequence of departing traffic.

According to the above results, Scenario C fulfilled the "Priority 1" objectives of the study.

The second part of the study aiming at fulfilling the "Priority 2" objectives of the simulation, demonstrated that the above proposed scenario, Scenario C, would be able to cope with the potential changes in runway usage at Oslo airport along with increased airport capacity (this was assumed, as this simulation was not an airport simulation). This part of the study had as well to generate noise contours for ENGM, based on TAAM trajectories.

The "Priority 2" objectives were achieved with the run of Scenarios D, E and F. Nevertheless, and mainly due to time constraints, the impact of runway usage on capacity and efficiency was not totally evaluated with the study. The same reasons prevented the simulation team to evaluate in detail the effects of the suppression of the Noise Critical altitude.

Initially, Scenario E, due to insufficient performance, was rejected. Then, according to the results, **Scenarios D and F**, validated the "philosophy" initially introduced with Scenario C (i.e. departures above arrivals). Finally, the results also showed that the proposals made with Scenario C had flexibility enough to accommodate different runway usage such as the ones proposed with Scenarios D and F.

In order to introduce a departure controller into the Oslo TMA, to reduce the conflicts related to the crossing points between the SIDs and STARs and to accommodate the more likely changes expected for ENGM runway usage, the changes proposed with Scenario C for Oslo TMA should be retained and implemented along the ones tested for Oslo ACC with the NORSIM/RAMS proposal C19B.

Of course, as with every model-based simulation, the results and the concepts established and evaluated during the course of the study should be validated through real time simulation exercises prior to operational implementation.

Nevertheless, the global trends were promising enough to consider this simulation as a first step into the validation of the proposed changes.

Traduction en langue française

RESUME

En 1999, l'administration Norvégienne de l'aviation civile *Luftfartsverket Hovedadministrasjonen / NATAM (**N**orwegian **AT**M and **A**irports **M**anagement)* a demandé l'aide d' EUROCONTROL (EATMP/DIS/STS) pour une série de simulations ayant pour but d'étudier et d'analyser la sectorisation et le réseau de routes ATC au sein de l'espace aérien norvégien.

Ces simulations composent le projet NORSIM. Au sein de ce projet, la première simulation par modèle était nommée NORSIM-MBS-OSLO. Elle étudiait le Centre de Contrôle d'Oslo et fut réalisée au Centre Expérimental EUROCONTROL de Brétigny sur Orge (France) à l'aide du simulateur RAMS. Cette simulation faisait suite à une évaluation SAAM effectuée par la section Espace de l'Unité Management de l'Espace et Navigation (AMN) d' EUROCONTROL Bruxelles.

Les résultats trouvés avec l'étude RAMS donnèrent de bonnes indications sur ce qui pouvait être entrepris au sein du Centre de Contrôle d'Oslo afin d'augmenter la capacité de ce centre en tenant compte des possibles interactions avec les FIR voisines. Néanmoins, les limitations du simulateur RAMS empêchèrent une étude détaillée de certains aspects TMA tels que l'utilisation précise des pistes ou les restrictions liées aux procédures anti-bruit. C'est la raison pour laquelle l'équipe de projet recommanda de compléter l'étude RAMS par une simulation plus complète de certains aspects de la TMA d'Oslo. Ceci fut réalisé entre Juin 2001 et Avril 2002 au moyen d'une simulation TAAM de la TMA d'Oslo sous le nom de projet ATI-S-TA-OSLO.

Les objectifs de l'étude étaient, principalement, de faire des propositions en vue d'améliorer les flots de trafic au sein de la TMA d'Oslo. Ceci devait être réalisé en tenant compte des changements évalués et proposés par la simulation RAMS. En outre, cela devait prendre en compte l'étude détaillée, avec l'aide du simulateur TAAM, des actuels et futurs réseaux de routes d'arrivée et de départ au sein de la TMA d'Oslo ainsi que les actuelles et futures utilisations possibles des pistes à l'aéroport d'Oslo Gardermoen.

Le projet a été réalisé au Centre Expérimental EUROCONTROL de Brétigny sur Orge (France) par une équipe composée de membres de NATAM et à l'aide du simulateur TAAM. Cette équipe a été conseillée et aidée par des personnels du Centre Expérimental. Ce projet a été considéré comme un Projet Pilote ayant pour but de définir les procédures à suivre par les états membres désirant utiliser les licences TAAM d' EUROCONTROL pour leurs propres études conduites au sein de projets EUROCONTROL. A la fin de l'étude, une revue du processus dans sa globalité faisait partie du projet afin d'évaluer la possibilité d'étendre une telle méthode de simulation à d'autres projets. Globalement, le processus mis au point lors de cette étude a été testé avec succès, puis validé.

La simulation TAAM de la TMA d'Oslo a testé sept scénarios représentant un total de quinze exercices.

Avec cette étude, la structure de routes offrant les meilleures perspectives au sein de la TMA d’Oslo retenait un système de SID et de STAR largement basé sur les propositions faites lors de la précédente simulation RAMS. Néanmoins, grâce aux possibilités du simulateur TAAM d’intégrer les aspects aéroports (comme par exemple l’utilisation détaillée des pistes), une large optimisation et un réglage fin des propositions initiales ont été possibles. En particulier, une série d’exercices retenant diverses options pour l’utilisation des pistes à l’aéroport d’Oslo Gardermoen a été réalisée. Finalement, un ensemble de contours de bruit, utilisant différents index et basés sur les trajectoires générées par le simulateur TAAM a été délivré à NATAM pour la plupart des exercices simulés.

Comme avec chaque simulation par modèle, les résultats et les concepts étudiés et définis durant le cours de cette étude devraient être, de façon idéale, validés au moyen d’une simulation en temps réel avant la mise en service opérationnelle.

1 INTRODUCTION

En 1999 , l'administration Norvégienne de l'aviation civile *Luftfartsverket Hovedadministrasjonen / NATAM (**N**orwegian **AT**M and **A**irports **M**anagement)* a demandé l'aide d' EUROCONTROL (EATMP/DIS/STS) pour une série de simulations ayant pour but d'étudier et d'analyser la sectorisation et le réseau de routes ATC au sein de l'espace aérien norvégien.

Ces simulations composent le projet NORSIM. Ce projet devrait inclure des simulations supplémentaires, à la fois par Modèle et Temps Réel, pour le centre d'Oslo et pour les autres centres de contrôle Norvégiens (Stavanger, Trondheim, Bodø).

Dans un premier temps, pour le Centre de Contrôle d'Oslo, une évaluation, utilisant l'outil SAAM, a été réalisée par la section Espace de l'Unité Management de l'Espace et Navigation (AMN) d' EUROCONTROL Bruxelles. Les résultats de cette étude furent fournis à NATAM à la fin du mois de Mars 2000.

Ensuite, une seconde étude fut lancée en Avril 2000, basée sur les résultats de l'évaluation SAAM. Cette étude consistait en une simulation par modèle (NORSIM-MBS-OSLO) de l'ensemble de l'espace aérien du Centre de Contrôle d'Oslo, en incluant la TMA d'Oslo. Cette simulation fut exécutée au Centre Expérimental EUROCONTROL à Brétigny sur Orge (France) à l'aide du simulateur RAMS, au sein du l'Unité ATI et du Centre d'Expertise OPS. Les résultats de cette étude furent délivrés à NATAM en Février 2001 (voir REF2).

La plupart des objectifs de cette étude furent atteints. Néanmoins, et afin d'avoir une solution complète aux problèmes encore non résolus au sein de la TMA d'Oslo, NATAM souhaita une simulation plus détaillée des aspects TMA. EUROCONTROL proposa alors à NATAM de réaliser une simulation par modèle en utilisant les licences TAAM d' EUROCONTROL avec l'aide et l'assistance des experts simulations par modèle du Centre Expérimental. Le procédé, décrit dans ce document, était tout à fait nouveau et a été considéré comme un Projet Pilote ayant pour but de définir les procédures à suivre par les états membres désirant utiliser les licences TAAM d' EUROCONTROL pour leurs propres études conduites au sein de projets EUROCONTROL. Cette simulation par modèle a été nommée Simulation TAAM de la TMA d'Oslo et a reçu le code projet ATI-S-TA-OSLO.

L'objectif principal de la Simulation TAAM de la TMA d'Oslo était de définir au mieux un système de SID et STAR reliant les pistes de l'aéroport d'Oslo Gardermoen au système de routes ATS établi pour la FIR Oslo durant l'étude RAMS (voir REF2, Scénario C19B). Ceci fut réalisé en considérant l'impact des diverses propositions sur le nombre et la sévérité des conflits (et par conséquent, sur la charge de travail des contrôleurs) au sein de l'espace TMA, la capacité estimée de l'aéroport d'Oslo (ENGM) et, grâce aux capacités graphiques de TAMM, la validation visuelle effectuée par les personnels opérationnels du Centre de Contrôle d'Oslo. En outre cette étude prenait en compte la mise en service d'une position de Contrôleur Départ au sein de la TMA d'Oslo, suivant en cela les recommandations de la précédente simulation réalisée avec RAMS.

La Simulation TAAM de la TMA d'Oslo aida également à définir l'endroit où les points de croisements entre les SIDs et les STARs devraient idéalement être placés afin d'optimiser les profils des vols en essayant d'éviter les paliers intermédiaires pendant les phases de montée et de descente depuis ou vers l'aéroport d'Oslo. L'emplacement de ces points de croisements devait en outre délivrer une séparation verticale nette entre les flux d'arrivées et de départs afin d'éviter les alarmes intempestives dans les cockpits.

La Simulation TAAM de la TMA d'Oslo évalua également différentes utilisations de piste pour l'aéroport d'Oslo Gardermoen (c'est à dire l'utilisation des deux pistes parallèles spécialisées ou non et de façon indépendante ou non).

Finalement, un ensemble de contours de bruit, utilisant différents index et basés sur les trajectoires générées par le simulateur TAAM a été délivré à NATAM pour la plupart des exercices simulés. Ceci a été réalisé en traitant les fichiers de données en sortie de TAAM avec l'outil ENHANCE. L'analyse des contours de bruit ne faisait pas partie de cette étude. Cette analyse sera faite, si nécessaire, par les experts en environnement, au sein de NATAM.

Cette étude TAAM a largement utilisé les données établies précédemment pour la simulation RAMS. De même, les résultats de la simulation RAMS ont été amplement utilisés durant la mise au point des exercices TAAM.

Pour cette étude, une première réunion de travail a eu lieu au Centre Expérimental EUROCONTROL à Brétigny le 03 Mars 2001. Ensuite, deux membres de NATAM (le chef de projet pour la simulation et son adjoint) ont suivi une formation de deux semaines sur le simulateur TAAM, au Centre Expérimental, au début du mois de Mai 2001. La réunion de travail lançant officiellement le projet a eu lieu à Oslo fin Mai 2001. La présentation finale des résultats de l'étude s'est tenue à Oslo le 07 Mai 2002.

Ce document est seulement un résumé de l'étude. Il contient :

- Des commentaires généraux sur la façon dont cette étude a été réalisée. En effet, cette simulation a été la première effectuée par des personnels d'un état membre utilisant les licences TAAM d' EUROCONTROL pour une de leurs études faisant partie d'un projet EUROCONTROL. Ceci a été accompli avec l'assistance des experts des simulations par modèle du Centre Expérimental.

- La description générale de l'espace simulé, des échantillons de trafic et un diagramme de l'étude.

- La description et l'analyse des principaux résultats obtenus avec chacun des scénarios et exercices testés lors de la simulation.

Tout renseignement supplémentaire sur la description complète des objectifs de l'étude, l'analyse des différents scénarios et les résultats de la simulation peuvent être obtenus auprès de NATAM, d'EATMP/DIS/STS – EUROCONTROL Bruxelles ou de l'unité ATI (ATM Implementation) du Centre Expérimental EUROCONTROL à Brétigny.

2 OBJECTIFS DE L’ETUDE

Les objectifs de l’étude étaient :

- (Priorité 1) Evaluer diverses solutions afin de définir un système de SID et STAR reliant les pistes de l’aéroport ENGM (aéroport d’Oslo Gardermoen) à la structure de routes ATS de la FIR Oslo, modifiée selon les propositions de la simulation RAMS, Scénario C19B. Ceci devait tenir compte de l’introduction d’un Contrôleur Départ au sein de la TMA d’Oslo. L’étude devait non seulement se concentrer sur les résultats chiffrés mais également sur l’organisation des flots de trafic avec l’objectif de minimiser le nombre de points de conflits et par conséquent de réduire les risques et la charge de travail totale des contrôleurs TMA.

- (Priorité 1) Identifier les points de croisements entre les SIDs et les STARs et trouver où ils devraient être idéalement placés afin d’éviter les paliers intermédiaires pour les vols en montée ou en descente. Un des objectifs étant d’éviter les alarmes intempestives dans les cockpits.

- (Priorité 2) Evaluer l’utilisation des pistes à l’aéroport d’Oslo Gardermoen en incluant les effets de la suppression de l’altitude critique de 5000 pieds liée aux procédures anti-bruit et étudier comment l’utilisation actuelle des pistes (chacune d’elles étant spécialisée pour les arrivées ou les départs) affecte la capacité et l’efficacité en comparaison d’une utilisation plus flexible des deux pistes.

- (Priorité 2) Livraison d’un ensemble de contours de bruits pour différents scénarios et exercices, l’analyse de ces contours de bruits devant être faite au sein de NATAM.

Ceci a nécessité l’examen :

- De la structure actuelle et future de l’espace aérien : routes aériennes, SIDs et STARs de l’aéroport d’Oslo Gardermoen, la sectorisation de l’approche (APP), procédures d’attente…

- De l’utilisation actuelle et future des pistes de l’aéroport d’Oslo Gardermoen.

- Des niveaux de trafic actuel et futur.

- Des résultats de la simulation RAMS du Centre de Contrôle d’Oslo.

Néanmoins, et principalement à cause des contraintes de temps, l’impact de diverses utilisations des pistes sur la capacité et l’efficacité n’a pas pu être totalement étudié durant cette simulation. Pour la même raison, l’équipe en charge de l’étude n’a pas pu évaluer en détail les effets de la suppression de l’altitude minimum liée aux procédures anti-bruit.

3 CONCLUSIONS

La Simulation TAAM de la TMA d'Oslo fut le premier projet EUROCONTROL où une équipe composée d'experts ATM d'une autorité fournissant les services ATS d'un état membre, a été en charge de l'exécution d'une simulation en utilisant, au Centre Expérimental EUROCONTROL, les licences TAAM d' EUROCONTROL avec l'aide et l'assistance des personnels du Centre Expérimental.

De ce point de vue cette étude a été considérée comme un Projet Pilote ayant pour but de définir les procédures à suivre par les états membres désirant utiliser les licences TAAM d' EUROCONTROL pour leurs propres études conduites au sein de projets EUROCONTROL.

Globalement, le processus mis en place pour cette étude a été testé et validé avec succès.

Pour les différents acteurs qui ont participé à ce projet, il a été clair que le processus proposé avec la Simulation TAAM de la TMA d'Oslo présentait beaucoup d'avantages. Parmi ceux-ci se trouvaient l'accès aux licences TAAM d'EUROCONTROL, la grande implication des personnels opérationnels directement concernés par l'étude ou encore l'utilisation plus efficace des ressources humaines. Cependant, le choix des projets devant être conduits de la sorte, la composition de l'équipe de simulation et le planning général du projet doivent être soigneusement préparés afin d'obtenir d'un tel processus le maximum de bénéfices.

Les résultats obtenus avec la Simulation TAAM de la TMA d'Oslo ont satisfait la plupart des objectifs de l'étude.

Les résultats et la validation des divers scénarios simulés durant cette étude ont été basés à la fois sur les rapports chiffrés délivrés par le simulateur et sur l'observation visuelle, grâce aux larges capacités graphiques du simulateur TAAM.

Les principaux résultats et conclusions peuvent être résumés comme suit :

La première partie de le Simulation TAAM de la TMA d'Oslo a défini un système de SID et STAR reliant les pistes de l'aéroport ENGM (aéroport d'Oslo Gardermoen) à la structure de routes ATS de la FIR Oslo, modifiée selon les propositions de la simulation RAMS, Scénario C19B.

Ceci fut réalisé en tenant compte de l'introduction d'un Contrôleur Départ au sein de la TMA d'Oslo et fut basé sur l'actuelle (2002) utilisation des pistes à ENGM. La première partie de l'étude fut conclue avec la réalisation du troisième scénario proposé, le **Scénario C**.

Avec le Scénario C,

- Les vols au départ d' ENGM, suivant les SIDs, étaient au-dessus des vols à l'arrivée, suivant les STARs, à leurs divers point de croisement. Pour réaliser ceci, les trajectoires des diverses STARs étaient généralement situées loin de l'aéroport d'Oslo. Un tel système a réduit de façon significative le nombre de conflits entre les arrivées et les départs en comparaison avec la situation actuelle (2002), simulée avec le Scénario de Référence.

- La ségrégation entre les flots arrivée et départ au sein de la TMA d'Oslo, devrait faciliter l'introduction d'une fonction de Contrôleur Départ comme précédemment proposée avec la simulation RAMS du Centre de Contrôle d'Oslo.

- De plus, le Scénario C laissait beaucoup d'espace libre pour les actions tactiques requises par le Contrôleur Départ, sans pour cela interférer avec les flots d'arrivées. Ceci devrait en outre ajouter de la flexibilité, soit, par exemple, dans l'utilisation des pistes de départ, soit en cas d'introduction de « départs dépendants » depuis l'aéroport d'Oslo. Un autre avantage du Scénario C était de pouvoir s'adapter aisément à des modifications ultérieures concernant soit l' ACC (au-dessus et autour de la TMA), soit les aspects aéroports (en dessous de la TMA).

- Finalement, le système de SID et de STAR proposé avec le Scénario C introduisait une double route d'arrivée pour les vols rejoignant l'aéroport d'Oslo depuis le Nord ou le Sud. Ceci devrait permettre une distribution du trafic concerné dans la partie Est ou dans la partie Ouest de la TMA, en fonction de la situation. L'utilisation optimale d'un tel système nécessite la possibilité d'anticiper la séquence de trafic au départ de l'aéroport d'Oslo.

Selon les résultats ci-dessus, le Scénario C a satisfait les objectifs de Priorité 1 de l'étude.

La seconde partie de l'étude en cherchant à satisfaire les objectifs de Priorité 2 de la simulation, démontra que le Scénario C, proposé ci-dessus, serait capable d'intégrer des changements dans l'utilisation des pistes de l'aéroport d'Oslo. Ce scénario permettait en outre une augmentation de la capacité de cet aéroport (celle-ci étant simplement supposée, cette étude n'était pas une simulation de l'aéroport d'Oslo). Cette partie de l'étude devait également générer des contours de bruit, basés sur les trajectoires du simulateur TAAM, pour l'aéroport d'Oslo.

Les objectifs de Priorité 2 furent atteints avec l'achèvement des Scénarios D, E et F. Néanmoins, et principalement à cause des contraintes de temps, l'impact de diverses utilisations des pistes sur la capacité et l'efficacité n'a pas été totalement étudié durant cette simulation. Pour la même raison, l'équipe en charge de l'étude n'a pas pu évaluer en détail les effets de la suppression de l'altitude minimum liée aux procédures anti-bruit.

Dans un premier temps, Le **Scénario E**, à cause de ses performances insuffisantes, a été rejeté.

Ensuite, au vu des résultats obtenus, les **Scénarios D et F** validèrent la « philosophie » initialement introduite avec le Scénario C (c'est à dire les départs au-dessus des arrivées). Finalement, les résultats montrèrent également que les propositions faites avec le Scénario C étaient assez flexibles pour intégrer différentes utilisations des pistes telles que celles évaluées avec les Scénarios D et F.

Afin de pouvoir introduire une position de Contrôleur Départ au sein de la TMA d'Oslo, de réduire le nombre de conflits liés aux croisements entre les SIDs et les STARs et de pouvoir intégrer aisément les changements attendus dans l'utilisation des pistes à l'aéroport d'Oslo, les modifications proposées pour la TMA d'Oslo avec le Scénario C devraient être retenus et mis en service en même temps que ceux testés pour le centre de contrôle d'Oslo à l'aide de la simulation NORSIM/RAMS, Exercice C19B.

Bien sûr, et comme avec chaque simulation par modèle, les résultats et les concepts étudiés et définis durant le cours de cette étude devraient être, de façon idéale, validés au moyen d'une simulation en temps réel avant la mise en service opérationnelle.

Néanmoins, les principales tendances obtenues avec cette étude furent jugées suffisamment encourageantes pour être considérées comme une première étape dans le processus de validation des changements proposés.

APPENDIX : Noise contours for Oslo airport Gardermoen

In addition to the TAAM simulation of Oslo TMA, noise contours were calculated around Oslo airport Gardermoen for the different simulated scenarios (including both arrivals and departures). The objective of this additional work package was to demonstrate the technical feasibility of producing noise contours with the FAA's Integrated Noise Model (INM) using TAAM output data (i.e. the simulated trajectories). This was achieved through the use of the ENHANCE tool, currently developed at EEC. Nevertheless, the analysis of the produced noise contours was not part of this project.

The European Harmonised Aircraft Noise-Contour Modelling Environment (ENHANCE) is a tool aiming at improving the quality of noise contours produced by a noise model like INM, particularly by improving the quality/level of details of the input data used by the noise model.

To calculate noise contours, models like INM need the successive values of five basic parameters specifying "how" the aircraft fly: x and y ground position, height, speed and thrust. To specify these data, noise models generally make use of nominal tracks (with Gaussian dispersion around these tracks to include more realism) and standard flight profiles (coming from an aircraft database). The principle of ENHANCE consists in replacing these nominal ground tracks and standard flight profiles with full 4-D trajectories (i.e. 3-D position and speed) taken from radar systems or ATC simulators (fast-time or real-time) - each flight being modelled individually. TAAM is able to produce these 4-D trajectories for each individual flight of a simulation exercise.

Through this approach, ENHANCE enables in particular to better account for real ground dispersions in the noise calculation process. Since the thrust parameter is generally not provided by these external sources of data (radar data in particular), ENHANCE calculates the thrust profile associated to each flight/trajectory, in a reverse-engineering way (using thrust equations derived from the INM performance model).

Through an interface/pre-processor combination, ENHANCE imports the “raw” data from the external sources and automatically generates the input data required by the noise model. In its current version, ENHANCE generates data for INM6.0c. The “raw” input data to be provided to the tool are defined in text files. These raw data include in particular a trajectory file specifying for each flight of the traffic sample to be studied the associated 3-D trajectory and speed (usually with a time step of 5 or 6 seconds).

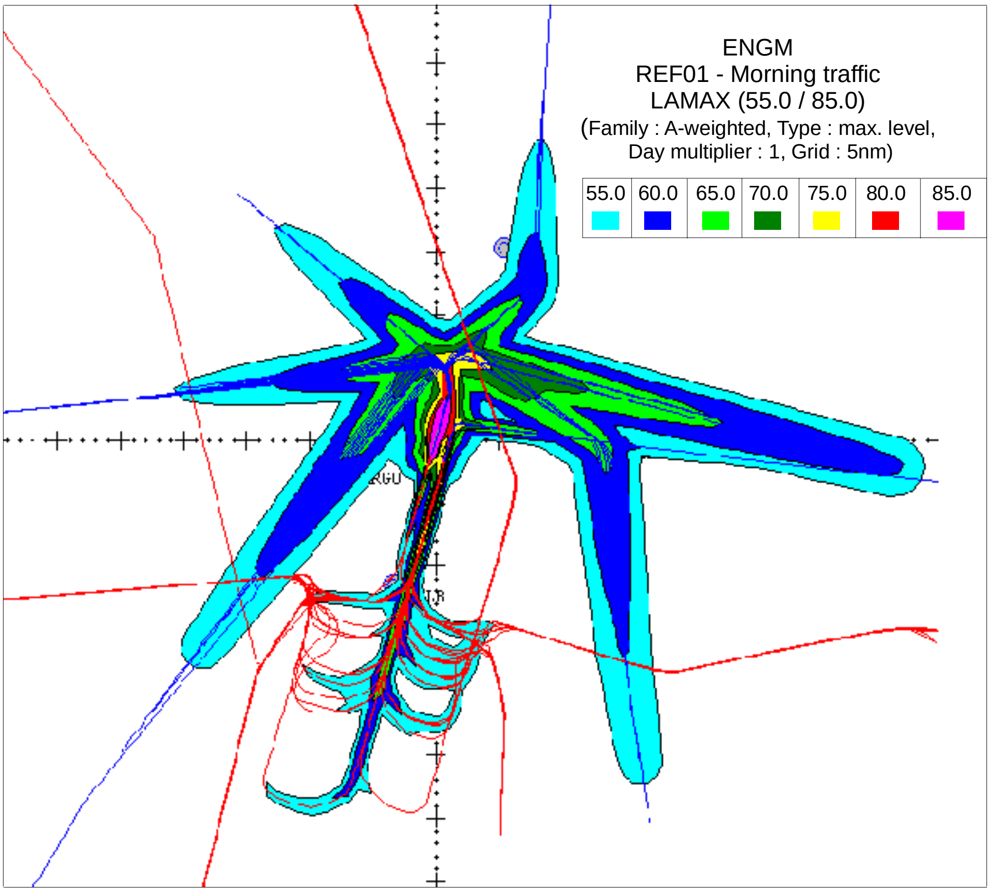
The main work of this feasibility study consisted in developing a tool (including an interface) to generate in an automated (and easy) way the ENHANCE-formatted “raw” input data files from TAAM output data files. This tool includes in particular filters to select the appropriate phases of the flights for noise impact assessment needs (e.g. removing taxiing).

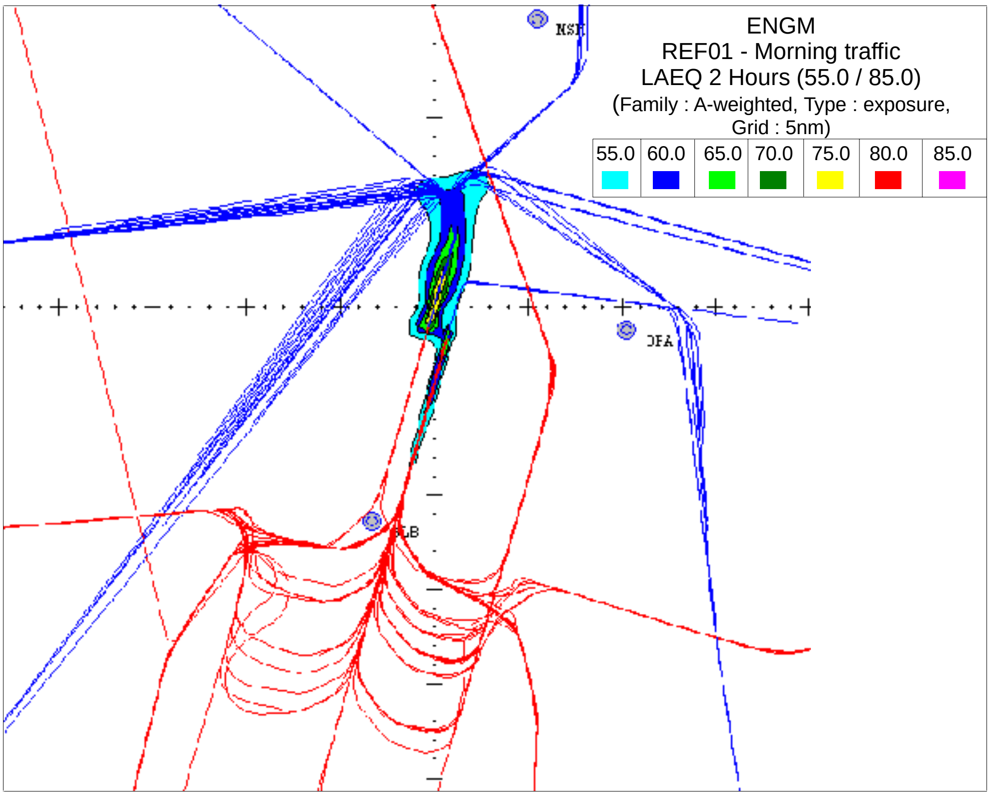
The technical feasibility of using 4-D trajectories simulated by TAAM to calculate noise contours with ENHANCE/INM tools was successfully demonstrated.

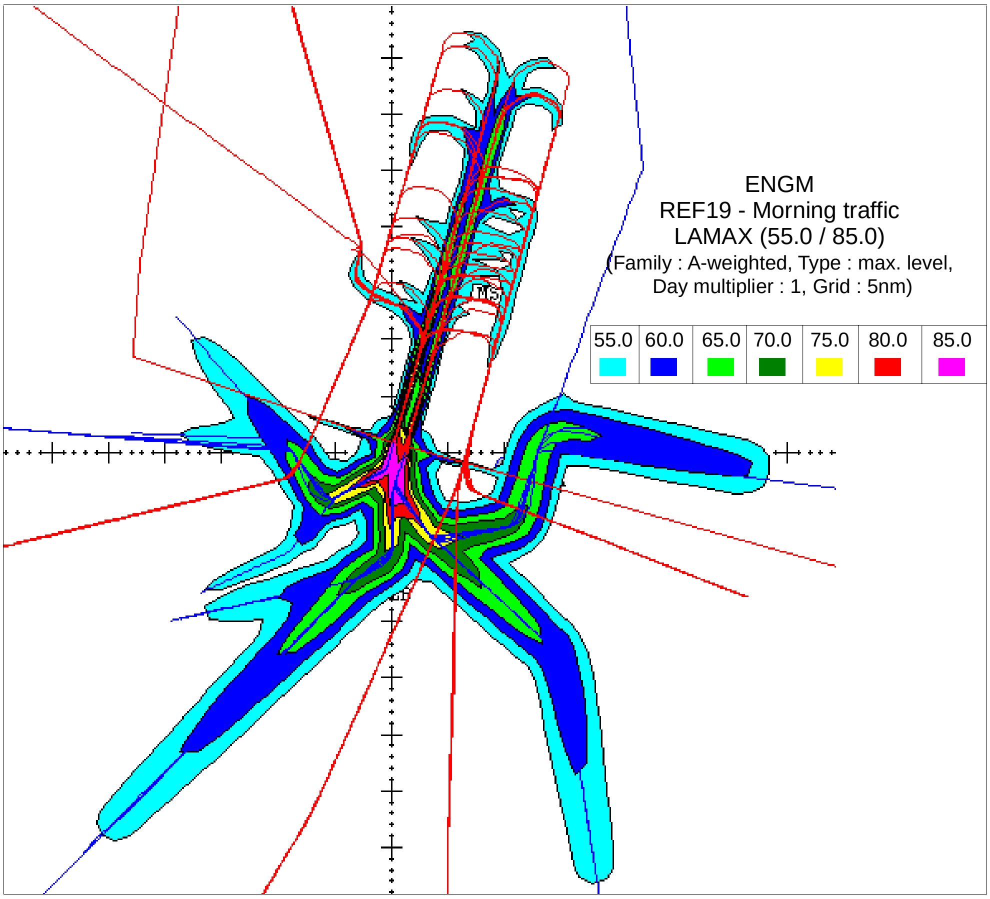
The noise contours contained in this Appendix to the TAAM Simulation of Oslo TMA report were established for:

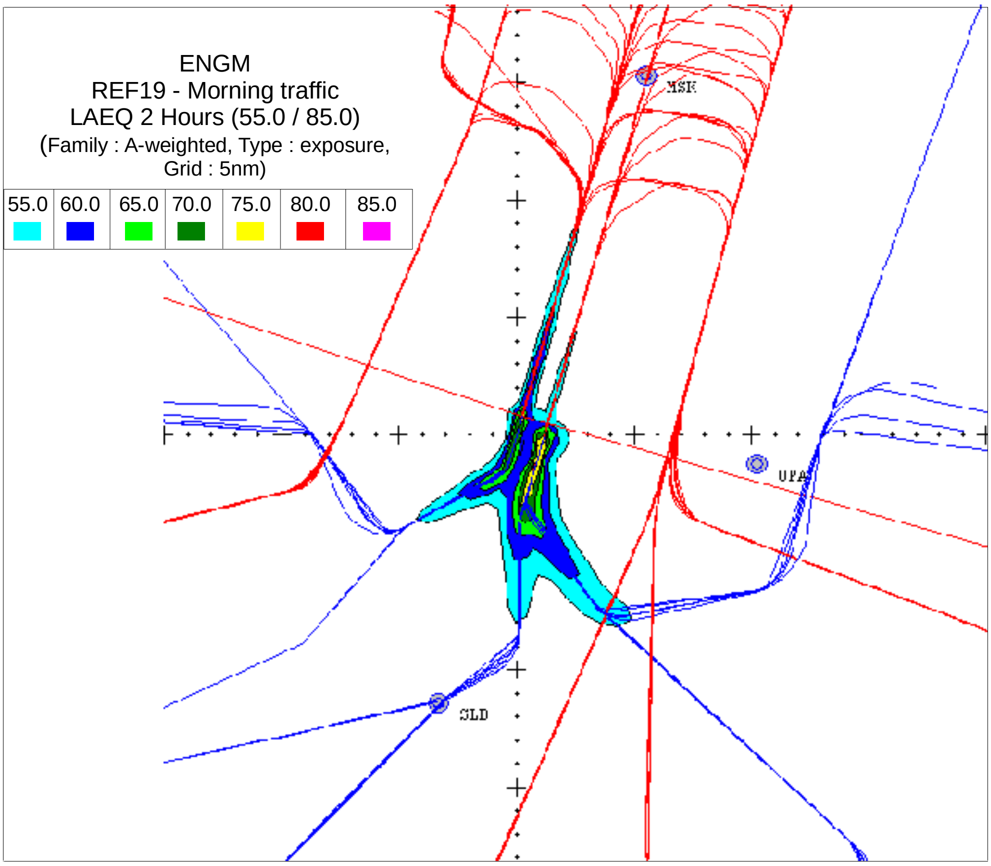
- Reference Scenario (Exercises REF01 and REF19),
- Scenario C (Exercises C01 and C19),
- Scenario D (Exercise D01),
- Scenario F (Exercises F01 and F19).

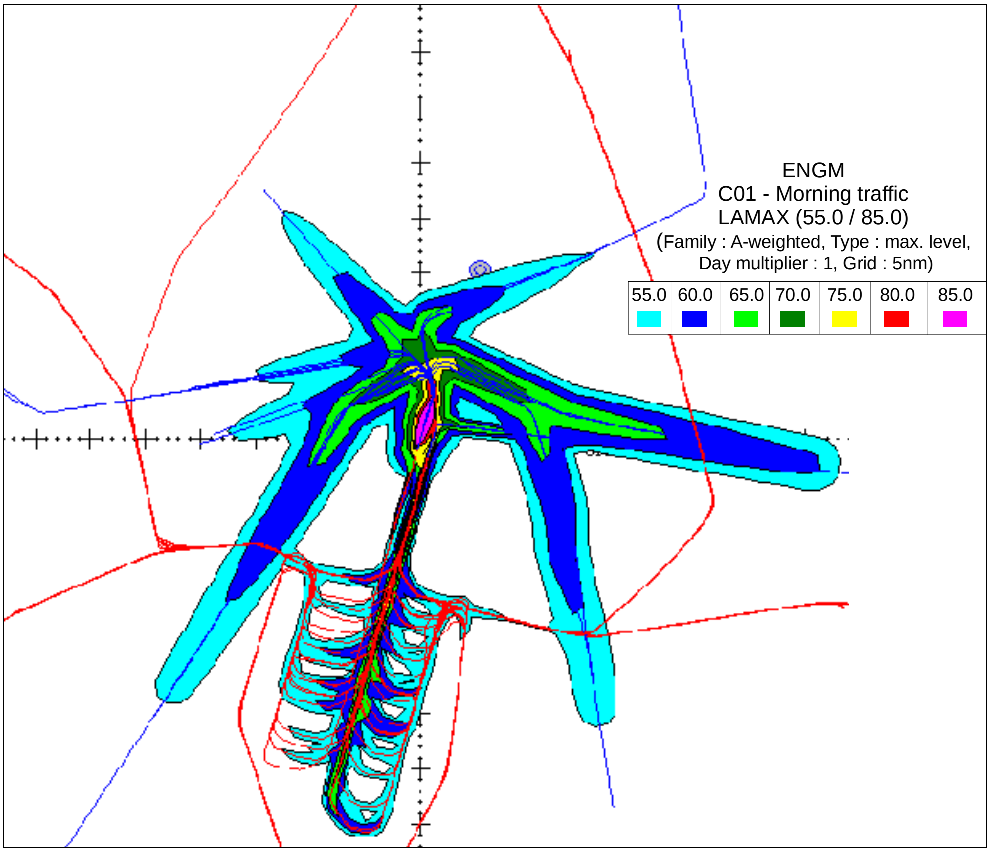
The noise contours retained two noise indexes (LAMAX and LAEQ over 2 hours). They were established using morning traffic sample.

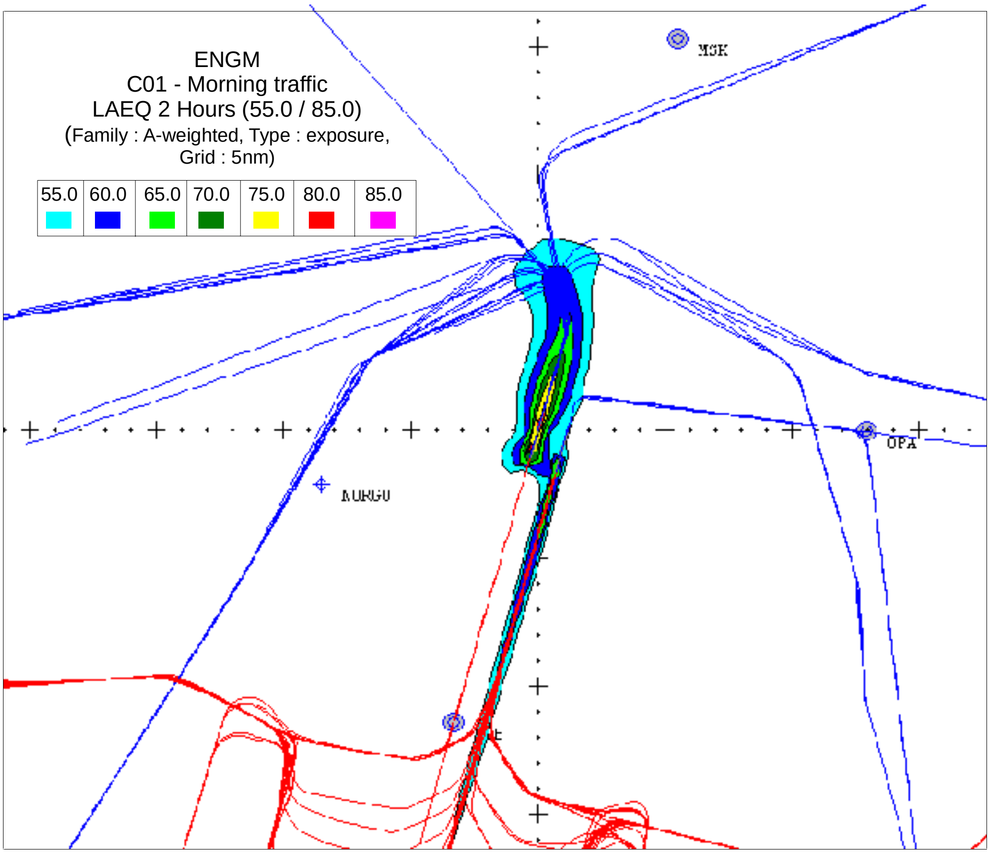

ENGM
REF01 - Morning traffic
LAMAX (55.0 / 85.0)
(Family : A-weighted, Type : max. level,
Day multiplier : 1, Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
RGU
TR

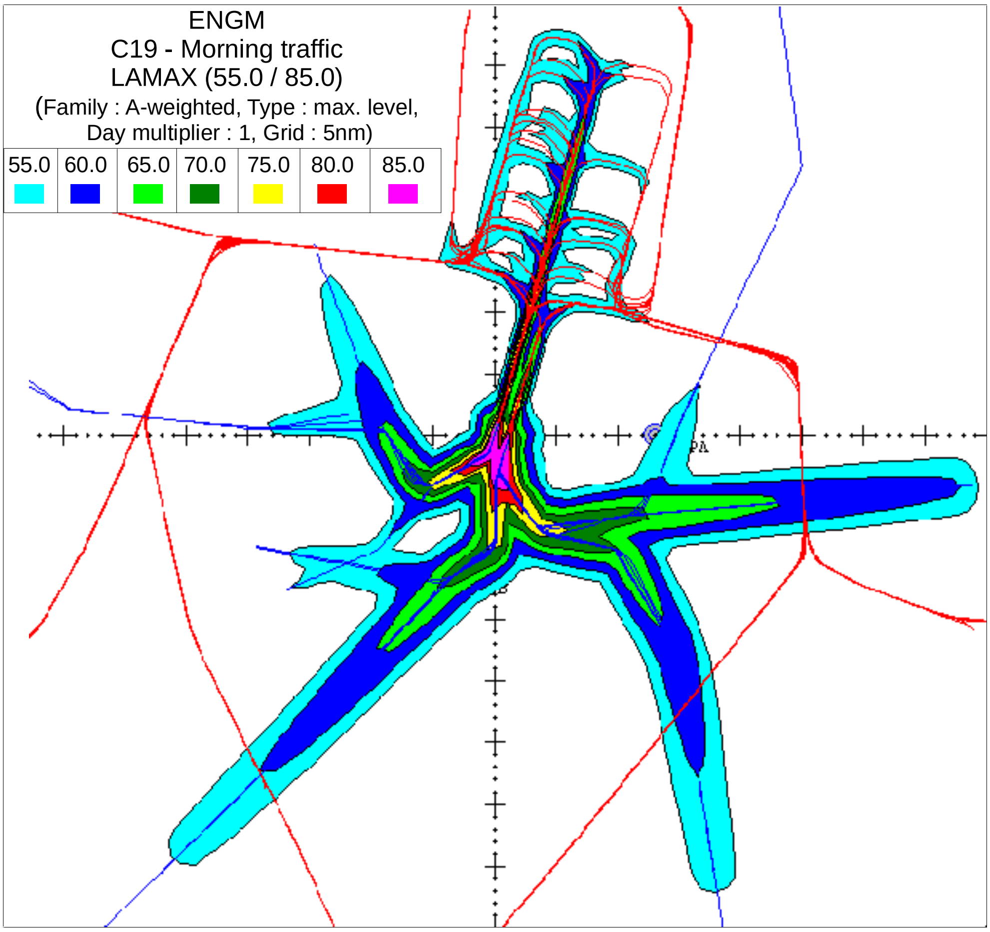

ENGM
REF01 - Morning traffic
LAEQ 2 Hours (55.0 / 85.0)
(Family : A-weighted, Type : exposure,
Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
NSR
DFA
LB

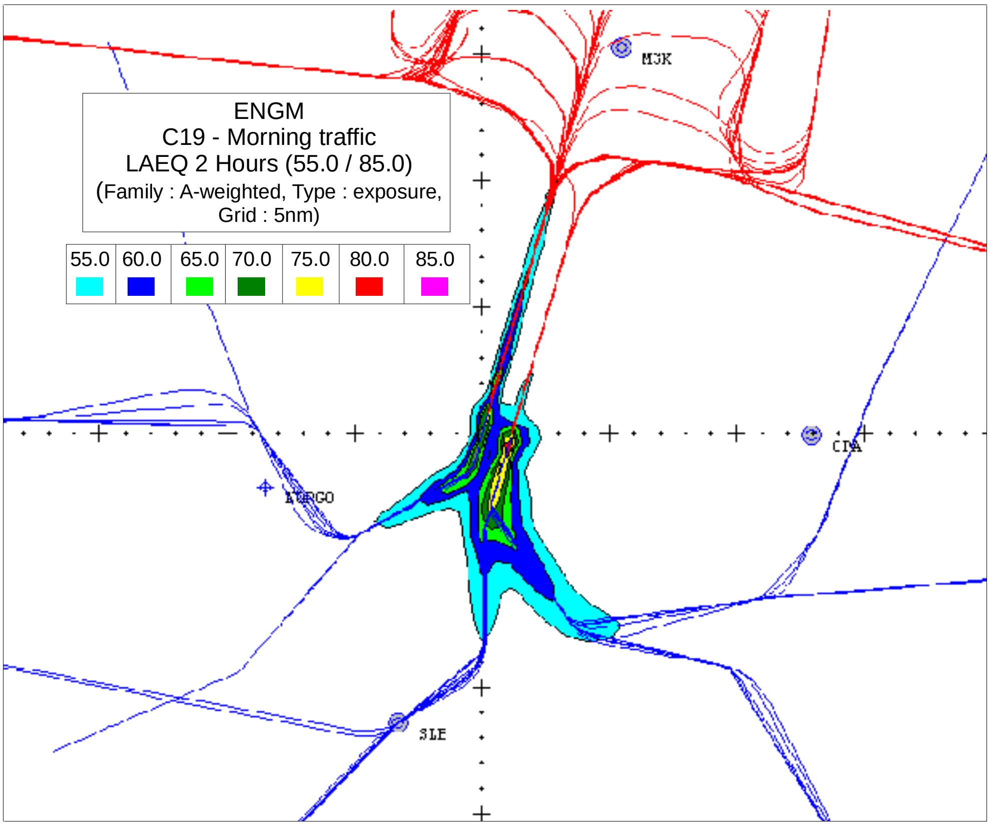

ENGM
REF19 - Morning traffic
LAMAX (55.0 / 85.0)
(Family : A-weighted, Type : max. level,
Day multiplier : 1, Grid : 5nm)
55.0 60.0 65.0 70.0 75.0 80.0 85.0
MSK

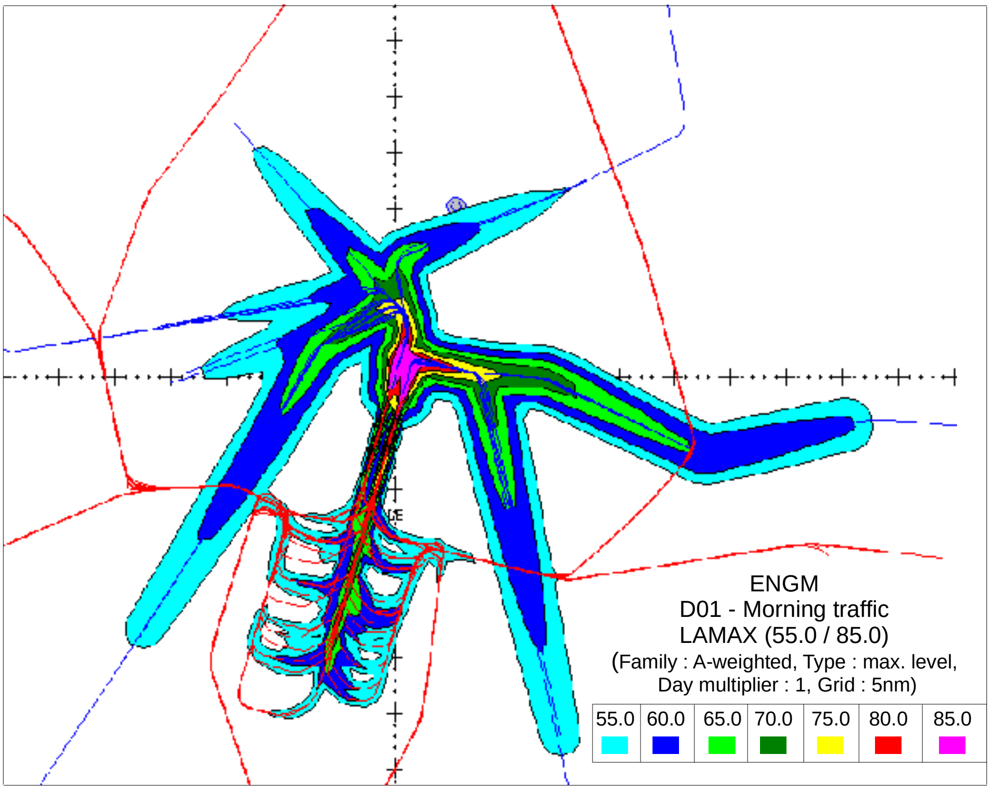

ENGM
REF19 - Morning traffic
LAEQ 2 Hours (55.0 / 85.0)
(Family : A-weighted, Type : exposure,
Grid : 5nm)
55.0 60.0 65.0 70.0 75.0 80.0 85.0
MSK
UPA
SLD

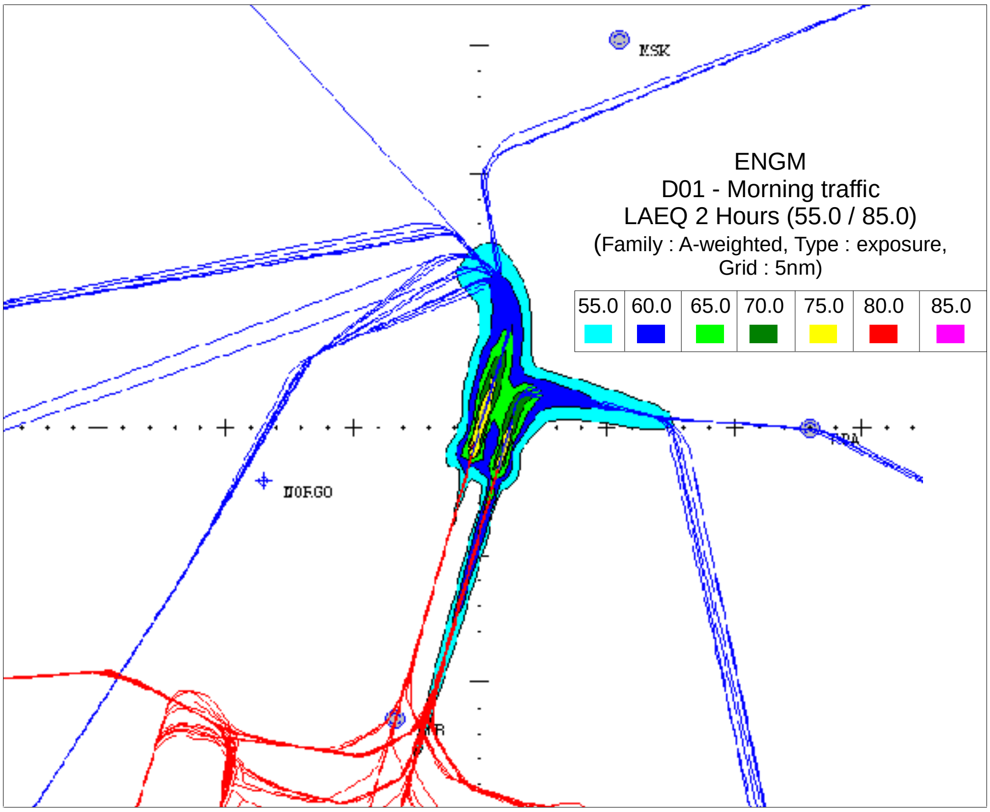

ENGM
C01 - Morning traffic
LAMAX (55.0 / 85.0)
(Family : A-weighted, Type : max. level,
Day multiplier : 1, Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0

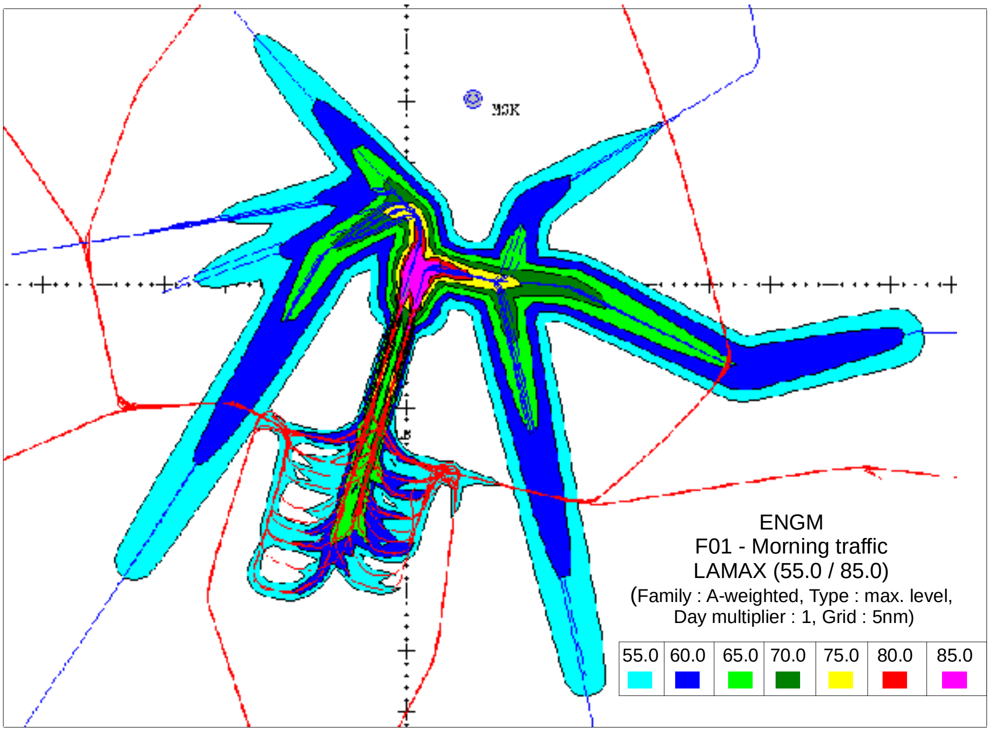

ENGM
C01 - Morning traffic
LAEQ 2 Hours (55.0 / 85.0)
(Family : A-weighted, Type : exposure,
Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
MSK
OPA
KURGU

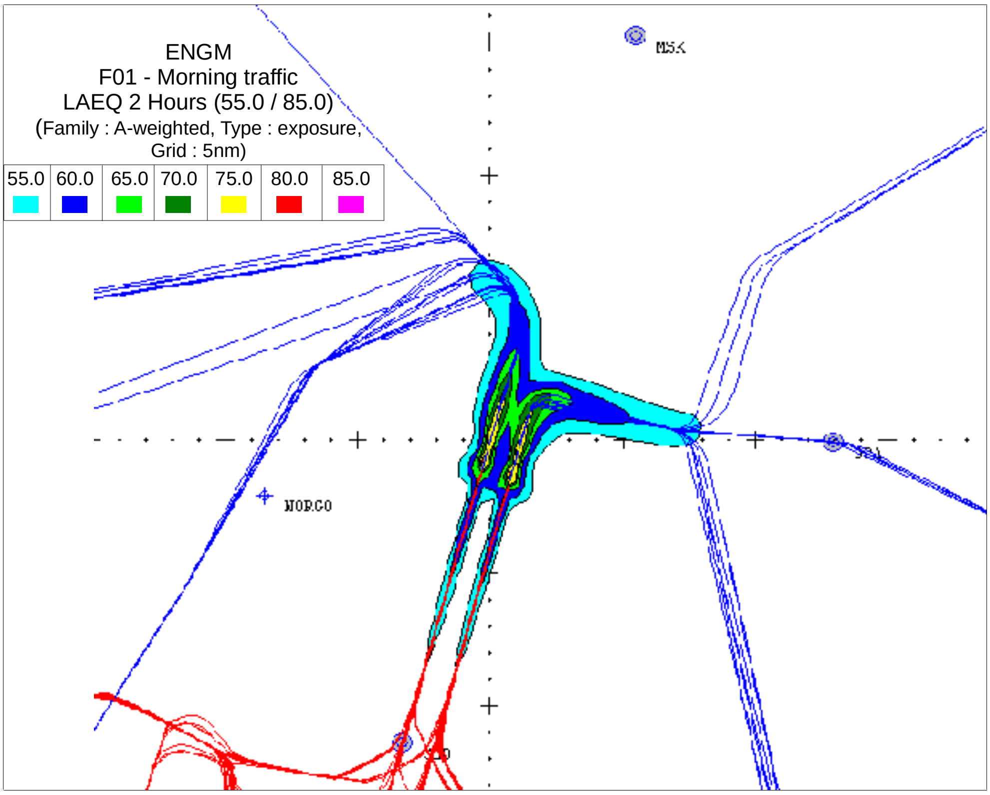

ENGM
C19 - Morning traffic
LAMAX (55.0 / 85.0)
(Family : A-weighted, Type : max. level,
Day multiplier : 1, Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
PA

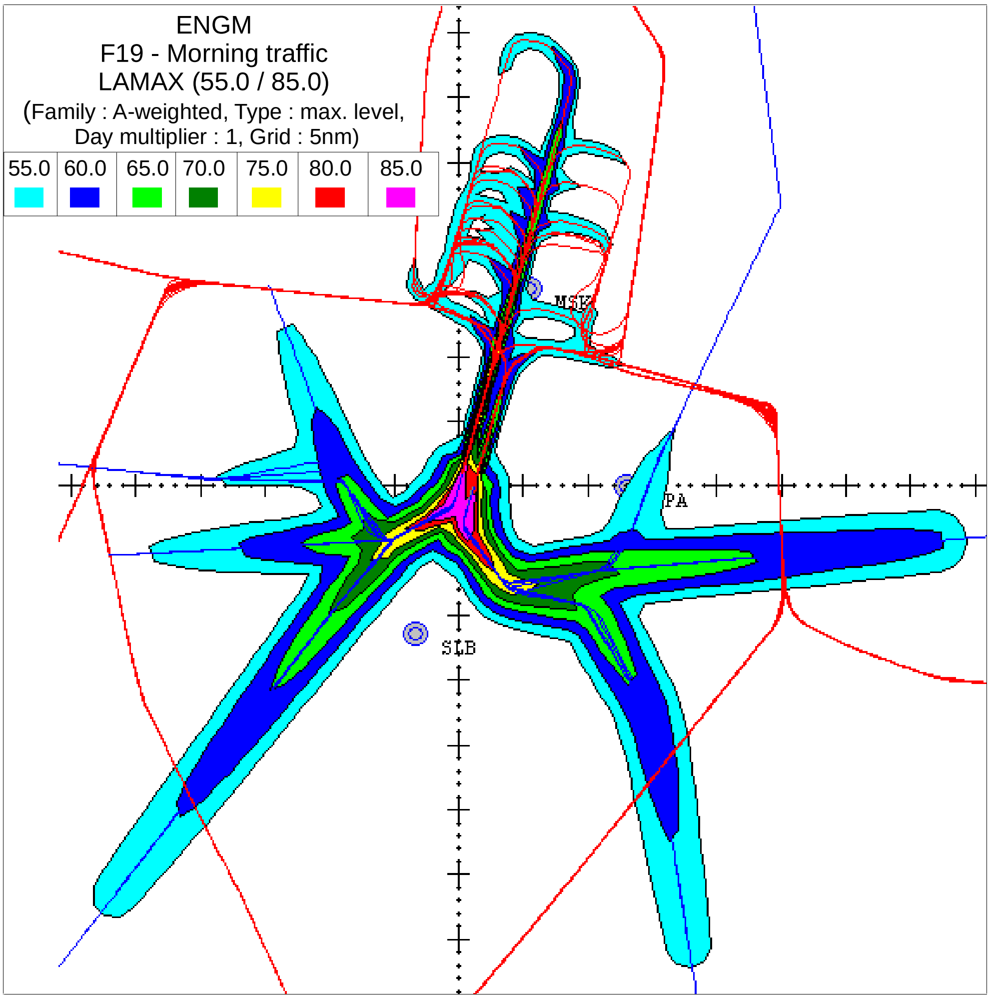

ENGM
C19 - Morning traffic
LAEQ 2 Hours (55.0 / 85.0)
(Family : A-weighted, Type : exposure,
Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
MJK
CIA
SLE

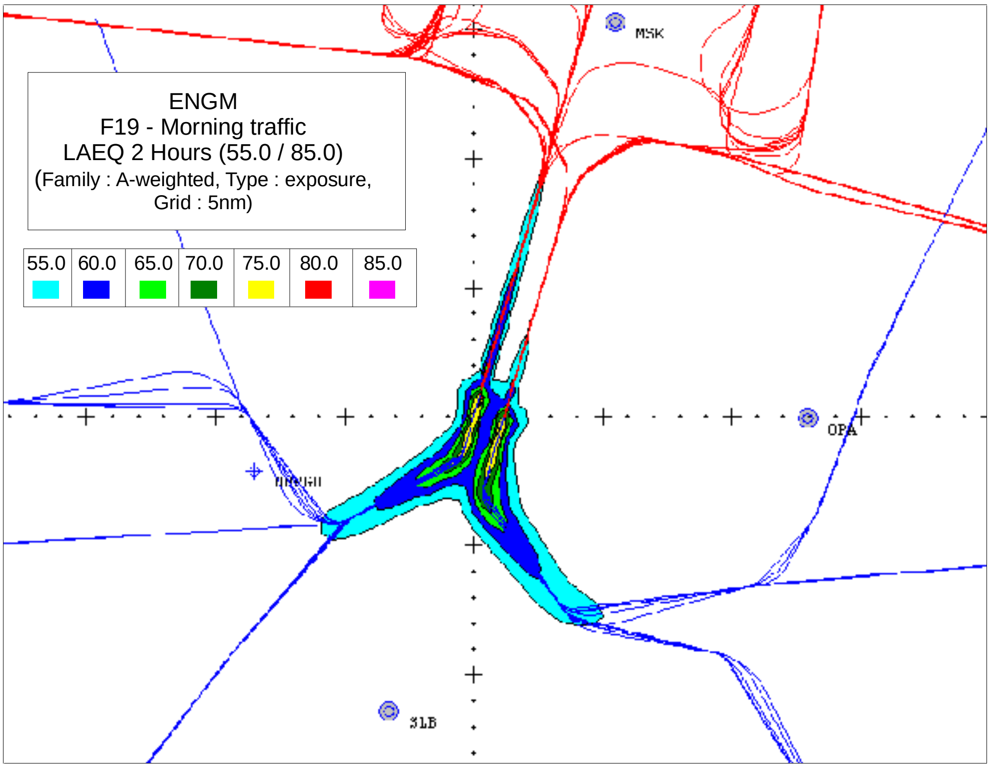

ENGM
D01 - Morning traffic
LAMAX (55.0 / 85.0)
(Family : A-weighted, Type : max. level,
Day multiplier : 1, Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0


MSK
ENGM
D01 - Morning traffic
LAEQ 2 Hours (55.0 / 85.0)
(Family : A-weighted, Type : exposure,
Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
NORGO


MSK
ENGM
F01 - Morning traffic
LAMAX (55.0 / 85.0)
(Family : A-weighted, Type : max. level,
Day multiplier : 1, Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0


ENGM
F01 - Morning traffic
LAEQ 2 Hours (55.0 / 85.0)
(Family : A-weighted, Type : exposure,
Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
MSK
NORCO


ENGM
F19 - Morning traffic
LAMAX (55.0 / 85.0)
(Family : A-weighted, Type : max. level,
Day multiplier : 1, Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
MSK
PA
SLB


ENGM
F19 - Morning traffic
LAEQ 2 Hours (55.0 / 85.0)
(Family : A-weighted, Type : exposure,
Grid : 5nm)
55.0
60.0
65.0
70.0
75.0
80.0
85.0
MSK
OPA
SLB