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EIGHT-STATES FREE ROUTE AIRSPACE PROJECT
1st SMALL SCALE REAL TIME SIMULATION

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SMALL SCALE REAL TIME SIMULATION NUMBER 1, SIMULATION REPORT

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Abstract:

This report describes the first 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 Maastricht Upper Information Region and København Flight Information Region were simulated. The simulation was designed to support the validation of the Free Routes Airspace and is the first of six planned real-time simulation studies. The study focused on the possible capacity gain by implementing the concept, 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 issues were addressed in a parallel study 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 1st Eight-States Free Routes Airspace Project Real-time Simulation. The simulation is the first in 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. Eleven controllers from DFS, CAA Denmark, CAA Norway and Maastricht UAC took part during one or two weeks. Airspace over Northern Germany and Denmark was simulated.

The platform used was based on the functionality and Human Machine Interface presently in use within the Eight-States, and included features such as Paper Strips, Electronic Flight Lists, Short Term Conflict Alert, OLDI, and VHF- and telephone communication.

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 that there is a potential capacity gain and a possibility of providing a better service to airspace users related to the implementation of Free Routes. The capacity gain is in addition to the capacity gain derived from RVSM. In the simulated area this capacity gain can be achieved with only a few minor system upgrades, however to fully exploit the possibilities provided by Free Routes, tools helping to support controllers to maintain situational awareness will be required.

The most important problem facing Free Routes operations in this simulation was the circumnavigation of segregated airspace.

No reduction in the level of service provided to military users was identified in the simulated airspace.

The results obtained should not be considered as final results, but only as first indicators. Only after more in-depth studies of the entire Eight-States airspace can the complete picture be seen.

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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
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
NASA TLX	**NASA T**ask **L**oad Inde**x**
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

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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-1 Facility Specification Part 1 (Conduct and Analysis)
4. Eight-States Free Routes Airspace Project SRT-1 Controller Handbook

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1. INTRODUCTION

The first Small Scale Real-time Simulation of the Eight-States Free Routes Airspace Concept (FRAC) took place at the EUROCONTROL Experimental Centre between 22nd November and 3rd December 1999. The simulation was designed to meet the requirements of FRAP to validate the Free Routes Concept (FRAC).

The simulation was the first of a number of real-time simulations that, together with a number of other activities, shall validate FRAC within the airspace of the 8 participating states (Belgium, Denmark, Finland, Germany, Luxembourg, The Netherlands, Norway, and Sweden.

This first 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 the northern part of Germany and parts of Denmark. The present airspace structure was used, and traffic was based on collected traffic data from June 1999, augmented to the agreed sector load. Civil and military traffic was simulated.

The simulation featured Reduced Vertical Separation Minimum (RVSM), as it is foreseen that RVSM will be implemented before FRAC.

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 Hart Beat Rate. The results of this study are published in a separate report.

2. OBJECTIVES AND MEASURES

2.1 OBJECTIVES

The objectives of the simulation were:

1. Assess the impact, in terms of controller workload and complexity, of the introduction of FRAC in an operational environment representing a typical ATC system in the year 2003

2. Further develop Controller Roles to be used in Free Routes Airspace.

3. Determine whether expected efficiency gains are likely to be met.

4. Assess the impact on military counterparts with respect to OAT transit flights and the use of segregated airspace when introducing FRAC.

5. Assess the proposed lateral and vertical limits of FRAC airspace with regard to traffic complexity, traffic load and interface problems using traffic samples reflecting the expected year 2003 traffic load and flows.

6. Provide feedback on the use of OLDI in a FRAC environment, and identify shortcomings

7. Provide relevant data to other studies in FRAP (Human Performance Study)

2.2 MEASURES

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

For objective number 1, 3 and 7 the results are based on a comparison between a Routes Structured scenario (ARN-v3) and a Free Routes Scenario (FRAC)

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)
- NASA TLX (See below)
- Debriefings. Controller opinions were collected during the daily debriefings

Objective data

- System data, The following data-sets were recorded
- The number of pilot inputs/controller tactical instructions
- Radio usage (not yet included)

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

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 the UKCAA 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.

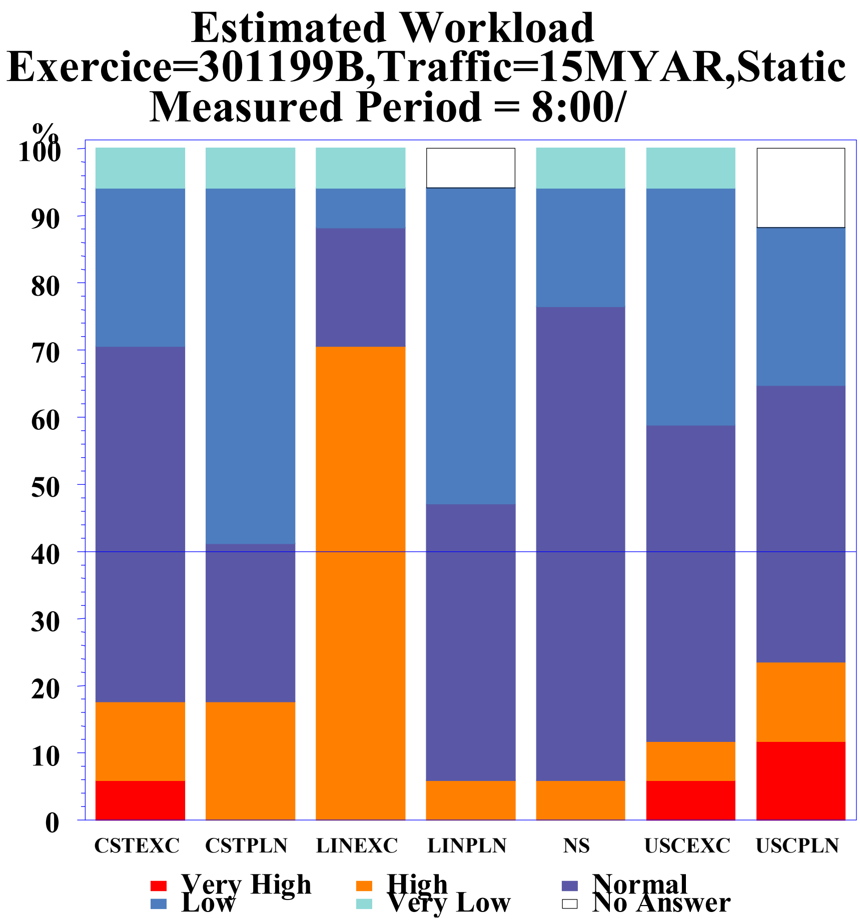

Fig. 1: Example of ISA recording

Sample and data collected

Eleven Controllers were involved in this study. Six Controllers participated in the full two-week period, two controllers participated in one week each on a measures position, and two controllers participated one week each, but on Feed sectors only. The main characteristics of this group are presented in table 1.

Total Sample	n = 8
Male	n = 8
Female	n = 0
Age – mean	40,5
Age – min	35
Age – max	52

Table 1: Sample description

3. SIMULATION CONDUCT

3.1 AIRSPACE

3.1.1 The simulated area

The simulation airspace included the parts of Hannover UIR, Amsterdam FIR and København FIR above FL 245

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/Costal	CST	1	1
Lippe/North	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 Date?.

3.1.4 Temporary Segregated Airspace

The following Temporary Segregated Airspace (TRA) was simulated:

FIR/UIR	Area Name	Level band
København	Nordsø 1 – 8	FL245 – FL380
	BR1	FL195 – FL460
Hannover	TRA 302	FL245 – FL350

Table 3: Temporary Segregated Airspace

3.1.5 Danger and Restricted Areas

The following Restricted Areas were simulated:

ED-D19A, ED-D41A&B, ED-D44, ED-D100, ED-R10B, EK-D51, EK-D52, EK-R12, EK-R13, EK-R14,

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. The levels of aircraft were then transformed into RVSM levels, using the guidelines developed by the RVSM project.

Three base samples were created, two representing the traffic flow in the morning (MX & MY) and one in the Afternoon (EX). 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.

For each of the three traffic samples, a similar FRAC traffic sample was created, In the FRAC samples, traffic was routed directly from the entry point to FRAC airspace to the exit point from FRAC airspace, however flightplans were constructed to avoid segregated airspace. This was achieved by entering one ore more way-points between the FRAC entry and exit point

During the simulation an additional set of traffic samples was created, in order to put additional load on controllers. These samples included an additional 20% traffic increase, without flightplans avoiding segregated airspace.

Traffic samples in fixed routes are labelled “AR”. Free Route samples are labelled “FR”.

The traffic samples representing today's workload have “13” as prefix. Samples including an additional traffic increase of 20% have “15” as prefix.

MX, MY, EX are denotes the different traffic samples in each scenario.

SECTOR	Actual Declared Capacity	Aimed throughput 13-samples	Aimed throughput 15-samples
CST	47	57	72
LIN	n/a	n/a	n/a
USC	47	50	65
USN	41	40	48

Table 4: Declared Sector Capacity

3.2.2 Traffic Sample Analysis

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

Simulated traffic figures	MX		MY		EX	
	Flow/ hour	Peak	Flow/ hour	Peak	Flow/ hour	Peak
CST	57	21	61	25	54	20
USC	40	15	49	14	49	16
USN	31	10	43	18	37	17

Table 5: Hourly Throughput and Instantaneous Peaks, 13AR samples

Simulated traffic figures	MX		MY		EX	
	Flow/ hour	Peak	Flow/ hour	Peak	Flow/ hour	Peak
CST	50	16	55	22	48	9
USC	41	12	41	13	41	20
USN	25	10	42	18	27	12

Table 6: Hourly Throughput and Instantaneous Peaks, 13FR samples

Simulated traffic figures	MX		MY		EX	
	Flow/ hour	Peak	Flow/ hour	Peak	Flow/ hour	Peak
CST	65	23	74	27	71	25
USC	62	15	69	22	65	20
USN	43	20	54	24	45	21

Table 7: Hourly Throughput and Instantaneous Peaks, 15AR samples

Simulated traffic figures	MX		MY		EX	
	Flow/ hour	Peak	Flow/ hour	Peak	Flow/ hour	Peak
CST	62	23	68	28	67	23
USC	50	15	59	16	61	16
USN	40	15	51	26	37	14

Table 8: Hourly Throughput and Instantaneous Peaks, 15AR samples

3.3 PROGRAM OF EXERCISES

Day/Date	Exercise 1	Exercise 2	Exercesi 3
Day 1, 22 Nov		Training	Training
Day 2, 23 Nov	13MX ARN	13MY ARN	13EX ARN
Day 3, 24 Nov	13MX FRAC	13MY FRAC	13EX FRAC
Day 4, 25 Nov	13MX FRAC	13MY FRAC	13EX FRAC
Day 5, 26 Nov	13MX ARN	13MY ARN	13EX ARN
Day 6, 29 Nov	15MX FRAC	15MY FRAC	15EX FRAC
Day 7, 30 Nov	15MX ARN	15MY ARN	15EX ARN
Day 8, 1 Dec	15MX ARN	15MY ARN	15EX ARN
Day 9, 2 Dec	15EX FRAC	15MY FRAC	15MX FRAC
Day 10, 3 Dec	15MX ARN		

Table 9: Program of exercises

24 measured exercises were executes, however for technical reasons recording were partially or fully lost or disrupted for 4 exercises (marked with grey in table 4)

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; (LIN PLC and USC PLC used a 21' monitor)
- 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 12 minutes before the flight time for passing the sector boundary.

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

The simulation used two different HMIs:

Maastricht/Lippe

Executive Controller (EXC) and Planner Controller (PLC) had radar windows with colour coding of the data label of flights assumed by the sector The data label contained callsign, Mode-C level, Cleared Flightlevel (CFL) and Exit Flightlevel (XFL). Flight plan data was presented in list format after the same principles as are used in the present MADAP System. A 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 Fl 400) within 2 minutes. Non-RVSM equipped aircraft were marked with a colour coding of the Mode-C information.

Copenhagen

The EXC had a radar window with colour coding of the data label of flights assumed by the sector The data label contained callsign and Mode-C level. STCA was activated if two flights were predicted to be within 5 NM and 1000’ (2000’ for non-RVSM equipped aircraft and above Fl 400) within 2 minutes. Non-RVSM equipped aircraft were marked with a colour coding of the Mode-C information.

The PLC had paper-strips with flightplan information.

3.4.4 ATC Procedures

A revised Letter of Agreement between Maastricht and Copenhagen was developed, in order to allow the use of Free Routes. All levels were following the RVSM semi-circular rule.

3.4.5 Provision of service

Maastricht/Lippe operated during the simulation with a two-service provider concept with very close co-operation between the civil and military controller. Data is automatically displayed for the other part, and the phone co-ordination is reduced to a minimum.

Copenhagen operated with a single-service provider concept. One sector-suite is handling all traffic within a given volume of airspace.

4. RESULTS

4.1 CONTROLLER WORKLOAD

4.1.1 Objective:

Assess the impact, in terms of controller workload and complexity, of the introduction of FRAC in an operational environment representing a typical ATC system in the year 2003.

4.1.2 Recordings

The ISA recordings shown below are lined up in two columns, the left being an exercise using the route structure, the right one being the same traffic sample in Free Routes, with the same controller on each working positing.

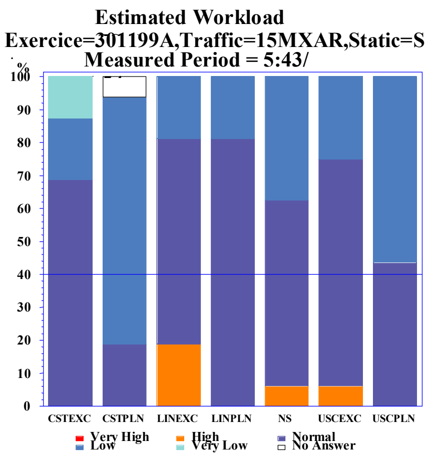

Fig. 2: ISA Sample 15MXAR (Route)

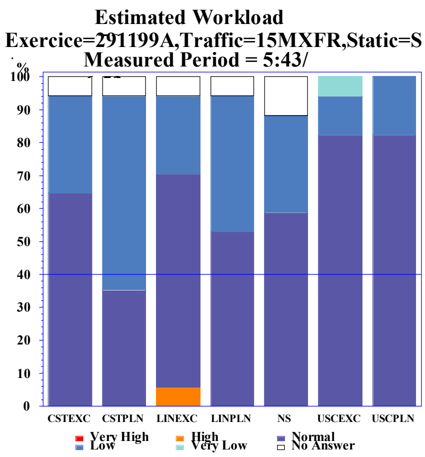

Fig. 3: ISA Sample 15MXAR (Free Routes)

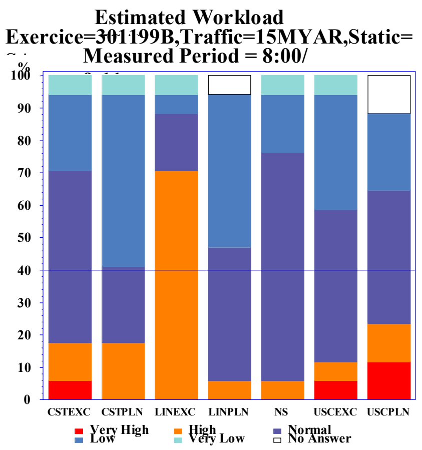

Fig.4: ISA Sample 15MYAR (Route)

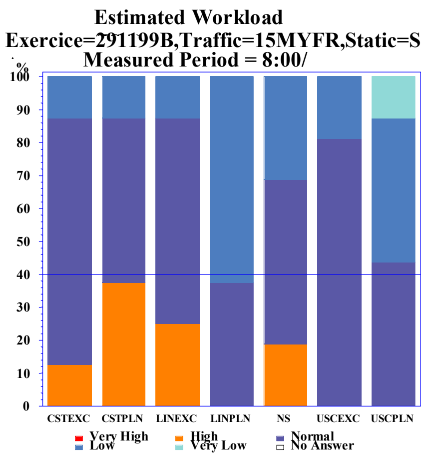

Fig. 5: ISA Sample 15MYFR (Free Routes)

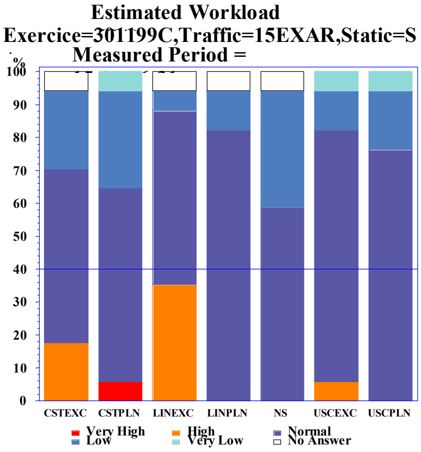

Fig. 6 ISA Sample 15EXAR (Route)

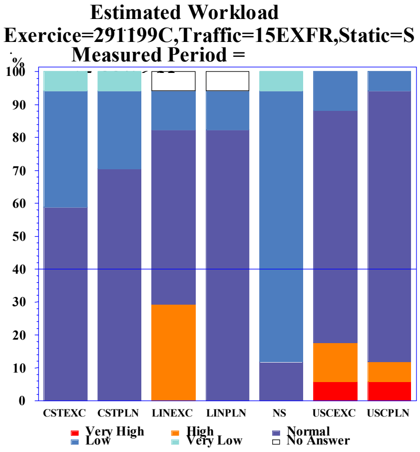

Fig. 7: ISA Sample 15EXFR (Free Routes)

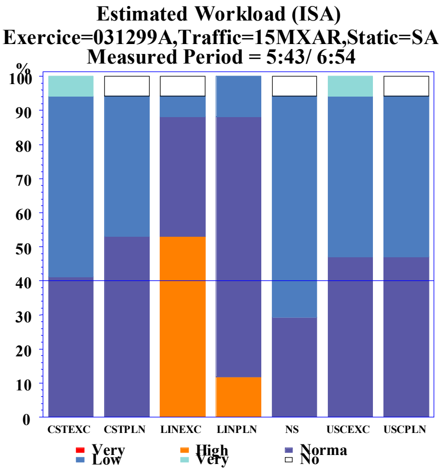

Fig. 8 ISA Sample 15MXAR (Route)

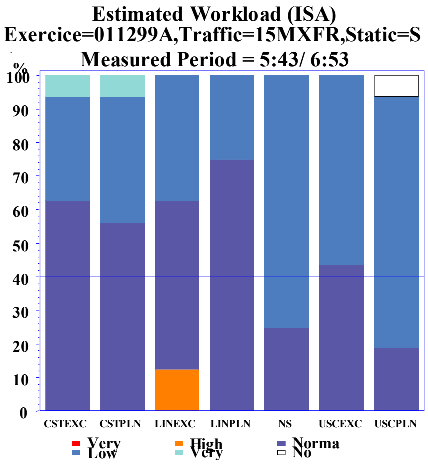

Fig. 9: ISA Sample 15MXFR (Free Routes)

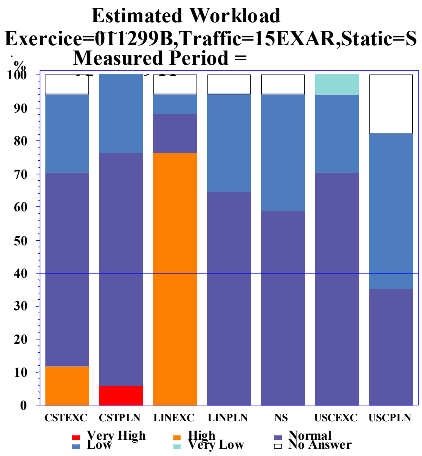

Fig. 10 ISA Sample 15MXAR (Route)

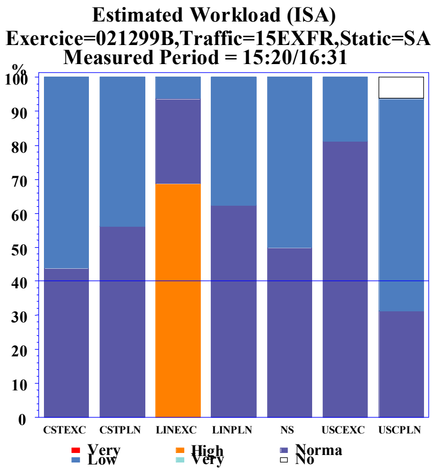

Fig. 11: ISA Sample 15MXFR (Free Routes)

ISA recordings show no clear change in workload between the route structured exercises and the Free Routes exercises, however there is a reduction in “Very High”, in Free Routes that indicates that the number of peaks where the controller is overloaded is reduced

The PLCs feel in general a higher workload than the EXCs. This is in contradiction to the statements made during de-briefings, where PLCs feels unable to support the EXC, and that the work becomes more tactical oriented in Free Routes.

The reason for this can be that the provided tool-set needs more development to provide good support to the PLC

4.1.3 Questionnaires

The concept of operations for Free Routes is difficult to understand.					
Strongly disagree	Disagree	slightly disagree	slightly agree	agree	strongly agree
0	7	1	0	0	0

- The concept is not difficult, but there are many areas where procedures need to be discussed.
- It is often difficult to understand why aircraft are proceeding via intermediate way points.

Free Routes procedures are easy to work with.					
Strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
0	0	0	1	6	1

- Has to become a habit, especially with RVSM.
- As far as procedures were available
- We still need to develop procedures for circumnavigation of airspace
- More monitoring and more conflict points, but workable (Mil)
- We are used to this during week-ends and evenings

It is easy to learn to work with Free Routes.					
Strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
0	0	0	2	5	1

- There is not to much to learn.
- It’s easy, we have the experience from our daily work.
- We need to agree on airspace circumnavigation procedures.

Free Routes changes routine communications tasks.					
Strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
0	3	2	2	1	0

- Circumnavigation of airspace may require a change.
- Adjustments may be needed, but we can work as today.

You had a good picture of the traffic on your sector during the Free Route exercises.					
Strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
0	0	0	0	8	0

- RVSM is a major factor here

4.1.4 De-briefings

It was the general feeling of the controllers that they were able to provide a better service in Free Routes, e.g more often aircraft got an uninterrupted climb to Requested Flightlevel (RFL).

Although it is outside the scope of the simulation, it was clearly stated by the controllers that the implementation of RVSM gave more benefits than they had expected. This resulted in a need for more traffic than originally planned in order to load controllers to permit them to distinguish differences in load and complexity of Free Routes compared with fixed route structured traffic.

4.2 CONTROLLER ROLES

4.2.1 Objective:

Further develop Controller Roles to be used in Free Routes Airspace.

4.2.2 Recordings

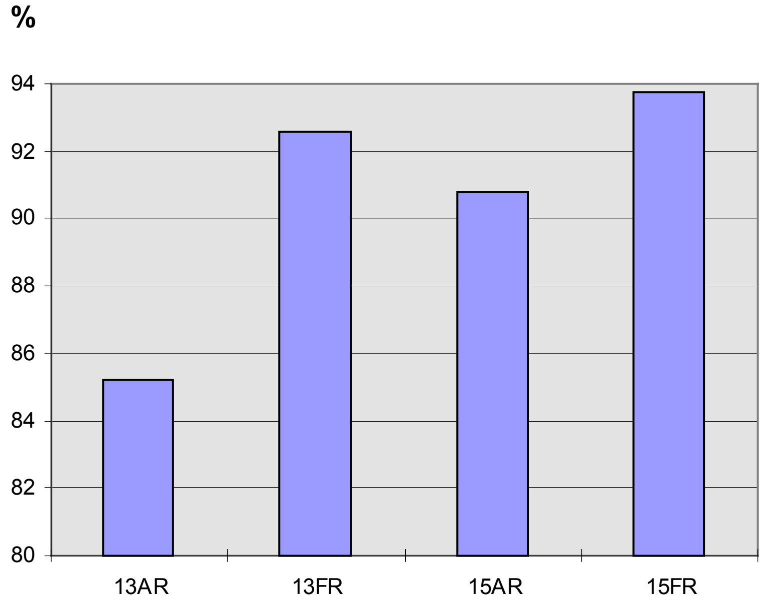

Fig. 12. Percentage of aircraft cleared to requested cruising level

Figure 12 shows that 8,6% more flights in the 130% samples and 3.2% more flights in the 150% samples were cleared to the requested flight level in Free Routes compared to the routes scenario.

Turbulence was introduced in 50% of the 130% samples, this explains why more aircraft are cleared to RFL in the 150% samples.

The recording of separation losses shows no difference between the two scenarios.

The data indicates a higher level of service, and less conflicts in the Free Routes Scenario.

4.2.3 Questionnaires

Free Routes will not fundamentally change the way that controllers work.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	0	1	2	5	0

- Free Routes is already applied in week-ends
- In Copenhagen, where we use strips, it will change, as we cannot identify the conflicts on the strips. Conflict search is left to the EXC.

Conflict solving becomes more tactical in Free Routes, it is difficult for the PLC/Coordinator to foresee conflicts.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	1	0	3	3	1

- The PLC must have a radar screen.
- It will not be difficult - only different.
- Difficult for both (Mil)
- Depending on the tools available and the environment you work in.
- But MTCD might give the PLC a better indication of conflicts.
- A question of experience

Free Routes enables a re-distribution of tasks within the team.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	2	1	1	4	0

- It requires different equipment and better tools.
- Not really in a paper-strip environment.
- Especially for the military coordinator.

Free Routes makes you think differently about the tasks.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	4	1	2	1	0

- Basically we are still separating aircraft.
- Closer coordination civil-military
- Only activate TRA's when needed

4.2.4 De-briefings

The job becomes more tactical. It is more difficult for the PLC to foresee and solve problems. At the same time the capacity gain stemming from RVSM and the expected capacity gain from Free Routes adds on the EXC's tasks. Higher traffic figures means an increase in routine tasks such as frequency changes, SSR-code modifications

This means that the load on the controller team becomes uneven distributed, and the EXC becomes the bottleneck in the system, as it is clearly shown in the ISA recordings.

There are several ways to reduce this problem:

- Sector that are bigger in the lateral plan, but with a vertical split will reduce the number of frequency changes, however it may not be possible to monitor the traffic safely in a big sector.
- Avoidance of SSR-code changes (mode-S)
- Introduction of monitoring tools such as Medium Term Conflict Detection (MTCD) and Area Proximity Warning (APW). The monitoring tools would empower the PLC to off-load the EXC, and hereby reduce the bottleneck. This would result in higher capacity.
- Air-ground data-link; even a limited implementation could releive the EXC for certain non-time-critical routine tasks such as frequency changes.

The above measures shall not be seen as constraints for the introduction of the Free Routes concept, but as ways to increase the capacity once Free Routes is implemented. They are mentioned because it is expected that the benefits of these measures will be higher in a Free Route environment that with fixed routes.

4.3 EFFICIENCY AND CAPACITY

4.3.1 Objective:

Determine whether expected efficiency gains are likely to be met.

4.3.2 Recordings

Number of instructions

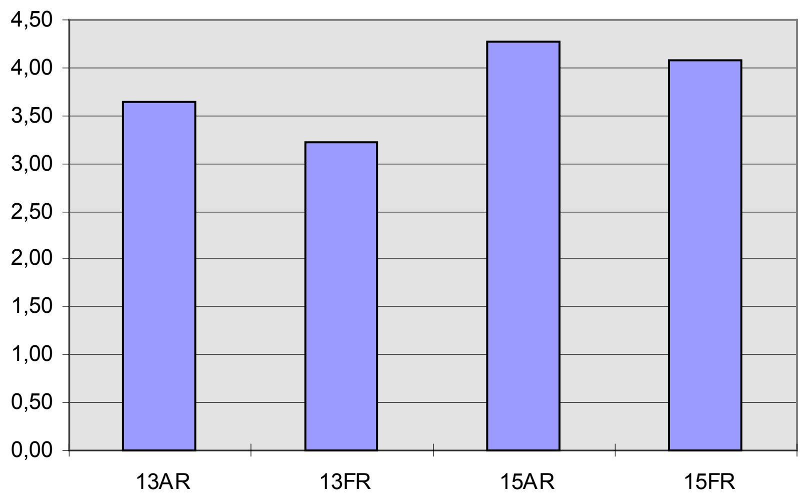

Fig. 13, Tactical instruction pr. aircraft/sector

Fig. 13 shows the average number of tactical instructions (level, heading and direct) pr sector in Air routes (AR) and Free Routes (FR) in the two traffic levels 130% (13) and 150% (15).

A reduction of tactical instructions of 11.8% in the 130% samples and 4.8% in the 150% samples were recorded. This indicates a possible capacity gain on the executive task of 5-10%. In combination with the lower number of conflicts encountered in the Free Routes scenario, a capacity gain of at least 10% seems to be likely in the simulated area.

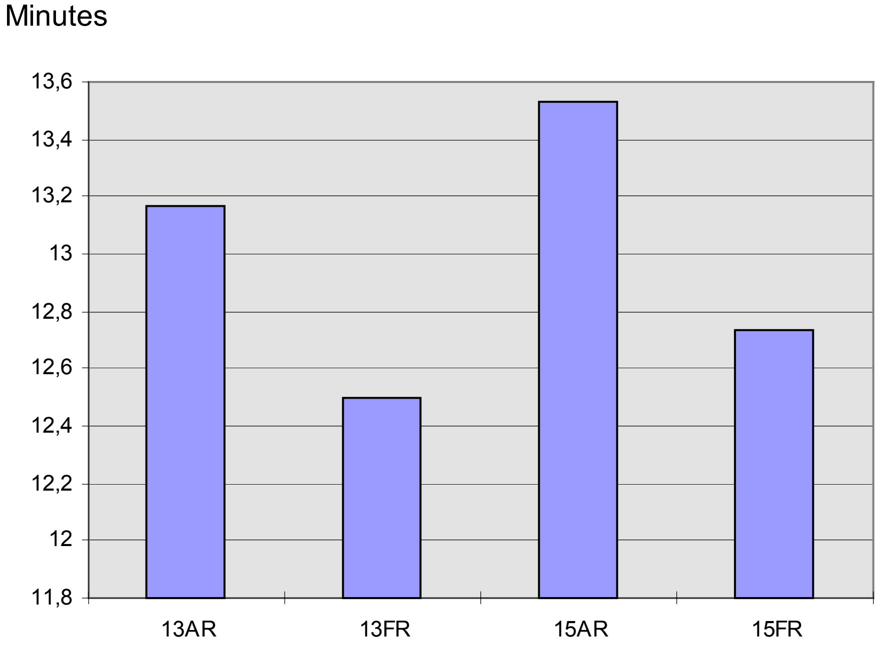

Fig 14: Mean flying time pr. aircraft/sector

Fig. 14 shows a reduced flying time after introduction of Free Routes of between 5 and 6% for all flights during the simulation**.**

4.3.3 Questionnaires

It requires more attention to monitor traffic in Free Routes.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	1	1	1	3	2

- Only as long as the pattern is new to the controller
- Only because you can handle more aircraft
- Yes because you have a larger areas, no because you have less congestion and overlapping of information
- We do not have our “standard” points any more

Conflicts are easier to solve in Free Routes.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
1	1	0	1	5	0

- More space available
- There are more “holes” for OAT
- Only when we have segregated airspace next to the ATS-route

Free Routes enabled you to handle more traffic in general					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	0	0	1	7	0

- Don’t underestimate the RVSM factor

Free Routes enabled you to handle more traffic as long as the number of active TRA’s and R&D Areas was low.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	0	1	0	5	1

Free Routes enabled you to provide the airspace users with a better service.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	0	0	1	6	1

- Shorter route, and more often at the requested level
- A more flexible use of the airspace is an advantage for all
- Usually straight up to requested level

Free Routes enabled you to execute your tasks more effectively.					
Strongly disagree	disagree	Slightly disagree	slightly agree	Agree	strongly agree
0	1	1	0	5	0

- As the aircraft are more spread out, conflict solving is easier

4.4 MILITARY ISSUES

4.4.1 Objective:

Assess the impact on military counterparts with respect to OAT transit flights and the use of segregated airspace when introducing FRAC.

4.4.2 Questionnaires

Civil-military coordination becomes more demanding in Free Routes					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	1	0	3	3	1

- When standard agreements are laid down, it should not be more demanding.
- Should be re-evaluated with live traffic.

4.4.3 Controller Opinions

The Lippe controllers (MIL) felt an increase in the monitoring task with Free Routes operations compared to route structured traffic, but this extra load was compensated by more space to manoeuvre between the civil flights. The general feeling was that the overall effect for OAT traffic was unchanged.

Some doubt was expressed about other areas, where the civil traffic is denser. Here Free Routes may cause problems to OAT traffic. The same doubt was expressed about regions where the civil-military cooperation is less flexible than between Lippe Radar and the civil Coastal Sector. The issue needs studying in one of the forthcoming simulations.

4.5 AIRSPACE AND PROCEDURES

4.5.1 Objective:

Assess the proposed lateral and vertical limits of FRAC airspace with regard to traffic complexity, traffic load and interface problems using traffic samples reflecting the 2003 traffic load and flows.

4.5.2 Questionnaires

Controlling a mixture of Free Routes and non-Free Routes flights is more demanding than controlling pure Free Routes traffic					
Strongly disagree	disagree	slightly disagree	slightly agree	Agree	strongly agree
0	2	0	4	2	0

- Disagree as an OAT-controller
- We only had a few non-Free Route flights
- In this simulation it was either fixed or free, in real life we also have hybrids, which will make it manageable.
- We want to be efficient and clear all flights direct. It’s just an irritation if some cannot or aren’t allowed.

Handling a mixture of Free Routes and non-Free Routes flights is confusing					
Strongly disagree	disagree	slightly disagree	slightly agree	Agree	strongly agree
0	4	0	3	1	0

- Not if it's determined by level
- For the controller there is no difference between Fixed Route and Free Routes with intermediate way-points

Sectors needs redesign for optimisation of Free Routes					
Strongly disagree	disagree	slightly disagree	slightly agree	Agree	strongly agree
0	0	0	5	2	1

- Needs a more detailed study.
- It's workable with the present lay-out, but a few changes would help
- Not in our case (Coastal)
- Otherwise the workload of the PLC may reduce the capacity

TRA's and R&D Areas needs redesign for optimisation of Free Routes					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	0	0	3	3	2

- It could be a good idea to divide areas into smaller parts, and only activate the necessary parts.

-Adjustments may be needed, but it can work as it is today.

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
0	1	0	1	6	1

- Reason could be that there is no concept for circumnavigation

I believe that the advantages of Free Routes will be higher in a single-service provider environment compared to a two-service provider scenario.					
Strongly disagree	Disagree	slightly disagree	slightly agree	Agree	strongly agree
0	0	2	1	4	0

- Or the two service providers have to be elbow-by-elbow.

4.5.3 De-briefings

Semi-circular levels were rigidly used throughout the simulation. It was agreed that it would be impossible to manage traffic not in accordance with the semi-circular rule in a Free Routes environment.

Circumnavigation of segregated airspace was by the controller team considered as a problem area. It is demanding for the PLC as well as for the EXC. The number of areas active has a direct impact on the sector capacity, and should be considered when sector capacities are determined.

Two basic principles can be used, either the aircraft operators consider areas that are expected to be active along the route in the flight plans, and insert route points that will prevent the flight from entering the areas, or the flightplan is constructed regardless of active areas, and the controller re-routes the flight on a tactical basis.

Tactical re-routing can be done in three different ways:

- By publishing of points around segregated airspace
- By use of intermediate points already existing
- By use of radar vectoring

The simulation did not give clear answers to these problems. It will be necessary to perform dedicated studies to conclude on this subject.

4.6 SYSTEMS

4.6.1 Objective:

Provide feedback on the use of OLDI in a FRAC environment, and identify shortcomings

Note: a number of findings related to SYSTEMS are listed under this objective.

4.6.2 Questionnaires

Free Routes increases the need for system support to identify conflicts in the medium term (2-10 minutes).					
Strongly disagree	disagree	slightly disagree	slightly agree	Agree	strongly agree
0	1	1	1	4	1

- It would be a good tool.

- Yes, but only because you will be able to handle more traffic. This requires support to monitor.
- 2-5 minutes ahead would do.

A graphical presentation of the flight path through the sector is required with Free Routes.					
Strongly disagree	disagree	slightly disagree	slightly agree	Agree	strongly agree
0	1	1	1	4	1

- But not permanently.
- It would be a good tool.
- Could I also have that in my present environment - please.
- This would also help to see infringements of segregated airspace.

4.6.3 De-briefings

It is expected that the OLDI standard (OLDI version 2.2) can support Free Routes, as this standard opens a possibility to work without fixed Coordination Points (COP). A COP can be defined for each individual point based on at radial and distance from a COP, or simply by lattitude/longitude, depending on bilateral agreements.

It is important for the controller to know to which sector information about a particular flight has been passed. In a route system this is implicitly linked to the route, as a route has a specific COP from each sector. This COP links to a particular sector in the next ACC. In a Free Routes environment this is not the case. A way must be found to present not only the next name of the ACC, as it is today, to the controller, but also to which sector within the ACC the information is passed.

The two Copenhagen sectors used paper-strips. It was the general opinion of the controllers that paper-strips only can provide the PLC with a very limited picture of the future traffic situation. The paper-strips only served as information containers for data such as CFL, XFL, Destination etc. It was the general feeling that the PLC would need an Air Situation Display to support the EXC in the monitoring and coordination task.

The controller needs information about airspace status not only from his own area of responsibility, but also the surrounding area. As an example, information concerning status of TRA's and R&D Areas within approximately 100NM should be available.

5. CONCLUSIONS

Assess the impact, in terms of controller workload and complexity, of the introduction of FRAC in an operational environment representing a typical ATC system in the year 2003

- Controllers had no problems to understand and to learn to work in the Free Routes environment. In this context it should be noted that the Maastrich and Copenhagen controllers are used to working in a “Direct Route” environment.
- Civil airspace users will have an improved level of service.
- This simulation did not identify deterioration in the service level to military users.
- Although it is the general opinion amongst the participating controllers that the monitoring task becomes more demanding, no objective data points in that direction.
- It becomes more difficult for the Planner Controller to monitor the traffic and foresee conflicts in a Free Routes Scenario.
- Especially in systems using paper strips will it be difficult for the PLC to predict conflicts.
- Higher capacity increases routine communication tasks; this increases the load on the EXC.
- Conflict detection becomes more tactical, and the EXC becomes the bottleneck.

Further develop Controller Roles to be used in Free Routes Airspace.

- In order to develop a more evenly balanced task distribution on the sector, it will be necessary to empower the PLC, i.e. give the PLC tools that enables him to solve problems before they become EXC tasks.

Determine whether expected efficiency gains are likely to be met.

- An ATC capacity gain of 10% compared to a fixed route environment can be expected in the simulated area was demonstrated.
- An improvement of PLC tools may lead to bigger capacity gains.
- Active areas will have a direct impact on sector capacity.

Assess the impact on military counterparts with respect to OAT transit flights and the use of segregated airspace when introducing FRAC.

- No negative effect was identified in this geographical area using the civil-military concepts as they are today.

Assess the proposed lateral and vertical limits of FRAC airspace with regard to traffic complexity, traffic load and interface problems using traffic samples reflecting the expected year 2003 traffic load and flows.

- No negative results or comments are recorded with regard to the proposed vertical level division.

- Mixed-mode operation (sectors operating with a mixture of Free Routes and fixed routes traffic) had only a initial negative effect.

Provide feedback on the use of OLDI in a FRAC environment, and identify shortcomings

- OLDI version 2.2 can support Free Routes.
- It is a requirement that the sector sequence is known to the controller (succeeding and preceding sector).

Other system related issues:

- Introduction of planning tools that can move tasks from the EXC to the PLC will have a positive effect on capacity.
- The PLC needs a presentation of surveillance data.
- A graphical presentation of the planned trajectory (Dynamic Flight Leg) and radar data is required for the Planning Controller.
- Paper strips are of very limited use in a Free Route environment, as they give no useful presentation of the flight path.
- Airspace status for surrounding areas shall be available.

6. RECOMMENDATIONS

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

1. Identify the best way to circumnavigate segregated airspace on a tactical basis.
2. Assess the consequences of implementing The Free Routes Concept in areas with separate civil and military service provision.
3. Assess possible ways to achieve a more evenly balanced distribution of task between PLC and EXC
4. Perform real-time simulation in the busiest and most complex areas of the Eight-States.
5. Develop OLDI/SYSCO requirements for Free Routes operation.