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FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL EXPERIMENTAL CENTRE

EIGHT-STATES FREE ROUTE AIRSPACE PROJECT
3rd SMALL SCALE REAL TIME SIMULATION

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TITLE:
EIGHT-STATES FREE ROUTE AIRSPACE PROJECT
SMALL SCALE REAL TIME SIMULATION NUMBER 3, SIMULATION REPORT

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Abstract:

This report describes the third small-scale real-time simulation study of the Free Routes Airspace Concept within the context of the Eight-States Free Routes Airspace Project. Parts of Copenhagen FIR and Hannover UIR were simulated. The simulation was designed to support the validation of the Free Routes Airspace Concept, and was the third of six planned real-time simulation studies. The study focused on the possible capacity gain by implementing the concept, using a future ATC system with Medium Term Conflict Detection, but was also designed to further develop the concept, identify the need to develop or redesign procedures, airspace lay-out, as well as civil-military issues. Human Performance and Safety issues were addressed in parallel studies conducted within the framework of the Free Routes Airspace Project, using the simulation as a vehicle to provide data

SUMMARY

This is the report of the 3rd Eight-States Free Routes Airspace Project Real-time Simulation. The simulation one of a series of 6 real-time simulations, that together with a number of other activities provides the basis for the validation of the Free Routes Airspace Concept.

The simulation was conducted at the EUROCONTROL Experimental Centre, and lasted for two weeks. Ten air traffic controllers from CAA Denmark, CAA Norway, Deutche Flug Sicherung and Maastricht took part in the simulation.

Functionality and Human Machine Interface expected to be in operations in the eight States within the next 5 years formed the basis for the platform used. This included OLDI/SYSCO and Short Term Conflict Alert, Medium Term Conflict Detection and Area Proximity Warning. The HMI was a stripless, object based, colour coded concept very close to the proposed EATMP HMI.

Flightplans assured that flights circumnavigated segregated airspace, in order to reduce the tactical workload when aircraft had to be vectored around segregated airspace

The methodology was mainly based on a comparison of controller workload in a Fixed Route and a Free Route environment. It was assumed that RVSM is introduced before Free Routes.

The simulation showed no reduction in controller workload, or potential for better service provision related to the implementation of Free Routes in the simulated area. Objective and subjective measures show some redistribution of controller tasks, but the total workload remains unchanged.

A previous simulation (FRAP SRT-1, EEC Note 28/99) of the same airspace shoved a reduction of distances flown when introducing Free Routes. This reduction could not be reproduced during this simulation, possibly due to an increased activation of segregated airspace

For the Operational Air Traffic, the task of monitoring the civil traffic picture became more demanding. RVSM caused many problems to the Operational Air Traffic. This may lead to a need for more segregated airspace, thus hampering the benefits of Free Routes.

The results obtained differ from the result obtained in the first real-time simulation of the same area (FRAP SRT-1, EEC Note 28/99) but are in line with the results of the Free Routes Simulation of parts of Finnish and Swedish airspace (FRAP SRT-2, EEC Note 6/2000).

The results of this simulation are specific for the simulated area and should not be considered as applicable to the entire Eight States area.

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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
CFL	**C**leared **F**light **L**evel
COP	**Co**ordination **P**oint
CWP	**C**ontroller **W**orking **P**osition
DFL	**D**ynamic **F**light **L**eg
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
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
TSA	**T**emporary **S**egregated **A**irspace
UIR	**U**pper **I**nformation **R**egion
XFL	E**x**it **F**light **L**evel

REFERENCES

1. Eight-States Free Routes Airspace Project Management Plan ver. 1.0
2. Eight-States Free Routes Airspace Project EEC Activity Plan Plan ver. 1.0
3. Eight-States Free Routes Airspace Project SRT-3 Facility Specification Part 1 (Conduct and Analysis)
4. Eight-States Free Routes Airspace Project SRT-3 Controller Handbook

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1. INTRODUCTION

The third Small Scale Real-time Simulation of the Eight-States Free Routes Airspace Concept (FRAC) took place at the EUROCONTROL Experimental Centre between 2nd and 12th May 2000. The simulation was designed to meet the requirements of FRAP to validate the Free Routes Concept (FRAC).

The simulation was one of six 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).

This simulation is seen as a study simulation, where the concept is further developed as well as validated. The simulation was based on the upper airspace over parts of Hannover UIR and København FIR. The present airspace structure was optimised to cater for the free routes traffic flows. Traffic was based on collected traffic data from June 1999, augmented to the agreed sector load. Civil and military traffic was simulated.

The simulation focussed on the introduction of Medium Term Conflict Detection to reduce controller workload and to facilitate a better distribution of work between the Executive Controller (EXC) and Planner Controller (PLC). A changed Free Routes Airspace flight planning concept was also introduced, it was assumed that segregated airspace activity plans were used to flightplan around active areas. Finally the ability of Operational Air traffic (OAT) to operate with Free Routes Airspace (FRA) was evaluated.

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

The FRAP Human Performance Study was also part of 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.

During the simulation the participating Air Traffic Controllers (ATCO's) took part in two half-day hazard analysis sessions to support the FRAP Safety Study.

2. OBJECTIVES AND MEASURES

2.1 OBJECTIVES

The objectives of the simulation were:

1. Assess the proposed lateral and vertical limits of the Free Routes Airspace with regard to traffic complexity, traffic load and interface problems.

2. Determined whether expected capacity gains are likely to be met.

3. Assess additional HMI requirements for a FRAC environment.

4. Provide support to studies concerning flight-planning issues in FRA, specifically the issue of strategical and tactical circumnavigation of segregated airspace.

5. Assess the use of ATC planning tools such as MTCD and APW and identify potential capacity gains related to these tools. Provide feedback on the simulated functionality and identify possible shortcomings

6. Further develop controller roles when working in a Free Routes environment.

7. Assess the impact on military operations, en-route as well as air defence and other special military operations in a 2008 scenario Free Routes Airspace.

8. Provide support to other work packages within FRAP, in particular the Human Resource and the Safety Study.

2.2 MEASURES

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

All objectives were discussed during controller debriefings, and included in the post-simulation questionnaire to obtain subjective controller opinions.

For objective number 2, and 5 the results are based on a comparison between a Fixed Route scenario (ARN-v3) and a Free Routes Scenario (FRA). Data recorded during the simulation was used to conduct this comparison.

The following data was collected during the simulation

Subjective data

- Questionnaires, The controllers were asked to fill in questionnaires before and after the simulation.
- Instantaneous Self Assessment (ISA) (See below)
- 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 flightplan

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

Example:

Towers should be build even higher to give a better view to the controllers.					
Strongly disagree	Disagree	slightly disagree	Slightly agree	Agree	strongly agree
				X	

In the above example the controller agrees with the idea that towers should be build higher.

The opinion of eight controllers working on measured sectors is included in this report. In this report, the answers are indicated as the number of controllers selecting each possibility.

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 position 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.

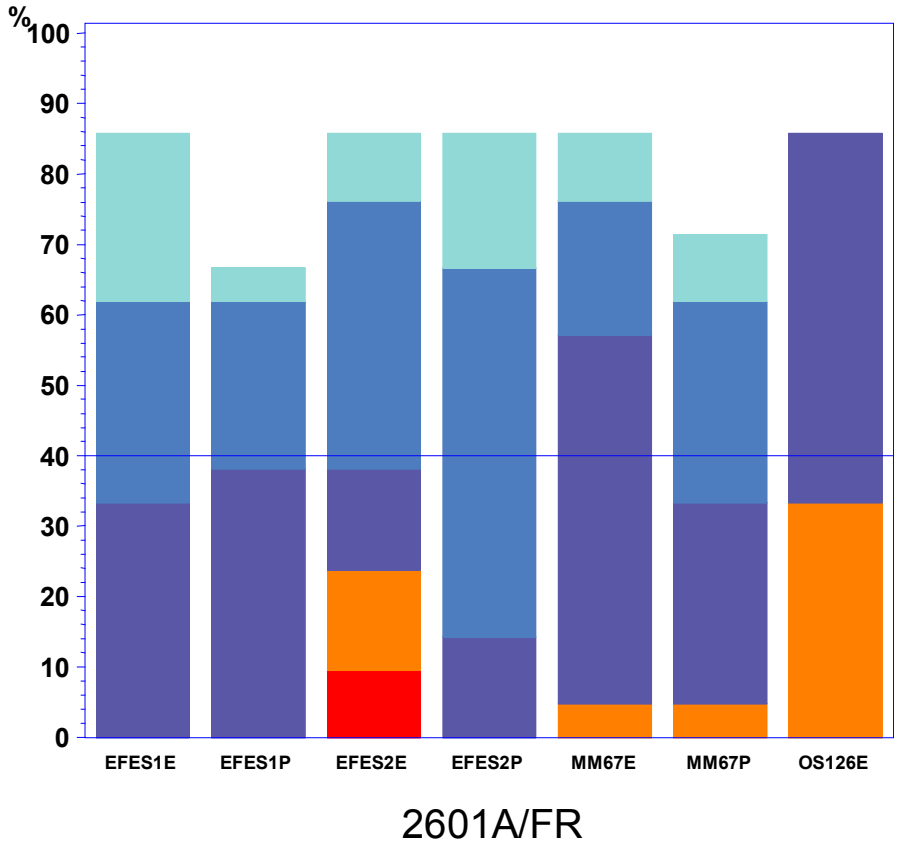


Fig. 1: Example of ISA recording

Sample and data collected

Nine controllers and two military air defence specialists were involved in this study. The main characteristics of this group are presented in table 1.

Total Sample	9
Male	9
Female	0
Age – mean	39,5
Age – min	28
Age – max	55

Table 1: Sample description

3. SIMULATION CONDUCT

3.1 AIRSPACE

3.1.1 The simulated area

The simulation airspace included parts of Hannover UIR and Copenhagen 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 Operations Room Configuration

The operations room was configured with 9 Controller Working Positions (CWPs). 7 of these CWPs were used for measures.

Measured sectors were as follows:

Sector Name	Sector Code	CWPs EXC	CWPs PLC
Maastricht Coastal	CST	1	1
Lippe Radar	LIN	1	1
Copenhagen C	USC	1	1
Copenhagen N	USN	1	0

Table 2: Controller Working Position Configuration

3.1.3 Route Structure

The routes used in the simulated airspace were as defined in ARN Version 3.

3.1.4 Restricted and Danger Areas and Temporary Segregated Airspace

The following Restricted and Danger Areas were included in the simulation:

Reference	Level
ED D19	Sea Level - 40000ft
ED D28	Sea Level - 48000ft
ED D41	Sea Level - 30000ft
ED D44	Sea Level - 48000ft
ED D46	Sea Level - 45000ft
ED D100	5500ft - 35000ft
ED D101B	24500ft - 35000ft
ED R10 (sector B)	Sea Level - 40000ft
ED R11	Sea Level - 48000ft
ED R33	GND - 40000ft
ED R34 (sector A)	GND - 30000ft
ED R302 (TRA-Weser2)	FL245 - FL500
EK D51	GND – UNL
EK D52	GND – UNL
EK D73	GND - 40000ft
EK R12	GND – UNL
EK R13	GND – UNL
EK R14	GND – UNL
EK BR1	GND - FL460
EK SKA	GND - FL340

Table 3: R&D Areas

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 units.

3.2 TRAFFIC

3.2.1 Creation

The 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.

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

The samples were adjusted, to include conflicting traffic situations within the measured sectors and to reflect a workload equivalent to present published sector capacity. This was done to compensate for the implementation of RVSM and the fact that simulated traffic gives a lower load than real traffic on the controller. 30% traffic was added on today's published capacity to achieve this. These 130% samples were not simulated, but used for the creation of the simulated future scenarios

Adding 20% and 40% traffic to the 130% samples then created two traffic levels. This gave two levels of traffic for the simulation, 150% and 170%

To prevent the controller from getting to familiar with the traffic samples, each traffic level existed in three different variants, with the same traffic load, but different flight.

For each of the traffic samples, a similar Free Routes (FRA) traffic sample was created. In the FRA samples, 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 flightplan around segregated airspace. The 170% route samples were not simulated. This gave a total of nine samples to be simulated.

SECTOR	Actual Declared Capacity	Aimed throughput	
		150% samples	170% samples
Maastricht Coastal (incl. Lippe radar)	47	70	80
Copenhagen C	42	63	71
Copenhagen N	37	56	63

Table 4: Declared Sector Capacity

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.

Simulated traffic figures 150% Fixed Route	Simulated traffic figures 150% Fixed Route		Simulated traffic figures 150% Free Route		Simulated traffic figures 170% Free Route	
	Flow/ hour	Peak	Flow/ hour	Peak	Flow/ hour	Peak
Maastricht Coastal Lippe Radar	60 25	26	57 25	24	71 25	27
Copenhagen C	57	17	56	17	67	20
Copenhagen N	42	21	41	20	50	25

Table 5: Hourly Throughput and Instantaneous Peaks during the 150% FRA exercises

3.3 PROGRAM OF EXERCISES

Traffic samples in fixed routes are labelled “AR”. Free Route samples are labelled “FR”, 150% samples are labelled “15”, 170% samples are labelled “17”. The three variants of each basic sample are labelled “mx”, “my” and “ex”.

Exercises run with Medium Term Conflict Detection (MTCD) was available to the controllers are labelled “_t” exercises where MTCD was not available are labelled “_b”

Day/Date	Exercise 1	Exercise 2	Exercise 3
Day 1, 2 May	15mxFR_b	15myAR_b	Lost due tech.prob.
Day 2, 3 May	15mxAR_t	15myFR_t	15exFR_t
Day 3, 4 May	15mxFR_b	15myFR_b	15exFR_b
Day 4, 5 May	15mxFR_t	15myFR_t	15exAR_t
Day 5, 8 May	15mxFR_b	15myAR_b	15exFR_b
Day 6, 9 May	15mxFR_t	15myFR_t	Briefing
Day 7, 10 May	17mxFR_t	15myFR_t	Briefing
Day 8, 11 May	17mxFR_b	17myFR_b	17exFR_b
Day 9, 12 May	17mxFR_t	Briefing	Briefing

Table 6: Program of exercises

22 measured exercises were executed.

3.4 SIMULATED ATC SYSTEM

3.4.1 Controller Working Positions

The Measured Controller Working Position consisted of:

- Sony 29’ square colour display, used to provide a multi-window working environment;
- Hewlett Packard processor and Metheus display driver;
- 3 Button Mouse;
- A 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 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 3000' to unlimited.

3.4.2.2. 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 coordination messages.

3.4.2.2. Medium Term Conflict Detection

Medium Term Conflict Detection (MTCD) was provided in some of the exercises. The information was presented to the Planner Controller (PLC) in a separate window for flights not yet under control of the particular sector. The look-ahead time was 15 minutes. For flights under control of the particular sector, MTCD information was presented to the Executive Controller (EXC) directly in the data label of the subject aircraft. Look-ahead time was 4 minutes before predicted loss of separation.

3.4.2.5. 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) had 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 5 NM and 1000' (2000' for non-RVSM equipped aircraft and above FI 400) within 2 minutes.

MTCD information was presented to the PLC in Conflict and Risk Display (CRD). A presentation of the vertical profile together with other traffic along the flight path was available in a separate window, Vertical Aid Window

3.4.4 ATC Procedures

Revised Letters of Agreement between the involved ACCs were developed, in order to allow the use of Free Routes. Levels were in accordance with the RVSM semi-circular rule.

3.4.5 Provision of service

All In Copenhagen ACCs the same controller provided ATC service to civil and military aircraft. For Maastricht, a military sector suite (Lippe Radar) managed military air traffic.

4. CONTROLLER TRAINING

The participating controllers received a training package consisting of two days of training on the HMI followed by 5 days training during the simulation acceptance week. The training package was a mixture of class-room training covering procedures such as FRAC, RVSM and related matters, and the HMI and functionality of the simulated system.

After the simulation the controllers were asked whether the training was sufficient, and whether the feed sectors and traffic samples were simulated in a realistic way.

The 4 questions and the answers are shown below.

There was enough training to get familiar with the FRAP procedures.

Strongly disagree	Disagree	Slightly disagree	Slightly agree	agree	Strongly agree
		3		6	

There was enough training on the HMI, its rules and its mechanisms.

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		3	2	3	

The traffic samples were realistic.

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
	1	1	1	5	1

The feed sectors were suitably simulated.

Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		1	2	6	

It is clear that as the simulated functionality is becoming more and more complicated, the need for training is increasing. Even with the 2 day training session before the Acceptance Week, training seems to be inadequate. It should be understood that the problem with regard to training is not to arrange and conduct more training within the project, but to get the controllers released from their administrations.

The main problem with the traffic samples seemed to be that they were to repetitive. Some repetitiveness is required for analysis purposes, however for future simulations the effect of the repetition will be reduced.

Based on the answers received, the simulated scenario is considered valid for the validation.

5. RESULTS

5.1 OBJECTIVE 1

Assess the proposed lateral and vertical limits of the Free Routes Airspace with regard to traffic complexity, traffic load and interface problems.

5.1.1 Recordings

None

5.1.2 Questionnaires

The lowest level for Free Routes should be higher than the simulated (Fl285).					
Strongl Disagre	Disagre	slightly disagre	slightly agree	agree	strongly agre
2	7				

The lowest level for Free Routes should be lower than the simulated (Fl285).					
Strongl Disagre	Disagre	slightly disagre	slightly agree	agree	Strongly agr
	4		1	4	

Controlling a mixture of Free Routing and non-Free Routing flights is more demanding tha controlling pure non-Free Routing flights.					
Strongl Disagre	Disagre	slightly disagre	slightly agree	Agree	strongly agre
	2	1	1	3	1

Handling a mixture of Free Routing and non-Free Routing flights is confusing.					
Strongl Disagre	Disagre	slightly disagre	Slightly Agree	agree	Strongly agr
	3	1	2	1	1

5.1.3 De-briefings

The following comments were brought up during the de-briefing:

- The bottom level of Free Routes airspace should be the same throughout the 8 states. To have different bottom levels would make it very complicated for the ATCO.
- Sectors with a mixture of Free Routes and Fixed Route traffic would be difficult for the ATCO to manage.
- The selected bottom level of FL 285 seems to be correct.

5.1.4 Discussion

The proposed bottom level of Fl 285 has now been simulated during 3 simulations. It seems to be a good choice. It is clear that a common bottom level should be chosen for the entire Free Routes area, in order to avoid a very complex situation where aircraft with the same destination within the same sector will be flying towards different points.

It is clear that the higher the bottom level is, the less the problem with segregated airspace will be, something that has to be considered.

Sectors should be purely Fixed Routes or purely Free Routes, at least in areas with high or medium traffic load. This will have an impact on the number of sectors, and could lead to a different bottom level for Free Routes in order to distribute traffic evenly between sectors.

5.2 OBJECTIVE 2

Determine whether expected capacity gains are likely to be met.

5.2.1 Recordings

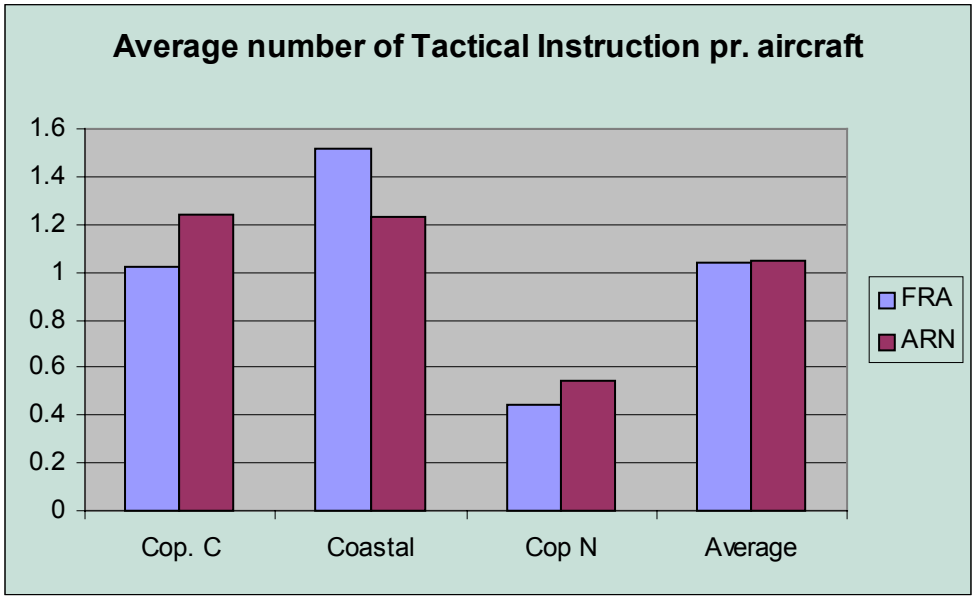


Fig 2. Average number of tactical instructions

Fig. 2 shows the average number of tactical instructions (climb/descend, heading, direct and speed) per aircraft. There is no difference between FRA and Fixed routes.

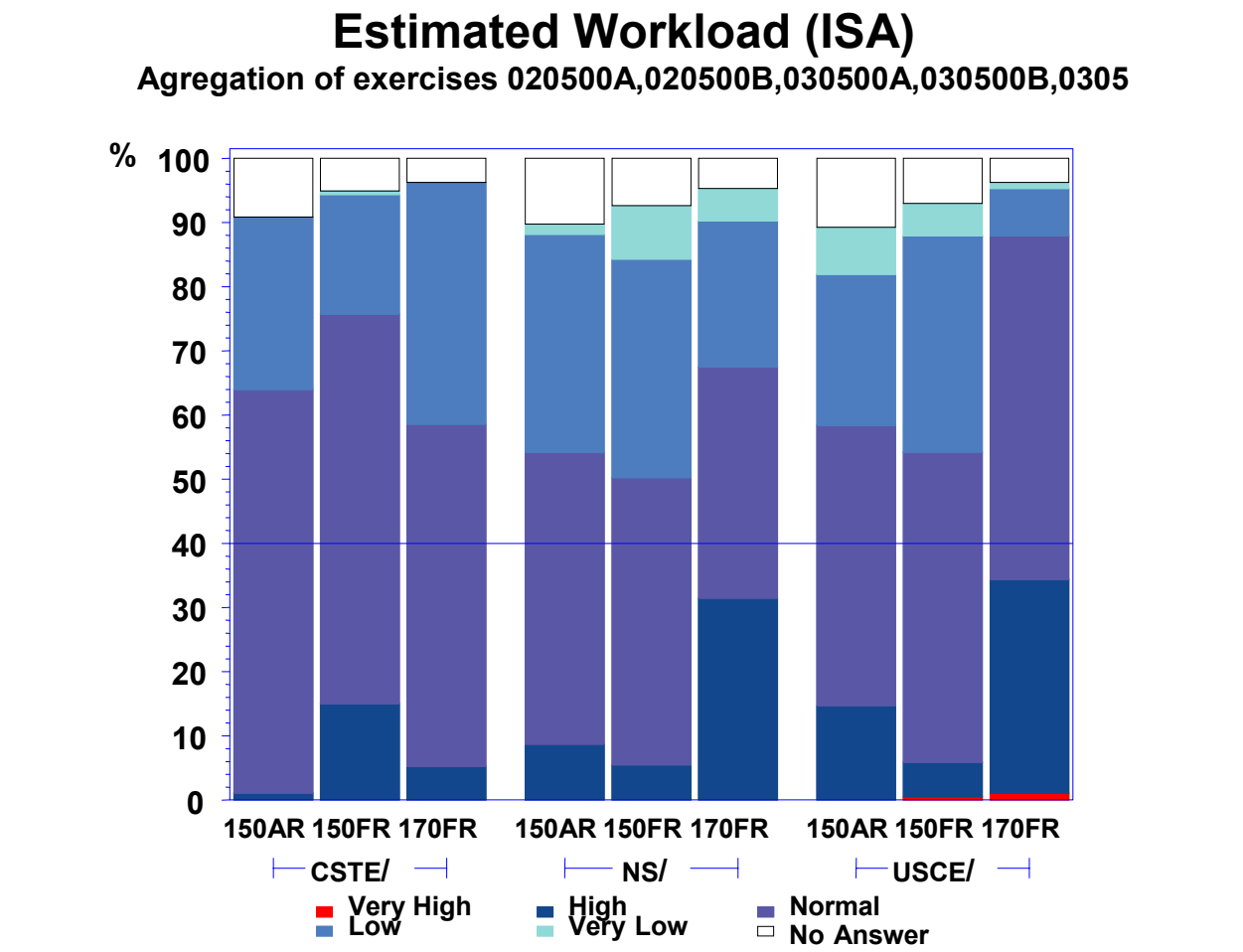


Fig. 3, Perceived workload (EXC)

Fig. 3 shows the perception of workload of the 3 EXCs Coastal, Copenhagen N and Copenhagen C. 150AR is the average of all Fixed Route exercises with 150% traffic, 150FR the average of all FRA exercises with 150% traffic and 170 the average of all 170% FA exercises.

For the Coastal Sector there is an increase in High load when moving from 150% Fixed to 150% FRA, but then a decrease when moving from 150% to 170%. This decrease cannot be explained.

For Copenhagen N and Copenhagen C there is a decrease when moving from Fixed routes to FRA with the same traffic load, and then the expected increase when traffic load is increased.

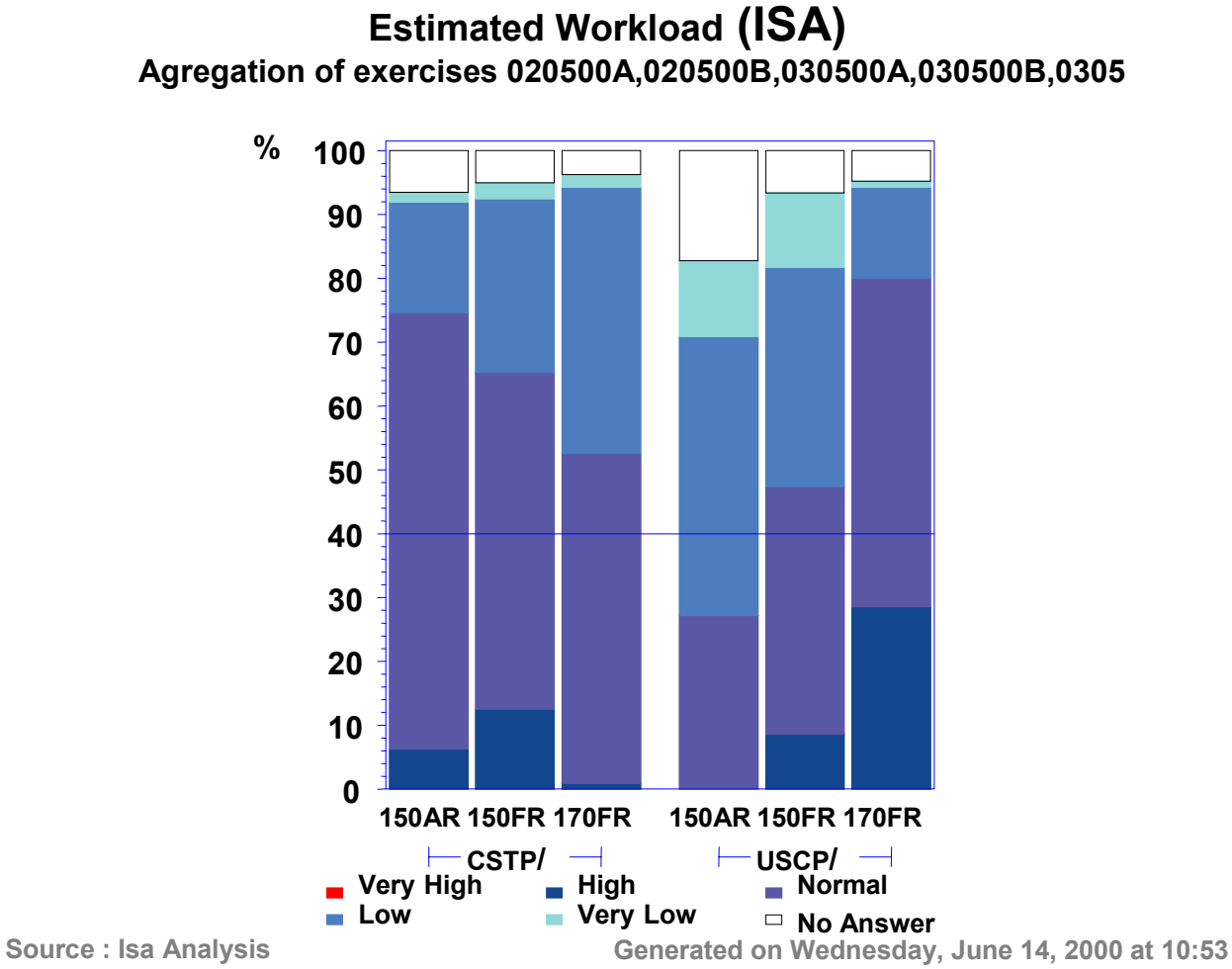


Fig. 4, Perceived workload (PLC)

Fig. 4 shows the perception of workload of the 2 PLCs Coastal and Copenhagen C.

For the Coastal Sector there is an unchanged workload moving from Fixed Routes to FRA. When increasing traffic load, workload goes down. This makes the results for this sector doubtful.

For Copenhagen C there is an increase in workload when moving from Fixed Routes to FRA, and again an increase when increasing workload.

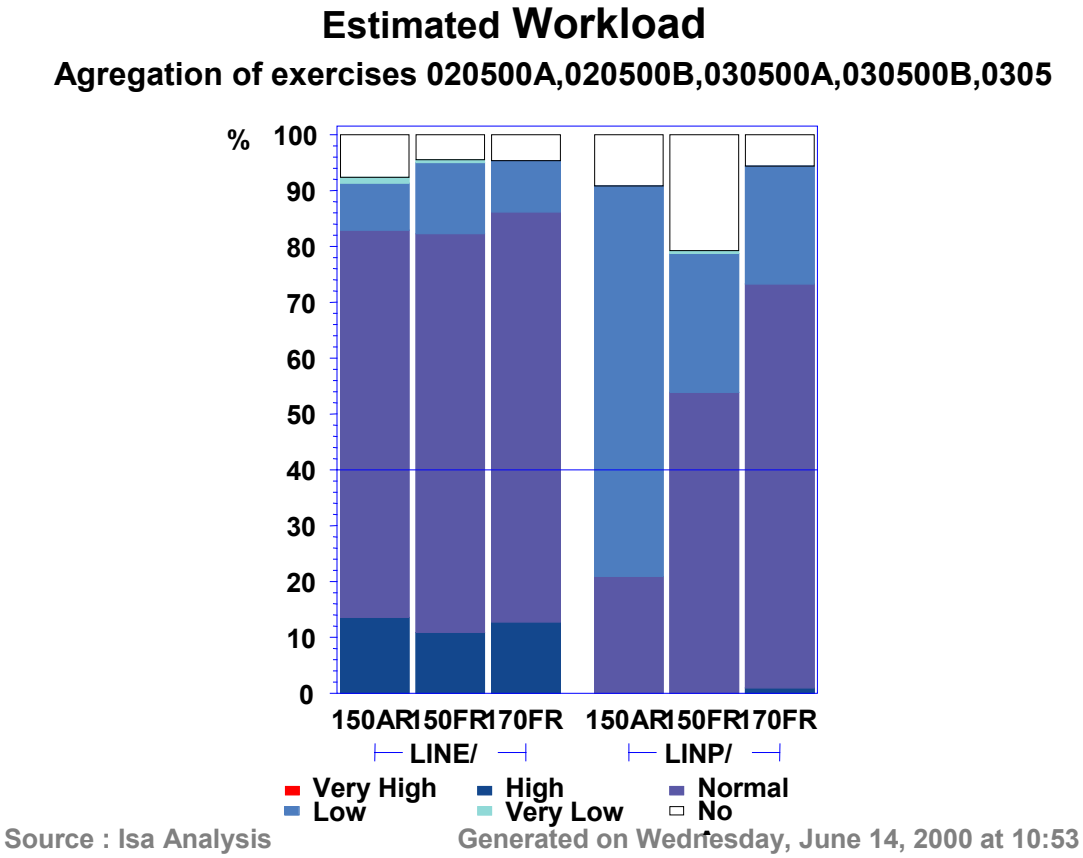


Fig. 5, Perceived workload (MIL)

Fig. 5 shows the perception of workload of the Lippe Radar EXC and PLC.

Military traffic load was the same under all conditions.

The perceived workload of the EXC is unchanged in Fixed Routes and FRA, even when the civil traffic increases.

The PLC indicates a clear increase in workload when moving from Fixed Routes to FRA and a further increase when civil traffic load goes up.

5.2.2 Questionnaires

Free Routing enabled you to handle more traffic in general.					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
	1	1	4	3	

Free Routing enabled you to provide the airspace users a better level of service.					
Strongly Disagree	Disagree	slightly disagree	Slightly Agree	agree	Strongly agree
	3	1		4	1

It requires more attention to monitor traffic in Free Routes					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
	1			5	3

Conflicts are easier to solve with Free Routes					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
	4	2	1	2	

Civil military coordination becomes more demanding in Free Routes					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
			2	5	2

OAT transit flights are more difficult to handle in Free Routes					
Strongly Disagree	disagree	Slightly disagree	slightly agree	agree	Strongly agree
	3	1		4	1

Activation of segregated airspace has a bigger impact on capacity in Free Routes than with a route structure.					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
			3	3	2

Free Routing enabled you to execute your tasks more effectively.					
Strongly Disagree	Disagree	slightly disagree	Slightly Agree	agree	Strongly agree
1	3	1	2	2	

5.2.3 De-briefings

- The general feeling amongst the civil ATCO's is that FRA leads to a small reduction in workload. The military controllers do not have the same feeling.
- The distribution of traffic is an advantage
- It is more demanding to monitor the traffic picture for the civil as well as for the military controller

5.2.4 Discussion

The civil ATCO's like the concept, and would like to see it implemented. It must be remembered that these results are valid for the simulated area only. Some concern have been raised by ATCO's about other areas, e.g. the southern part of Maastricht airspace.

The average number of tactical instructions per aircraft is the same in FRA and Fixed Routes. This indicated that that task remains unchanged for the EXC. It also indicates that the frequency load is the same in the two conditions.

The ISA recordings of perceived workload show a decrease in workload for the EXC's in Copenhagen ACC. It is assumed that this decrease is due to a reduced number of conflicts. For the Copenhagen PLC, FRA leads to an increase of workload, indicating that the monitoring task becomes more demanding.

The Coastal Sector ISA results are to be considered as doubtful, as an increase in traffic leads to a decrease of perceived workload

On the military sector, FRA does not lead to any change of workload for the EXC, but the workload of the PLC increases.

All flights were circumnavigating segregated airspace. Only a very few flights had to be co-ordinated through military airspace. Depending on the procedures chosen in each individual country, this may lead to additional workload.

If flights are not flightplanning around segregated airspace, additional workload will be added to issue tactical instructions or to co-ordinate flights through military airspace.

5.3 OBJECTIVE 3

Assess additional HMI requirements for a FRAC environment.

5.3.1 Recordings

None

5.3.2 Questionnaires

Free Routes require an HMI different from the one used in a Route Scenario.					
Strongly Disagree	Disagree	Slightly disagree	Slightly Agree	agree	Strongly agree
	1	2		6	

5.3.3 De-briefings

- In general the controllers disliked the HMI used, the colour concept was confusing, there was not enough contrast on the screen, labels took up to much space.

5.3.4 Discussion

The fact the participating controllers had a negative attitude towards the simulated HMI made it difficult to discuss HMI features related to FRA.

5.4 OBJECTIVE 4

Provide support to studies concerning flight-planning issues in FRA, specifically the issue of circumnavigation of segregated airspace on a strategical and a tactical level.

5.4.1 Recordings

No recordings

5.4.2 Questionnaires

Under Free Routing, it was not always clear why an aircraft was choosing to fly its particular route.					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
	2	3	2	1	

Operator should send flightplans that assured separation to segregated airspace.					
Strongly Disagree	disagree	Slightly disagree	Slightly Agree	agree	Strongly agree
2	3	1		2	1

5.4.3 De-briefings

- Flightplanning should be directly from FRA-entry to FRA-exit in order to
  - Improve situational awareness
  - Reduce complexity
  - Increase simplicity
- This will give a false security. There is a risk that we will not discover flights that by mistake do not circumnavigate by themselves.
- We should not wait for now features to be in place before introducing FRA

5.4.4 Discussion

In this simulations all flights were planned to, and flightplans were constructed to, circumnavigate active segregated areas. This gave a reduction in the co-ordination workload for the PLC and tactical instructions for the EXC.

The controllers did not like this concept, they felt that it was more difficult to maintain the traffic picture, conflicts were more difficult to predict, as aircraft sometimes turned without prior notice.

It was a general concern amongst the controllers, that with the complexity of areas being activated and deactivated, many flightplans would not be correct, leaving an even more complicated task to the controller.

In the first FRAP simulation of the same area, a reduction in flown distances of 2 % was found when introducing FRA. This was not reproduced during this simulation. The reason for this is probably that more segregated airspace was activated, confirming that segregation of airspace has a bigger impact in FRA.

Although it is understood that the operators may wish to be able to plan the route as close to reality as possible, to be able to estimate fuel etc, the controllers would prefer flightplans directly from FRA-entry to FRA-exit.

5.5 OBJECTIVE 5

Assess the use of ATC planning tools such as MTCD and APW and identify potential capacity gains related to these tools. Provide feedback on the simulated functionality and identify possible shortcomings

5.5.1 Recordings

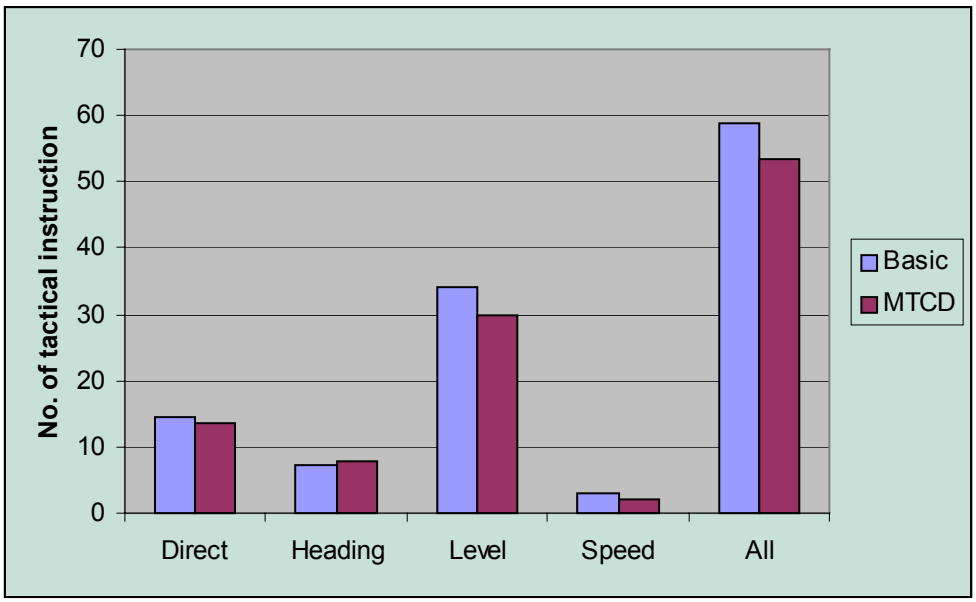
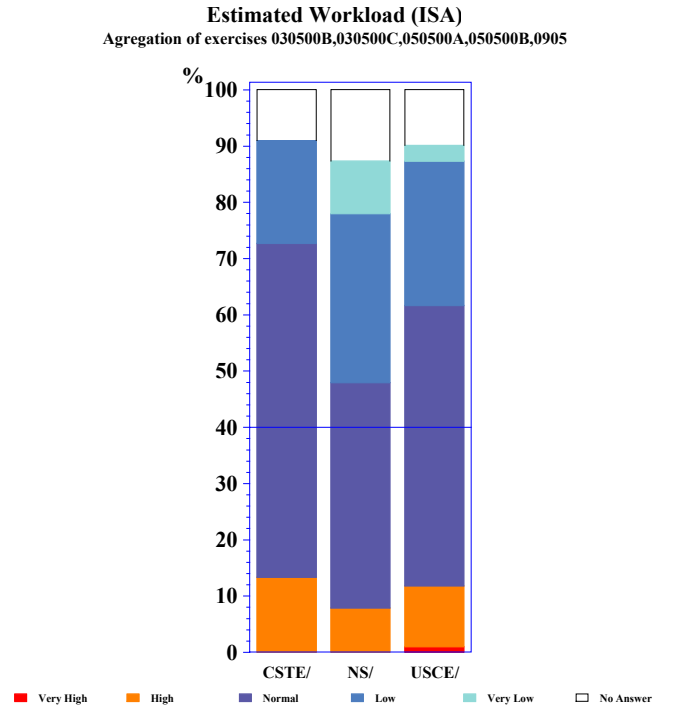


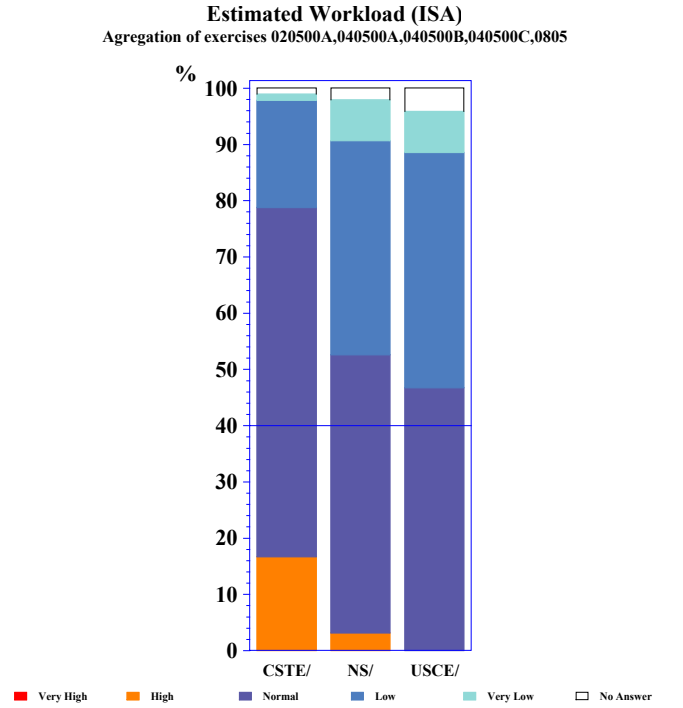
Fig. 6, Number of Tactical Instructions

Fig. 6 shows that there is a reduction of about 12% in the number of tactical instructions when MTCD is available to the controllers.



Source : Isa Analysis Generated on Friday, June 23, 2000 at 11:17

Fig. 7, Perceived workload, all FRA exercises without MTCD (EXC)



Source : Isa Analysis Generated on Friday, June 23, 2000 at 11:18

Fig. 8, All FRA exercises with MTCD (EXC)

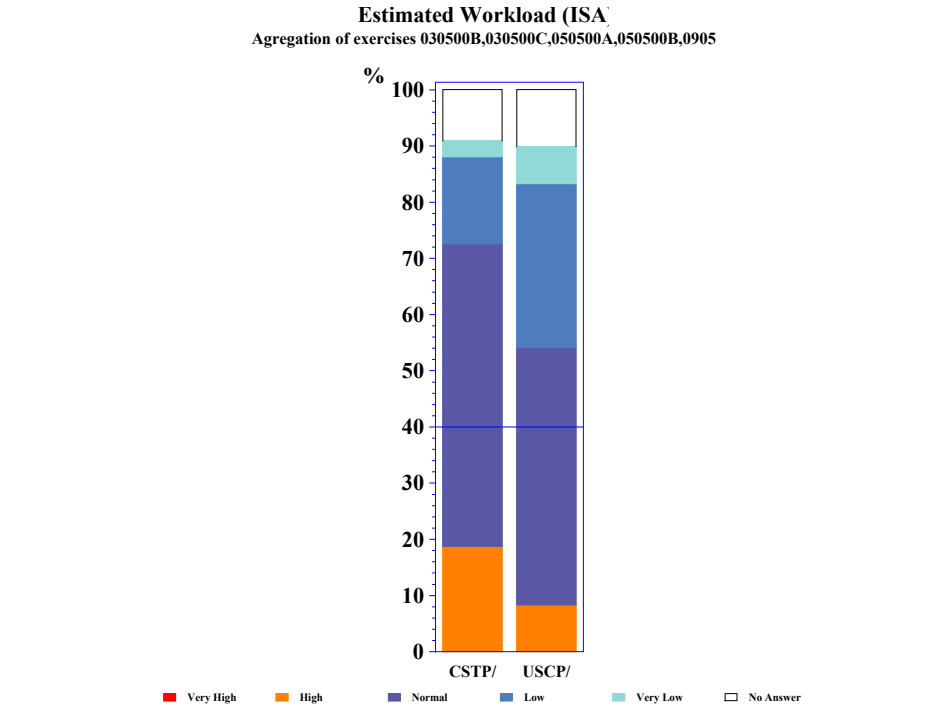


Fig. 9 Perceived workload, all FRA exercises without MTCD (PLC)

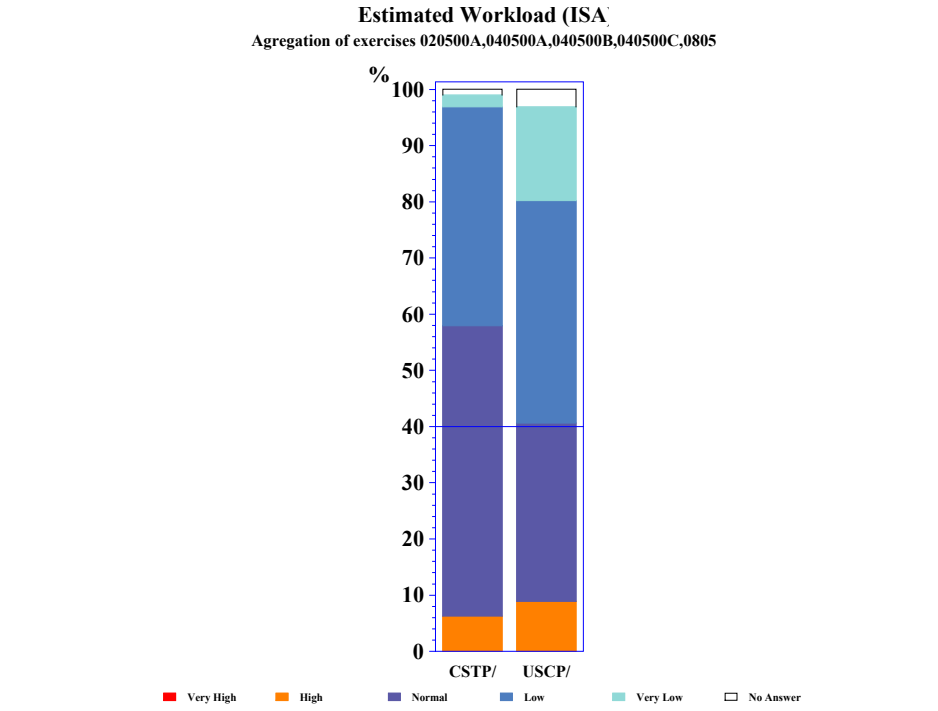


Fig. 10, Perceived workload, all FRA exercises with MTCD (PLC)

Fig. 7 shows average ISA values for EXCs of all FRA exercises where MTCD was not available, Fig. 8 shows the exercises where MTCD was available. The results show a small reduction in perceived workload for the EXC when MTCD was introduced. The results from Coastal sector may be incorrect, as it was seen before.

Figure 9 and 10 show the same date for the PLCs. Also here is there a small reduction of perceived workload when MTCD is introduced.

5.5.2 Questionnaires

It requires more attention to monitor traffic in Free Routes					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
	1			5	3

Free Routing should include more automation of my routine tasks.					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
		1	2	5	1

Conflict solving becomes more tactical in Free Routes, it is difficult for the planner/coordinator to foresee conflicts.					
Strongly Disagree	Disagree	slightly disagree	Slightly Agree	agree	Strongly agree
	1	1	1	5	1

Free Routing enabled you to execute your tasks more effectively.					
Strongly disagree	Disagree	slightly disagree	Slightly Agree	agree	Strongly agree
1	3	1	2	2	

The MTCD used during the simulation enables me to accept more traffic.					
Strongly Disagree	disagree	Slightly disagree	Slightly Agree	agree	Strongly agree
5	3		1		

A better MTCD than the one used in this simulation would increase my capacity.					
strongly disagree	Disagree	Slightly disagree	Slightly Agree	agree	Strongly agree
	4			3	2

Introduction of MTCD will be necessary before introduction of Free Routes.					
strongly disagree	Disagree	Slightly disagree	Slightly Agree	agree	Strongly agree
	6	1	1	1	

System Supported Coordination reduces the workload.					
Strongly Disagree	Disagree	Slightly disagree	Slightly Agree	agree	Strongly agree
		1	3	3	2

5.5.3 De-briefings

- The MTCD used is not optimised to the way we work, it gives to many false alarms
- Bad MTCD is worse than no MTCD
- The MTCD should also include a buffer around the sector
- MTCD in an environment with OAT is very difficult to make
- MTCD is not an enabler for FRA

5.5.4 Discussion

The quality of the MTCD used during the simulations was regarded by the ATCO's to be very poor. There are two factors that leads to this, the MTCD concept, which was quite simple, and the quality of the Trajectory prediction in the simulator, which leads to wrong or missing conflicts.

It was not the general opinion amongst the ATCO's that MTCD would lead to higher capacity by it self. MTCD was more seen as a necessary support to assist the controller in the task of identifying conflicts at high traffic levels.

Regardless of the subjective feeling of the ATCO's, MTCD had an impact on the controller workload. In exercises where MTCD was available 12% less tactical instructions were issued, indicating that it was easier to judge correctly whether a conflict would occur or not when MTCD was available. Also the perceived workload was reduced for the EXCs when MTCD was available, as indicated in the ISA figures.

Controller acceptance is one of the main parameters when validating a tool like MTCD, and that was not achieved.

One of the objectives of the tools is to facilitate a better distribution of tasks between the PLC and the EXC. This was not achieved with the simulated set-up. There was a clear tendency to solve problems on a tactical basis, the PLC being unable to assist with more strategic decisions, with or without MTCD.

Although MTCD is not considered an enabler for FRA, it was the general impression that the requirement for MTCD will come at a lower traffic level in FRA than with Fixed Routes

5.6 OBJECTIVE 6

Further develop controller roles when working in a Free Routes environment.

5.6.1 Recordings

None

5.6.2 Questionnaires

The Free Routing will not fundamentally change the way that controllers work.					
Strongly Disagree	Disagree	slightly disagree	Slightly Agree	agree	Strongly agree
6	1	1	1		

Free Routing will require a re-distribution of tasks within the team.					
Strongly Disagree	disagree	slightly disagree	Slightly Agree	agree	Strongly agree
	1	1	4	3	

The Free Routing changes routine communication tasks					
strongly disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
1	5	1	2		

Free Routing changes the Executive job more than it changes the Planner job					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
1	6		1		

Free Routing changes the Planner job more than it changes the Executive job					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
			5	1	3

It requires more attention to monitor traffic in Free Routes					
Strongly Disagree	disagree	slightly disagree	slightly agree	agree	Strongly agree
	1			5	3

5.6.3 De-briefings

- The PLC is doing nothing, the EXC is busy
- The PLC is not able to support the EXC
- It all become more tactical

5.6.4 Discussion

It is clear that FRA not fundamentally changes the way controllers work, there is however a change in the effort required for each task. The monitoring of the traffic situation is more demanding, but there are fewer conflicts to solve.

The simulation was based on the philosophy that the MTCD would enable the PLC to assist the EXC in the search for conflicts, thus reducing the monitoring task, and solve some conflicts before the flights entered the sector. This did not work during the simulation, MTCD did not give sufficient support to the PLC to enable him to offload the EXC.

It should be noted, that also in the Fixed Route exercises, the PLC and EXC both worked in a very tactical mode, probably due to the relatively high traffic levels simulated.

Even if the recorded data shows a reduction in perceived workload when MTCD was available, it would be wrong to say that the simulation gave a clear answer to the problem of work distribution between EXC and PLC in a stripless system.

The participating controllers seemed to be happy with this way of working, but it was expected that a more strategic view could reduce the workload.

5.7 OBJECTIVE 7

Assess the impact on military operations, en-route as well as air defence and other special military operations in a 2008 scenario Free Routes Airspace.

5.7.1 Recordings

None

5.7.2 Questionnaires

None

5.7.3 De-briefings

- To bring OAT from A to B is not more difficult in FRA
- Conflict analysis is more demanding
- RVSM is a bigger problem than expected
- The OAT controller has to be more alert in FRA

5.7.4 Discussion

As during the first simulation, it was clear that FRA as such requires more attention of the OAT controller, as traffic is flying random routes, and not in regulated streams. It is not more difficult to get enough space to manoeuvre, as the civil traffic is less concentrated.

Although outside the scope of the simulation, RVSM was discussed. It was clear that RVSM will cause problems to OAT not capable of flying RVSM. Finding space between civil flights with 4000' vertical spacing will be difficult. This may call for more segregated airspace, e.g. for test flights, refuelling tracks, AWACS.

The NON-RVSM capability of OAT flights may have a strong impact on OAT flight profiles, traffic density below Fl 280, and air defence training exercises within the GAT environment

6. CONCLUSIONS

Assess the proposed lateral and vertical limits of the Free Routes Airspace with regard to traffic complexity, traffic load and interface problems.

- The proposed bottom level of Fl 285 seems to be correct
- The bottom level of FRA should be the same throughout the FRA area
- In medium and high density traffic areas, sectors should also be split at the bottom level of FRA

Determined whether expected capacity gains are likely to be met.

- No reduction in controller workload was demonstrated.
- The civil controllers in general like the Free Routes Concept

Assess additional HMI requirements for a FRAC environment.

- The participating ATCO's did not accept the HMI used during the simulation. This made it difficult to discuss details.

Provide support to studies concerning flight-planning issues in FRA, specifically the issue of strategic and tactical circumnavigation of segregated airspace.

- ATCO's prefer flightplans directly from FRA-entry to FRA-exit in order to avoid operational and technical complexity.

Assess the use of ATC planning tools such as MTCD and APW and identify potential capacity gains related to these tools. Provide feedback on the simulated functionality and identify possible shortcomings.

- Availability of MTCD reduced the number of tactical instructions with about 12%
- The controller perceived workload was reduced when MTCD was available
- ATCO's did not like the simulated MTCD concept
- The planners did not tale more strategic decisions when MTCD was available

Further develop controller roles when working in a Free Routes environment.

- Although there is no dramatic change to the way controllers work in FRA, it is evident that the work becomes more tactical
- A better distribution of tasks was not achieved

Assess the impact on military operations, en-route as well as air defence and other special military operations in a 2008 scenario Free Routes Airspace.

- Monitoring the traffic situation becomes more demanding in FRA
- The combination of FRAC and RVSM will cause problems for transiting OAT flights not RVSM equipped

7. RECOMMENDATIONS

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

1. It is becoming more and more urgent to conduct a real time simulation in the busiest areas of the Eight States, in order to find out whether the concept is feasible at all in that area.

2. An optimised MTCD concept with a better support from Trajectory Prediction is crucial for future real time simulations.

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