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EIGHT-STATES FREE ROUTE AIRSPACE PROJECT
LARGE SCALE REAL TIME SIMULATION
SOUTH SCENARIO

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TITLE:

EIGHT-STATES FREE ROUTE AIRSPACE PROJECT
LARGE SCALE REAL TIME SIMULATION SOUTH SCENARIO, SIMULATION REPORT

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Abstract:

This report describes the Eight States Free Routes Project Large Scale Simulation/South. Parts of Brussels UIR, Rhein UIR and Munich FIR were simulated. The simulation was part of the Free Routes Airspace Concept Validation, and was the second of two planned large-scale simulations where the Free Routes concept was validated in an environment with several ACCs involved. The simulation was set up to be a comparison between Free Routes and the Fixed Route environment in terms of controller workload, and to validate the procedures and principles laid down in the Draft Free Routes Airspace Operational Concept, such as system support to controllers, entry/exit procedures and flight planning principles. Human Performance, Human Error and Safety issues were addressed in parallel studies conducted within the framework of the Free Routes Airspace Project.

SUMMARY

This is the report of the Eight-States Free Routes Airspace Project Large-scale Real-time Simulation, South. The simulation is the second of two large-scale real-time simulations following the small-scale simulations conducted within the project. These simulations provide, together with a number of other activities, the basis for the validation of the Free Routes Airspace Concept.

The simulation was conducted at the EUROCONTROL Experimental Centre, Bretigny and lasted for two weeks. 26 air traffic controllers, mainly from Karlsruhe ACC Munich ACC, Maastricht UAC, and BELGA Radar (Mil) participated in the simulation where airspace covering Belgium and the southern parts of Germany simulated.

Functionality and Human Machine Interface similar to the ones that are expected to be in operation in the ACCs within the simulated area before year 2005 formed the basis for the platform used. This included OLDI/SYSCO, System Supported Civil-military Co-ordination, Medium Term Conflict Detection and Short Term Conflict Alert. The HMI was a strip less, object based, colour coded concept.

Free Routes was simulated in accordance with the draft Free Routes Operational Concept.

Two organisations were simulated, Free Routes and Fixed Routes. The Fixed Route organisation was based on ARN V4 for Maastricht and EAM04 for German Airspace. (EAM04, for practical reasons the draft airspace structure available in July 2000 was used, this may not be the final version) One of the important objectives of the simulation was to compare the controller workload in the two organisations.

The simulation showed that although the Free Routes Concept could be implemented when the required functionality is in place in the ACCs, and can lead to certain benefits, the controller workload will not be reduced using the simulated controller support.

Further studies directly focused on implementation issues will have to be carried out for the simulated area, in order to avoid some of the procedural and technical problems encountered during the simulation.

A number of findings from previous simulation were confirmed, indicating that the validation process is reaching a mature state.

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ABBREVIATIONS

Abbreviation	De-Code
APW	**A**rea **P**roximity **W**arning
ATFM	**A**ir **T**raffic **F**low **M**anagement
AR	**A**ir **R**outes
ARN	**A**TS **R**outes and associated **N**avigation means
ATC	**A**ir **T**raffic **C**ontrol
ATM	**A**ir **T**raffic **M**anagement
ATS	**A**ir **T**raffic **S**ervices
BAF	**B**elgian **A**ir **F**orce
CFL	**C**leared **F**light **L**evel
COP	**Co**ordination **P**oint
CWP	**C**ontroller **W**orking **P**osition
EEC	**E**UROCONTROL **E**xperimental **C**entre
EXC	**Ex**ecutive **C**ontroller
FDP	**F**light **D**ata **P**rocessing
FIR	**F**light **I**nformation **R**egion
FR	**F**ree **R**outes
FRA	**F**ree **R**outes **A**irspace
FRAC	**F**ree **R**outes **A**irspace **C**oncept
FRAP	8-States **F**ree **R**outes **A**irspace **P**roject
GAT	**G**eneral **A**ir **T**raffic
HMI	**H**uman **M**achine **I**nterface
ISA	**I**nstantaneous **S**elf **A**ssessment
MTCD	**M**edium **T**erm **C**onflict **D**etection
OAT	**O**perational **A**ir **T**raffic
OLDI	**O**n-**L**ine **D**ata **I**nterchange
ODS	**O**perator **D**isplay **S**ystem
PLC	**Pl**anner **C**ontroller
R&D Areas	**R**estricted and **D**anger **Areas**
RFL	**R**equested **F**light **L**evel
RNLAF	**R**oyal **N**etherlands **A**ir **F**orce
RVSM	**R**educed **V**ertical **S**eparation **M**inima
SSR	**S**econdary **S**urveillance **R**adar
STCA	**S**hort **T**erm **C**onflict **A**lert
TRA	**T**emporary **R**eserved **A**irspace
UIR	**U**pper **I**nformation **R**egion
XFL	E**x**it **F**light **L**evel

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1. INTRODUCTION

The second Large-scale Real-time Simulation of the Eight-States Free Routes Airspace Concept (FRAC) took place at the EUROCONTROL Experimental Centre between 22nd January and 02nd February 2001. The simulation was designed to meet the requirements of FRAP to validate the Free Routes Concept (FRAC).

The simulation was the second of two large scale simulation following four small-scale real-time simulations that, together with a number of other activities, shall validate FRAC within the airspace of the eight participating states (Belgium, Denmark, Finland, Germany, Luxembourg, The Netherlands, Norway, and Sweden).

Where the small-scale simulations can be regarded as study and development session, this simulation is seen as a validation of the Free Routes Airspace Operational Concept with more emphasis on validation than on development. The simulation was based on the upper airspace of parts of Brussels, Rhein and Munich FIRs/UIR. The airspace structure and sectorisation was based on the outcome of the FRAP Fast-time Simulations, and where not following the existing FIR/UIR boundaries. It must be noted that this sectorisation is created for validation purposes only, and is not an implementation proposal.

The simulation was based on RVSM, OAT considered as non-RVSM capable.

The Letters of Agreement (LoA's) and procedures as they exists today where used with the necessary changes to allow for RVSM and Free Routes.

The simulation used the standard EUROCONTROL Experimental Centre platform comprising OLDI2, System Supported Civil-military Co-ordination and MTCD based on a strip less Human Machine Interface.

The FRAP Human Performance Study was took part in the simulation, and performed a number of measurements related to human performances, such as eye movement tracking and heart beat rate. The results of this study are published in a separate report. In addition to this the participating the simulation was also used to obtain information used in the Free Routes Fast-time study and the Safety Study.

2. OBJECTIVES AND MEASURES

2.1 OBJECTIVES

The general objective of the LRT-South real-time simulation is to validate the Free Routes Airspace Concept based on the draft FRA ORD during a real-time simulation with several ACCs involved.

More specifically the objectives were to:

1. Asses variations in controller workload stemming from the introduction of FRAC
2. Validate and optimise the sectorisation derived from the FRAP Fast-time simulation to support the validation of the FRAP concept.
3. Identify the impact on controller workload of the introduction of simple conflict detection.
4. Assess the proposed procedures for entry and exit to/from Free Routes airspace, identify possible problems related to this and propose procedures to overcome these problems.
5. Assess the effect on controller workload, situational awareness, and identify related system requirements, of tactical re-routing around segregated airspace.
6. Analyse the effect of tactical interventions on downstream sectors including the requirements on
   - OLDI/SYSCO
   - Trajectory prediction
   - Flight data distribution
   - Conflict detection
7. Validate the various procedures for handling OAT.
8. Provide support to the following work packages in FRAP, Fast time simulation, Safety Study and Human Resource Study.

2.2 MEASURES

In order to achieve the objective, the following measures were taken:

Subjective data

- Questionnaires, The controllers were asked to fill in questionnaires before and after the simulation.
- Instantaneous Self Assessment (ISA)
- Debriefings. Controller opinions were collected during the daily debriefings

Objective data

The following data-sets were recorded:

- The number of pilot inputs/controller tactical instructions (level, heading, direct)
- Radio usage (number of calls per aircraft, average length of calls)
- Average flying time per sector
- The percentage of the flights cleared to cruise in the level requested in the flight plan

2.2.1 Questionnaires

The participating controllers were asked to decide how much they agreed with a number of statements related to ATC and FRAC, as described in the example below

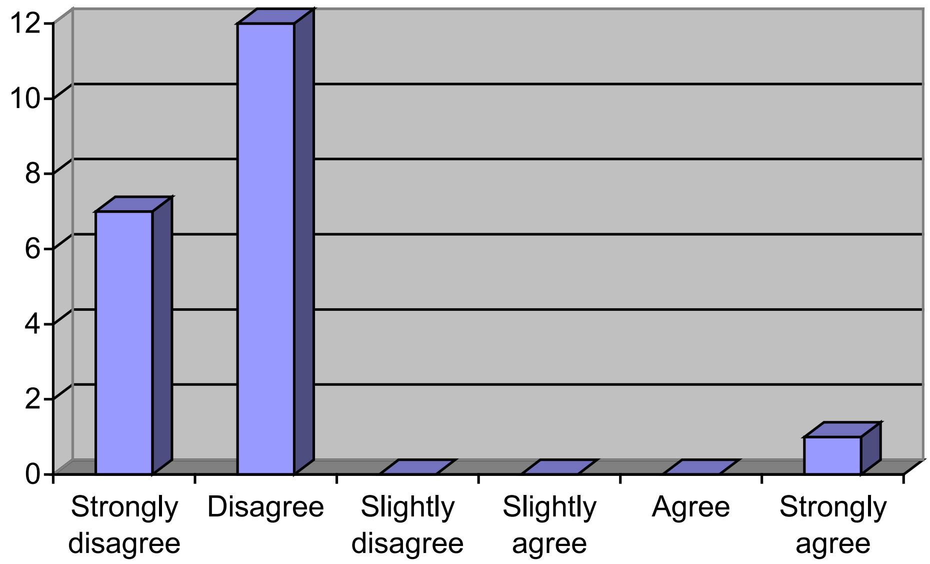


Figure 1: Example of question, Control towers should be build higher to give controllers a better view of the surrounding landscape

In the above example 7 controllers strongly disagree, 12 disagree but 1 strongly agrees to the statement that control towers should be build higher.

Comments given by the controllers in the questionnaires are listed below the subject question.

2.2.2 ISA

ISA stands for Instantaneous Self-Assessment. It is a technique originally developed by DRA Portsmouth Maritime Command and Control and used here at the EEC for several years.

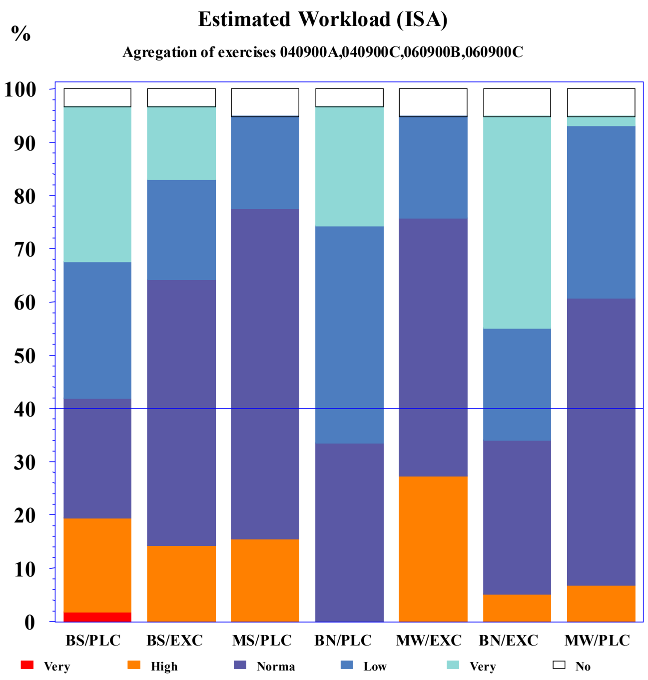
Each control poQuestion 1: Control towers should be build higher to give controller a better view of the surrounding landscape?sition is equipped with a small box containing 5 buttons labelled:

- Very High
- High
- Fair
- Low
- Very Low

At five-minute intervals the controller is prompted by a flashing red light to press one of the five buttons corresponding to his perceived workload during the previous five minutes. The light flashes for 30 seconds during which time the controller must respond. At each interval a record is written of the button selected and the delay in responding so that by the end of the exercise we have a history of the variation of each controller's perceived workload.

The main advantage of ISA is it's simplicity. The procedure is very simple to explain and administer. The results are usually used to identify busy periods within a sector rather than as an absolute measure of workload.

The principle disadvantages concern the intrusiveness, especially in simulations involving new HMI and also the ease with which the results can be corrupted if the participants are not suitably motivated.



Source : Isa Analysis

Figure 2: Example of ISA recording

Sample and data collected

24 *controllers* and one military air defence specialists were involved in this study. Only the 20 controllers working on measured positions used ISA and filled in questionnaires, but all 25 controllers took part in de-briefings. The main characteristics of this group are presented in Table 1 and Figure 3.

Total Sample	20
Male	20
Female	0

Table 1: Sample description

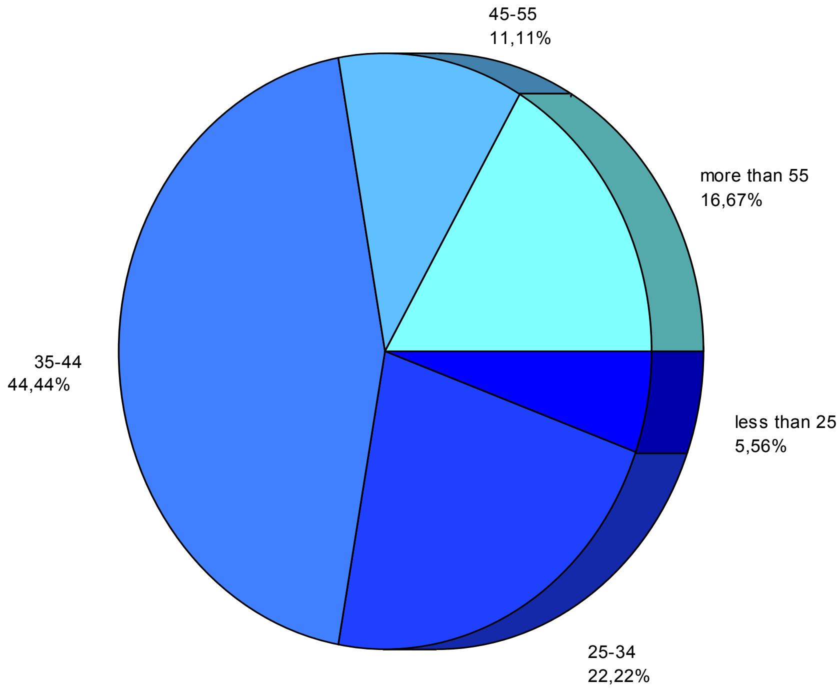


Figure 3: Age distribution amongst participating controllers

As it can be seen, there was a wide distribution of ages amongst the participating controllers, equally distributed over the spectrum.

3. SIMULATION CONDUCT

3.1 AIRSPACE

3.1.1 The simulated area

The simulation airspace included parts of Brussels UIR, Rhein UIR and Munich FIR.

In order to create a realistic traffic picture, parts of the surrounding airspace was included in the simulation as feed sectors.

3.1.2 Simulated Airspace Organisations

Two different Airspace Organisations were simulated.

Organisation 1, FREE ROUTES AIRSPACE was based on the results of the FRAP Fast-Time Simulation.

Organisation 2, FIXED ROUTES was based on the current or foreseen route structure (ARNv4 and EAM04), using a combination of today's and planned future sectorisation and procedures in place between the different units.

Maps of the simulated airspace, sector layout etc. can be found in Appendix A to this report.

3.1.3 Sector Design Principles for the FREE ROUTE Organisation

In the FRAP Fast-time simulation a sector plan has been developed for the FRAC validation study. The sector boundaries in this plan are not following UIR/FIR boundaries.

Operational Air Traffic (OAT) in the Brussels UIR was controlled by a dedicated military sector manned by a Military controller from Belga Radar

In the remaining sectors, the civil sector suite controlled OAT.

Sector layout, names of the sectors and frequencies used shall not be seen as an implementation proposal, but as support the validation process only.

3.1.4 Operations Room Configuration

The operations room was configured with 25 Controller Working Positions (CWPs). 19 of these CWPs were used for measures.

Measured sectors were as shown in Tables 2 and 3

The Operations Room layout can be found in Appendix A to this report.

Org	Sector Name	Sector Code	Lower Limit	Upper Limit	CWP's EXC	CWP's PLC
FREE	MAS DEN	DEN	FL285	FL355	1	1
FREE	MAS DIK	DIK	FL285	FL355	1	1
FREE	MAS NTM	NTM	FL285	FL355	1	1
FREE	Rhein FFM	FFM	FL285	FL355	1	1
FREE	Rhein WUR	WUR	FL285	FL355	1	1
FREE	Rhein SBN	SBN	FL285	FL355	1	1
FREE	Rhein TGO	TGO	FL285	FL355	1	1
FREE	Munich RDG	RDG	FL285	UNL	1	1
FREE	Munich MUN	MUN	FL285	UNL	1	1
FREE	Belga		FL285	FL355	1	-

Note : Belga was handling OAT Traffic in DEN and DIK sectors

Table 2: Controller Working Position Configuration, Org. 1

Org	Sector Name	Sector Code	Lower Limit	Upper Limit	CWP's EXC	CWP's PLC
FIXED	MAS WST	WST	FL285	FL355	1	1
FIXED	MAS OLNO	OLN	FL285	FL355	1	1
FIXED	MAS LUX	LUX	FL285	FL355	1	1
FIXED	Rhein MOS	MOS	FL285	FL355	1	1
FIXED	Rhein HAN	HAN	FL285	FL355	1	1
FIXED	Rhein FRA	FRA	FL285	FL355	1	1
FIXED	Rhein KRH	KRH	FL285	FL355	1	1
FIXED	Munich ALG	ALG	FL285	UNL	1	1
FIXED	Munich RID	RID	FL285	UNL	1	1
FIXED	Belga		FL285	FL355	1	-

Note : Belga was handling OAT Traffic in WST, OLN and LUX sectors

Table 3: Controller Working Position Configuration, Org. 2

3.1.5 Route Structure

Military TACAN routes were simulated as they are today.

Civil route structure in the Fixed Route scenario was in accordance with ARN V4 and EAM04.

No civil route structure was used during the Free Route scenario.

3.1.6 Temporary Segregated Airspace

The following Temporary Segregated Areas were included in the simulation and used in both Organisations:

Reference	Level
EB - TRA SOUTH BRAVO	FL095 - UNL
EB - TRA NORTH BRAVO	FL195 - UNL
EB - CBA1C	FL115 - UNL
ED - TRA305	FL095 - UNL
ED - TRA307	FL095 - UNL
ED - TRA309	FL095 - UNL
ED - TRA EIFEL	GND - FL285

Table 4: Simulated TRA's

All areas were designed in accordance with the national AIP's or plans. Areas were activated and deactivated during simulation exercises in accordance with a schedule agreed with the participating military authorities.

3.2 TRAFFIC

3.2.1 Creation

Civil traffic samples were created from IFPS traffic recordings of 18th June 1999. After the data collection, the traffic samples were analysed and considered to be representative. No unusual ATFM or weather constraints were identified for that particular day. The levels of aircraft were then transformed into RVSM levels, using the guidelines developed by the RVSM project finally the civil traffic was combined with the military traffic samples.

Specialists from BAF created military traffic samples for Belgian Airspace, including all the different types of flights required for the simulation. For German airspace IFR transit flights were created. These samples were then processed and converted into the civil traffic samples.

Military activity within segregated airspace was not simulated.

Four base samples were then created corresponding to different periods along the day, to get a realistic picture of the different traffic situations that occurs during the day, with traffic levels corresponding to year 2003 forecasts.

A set of traffic samples with reduced traffic load was created for training purposes, here traffic was reduced to approximately 60% of the 2003 traffic levels.

The number of flights in each traffic sample can be seen in Table 6 below.

Each sample covered a time period of 1 hour 15 minutes, 60 minutes of which was measured for analysis purposes.

Civil traffic was routed directly from the entry point to FRA airspace to the exit point from FRA airspace, however segregated airspace was circumnavigated by adding additional points to the route in order to simulate a scenario where operators were obliged to flight plan around segregated airspace.

3.2.2 Traffic Sample Analysis

The analysis of the traffic samples below show the actual simulated load that each sample represented for the simulated measured sectors.

Traffic sample	Time slot
1A / 2A	06:10 - 07:10
1B /2B	08:10 – 09:10
1C / 2C	14:10 – 15:10
1D / 2D	17:10 – 18:10

Table 5: Simulated time slots

Org	Sector	Min. flow pr. hour	Max. flow pr. hour
FIXED	WST	47	67
FIXED	OLN	38	48
FIXED	LUX	34	38
FIXED	HAN	44	81
FIXED	MOS	40	57
FIXED	FRA	48	76
FIXED	KRH	57	82
FIXED	ALB	33	55
FIXED	RID	21	46
FREE	DEN	50	66
FREE	DIK	65	76
FREE	NTM	40	69
FREE	FFM	56	81
FREE	SBN	43	67
FREE	WUR	51	73
FREE	TGO	31	57
FREE	RDG	33	50
FREE	MUN	46	75

Table 6: Average Hourly Throughput

3.3 PROGRAM OF EXERCISES

In the Program of Exercises below exercises run in the Free Routes Organisation are marked 1, Fixed Routes 2. The letter A, B, C or D corresponds to the time slot ref. Table 4. Basic System Scenario exercises are labelled _b, exercises run with MTCD are labelled _m. A description of the system scenarios is included in Para. 3.4.4. The letter in brackets links exercises using the same traffic and system scenario together two by two, in order to be able to measure the impact on controller workload of introducing FRA.

Day/Date	Exercise 1	Exercise 2	Exercise 3
Day 1, 22 Jan.	2C_b (S)	2D_b (R)	2A_b (Q)
Day 2, 23 Jan.	1D_b (R)	1A_b (Q)	1C_b (S)
Day 3, 24 Jan.	1A_m (Z)	1B_m (Y)	1C_m (X)
Day 4, 25 Jan.	1D_m (W)	1C_m (V)	2A_m (Z)
Day 5 26 Jan.	2A_m (Y)	2B_m (X)	De-briefing
Day 6 29 Jan.	2A_m (Z)	2C_m (V)	Safety Briefing
Day 7 30 Jan.	2B_m (U)	1C_b (N)	Safety Briefing
Day 8 31 Jan.	1B_b (P)	2C_b (N)	Safety Briefing
Day 9 1 Feb.	2B_b (P)	2D_b (M)	1B_b(U)
Day 10 2 Feb.	1D_b (M)	Final de-briefing	

Table 7: Program of exercises

All 24 planned measured exercises were executed.

3.4 SIMULATED ATC SYSTEM

3.4.1 Controller Working Positions

The Measured Sectors were all manned with two controllers, Executive Controller (EXC) and Planner Controller (PLC), each controller had a separate Controller Working Position (CWP). The CWP consisted of:

- Sony 29’ square colour display, used to provide a multi-window working environment;
- Hewlett Packard processor (240/360/3000) and Metheus display driver;
- 3 Button Mouse;

- AUDIOLAN simulation telecommunication system with headset, foot switch and panel-mounted push-to-talk facility.

Each CWP included a subjective workload panel (Instantaneous Self-Assessment – ISA) used by the controller for periodic input (every 5 minutes) during measured exercises.

3.4.2 System Functionality

3.4.2.1 Surveillance

The entire simulated area was covered by radar. In general the vertical limits of radar coverage were from ground' to unlimited.

3.4.2.2 Trajectory Prediction

Most of the simulated functionality were supported by Trajectory Prediction (TP). The TP in the simulator is predicting the future position of aircraft based on an aircraft model, constraints build into the simulator flight plan and a set of rules that interpret controller orders.

Longitudinal Deviation was corrected automatically by the system

Note: Due to system problems, Longitudinal Deviation was not always correctly updated. This lead to errors in MTCD for about 10% of the flights.

3.4.2.3 Conformance Monitoring

Lateral deviation between the predicted and the actual position of the aircraft was not (and should not be) corrected automatically by the TP. A Conformance warning was presented for the controller, who then could choose if or when the TP should be updated taking the actual position of the aircraft into consideration.

3.4.2.4 OLDI/SYSCO

Estimates were sent by the preceding sector 9 minutes before the flight time for passing the sector boundary.

Time revisions were passed automatically by the system. Level revisions were passed as OLDI messages after input by the controller. Negotiations possibilities were available in the form of Counterproposal and Reject of level co-ordination messages.

3.4.2.5 Medium Term Conflict Detection

A relatively simple Medium Term Conflict Detection (MTCD) was provided to the controllers. In order to support distribution of task between the PLC and EXC, conflicts were divided into Planning Conflicts or Executive Conflicts

- Conflicts were classified as Planning Conflict if at least one of the flights involved in the conflict was still not under control of the sector.

- Conflicts were classified as Executive Conflict if at least one of the flights involved in the conflict was under control of the sector.

- Conflicts where one aircraft was controlled by the sector and the other aircraft was not under control by the sector was classified Planning Conflict and Executive Conflict.

The PLC received MTCD information about Planning Conflicts via a dedicated window, Conflict and Risk Display (CRD). In the CRD the PLC could select to see Planning Conflicts only, or to see all conflicts.

The EXC received MTCD information directly in the data label of the subject aircraft, in order to avoid windows covering parts of the EXC radar picture. EXC could call select the CRD to be presented.

Both controllers could call down additional information about conflicts via

- The Dynamic Flight Leg (DFL), where DFLs of conflicting aircraft would be shown with a colour coding of the portion of the trajectory where the aircraft were in conflict.

- The Vertical Aid Window, that provided a vertical presentation of the conflicting flights and other flights along the trajectory of the subject aircraft.

In the CRD the controllers could choose to see Conflicts and Risks, or Conflicts only.

A Risk is defined as two aircraft within a defined lateral distance, where there is an overlap of the level bands Actual Level/Exit Level/Cleared Level of the two aircraft. A Conflict is a Risk where the level bands Actual Level to Cleared Level of the two aircraft are overlapping.

MTCD look-ahead time was set to 15 minutes for Planning Conflicts and 5 Minutes for Executive Conflicts. Only conflicts where the predicted minimum distance between aircraft were 8 NM or less were presented to the controllers.

3.4.2.6 System Supported Civil-Military Coordination

Civil-Military co-ordination enabled civil controllers to request transit of TRA via input in the data label of the subject flight. After having received a crossing request, the military sector could either accept, reject or counter propose a different crossing level.

3.4.2.7 Safety Nets

- Short Term Conflict Detection (STCA)

  Short Term Conflict Alert (STCA) was defined within the radar coverage area, taking into consideration Cleared Flight Level. The look-ahead time was 2 minutes.

3.4.3 Human Machine Interface (HMI)

3.4.3.1. General

Executive Controller (EXC) and Planner Controller (PLC) each had a radar windows with colour coding of the data label to indicate the Flight Plan Life State. The data label contained callsign, Mode-C, Entry level (EFL), Cleared level (CFL), Exit level (XFL) and Route elements. Additional information such as heading and speed instructions could be added to the data label.

Flight plan data was presented on a call-down basis for one flight at a time in a dedicated window and in Sector Entry Lists for flights about to enter the sector.

A graphical presentation of the flights planned trajectory was available on a call-down basis.

Input of instructions was performed directly via the data label.

Short Term Conflict Alert (STCA) was activated if two flights were predicted to be within 3,7 NM and 700' (1700' for non-RVSM equipped aircraft and above Fl 400) within 1 minute.

3.4.4 Simulated System Scenarios

Two system scenarios were simulated, the **Advanced Scenario** where all the specified functionality was available to the controllers, and the **Basic Scenario** where MTCD was disabled.

3.5 ATC PROCEDURES

Revised Letters of Agreement between the involved ACCs were developed, in order to allow the use of Free Routes.

In general all traffic from airports below or close to the simulated airspace climbed to FL280. Traffic with destination at airports below or close to the simulated airspace was descended to FL290 by the measured sector and transferred to the Feed Sector below, released for further descend.

Levels were in accordance with the RVSM semi-circular rule.

Procedures for Operational Air Traffic were simulated as described below.

3.5.1 Operational Air Traffic

3.5.1.1 General

Apart from the sectors where Belga Radar controlled OAT, the GAT sectors controlled OAT.

3.6 SIMULATION LIMITATIONS

The TP problems lead to unreliable MTCD information for about 10% of the simulated flights. By the controllers this was considered unacceptable to use the MTCD in a meaningful way.

Sector sequence problems as a consequence of FRA routings lead to erroneous Flight States, preventing the controllers to manage the particular flights.

Surrounding airspace, in particular below the measured sectors, was not fully simulated. This lead to too little impact and restrictions from these sectors.

4. CONTROLLER TRAINING

All the participating controllers took part in the 5 day Acceptance and Training period in the week preceding the simulation. The program of the Acceptance and Training Week included theoretical lessons on HMI and system related matters as well as issues related to the Free Routes concept and the use of RVSM. After each theoretical lesson, the controllers trained on the simulation platform, in order to learn the required skills. The last two days of the week were used entirely to run simulated traffic at increasing traffic levels.

5. RESULTS

As described in Paragraph 2.2 results are derived from three different sources

- System recordings, data recorded by the simulator system, e.g. radio usage
- Questionnaires, Controllers working on measured sectors were asked to fill in a questionnaire at the end of the simulation
- De-briefings, anecdotal information derived during discussions with the participating controllers

For each objective, results are listed under these three headings, followed by a discussion to sum up the findings for the particular objective.

5.1 GENERAL FINDINGS

5.1.1 Questionnaires

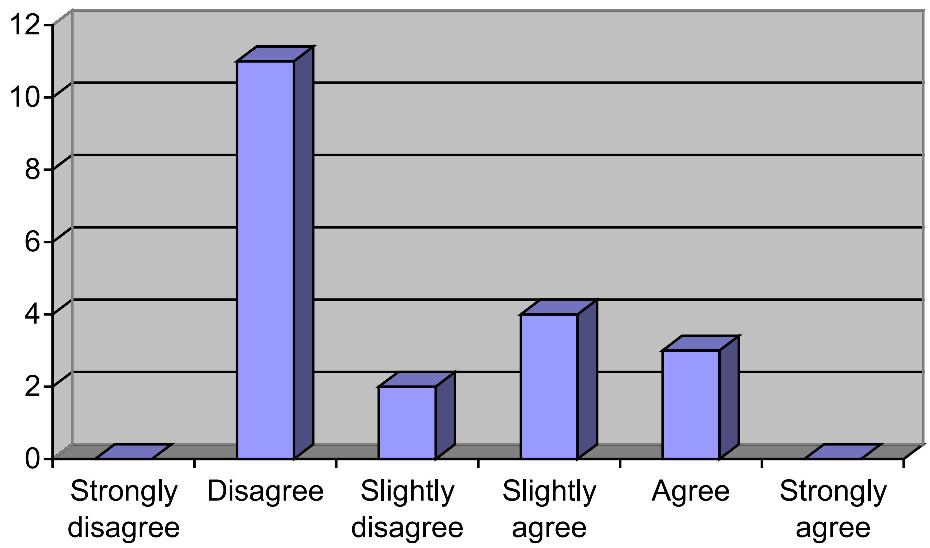


Figure 4: Question 1.1: The concept of Operations for FRA is difficult to understand?

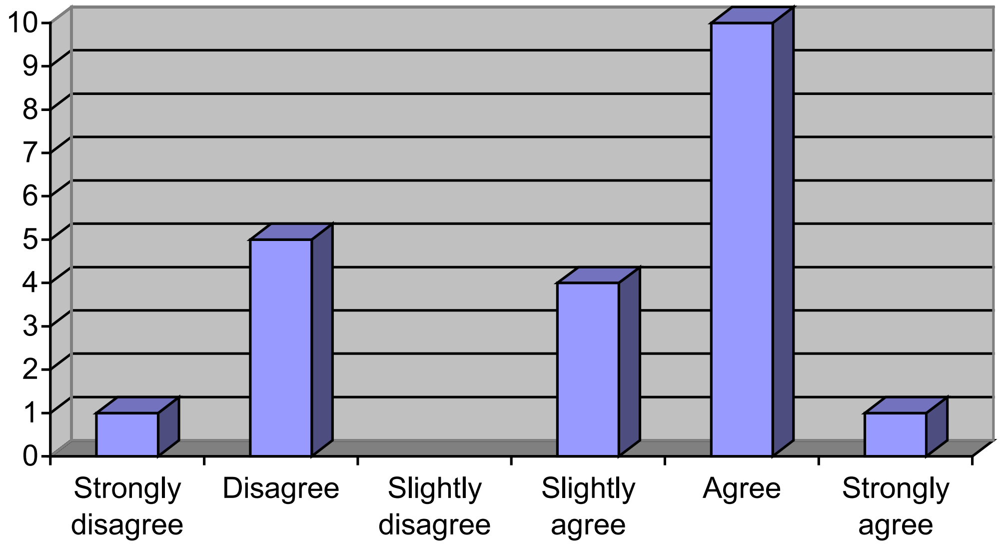


Figure 5: Question 1.2: The FRA procedures are easy to work with?

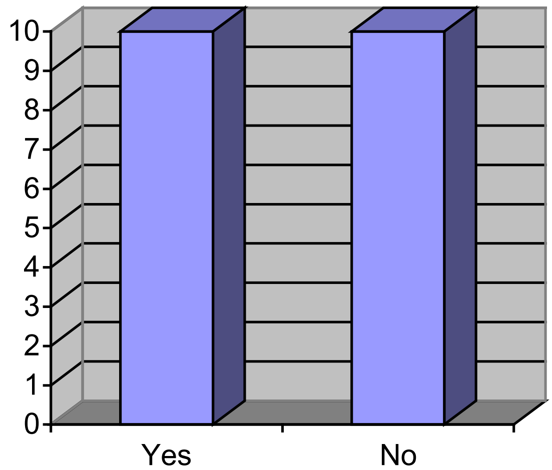


Figure 6: Question 1.3: Do you think that the way you work as controller will change in FRA, will you get new or changed tasks

Additional comments to Question 1.3:

- *More system supported tactical preplanning required*
- *EXC get even more involved in pure conflicts solution and climb descent within the sector. PLN will be responsible for proper planning of entry/exit conditions.*
- *More tactical preplanning in high traffic load is required.*
- *PLC need his own radar screen, he has to solve entry and exit conflicts in advance*
- *Tasks might change between PLC and EXE, more effort to see the route of the aircraft and to see problems, you have to solve problems much earlier*

- *With a stripless system the controller needs a precise and reliable preplanning system, especially for PLC.*
- *You have to rely much more on your system*
- *Only small changes to the way I work today.*

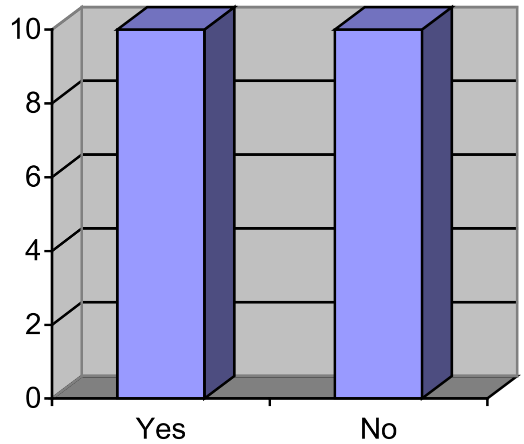


Figure 7: Question 1.4: Do you feel that the task distribution between PLC and EXC will change in FRA?

Additional comments to question 1.4:

- *Perhaps the task of the planner becomes more than one of the second radar controller in the sector preparing instructions given to the pilot*
- *the division between exe*
- *PLC become greater due to higher workload for planning and detection of conflicts on the planner side . the exe will only be responsible to keep up planner plan*
- *PLC more assistance to the Radar help radar with system inputs*
- *because the technical system change the tasks have to change as well*
- *the PLC has to plan much more in advance*
- *PLC job is new*

What is your overall impression of FRAC:

- *For Belgian airspace not much will change*
- *It will work above a certain level with the help of an optimal system support*
- *It works like we are doing already during night, sometimes during the day and at high levels.*
- *Free route may work well provided division level could be raised, systems are updated, and new items could be available*
- *Workable, higher division level would give some advantages*
- *Positive, if the requirements are met it will work*
- *Might work but still too many questions unsolved*
- *This concept sounds easy but raises a lot of problems, strange routing, problem at entry exit point, military flights.*
- *For my daily work I'll expect more disadvantages than in Fixed Route, I doubt that the advantages for the airline are as great as expected*
- *A lot of problems for the implementation of Free Route rises (weather, military, exit point)*

- *Too many factors have not been considered, I don't see the advantage for the companies, they will lose the gained money in lower airspace*
- *It's workable if the entry and exit point are known in advance and aircraft must flight on a straight line directly from entry to exit*
- *I'll like to work with this concept when I have the proper system support*
- *I doubt that the CFMU will be able to control such system, I doubt the politician will be agree to reshape the sectors. The effect of free flight planning without any reference to named point introduces a part of possible error*
- *This was already done in MUACC with the weekend routes*
- *The Free Routes concept is already use during the nights and week-end, if you would work with every day, a lot depends on what information you are able to give to the controller*
- *it's workable but it will be very difficult for controller to know where aircraft are going.*

5.1.2 Discussion

Unlike previous simulations, the controllers participating in this simulation did not unanimous support FRAC. One third of the controllers agreed to the statements that FRAC was difficult to understand and not easy to work with. Rhein and Munich controllers found it difficult for the PLC to support the EXC with a proper pre-planning. Maastricht controllers did not express the same problem.

The PLC often finds himself as a second EXC, it is difficult to work ahead, a keep in front of real-time. This is considered to be not only a consequence of FRA, but also caused by the strip-less system used for the simulation.

It is clear from discussions held during de-briefing sessions that the three ACCs participating in the simulation have developed different working methods, due to the differences they have in system and airspace environment. This of cause has an impact on the results of the simulation. In general it can be said that the difference between today’s working methods and FRAC is biggest in Munich and smallest in Maastricht. In Maastricht the planning scope has been reduced, detailed conflict detection is not performed by the PLC anymore. The controllers are only working in the tactical time horizon.

5.2 OBJECTIVE 1

Assess variations in controller workload stemming from the introduction of FRAC

5.2.1 Recordings

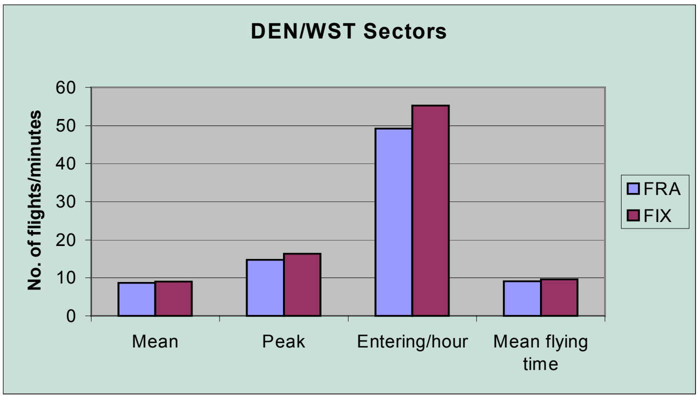


Figure 8: Comparison traffic load, DEN/WST, sectors

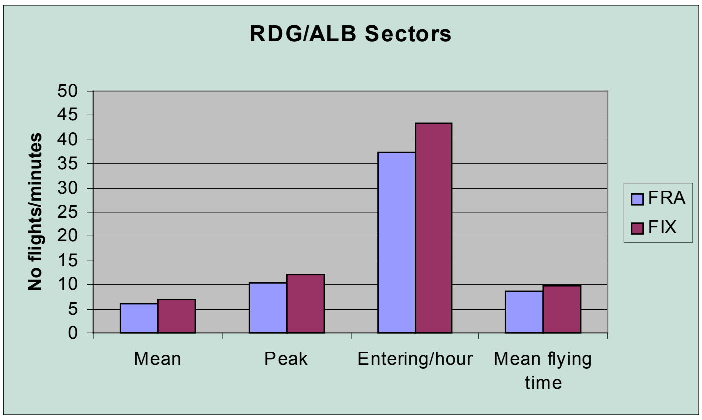


Figure 9: Comparison traffic load, RDG/WSR sectors

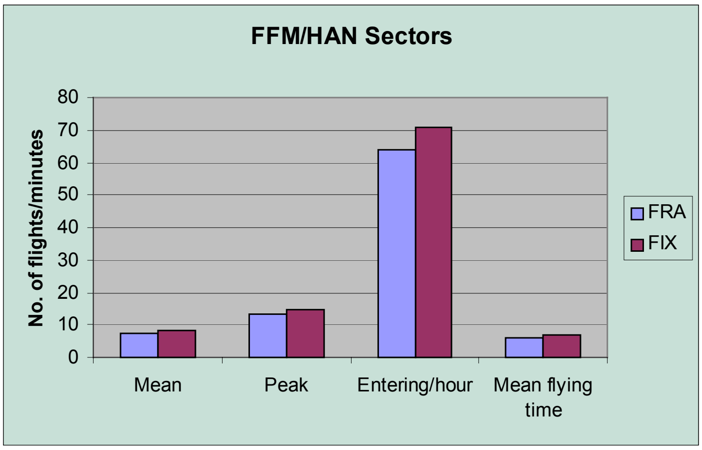


Figure 10: Comparison traffic load, FFM/HAN sectors

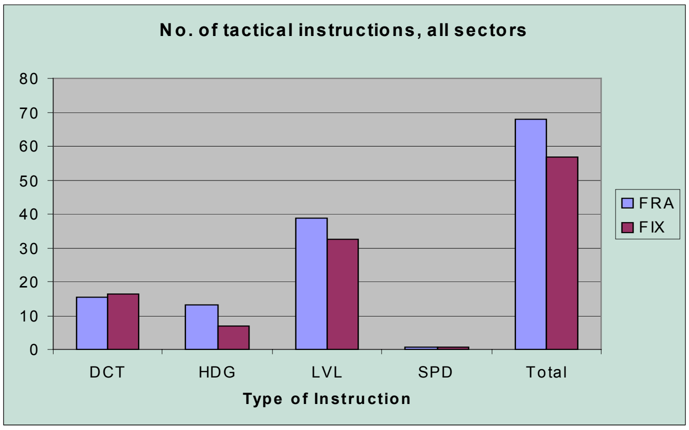


Figure 11: Number of tactical instructions, all sectors

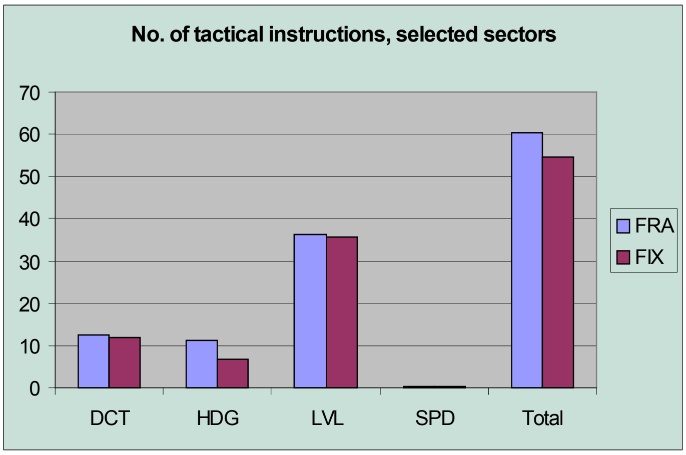


Figure 12: Number of tactical instructions, selected sectors (DEN/WST, RDG/WSR, FFM/HAN)

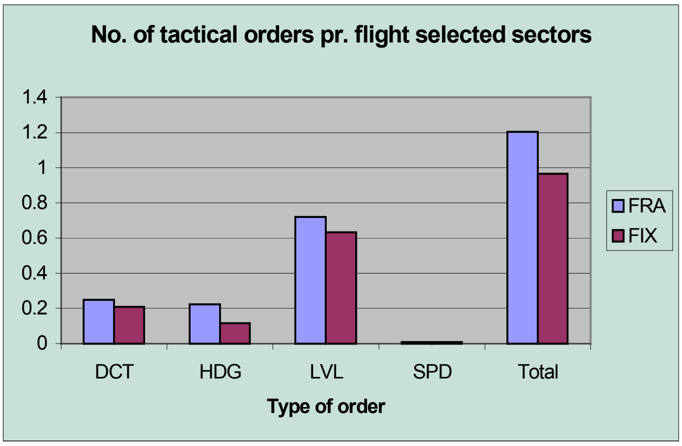


Figure 13: Number of tactical instructions pr. flight, selected sectors (DEN/WST, RDG/WSR, FFM/HAN)

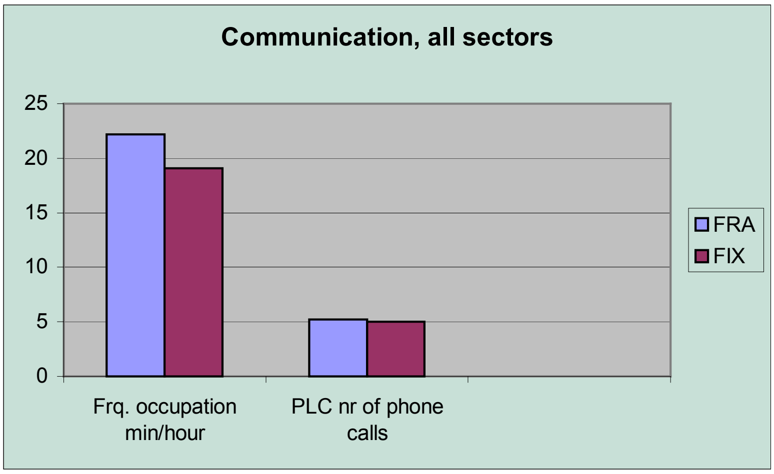


Figure 14: Communication load, all sectors

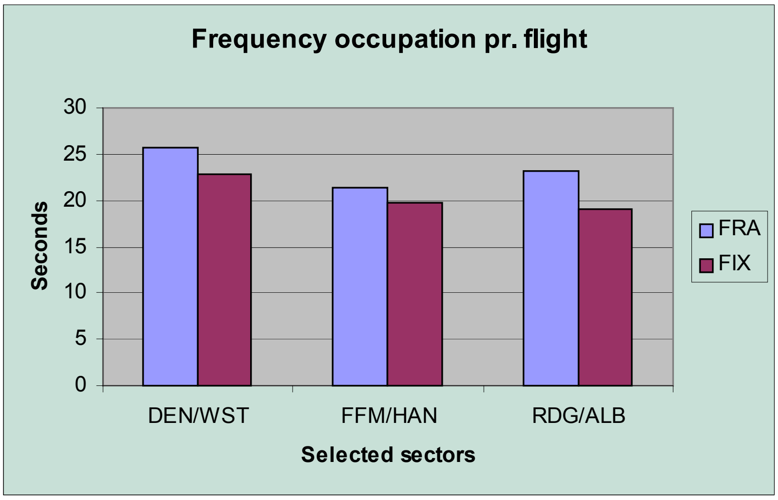


Figure 15: Frequency occupation, selected sectors

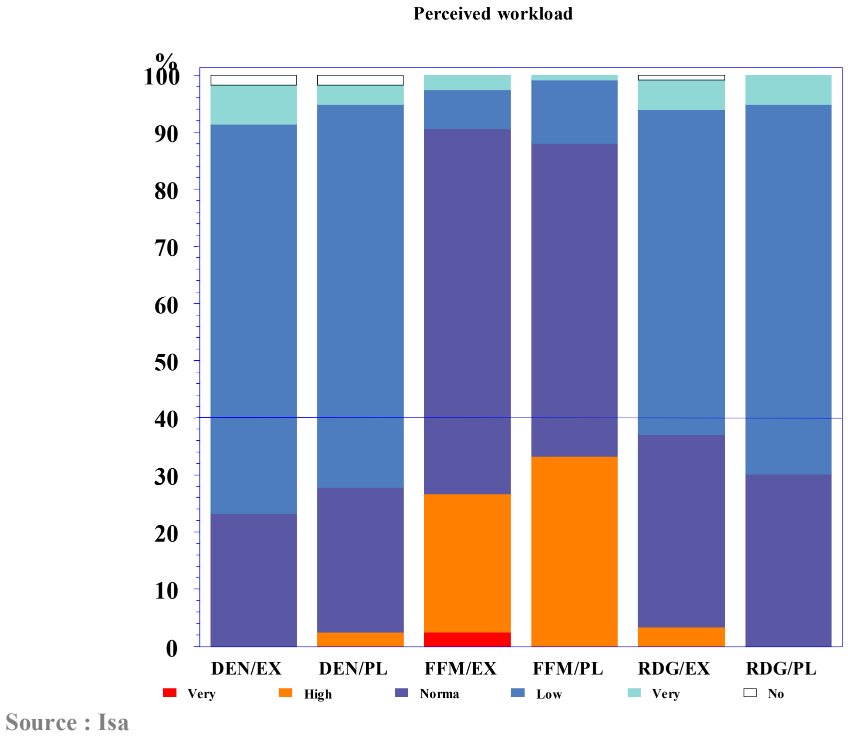


Figure 16: Perceived workload, selected sectors, FRA

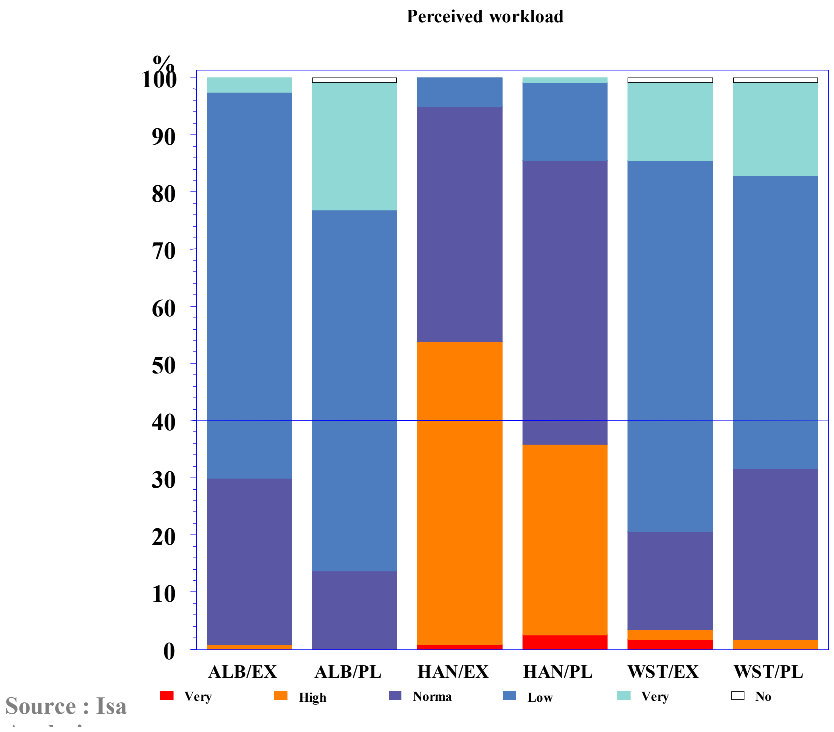


Figure 17: Perceived workload, selected sectors, Fixed Routes

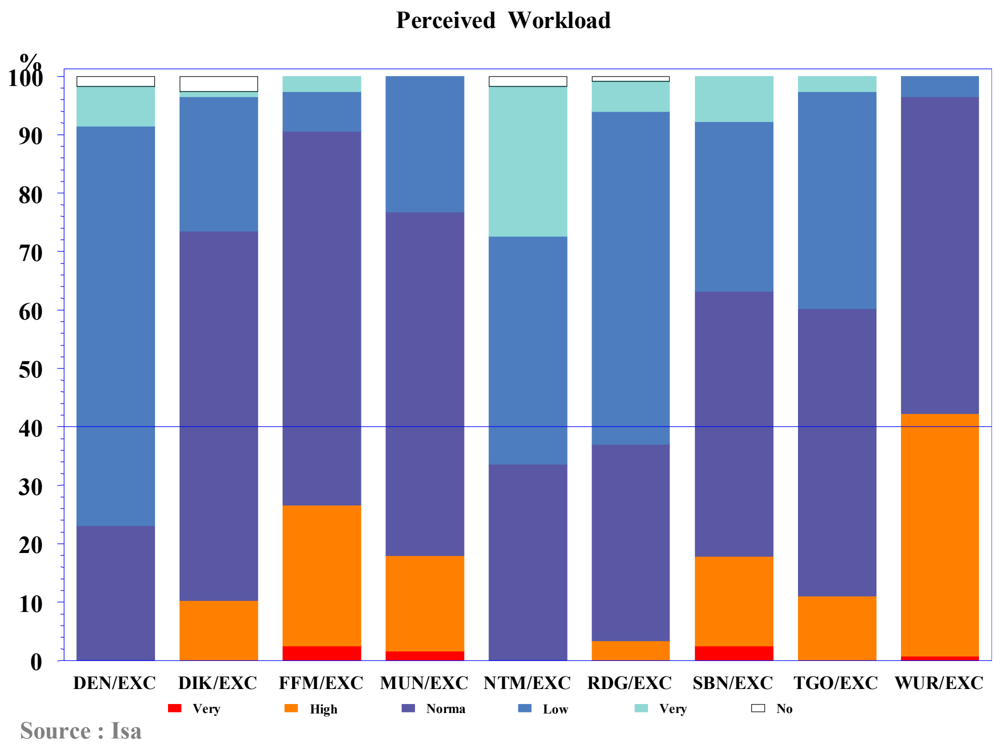


Figure 18: Perceived workload, EXC, FRA

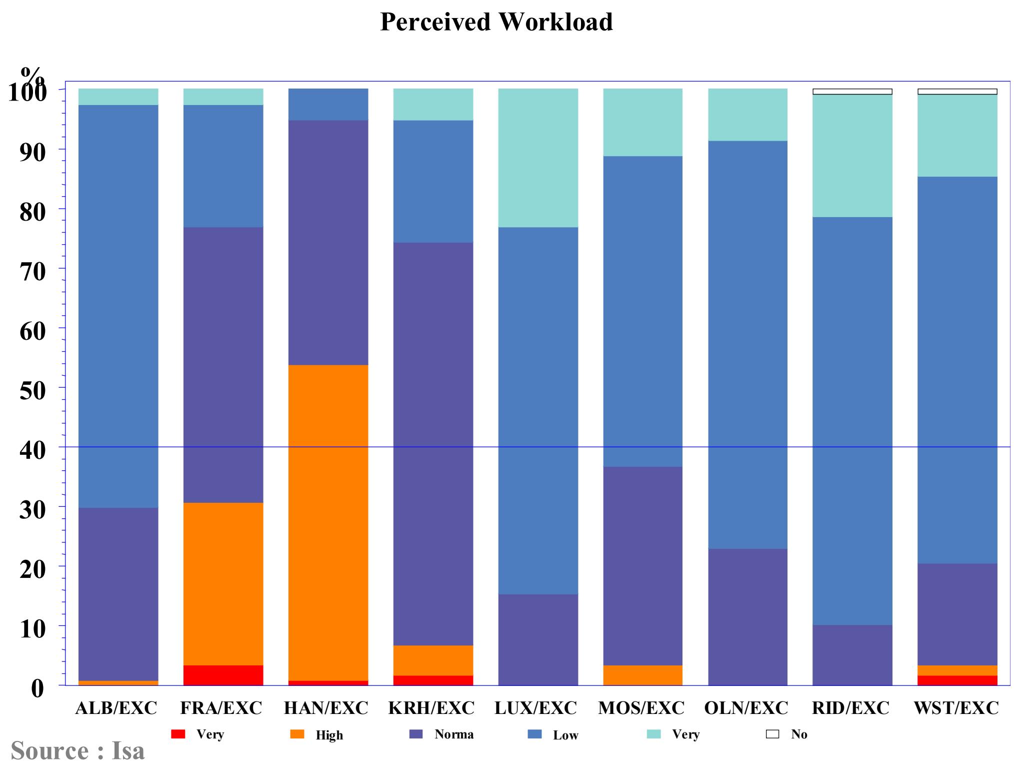


Figure 19: Perceived workload, EXC, Fixed Routes

5.2.2 Questionnaires

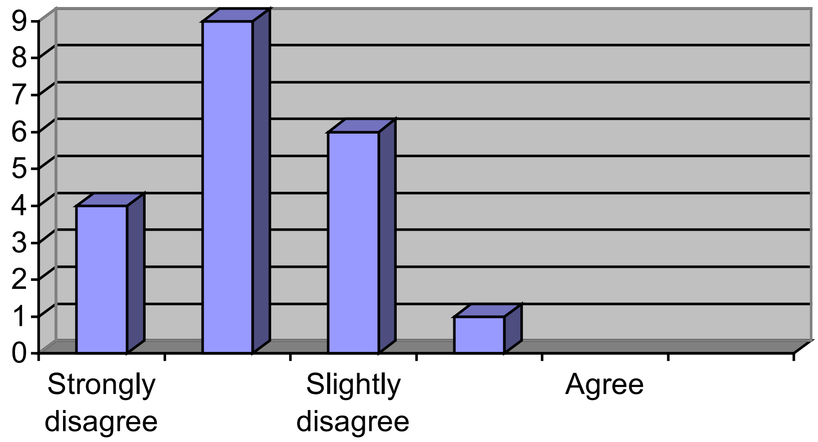


Figure 20: Question 2.1: It requires more attention to monitor traffic in FRA?

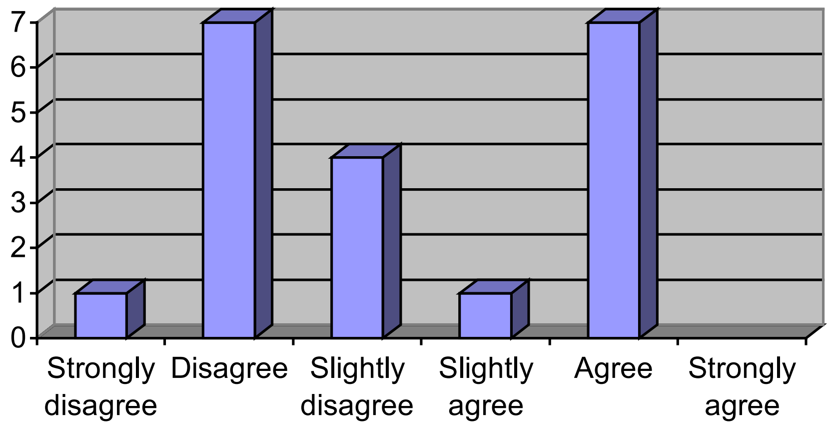


Figure 21: Question 2.2: Conflicts are easier to solve in FRA?

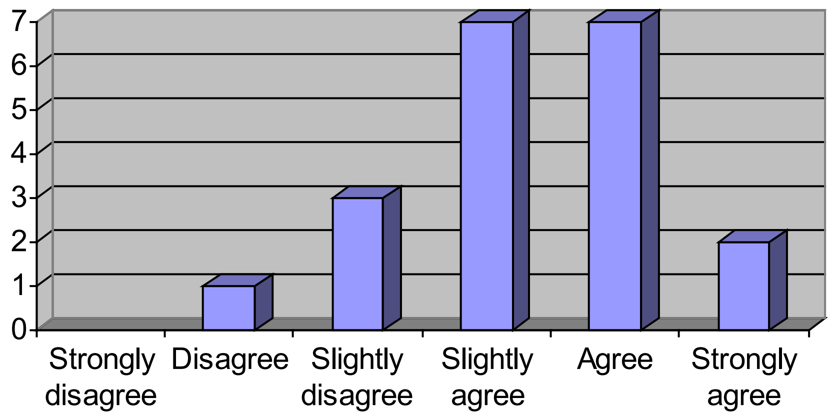


Figure 22: Question 2.3: Conflict solving becomes more tactical in FRA?

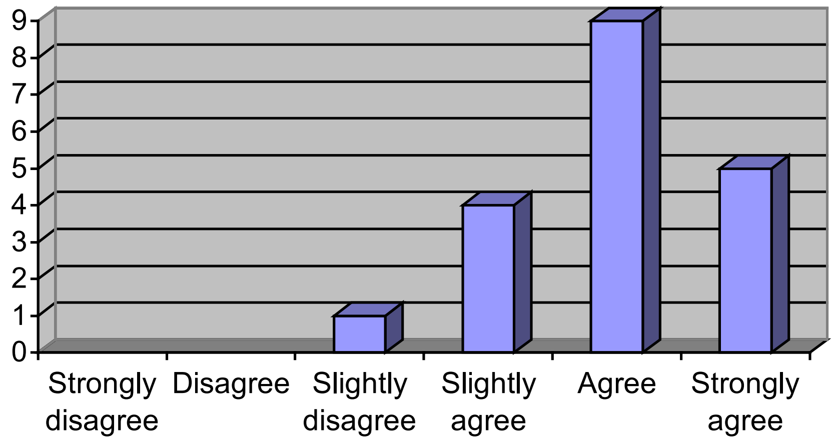


Figure 23: Question 2.4: Activation of segregated airspace has a bigger impact on your workload in FRA than with a route structure?

5.2.3 De-briefings

- FRA leads to more conflicts around airports between climbing/descending traffic and over flying traffic
- There is an extra task in FRA concerning sequencing of traffic leaving FRA airspace

5.2.4 Discussion

In addition to a general comparison between the two organisations FRA and Fixed Routes, the three sectors DEN, FFM and RDG in the FRA organisation are compared with the three sectors WST, HAN and ALB in the Fixed Route organisation (Selected sectors), as these three sectors have similar designs in the two organisations. As it can be seen from the Figures 8, 9 and 10, the traffic load in FRA is slightly lower than the Fixed Route load in all three sectors.

Figures 11, 12 and 13 show a higher number of tactical instruction in the FRA organisation than in the Fixed Route organisation, indicating a higher workload for the tactical controller related to conflict solving.

Following observations during the simulation, it can be concluded that the increased number of heading instructions mainly is linked to avoidance of airspace. The higher number of level instructions is linked to the fact that climb/descend routes linking to the lower airspace not are separated from over flying traffic.

The higher number of tactical instructions in FRA leads to higher frequency load, as it can be seen in Figures 14 and 15.

When looking at the perceived workload in the three selected sectors, it is rated lower in the WST sector (FIX) in the corresponding DEN sector (FRA), lower in the ALB sector (FIX) than the corresponding RDG sector (FRA), but higher in the HAN sector (FIX) than the FFM sector (FRA).

Looking at the perceived workload for EXCs at all measured sectors there is a tendency to higher workload in the FRA organisation.

In the questionnaires, the general opinion is that it requires more attention to run traffic in FRA, and that conflict solving becomes more tactical, moving workload from the PLC to the EXC.

As stated earlier, most traffic had been re-routed around segregated airspace, never the less it is the impression that segregated airspace has a greater impact on capacity in FRA than today.

In the simulated airspace a number of strategic initiatives have been taken to reduce controller workload. It seems that this leads to the above results. Previous simulations of other areas where strategic measures have been taken have lead to the same results, whereas simulation of areas where less effort has been put in reducing conflicts in the route system, e.g. Northern Germany or Denmark has pointed towards a reduction of controller workload in FRA.

5.3 OBJECTIVE 2

Validate and optimise the sectorisation derived from the FRAP Fast-time simulation to support the validation of the FRAP concept

5.3.1 Questionnaires

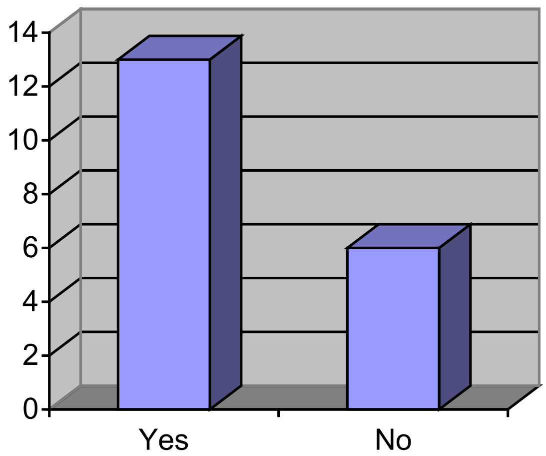


Figure 24: Question 3.1: Did you experience any problem with the simulated sectorisation ?

Additional comments made in relation to this question:

- *Sectorisation has to be changed to cope with the major traffic flows and major crossing areas before implementation.*
- *Aircraft only touching the sectors raise frequency workload*
- *Interface between sectors was cut by several flight paths just on the boundary*
- *Responsibility for separation was not clear, rerouting the traffic around TRA's did suddenly change sector sequence*
- *The sectorisation has to be adapted because when Free routes was active, traffic streams were at the 4 border crossing points*
- *It was not clear who was responsible of the traffic riding the corner of 2 sectors*

- ♦ *Shape of the sectors, sectors boundary sometimes to close to the main stream of traffic*

What sort of modification would you like to see?

- ♦ *Reshaping of sector taking into account climb and descend areas*
- ♦ *A big influence has to come from the major flows of traffic which has to be examined very carefully*
- ♦ *Sector designed more adapted to the critical flights*
- ♦ *Modify sector to the main traffic streams*
- ♦ *Better sector shape based on main streams, fixed agreement between the sector involved about the obligation of separation*
- ♦ *Redo the exercise with lower airspace and adjacent units too*
- ♦ *Change the shape of sectors, forget national boundaries and create straight lines*

5.3.2 De-briefings

- It is too easy to deliver aircraft to lower airspace, the lower airspace should be correctly simulated.
- Segregated airspace will have to be
- Sector layout shall follow traffic stream not FIR boundaries.

5.3.3 Discussion

This issue has been studied in several of the previous simulations, and most of the findings in this simulation have already been described in previous reports.

The participating controllers suggested a more detailed simulation including the lower airspace be conducted before implementation, in order to clearly identify the interface problems and to take the necessary actions to reduce the problems. The environment, as it was simulated here did not identify all these problems, as the lower airspace was simulated as a feed sector only.

In the report on FRAP LRT/North examples on good and bad sector design were shown. Two of these examples, one bad and one good were included in this simulation.

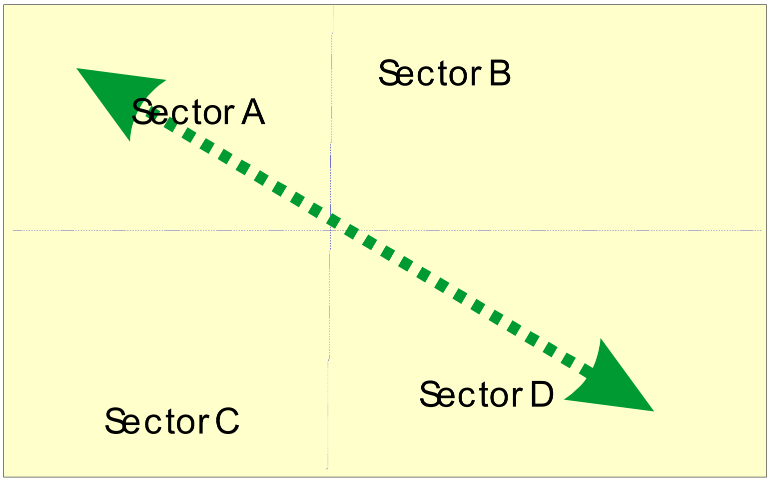


Figure 25: Sector design example A

Four sectors having a common corner point, as shown in Fig. 25 is not a practical solution for a FRA environment. A number of flights are flying so close to the common corner point that they have to be known by all four sectors. This also means that any co-ordination, change in route or altitude has to co-ordinated with three other sectors. The problem of who is responsible for the separation is also quite complex in this situation, and calls for advanced system support. On the system side it is difficult to handle the shown sector design. The sector sequence can change from radar update to radar update. During the simulation this was often the case, and the system was not able to manage the message flow in a correct manner. This lead to erroneous messages being distributed and to loss of co-ordination messages, etc.

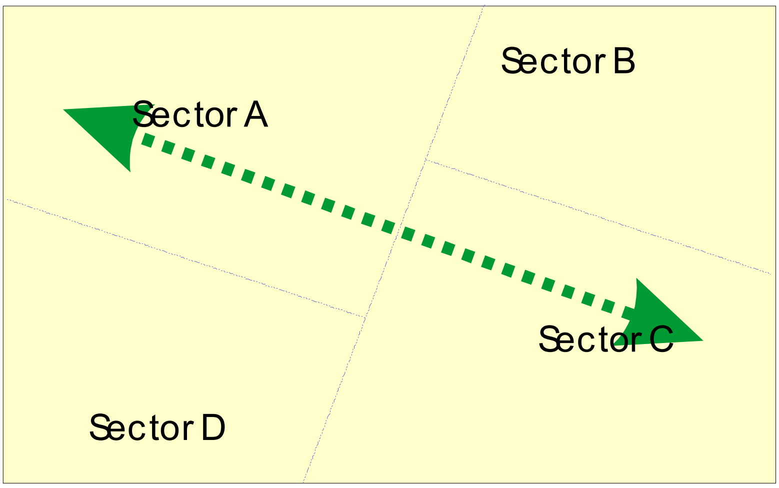


Figure 26: Sector design example B

With predominant traffic flows as indicated with the arrow, the problems related to Fig. 26 are reduced. Maximum two other sectors will be involved in a co-ordination, and although some confusion still can remain as to who is responsible for a separation of two aircraft, it is easier to handle. Also on the system side far less problems were encountered with this sector design.

5.4 OBJECTIVE 3

Identify the impact on controller workload of the introduction of simple conflict detection

5.4.1 Recordings

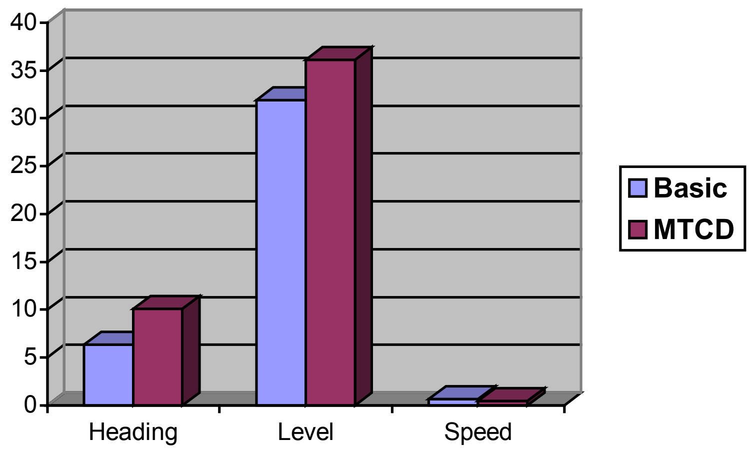


Figure 27: No. of pilot inputs, average for all measured sectors in the FRA organisation

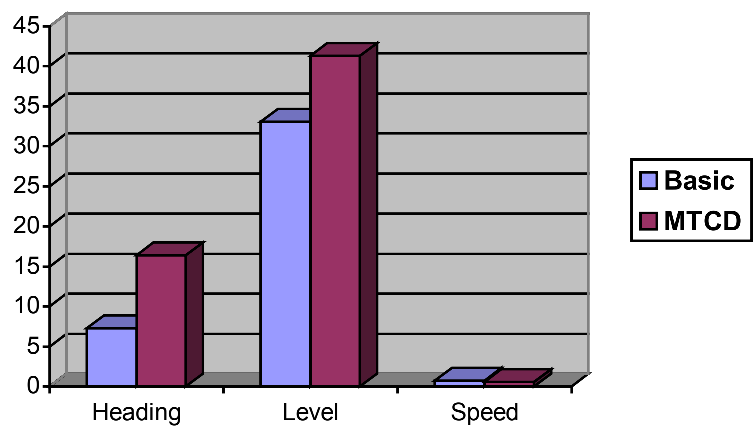


Figure 28: No. of pilot inputs, average for all measured sectors in the FIX organisation

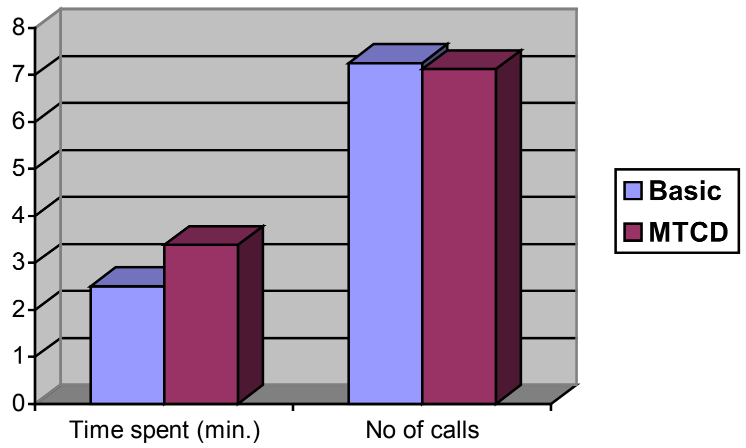


Figure 29: Frequency usage

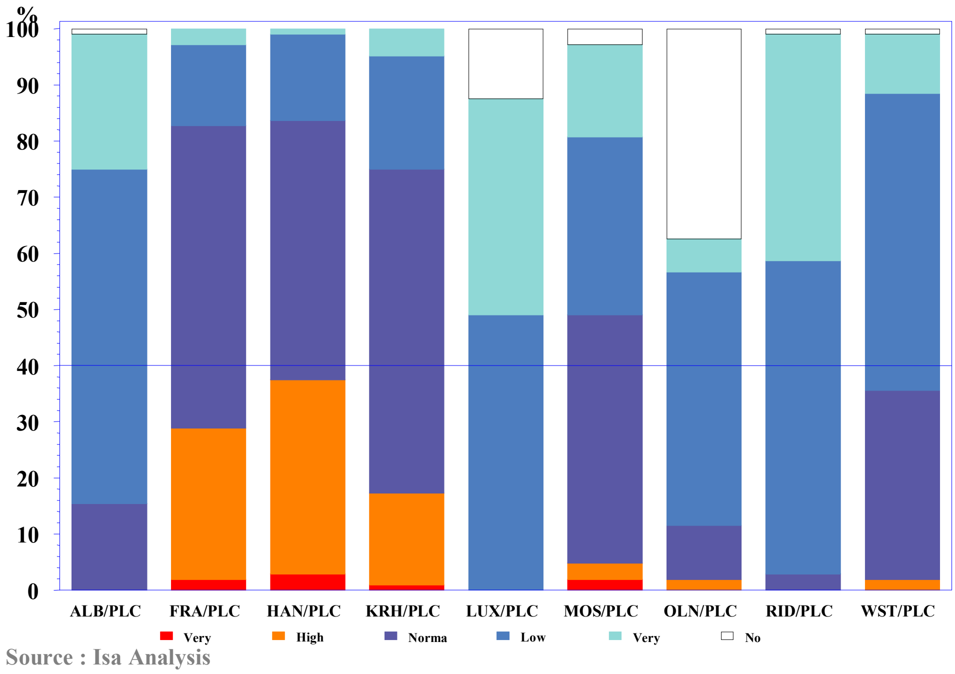


Figure 30: Perceived workload PLCs, Without MTCD in FRA

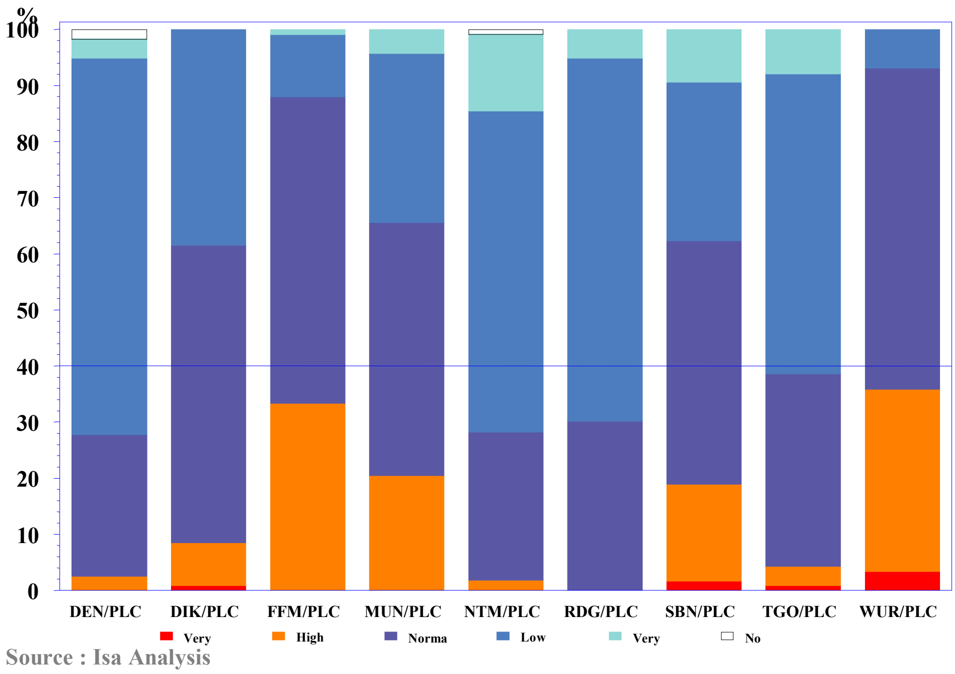


Figure 31: Perceived workload PLCs, With MTCD in FRA

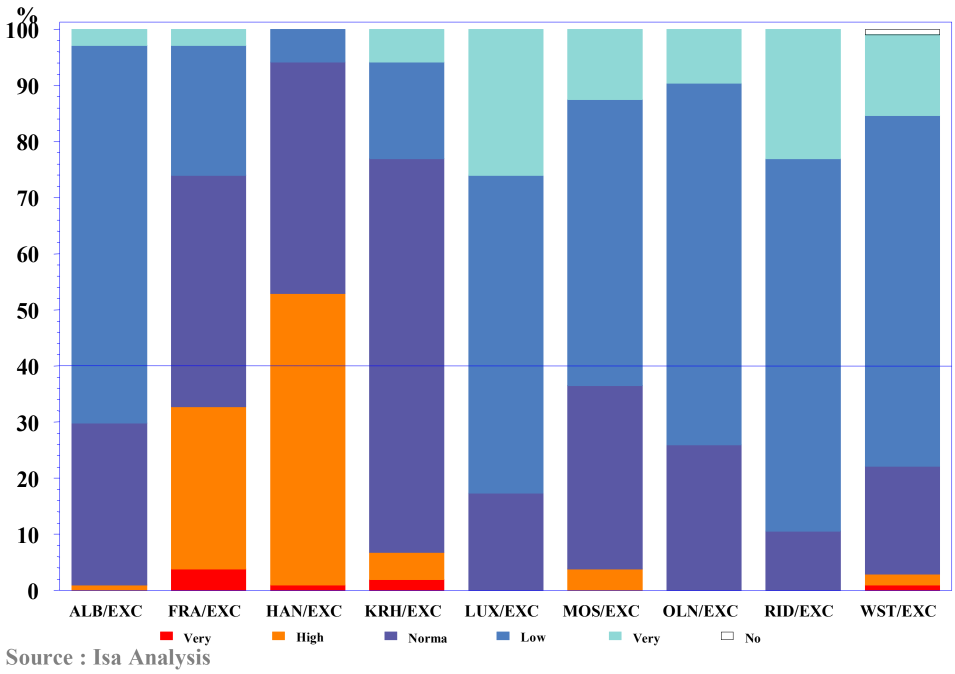


Figure 32: Perceived workload EXC, without MTCD in FRA

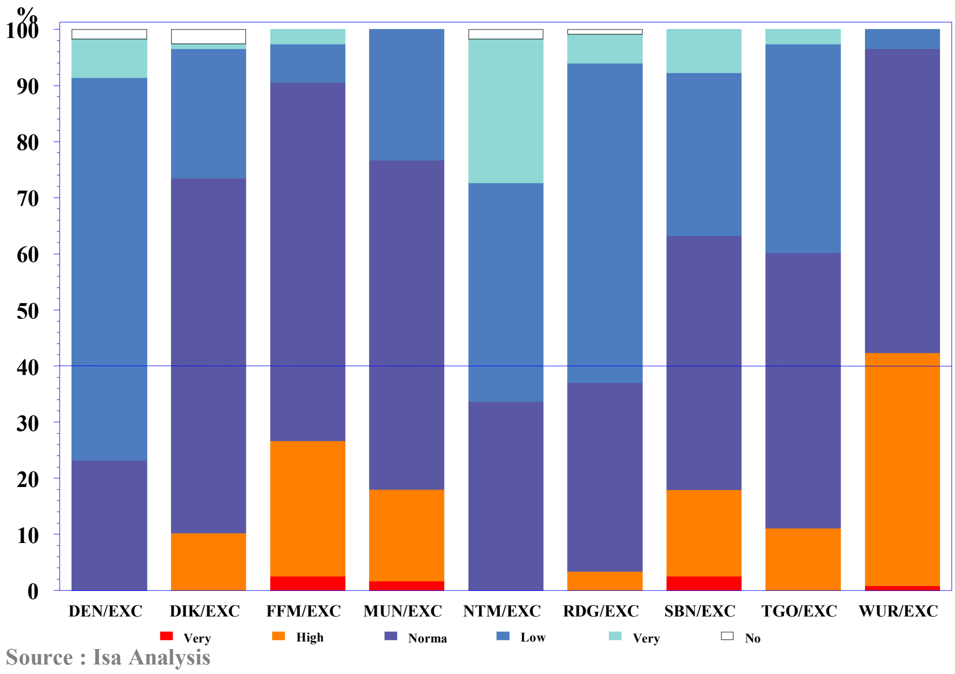


Figure 33: Perceived workload EXCs, with MTCD in FRA

5.4.2 Questionnaires

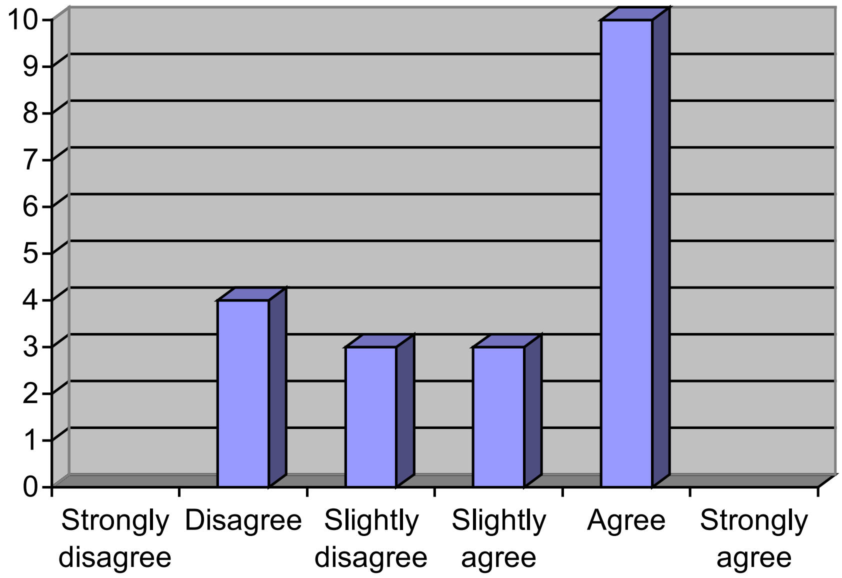


Figure 34: Question 4.1: FRA will require a re-distribution of tasks within the controller team?

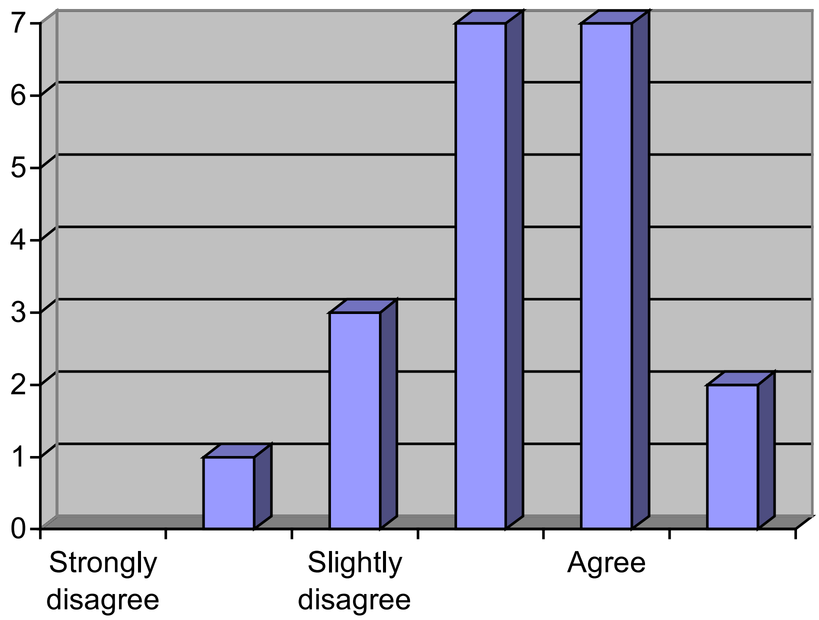


Figure 35: Question 4.2: Conflict solving becomes more tactical in FRA?

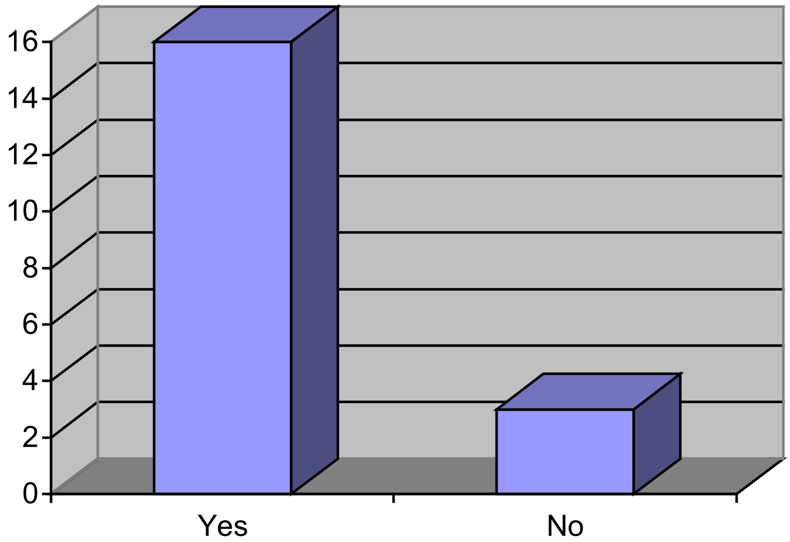


Figure 36: Question 4.3: Do you think a well functioning MTCD will be required in order to introduce FRA in the ACC where you normally work?

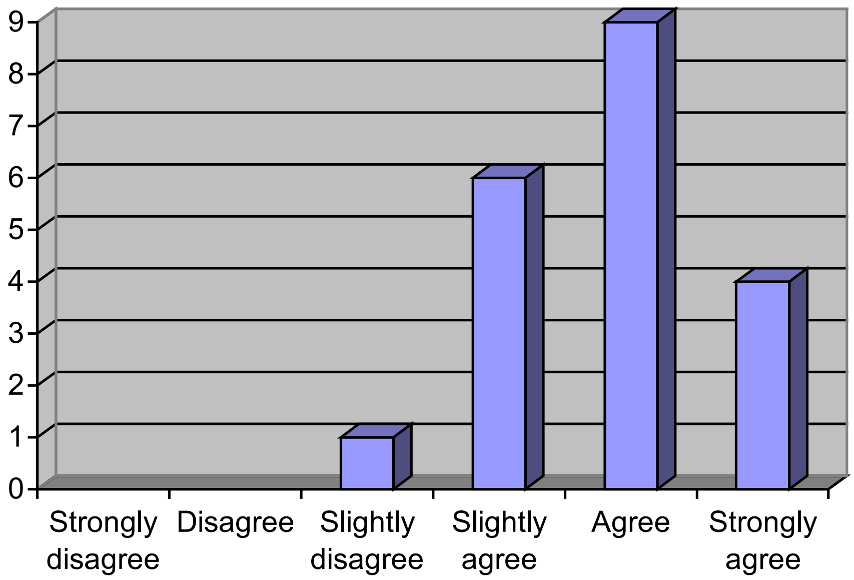


Figure 37: Question 4.4: It requires more attention to monitor traffic in FRA?

5.4.3 De-briefings

- It is more difficult to maintain the mental picture of the traffic. Conflicts are not only on 1 or two points within the sector.
- Quality of MTCD was not good enough to give a meaningful opinion.

5.4.4 Discussion

The simulation was set up to answer the question whether MTCD is an enabler for FRA or not. It has to be said that the quality of the MTCD was less than 100%.

It is estimated that 80-90% of the conflicts was presented for the controllers in a correct way. The participating controllers considered that unacceptable.

The logic behind the MTCD was rather simple, and did not take the rate of climb of aircraft into consideration like the MTCD developed by EATMP, however as the simulation was upper airspace only, this had a limited effect.

Question 3.1 confirms the results from previous simulations that there is a need for system support to the controller to perform the monitoring tasks.

In this simulation, as in previous, there were a shift of workload towards the EXC. A tool to enable the PLC to assist the EXC would give a better task distribution on the sector, and potentially increase sector capacity.

The table showing perceived workload indicates that workload is unchanged when MTCD is provided to the controller.

It must be remembered that this is based on an MTCD not working 100% correct. The general feeling amongst most of the controllers that MTCD would be required in order to identify all conflicts in due time. It is also clear that the EXC is becoming the bottleneck as the work is becoming more and more tactical.

Further work aiming at developing a tool that will enable the PLC to offload the EXC is required.

5.5 OBJECTIVE 4

Assess the proposed procedures for entry and exit to/from Free Routes airspace, identify possible problems related to this and propose procedures to overcome these problems.

5.5.1 Questionnaires

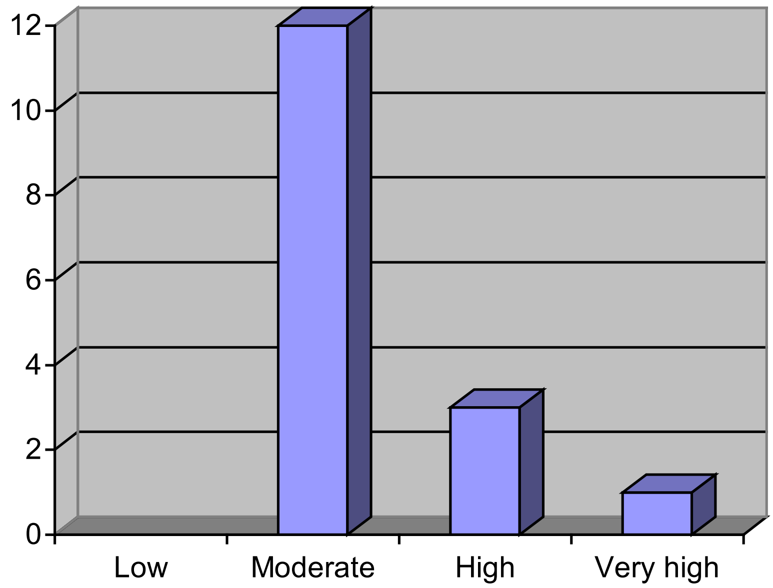


Figure 38: Question 5.1: Dealing with traffic at entry/exit points to/from FRA airspace, e.g. descending towards airports, how would you rate your work devoted to this?

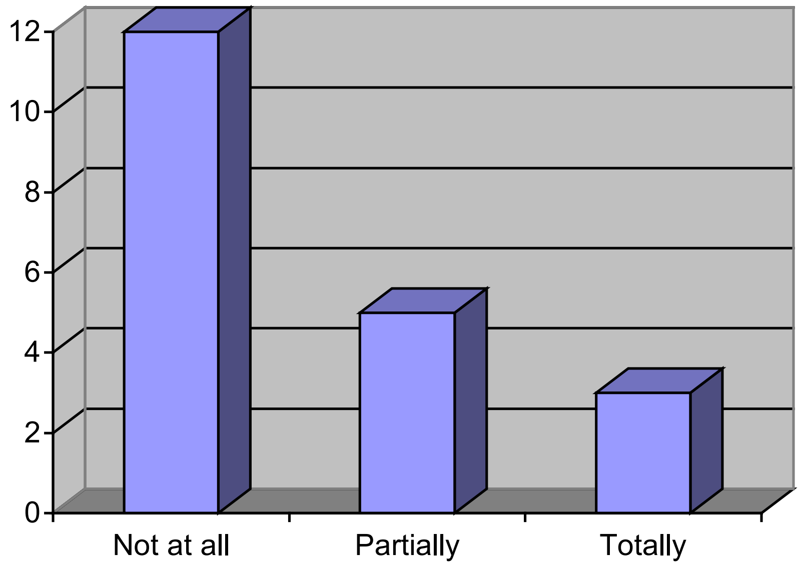


Figure 39: Question 5.2: Do you think it is more difficult to assure separation on entry/exit points in FRA compared to non-FRA?

5.5.2 De-briefings

- Unlike the situation in today's route system, where climbing and descending flights are separated from transit flights, there are many conflicts like that in FRA
- If the bottom level of FRA was e.g. Fl 335, it would be easier to handle the climb and descend phase.
- Sequencing into the route system of adjacent centres is difficult, and requires a tool to support the controller.
- To give a correct validation of this, lower airspace should be simulated as well.

5.5.3 Discussion

For traffic exiting to neighbouring ACCs, there seems to be a need for a simple tool to manage the outbound flow. This could be as simple as an exit list, providing times and levels over the exit point.

For traffic climbing and descending to/from entry/exit point, the number of conflicts is increased in FRA. It was suggested that a higher bottom level would reduce this problem, which seems logical, however the problem remains. It is not possible in FRA, like in the Fixed Routes to have segregated route segments where climb and descend can take place. These finding are in line with what was found in FRAP SRT-2 around Stockholm Airport (EEC Note 6/00). In order to cope with this, departing traffic was only climbed to Fl 280 by all lower sectors.

A model-based simulation of the Frankfurt area followed by a real-time simulation including lower airspace would be required to establish the optimal solution for implementation.

5.6 OBJECTIVE 5

Assess the effect on controller workload, situational awareness, and identify related system requirements, of tactical re-routing around segregated airspace.

5.6.1 Questionnaires

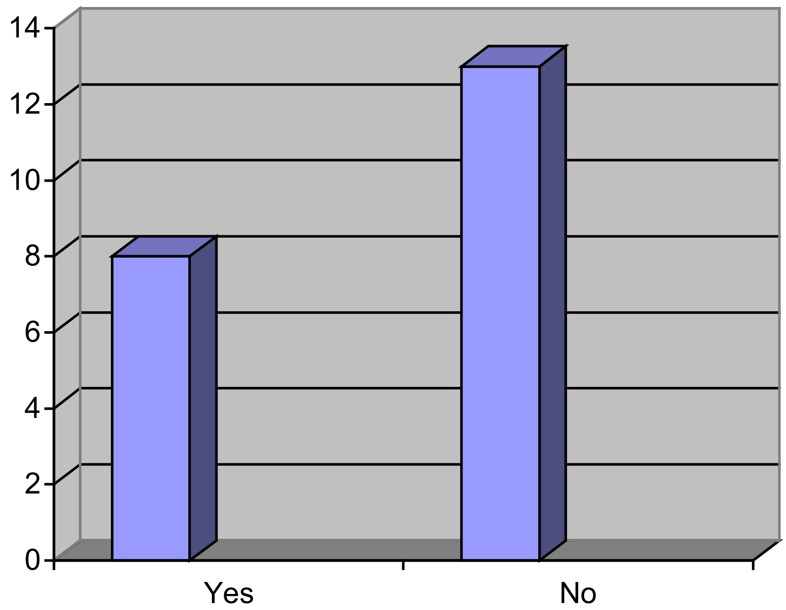


Figure 40: Question 6.1: Would you prefer that flight plans were direct from FRA entry to exit, leaving conflicts with segregated airspace as a task to you?

5.6.2 De-briefings

- Route information in flightplans was often difficult to understand.
- When TRAs are active, FRA does not give much benefit in the simulated area.
- A 4D tool that could help you identifying areas that were active along an aircraft's route would be practical.

5.6.3 Discussion

Like previous simulations, it seems that the results point towards a requirement that operators shall plan flights around segregated airspace. The workload related to the re-routing around segregated airspace would be considerable, even after a re-design of military airspace.

It was proposed that it would be useful to have a tool that could probe conflicts between a flight and segregated airspace. This tool (the name FRITS, Free Routes Infringement ToolS was proposed by the participating controllers) should check a flights 4d-trajectory against airspace planned to be active while the flight crossed the airspace.

Again the need to know why a particular point is in the flight plan was raised. Today routes are based on procedures laid down in AIPs and checked by IFPS. In the FRA environment this is not supposed to be the case, many routes will be used between the same city-pair. There seems to be a need for a naming convention, even if this will be a difficult task, considering ICAO naming conventions.

5.7 OBJECTIVE 6

Analyse the effect of tactical interventions on downstream sectors including the requirements on

- OLDI/SYSCO
- Trajectory prediction
- Flight data distribution
- Conflict detection

5.7.1 De-briefings

- Sector layout has an impact on the OLDI.
- It should be able to manage flights, even if they are outside the sector.
- A function enabling the controller to inform the previous sector that the aircraft shall be transferred directly to the following sector, “skip a sector”, should be available, at least internally within an ACC.

5.7.2 Discussion

Like in many other ACCs, controllers in Maastricht UAC do not always strictly follow the sector sequence when flights are managed, sectors are omitted for various reasons, flights are taken within other sectors after co-ordination, but without updating the flightplan. As a consequence, flights are not always handled by the sector where they physically are. The simulator was not able to cope with this, which lead to many problems. It is clear that either the system has to be adapted to the way the controllers work, or the controllers have to change their working habits. In this case, the second solution was chosen, there was not enough time to make the considerable changes required to adjust the system to the way the controllers worked, so the Maastricht controllers had to change their way of working.

Although not completely adapted, the system seemed to be more in line with the way the Karlsruhe Munich controllers worked.

To sum-up, it can be concluded that:

- Basic flight data for flights close to your sector boundary shall be available to support the situational awareness of the controller and in order to support functionality, e.g. MTCD.

- OLDI shall be able to handle a change in sector sequence, and the controller must know next sector, even if the aircraft is transferred to another ACC.

- A simple tool, e.g. an Exit List, may be required to support the transition back to the Fixed Routes.

- A tool to support the controller in identifying the segregated airspace along the route of a flight can be useful.

5.8 OBJECTIVE 7

Validate the various procedures for handling OAT.

5.8.1 De-briefings

- Adjustment of TRAs, considering FRA traffic flows as well as the lower level route structure is required.
- IFR transit flights can be conducted as in the present system.
- Some Air defence operations outside TSAs may be interrupted.
- Findings from FRAP SRT-4 (EEC Note no 17/2000) are still valid.

5.8.2 Discussion

The Belgian airspace was simulated in FRAP SRP-4. The participating controllers had nothing to add to that. FRAP will increase the workload for the military controller, but it is not the feeling that there will be an impact on military operations outside TSAs.

For the German airspace there is not much activity in the simulated area outside TSAs. It was the impression that the military transit flights not would be effected, but some air defence operations, interceptions, that today take place outside TRAs away from the airways, may be disturbed, as these portions of airspace will have more civil traffic in FRA. To maintain these operations, more segregated airspace may be required.

5.9 OBJECTIVE 8

Provide support to the following work packages in FRAP, Fast time simulation, Safety Study and Human Resource Study.

5.9.1 Discussion

The results of these activities are available in separate reports issued within FRAP. The Reports are available through the EUROCONTROL FRA Project Manager.

6. CONCLUSIONS

Validate the Free Routes Airspace Concept based on the draft FRA ORD during a real-time simulation with several ACCs involved, General Findings:

- Unlike previous simulations, FRAC did not get unanimous support from the participating controllers. About one third of the participators found it difficult to understand and work with.
- The PLC starts to work like a second EXC.
- The planning scope gets reduced, traffic is only processed in a tactical time horizon.

Assess variations in controller workload stemming from the introduction of FRAC

- In the simulated airspace the EXC workload is higher in FRA, more tactical instructions have to be issued, frequency load is higher.
- In the simulated airspace the PLC workload is higher, the effort required to maintain the mental picture of the traffic is higher, conflicts are more difficult to identify.
- It shall be noted the findings in less dense traffic previous reports have pointed towards a reduction of controller workload. (FRAP SRT-1, EEC Note No. 22/99 and FRAP SRT-3, EEC Note No. 14/2000)
- It seems that for airspace where a lot of strategic de-conflicting of traffic has taken place, or where traffic density is high, FRA is a disadvantage, elsewhere FRA is an advantage.

Validate and optimise the sectorisation derived from the FRAP Fast-time simulation to support the validation of the FRAP concept.

- Findings from previous simulation in the area of sector design were confirmed.
- More detailed studies in model-based simulations are required.
- Real-time Simulations where the lower airspace is fully simulated are required before final airspace design.

Identify the impact on controller workload of the introduction of simple conflict detection.

- The quality of the MTCD used during the simulation was bad.
- It seems that MTCD will be required in the simulated area for FRA operations.
- No reduction in workload was recorded when providing MTCD.
- There is a need to further develop tools to support the PLC identifying conflicts and support the EXC in the monitoring task.

Assess the proposed procedures for entry and exit to/from Free Routes airspace, identify possible problems related to this and propose procedures to overcome these problems.

- There seems to be a need for a simple tool (Exit List) to establish the sequence into fixed route airspace.
- The simulation showed many conflicts between climbing and descending traffic. It may be possible to reduce this with a redesign of entry and exit points.
- Present LoAs with neighbouring ACCs will have to be renegotiated.

Assess the effect on controller workload, situational awareness, and identify related system requirements, of tactical re-routing around segregated airspace.

- Flight planning should be made around segregated airspace to reduce workload.
- A tool to support prediction of possible airspace infringements should be developed.
- As in previous simulations, controllers asked for a naming convention that could allow them to identify why particular points are in the flight plan.

Analyse the effect of tactical interventions on downstream sectors including the requirements on

OLDI/SYSCO
Trajectory prediction
Flight data distribution
Conflict detection

- The way airspace is designed has an impact on how well OLDI will work.
- To support the working method of Maastricht controllers, the system functionality should be able to accept that aircraft are not physically following the sector sequence defined by the Trajectory Prediction.
- Basic flight data for flights close to your sector boundary shall be available to support the situational awareness of the controller and in order to support functionality, e.g. MTCD.
- OLDI shall be able to handle a change in sector sequence, and the controller must know next sector, even if the aircraft is transferred to another ACC.
- A simple tool, e.g. an Exit List, may be required to support the transition back to the Fixed Routes.
- A tool to support the controller in identifying the segregated airspace along the route of a flight can be useful, and should be developed.

Validate the various procedures for handling OAT.

- FRA is not a hindrance to OAT
- Workload on the OAT controller will increase.
- Some OAT operations taking place outside TRAs today may have to take place in a TRA in FRA.

Provide support to the following work packages in FRAP, Fast time simulation, Safety Study and Human Resource Study.

- This subject is covered in individual reports from the above studies.

7. RECOMMENDATIONS

The following additional studies should be carried out during the Validation Phase of the Eight-States Free Routes Project

1. Before implementation, model-base studies should be conducted, followed by real-time simulations around major airports, to develop optimised entry and exit procedures.

2. Work should be undertaken to further develop tools that will enable the PLC to offload the EXC and supporting the EXC in the monitoring task.

3. Once the required functionality is available, further real-time simulations should be conducted, to develop the related working methods.

TRADUCTION EN LANGUE FRANÇAISE

RÉSUMÉ

On trouvera ci-dessous le rapport de la simulation en temps réel à grande échelle de la partie sud du Projet d'espace aérien à itinéraire libre dans huit États. Il s'agit de la seconde de deux simulations en temps réel de grande envergure, qui font suite aux simulations de moindre ampleur déjà réalisées dans le cadre de ce projet. Associées à une série d'autres activités, ces simulations doivent servir de fondement à la validation du Concept d'espace aérien à itinéraire libre.

La simulation a été menée au Centre expérimental d'EUROCONTROL, à Brétigny, et a duré deux semaines. Vingt-six contrôleurs de la circulation aérienne, principalement issus des CCR de Karlsruhe et de Munich, du Centre de contrôle de Maastricht et du centre radar militaire BELGA, ont pris part à l'exercice, qui a porté sur l'espace aérien simulé correspondant à la Belgique et à la partie sud de l'Allemagne.

La plate-forme utilisée faisait intervenir des fonctions et une interface homme-machine semblables à celles qui seront vraisemblablement mises en œuvre, avant 2005, dans les CCR de la zone simulée. Au nombre de ces fonctions figuraient l'échange de données en ligne et la coordination automatisée (OLDI/SYSCO), la coordination civile-militaire automatisée, la détection des conflits à moyen terme et l'avertissement de conflit à court terme. L'interface homme-machine (HMI) se présentait sous la forme d'un dispositif sans bande, à base objet et avec codage chromatique.

La simulation des itinéraires libres reposait sur l'application du projet de Concept opérationnel d'espace aérien à itinéraire libre.

La simulation a porté sur deux modes d'organisation : les itinéraires libres et les routes fixes. Le modèle à route fixe était basé sur l'ARN V4, dans le cas de Maastricht, et sur l'EAM04 pour ce qui est de l'espace aérien allemand. (Remarque concernant l'EAM04 : pour des raisons pratiques, c'est le projet de structure de l'espace aérien disponible en juillet 2000 qui a été utilisé, bien qu'il puisse ne pas s'agir de la version finale.) L'un des objectifs majeurs de cette simulation était de comparer la charge de travail respective des contrôleurs en fonction du modèle organisationnel retenu.

Il ressort de la simulation que, si le concept d'espace aérien à itinéraire libre pourra être mis en oeuvre lorsque les CCR disposeront des fonctions requises et comportera certains avantages, l'utilisation du dispositif simulé d'appui aux contrôleurs ne diminuera pas la charge de travail de ces derniers.

D'autres études directement axées sur les questions de mise en oeuvre devront être menées à bien dans la zone simulée, afin d'éviter certains des problèmes techniques et de procédure qui ont été observés pendant la simulation.

1. INTRODUCTION

La seconde simulation en temps réel à grande échelle du Projet d'espace aérien à itinéraire libre dans huit États (FRAP) s'est déroulée du 22 janvier au 2 février 2001 au Centre expérimental d'EUROCONTROL. Son objectif était de répondre aux spécifications du FRAP à l'appui de la validation du Concept d'espace aérien à itinéraire libre (FRAC).

Il s'agissait en l'occurrence de la seconde de deux simulations à grande échelle faisant suite à quatre simulations en temps réel de moindre envergure, le but étant de permettre, en combinaison avec un certain nombre d'autres activités, la validation du FRAC dans l'espace aérien des huit États participants (Allemagne, Belgique, Danemark, Finlande, Luxembourg, Norvège, Pays-Bas et Suède).

Alors que les simulations à petite échelle peuvent être considérées comme une phase d'étude et de mise au point, la simulation à grande échelle dont il est ici question a mis davantage l'accent sur la validation que sur l'affinement du Concept opérationnel d'espace aérien à itinéraire libre. Elle a porté sur l’espace aérien supérieur de certaines parties des FIR / UIR de Bruxelles, Rhein et Munich. La structure et la sectorisation de l'espace aérien se fondaient sur les résultats des simulations en temps accéléré du FRAP et ne respectaient donc pas les limites de FIR / UIR actuelles. Il convient de noter que la sectorisation utilisée a été conçue uniquement pour les besoins de la validation et ne constitue dès lors pas une proposition de mise en œuvre.

La simulation était basée sur le RVSM et la COM était considérée comme dépourvue de moyens RVSM.

Les lettres d’accord (LoA) et procédures actuelles ont été utilisées, mais avec les modifications nécessaires afin de tenir compte du RVSM et des itinéraires libres.

La simulation a été réalisée sur la plate-forme standard du Centre expérimental d'EUROCONTROL, laquelle intègre la version 2 d'OLDI, un système de coordination civile-militaire automatisée et un dispositif MTCD reposant sur une interface homme-machine sans bande.

L'équipe FRAP chargée de l'étude des performances humaines a pris part à la simulation et réalisé un certain nombre de mesures spécifiques ayant trait, notamment, aux mouvements oculaires et à la fréquence cardiaque. Les résultats de ces travaux font l'objet d'un rapport distinct. De plus, les résultats de la simulation ont été exploités en vue d’obtenir des informations utiles pour la simulation en temps accéléré du concept d'itinéraires libres et l'étude des aspects liés à la sécurité.

2. OBJECTIFS

La simulation en temps réel à grande échelle de la partie sud du FRAP avait pour objectif global de valider le Concept d'espace aérien à itinéraire libre sur la base du projet d'ORD du FRA dans le cadre d'un exercice faisant intervenir plusieurs CCR.

Plus spécifiquement, les objectifs poursuivis étaient les suivants :

1. Évaluer les variations de la charge de travail des contrôleurs résultant de la mise en application du FRAC.

2. Valider et optimiser la sectorisation découlant de la simulation en temps accéléré du FRAP à l'appui de la validation du Concept d'espace aérien à itinéraire libre.

3. Déterminer l'incidence, sur la charge de travail des contrôleurs, de l'introduction de la détection simple de conflits.

4. Évaluer les procédures proposées aux points d'entrée / sortie de l'espace aérien à itinéraire libre, cerner les problèmes éventuels et suggérer des solutions.

5. Apprécier les incidences, sur la charge de travail des contrôleurs et leur perception de l'environnement, des réacheminements tactiques autour de zones d'espace aérien réservé, et identifier les besoins correspondants au niveau des systèmes.

6. Analyser les incidences des interventions tactiques sur les secteurs en aval, notamment les exigences posées en termes :
   - d'échange de données en ligne et de coordination automatisée (OLDI / SYSCO) ;
   - de prévision de trajectoires ;
   - de diffusion des données de vol ;
   - de détection des conflits.

7. Valider les différentes procédures de prise en charge de la COM.

8. Appuyer les ensembles de travaux FRAP suivants : simulation en temps accéléré, étude des aspects liés à la sécurité et étude des facteurs humains.

3. CONCLUSIONS

Valider le Concept d'espace aérien à itinéraire libre sur la base du projet d'ORD du FRA dans le cadre d'une simulation en temps réel faisant intervenir plusieurs CCR – conclusions générales :

- Contrairement aux simulations précédentes, le FRAC n'a pas recueilli un soutien unanime de la part des contrôleurs participant à l'exercice. Environ un tiers d'entre eux ont éprouvé des difficultés à l'appréhender et à l'utiliser.
- Le PLC commence à travailler comme un deuxième EXC.
- La planification ne porte plus que sur une période réduite, la circulation aérienne n'est traitée que sur une base tactique.

Évaluer les variations de la charge de travail des contrôleurs résultant de la mise en application du FRAC.

- Dans l'espace aérien simulé, la charge de travail des contrôleurs exécutifs est supérieure dans le cas du FRA, davantage d'instructions tactiques doivent être données et la charge des fréquences est plus importante.
- Dans l'espace aérien simulé, la charge de travail des contrôleurs de planification est plus lourde, l'effort nécessaire pour visualiser mentalement le trafic est plus important et il est plus difficile de déceler les conflits.
- Pour rappel, les conclusions de rapports antérieurs, portant sur un trafic de moindre densité, laissaient entrevoir une diminution de la charge de travail des contrôleurs (voir FRAP SRT-1, note ECC n° 22/99 et FRAP SRT-3, note ECC n° 14/2000).
- Il semble que le FRA constitue un inconvénient là où les activités de résolution stratégique des conflits sont nombreuses, tandis qu'il apparaît comme un avantage ailleurs.

Valider et optimiser la sectorisation découlant de la simulation en temps accéléré du FRAP à l'appui de la validation du Concept d'espace aérien à itinéraire libre.

- Les conclusions de la simulation précédente en matière de sectorisation de l'espace aérien ont été confirmées.
- Des études de modélisation plus fouillées sont requises.
- Des simulations en temps réel modélisant la totalité de l'espace aérien inférieur sont nécessaires avant de finaliser la conception de l'espace aérien.

Déterminer l'incidence, sur la charge de travail des contrôleurs, de l'introduction de la détection simple de conflits.

- La qualité de la MTCD utilisée dans le cadre de la simulation était médiocre.
- Il semble que la MTCD sera requise dans la zone simulée pour les activités FRA.
- La fourniture de la MTCD ne s'est pas traduite par une diminution de la charge de travail.
- Il y a lieu de poursuivre le développement d'outils destinés à aider le PLC à détecter les conflits et à assister le EXC dans sa mission de contrôle.

Évaluer les procédures proposées aux points d'entrée / sortie de l'espace aérien à itinéraire libre, cerner les problèmes éventuels et suggérer des solutions.

- Il apparaît nécessaire de disposer d'un outil simple (liste des sorties) permettant de définir la séquence dans un espace aérien à route fixe.
- La simulation a révélé l'existence de nombreux conflits entre les vols ascendants et descendants. Peut-être est-il possible de résorber ce problème en redéfinissant les points d'entrée et de sortie.

- Les lettres d'accord actuelles signées avec les CCR voisins devront être renégociées.

Apprécier les incidences, sur la charge de travail des contrôleurs et leur perception de l'environnement, des réacheminements tactiques autour de zones d'espace aérien réservé, et identifier les besoins correspondants au niveau des systèmes.

- Il conviendrait, dans le but de réduire la charge de travail, de planifier les vols autour des zones d'espace aérien réservé.
- Il y a lieu de développer un outil d'aide à la prévision des risques de violation d'espace aérien.
- Comme lors des simulations précédentes, les contrôleurs ont demandé l'adoption d'une dénomination conventionnelle, qui devrait leur permettre de comprendre pourquoi certains points particuliers figurent dans le plan de vol.

Analyser les incidences des interventions tactiques sur les secteurs en aval, notamment les exigences posées en termes :

- d'échange de données en ligne et de coordination automatisée (OLDI / SYSCO) ;
- de prévision de trajectoires ;
- de diffusion des données de vol ;
- de détection des conflits.

- La façon dont l'espace aérien est organisé influe sur le fonctionnement de l'OLDI.
- À l'appui de la méthode de travail des contrôleurs de Maastricht, le système devrait pouvoir accepter qu'un aéronef ne suive pas physiquement la séquence des secteurs telle que définie par la prévision de trajectoire.
- Le contrôleur aérien doit pouvoir disposer des données de base relatives aux vols proches de la limite de son secteur afin d'améliorer la perception qu'il a de son environnement et d'appuyer les fonctions, par ex. la MTCD.
- L'OLDI doit être capable de traiter une modification affectant la séquence des secteurs, et le contrôleur doit connaître le secteur suivant, même si l'aéronef est transféré vers un autre CCR.
- Un outil simple, par exemple une liste des sorties, peut se révéler nécessaire à l'appui d'un retour vers l'espace aérien à routes fixes.
- Un outil de nature à aider le contrôleur à délimiter l'espace aérien réservé situé le long de l'itinéraire d'un vol peut se révéler utile et devrait donc être développé.

Valider les différentes procédures de prise en charge de la COM.

- Le concept FRA ne constitue pas une entrave pour la COM.
- La charge de travail du contrôleur COM augmentera.
- Il se pourrait que certains vols COM actuellement effectués hors TRA doivent se faire en TRA en cas de mise en œuvre du concept FRA.

Appuyer les ensembles de travaux FRAP suivants : simulation en temps accéléré, étude des aspects liés à la sécurité et étude des facteurs humains.

- Cet aspect est abordé dans les différents rapports concernant les études précitées.

4. RECOMMANDATIONS

Il convient d'entreprendre, dans le cadre de la phase de validation du Projet d'espace aérien à itinéraire libre dans huit États, les études complémentaires ci-après :

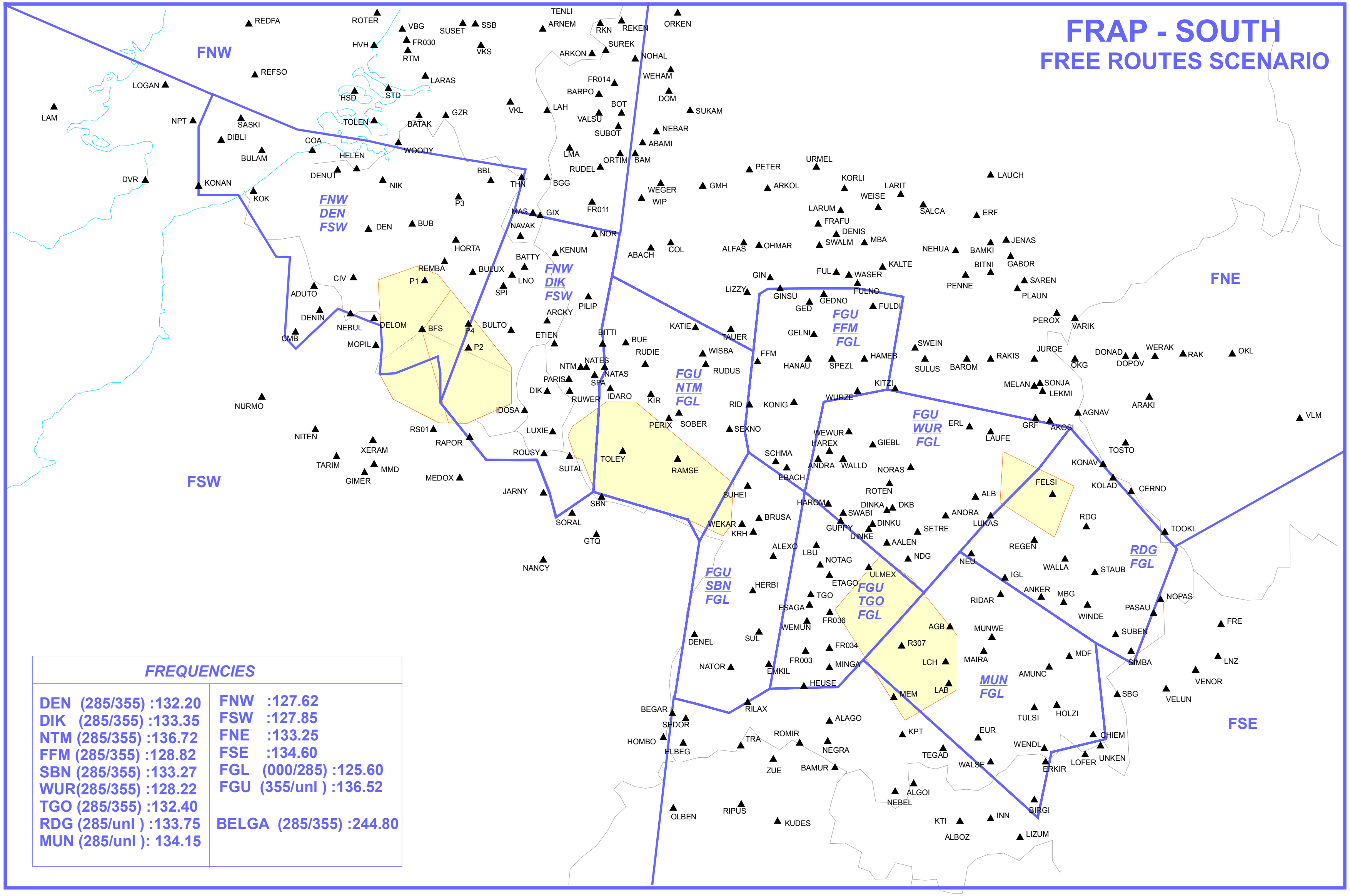
1. Préalablement à la mise en oeuvre, il y a lieu de mener des études de modélisation, suivies de simulations en temps réel aux abords d'aéroports importants, aux fins d'élaborer des procédures d'entrée et de sortie optimales.

2. Il conviendrait de poursuivre la mise au point d'outils qui permettent au contrôleur de planification de décharger le contrôleur exécutif et qui assistent ce dernier dans sa tâche de contrôle.

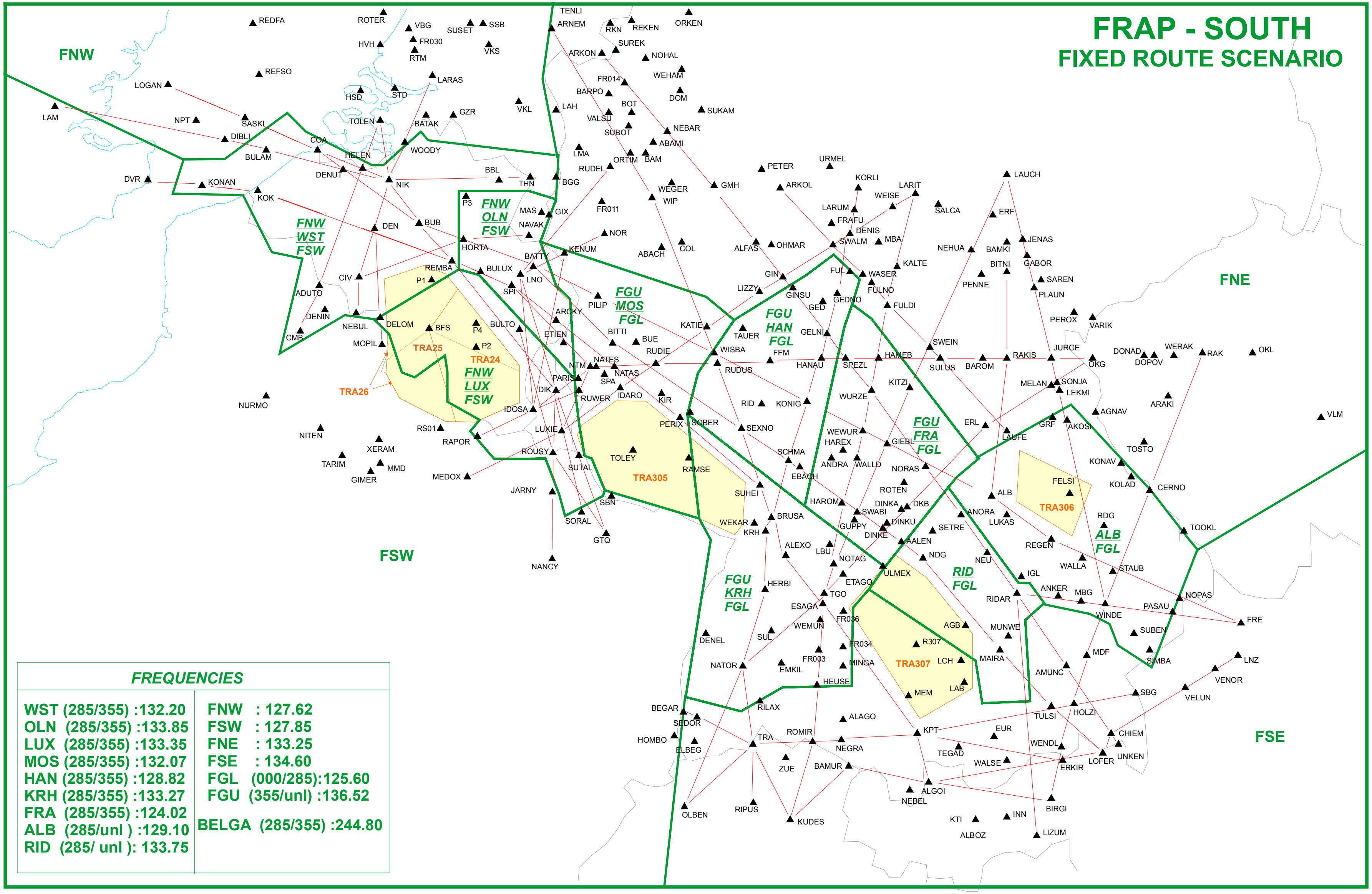
3. Une fois les fonctions requises disponibles, de nouvelles simulations en temps réel devraient être réalisées, afin de mettre au point les méthodes de travail correspondantes.

APPENDIX A

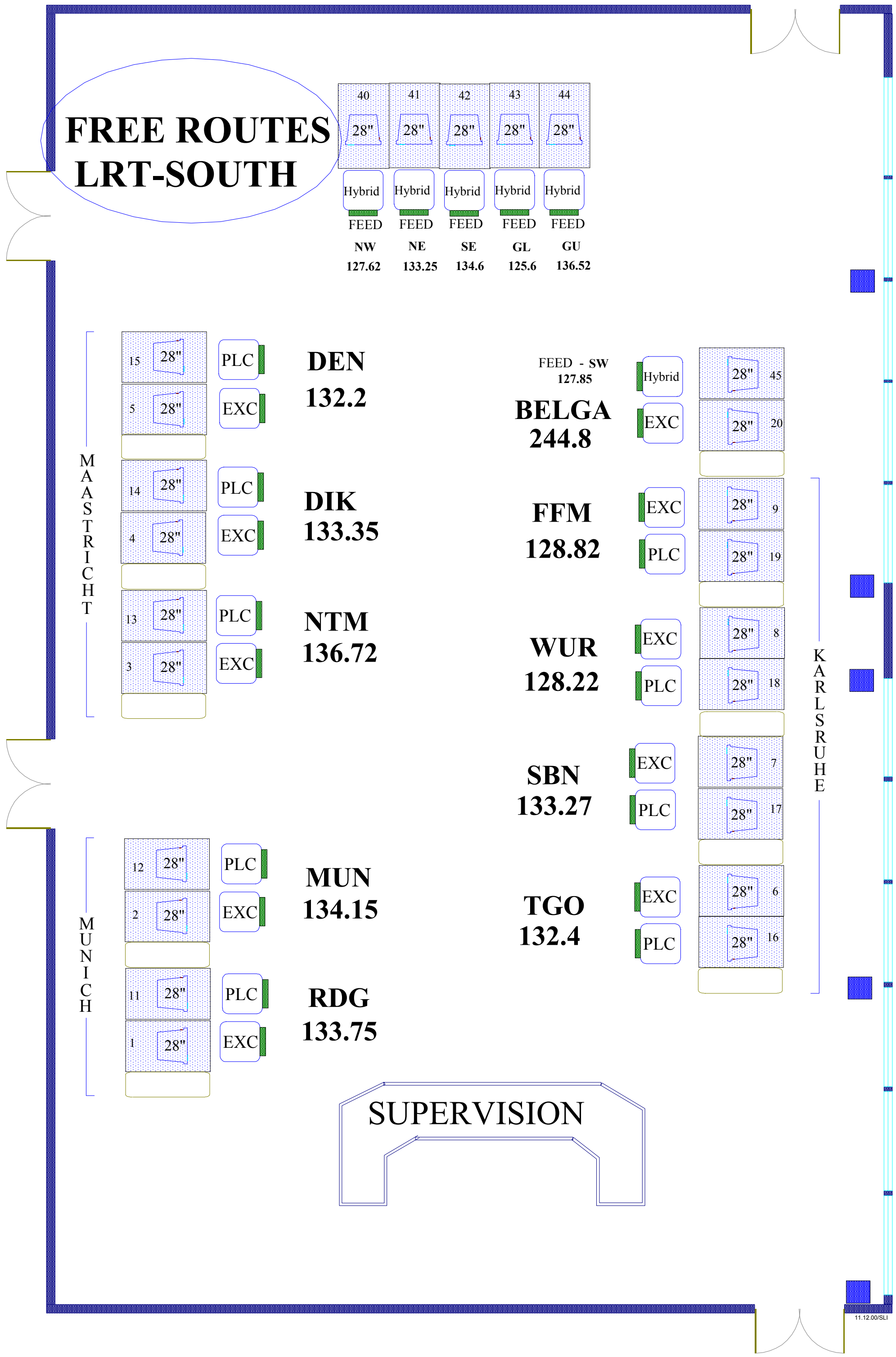
SIMULATED AIRSPACE AND ROOM LAY-OUT



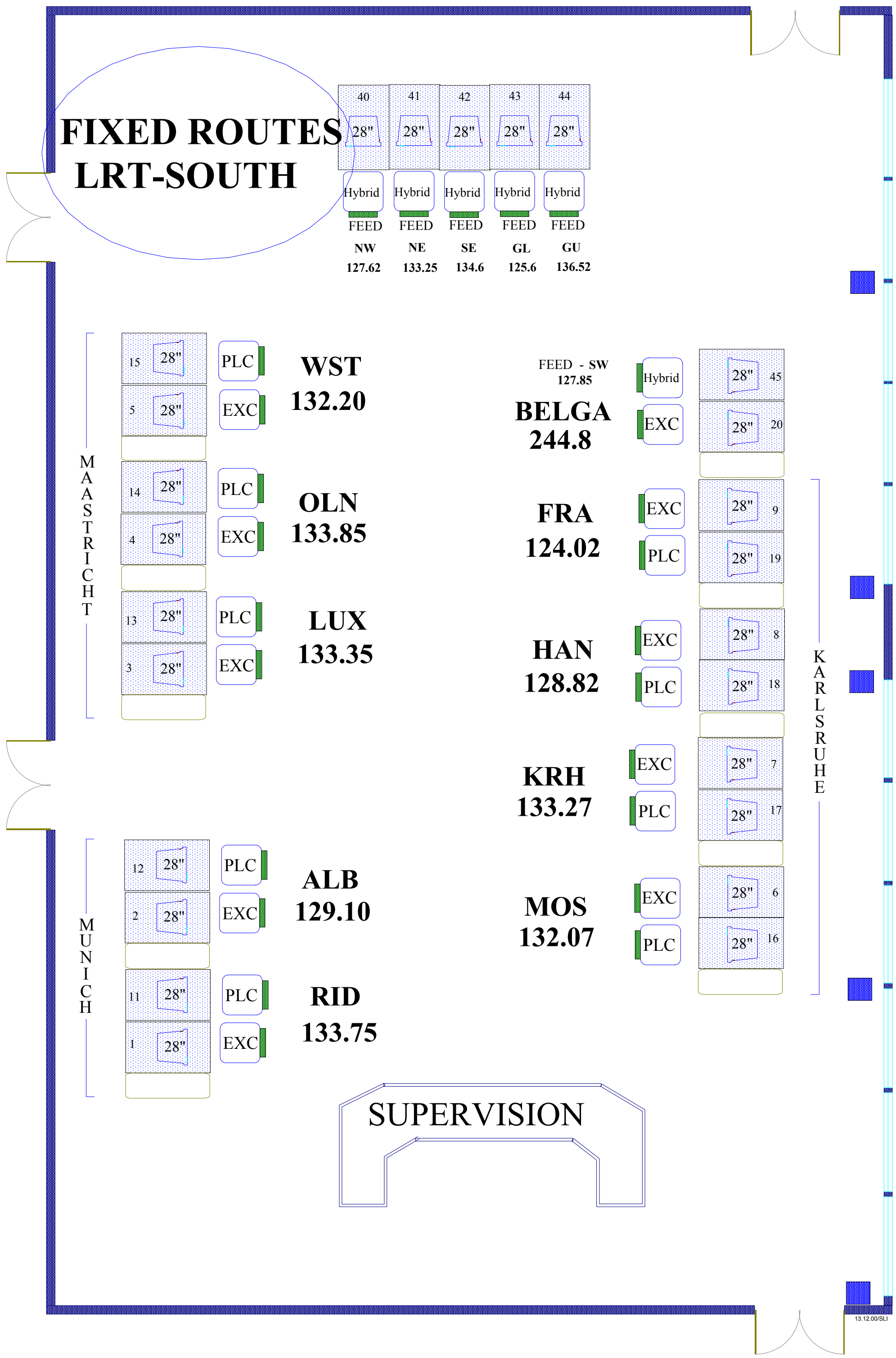
Simulated Airspace, Org. 1, Free Routes



Simulated Airspace, Org. 2, Fixed Routes



Operations Room Lay-out, Org. 1, Free Routes



Operations Room Lay-out, Org. 2, Fixed Routes