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ROMANIA 99 REAL-TIME SIMULATION

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ROMANIA 99 REAL-TIME SIMULATION

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Abstract:

This report describes a EUROCONTROL real-time simulation study of Romanian airspace conducted on behalf of ROMATSA Romania. The study was designed to assist ROMATSA in the detailed specification of the new Romanian Air Traffic Management system, in particular the specification of the Human Machine Interface and system functionality. The simulation included military as well as civil sectors with electronic civil-military co-ordination and the Flexible Use of Airspace. In conjunction with EUROCONTROL AMN Division a study was also made of RNAV SID and STAR procedures for the Bucharest TMA. The simulated area included the entire Romanian airspace with revised sector and Bucharest TMA dimensions. The simulation formed part of the joint simulation project - ROMBULPO, and this report also includes results of the Bulgaria-Romania joint simulation which preceded Romania 99 and which concentrated on cross-border issues including the use of electronic inter-centre co-ordination and reduced longitudinal separation. Traffic samples representing 2005-2007 forecast levels were simulated. These simulations were also designed to complement a previous real-time simulation - Romania 97 (EEC Report No. 320).

SUMMARY

Two real-time simulations were conducted by EUROCONTROL during 1999 for the benefit of Romania. This report combines the results of both these experiments applicable to Romania.

The Romania 99 real-time simulation and the Bulgaria/Romania joint real-time simulation took place at the EUROCONTROL Experimental Centre between June 21st and July 30th 1999. During Romania 99, 48 Romanian controllers plus Bulgarian and Hungarian controllers participated in 40 simulation exercises. During the Bulgaria/Romania Joint Simulation 47 Bulgarian and Romanian controllers plus Turkish feed controllers participated in 27 simulation exercises.

The entire Romanian Civil En-route ATC system was evaluated along with the Bucharest TMA and Approach control plus 3 military positions which provided a control service to Military Operational Air Traffic (OAT) in a shared airspace environment. In the Bulgaria/Romania Joint Simulation sectors on either side of the international frontier were realistically simulated. The largest simulation configuration consisted of 15 sectors comprising 26 Controller Working Positions (CWP) plus 6 feed sectors. The simulated ATC system was the future Romanian system that is fully electronic and does not include paper strips.

These simulations formed part of the ROMBULPO series of simulations conducted on behalf of Romania, Bulgaria and Poland. A common simulator configuration was used for all these simulations in which underlying functionality was identical but each state was provided with a specific Human Machine Interface (HMI). The system included simulated electronic inter-sector and inter-centre communication in line with OLDI 2.2, the civil-military electronic co-ordination resulting from the EATCHIP studies plus Medium Term Conflict Detection (MTCD) and Safety Nets such as STCA (Short Term Conflict Alert) and APW (Area Proximity Warning).

The Romanian CWP was evaluated in a previous EUROCONTROL real-time simulation - Romania 97 (EEC Report 320). The simulations conducted during 1999 were designed primarily to evaluate the latest version of the prototype CWP and to build on the 1997 results. A particular aim was to evaluate the Touch Input Device (TID) which had not been possible in the 1997 simulation. The results of the simulations indicate that the Romanian HMI is now well developed with a very high level of acceptability by the controllers. The TID is a useful secondary input device, but the mouse was confirmed as the most suitable primary input device.

A close working relationship developed between civil and military controllers during the simulation. Electronic co-ordination was successfully used between civil and military in both directions in a shared airspace environment. The simulation represented a major step forward towards even closer co-operation and the efficient sharing of airspace.

In a parallel study conducted in conjunction with EUROCONTROL Airspace Management and Navigation Division, RNAV procedures in the Bucharest TMA were evaluated. This study has provided much valuable information for the Terminal Area RNAV Applications Task Force (TARA).

In the Bulgaria/Romania Joint Simulation, full electronic co-ordination and radar coverage allowed the successful evaluation of reduced longitudinal separation standards with the participants declaring that “the border between Romania and Bulgaria could be considered as any other sector boundary in the simulated environment”.

ACKNOWLEDGEMENTS

The project team would like to thank the experts of ROMATSA (the Romanian Air Traffic Services Administration) namely Antonio Licu, Nicolai Cojocariu and Daniel Avram for all their assistance and co-operation during the preparation and testing of the simulations. A particular thank you goes to Cristiana Dinculescu of ROMATSA who worked at the EEC for 9 months assisting in the technical preparation of the simulations.

The author would also like to thank all the EUROCONTROL staff who worked with him on the ROMBULPO project. In particular José Seixo the Simulation Technical Co-ordinator who efficiently configured and managed a very complex simulation facility and also Geraldine Flynn (Project Manager Poland 99) and Rod McGregor (Project Manager Bulgaria 99) for their help and support.

Thanks must also go to the Hungarian and Turkish ATC administrations for the loan of their controllers to man feed sectors and to TAROM and BALKAN airlines for the loan of pilots who flew the MCS.

Finally, thanks to the Romanian and Bulgarian civil and military controllers who participated in the simulations. They all displayed a high level of professionalism and enthusiasm and it is their input that provided the results to be found in this report.

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ABBREVIATIONS

ABI . . . . **A**dvance **B**oundary **I**nformation (OLDI)
ACC . . . . **A**rea **C**ontrol **C**entre
ACT . . . . Activation Message (OLDI)
AFL . . . . **A**ctual **F**light **L**evel
AMN . . . . EUROCONTROL **A**irspace **M**anagement and **N**avigation Unit
ANT . . . . Airspace and Navigation Team
APP . . . . Approach Control
APW . . . . **A**rea **P**roximity **W**arning
ARN . . . . **A**TS **R**outes and associated **N**avigation means plan
ATC . . . . **A**ir **T**raffic **C**ontrol
ATS . . . . **A**ir **T**raffic **S**ervice
ATSA . . . . Bulgarian Air Traffic Services Agency
B-RNAV . . . . **B**asic Area Navigation
CDN . . . . **C**o-ordination Message (OLDI)
CFL . . . . **C**leared **F**light **L**evel
COF . . . . **C**hange of Frequency Message (OLDI)
CWP . . . . **C**ontroller **W**orking **P**osition
DFL . . . . **D**ynamic **F**light **L**eg
EATCHIP . . . . **E**uropean **ATC** **H**armonisation and **I**ntegration **P**rogramme
ECAC . . . . **E**uropean **C**ivil **A**viation **C**onference
EEC . . . . **E**UROCONTROL **E**xperimental **C**entre
EFL . . . . **E**ntry **F**light **L**evel
EONS . . . . **E**UROCONTROL **O**pe**N** and generic graphic **S**ystem
ETL . . . . **E**xtended **T**rack **L**abel
ETO . . . . **E**stimated **T**ime **O**ver
EUR-ANP . . . . **Eur**opean **A**ir **N**avigation **P**lan
EXC . . . . **Ex**ecutive **C**ontroller
FDP . . . . **F**light Plan **D**ata **P**rocessing
FIR . . . . **F**light **I**nformation **R**egion
FUA . . . . **F**lexible **U**se of **A**irspace
GAT . . . . **G**eneral **A**ir **T**raffic
HMI . . . . **H**uman **M**achine **I**nterface
ILS . . . . **I**nstrument **L**anding **S**ystem
ISA . . . . **I**nstantaneous **S**elf **A**ssessment
L-NAV . . . . **L**ateral **Nav**igation
MAS . . . . **M**anual **As**sume of Control Message (OLDI)
MCS . . . . **M**ulti-**C**ockpit **S**imulator
MDFL . . . . **M**ilitary **D**ynamic **F**light **L**eg
MSAW . . . . **M**inimum **S**ector **A**ltitude **W**arning
MTCD . . . . **M**edium **T**erm **C**onflict **D**etection
OAT . . . . **O**perational **A**ir **T**raffic
ODS . . . . **O**perational **D**isplay **S**ystem

OLDI. . . . . **O**n-**l**ine **D**ata **I**nterchange
PLC . . . . **Pl**anning **C**ontroller
RDP . . . . **R**adar **D**ata **P**rocessing
RNAV . . . . Area Navigation
ROMATSA . . . . **Rom**anian **A**ir **T**raffic **S**ervices **A**dministration
RRV . . . . **R**eferred **R**evision Message (OLDI)
RTF . . . . Radio Telephony
SEL . . . . **Se**ctor **L**ist
SFL . . . . **S**upplementary **F**light **L**evel
SID . . . . **S**tandard **I**nstrument **D**eparture
SLW . . . . **S**elected **L**abel **W**indow
SSR . . . . **S**econdary **S**urveillance **R**adar
STAR . . . . **St**andard **A**rrival **R**oute
STCA . . . . **S**hort **T**erm **C**onflict **A**lert
StS . . . . **S**upport **t**o **S**tates (EUROCONTROL)
SYSCO. . . . . **Sys**tem Assisted **Co**-ordination
TARA . . . . **T**erminal **A**rea **R**NAV **A**pplications Task Force
TID . . . . **T**ouch **I**nput **D**evice
TIM. . . . . **T**ransfer **I**nitiation **M**essage (OLDI)
TMA . . . . **T**erminal **M**anoeuvring **A**rea
TSA . . . . **T**emporary **S**egregated **A**rea
TWR. . . . . Aerodrome Control
UIR. . . . . **U**pper Flight Information Region
XCM. . . . . Crossing Request Cancellation Message (OLDI)
XFL . . . . Exit Flight Level
XRQ . . . . Military Crossing Request (OLDI)

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9. Romania 99 Simulation Facility Specification Part 1 - Operational

1. INTRODUCTION

The Romania 99 real-time simulation and Bulgaria-Romania joint real-time simulation took place at the EUROCONTROL Experimental Centre between June 21st and July 30th 1999. These simulations were designed to meet the requirements of the Romanian Air Traffic Services Administration (ROMATSA) and the Bulgarian Air Traffic Services Agency (ATSA).

This report contains the results of the Romania 99 simulation and the results of the Bulgaria-Romania Joint simulation relevant to Romania.

ROMATSA is in an advanced stage of specification for the future Romanian ATC System and has developed a detailed Controller Working Position (CWP) prototype including a Touch Input Device (TID) to support the on-screen mouse functions. The Romanian CWP was evaluated in a previous EUROCONTROL real-time simulation - Romania 97 (Ref. 1 - EEC Report 320). The simulations conducted during 1999 were designed primarily to evaluate the latest version of the prototype CWP and to build on the 1997 results. A particular aim was to evaluate the TID which had not been possible in the 1997 simulation.

The simulations also included the evaluation of RNAV SID and STAR procedures in the Bucharest TMA in collaboration with EUROCONTROL Airspace Management and Navigation (AMN) unit.

The Romania 99 simulation included military sectors with full 2-way electronic co-ordination between civil and military controllers and the application of the Flexible Use of Airspace (FUA).

2. ROMBULPO

The Romania 99 simulation and the Bulgaria-Romania joint simulations formed part of the ROMBULPO project which encompassed real-time simulations for Romanian, Bulgarian and Polish clients. Following initial meetings with representatives from the states in mid 1998 it was decided that a common simulator configuration could be used for all of these simulations. The concept had been proven during 1998 when a real-time simulation was conducted at the EEC for Denmark and Sweden in which underlying functionality was identical but each state was provided with a specific Human Machine Interface (HMI). The advantage of this approach was the likelihood of a more stable simulator as no major re-configuration would be required between simulations. Another significant aspect was the composition of the basic simulator specification. The system included simulated electronic inter-sector and inter-centre communication in line with OLDI 2.2 (Ref. 5), the civil-military electronic co-ordination resulting from the EATCHIP studies plus Medium Term Conflict Detection (MTCD) and Safety Nets such as STCA (Short Term Conflict Alert) and APW (Area Proximity Warning). At the last minute some additional EATCHIP features were included - flight level deviation warning and transfer reminder.

3. OBJECTIVES

3.1 ROMANIA 99 OBJECTIVES

1. To evaluate the new ROMATSA Controller Working Position, specifically:
   - the Human Machine Interface including, colour, text, radar labels, data windows and graphic information presentation
   - the 3 button mouse for data access and input including extensive use of elastic vectors»
   - the ROMATSA TID for data input and co-ordination purposes including specifically:
     - data selection
     - speed of access and input compared with the mouse
     - specific uses including multiple inputs and approach tasks
     - ergonomic aspects including location and parallax
   - controller aids including MTCD and Safety Nets
2. To evaluate new Civil/Military co-ordination procedures.
3. To further evaluate new co-ordination procedures between ACC sectors, ACC and APP sectors, and APP and TWR sectors.
4. To evaluate the use of RNAV arrival and departure routes for Bucharest and associated ATC and aircrew procedures.
5. To evaluate the dimensions and operating procedures for an enlarged Bucharest TMA and associated civil/military co-ordination.
6. To evaluate sectorisation and route structure by the comparison of existing (August 1998) route structure combined with a sectorisation including 3 Arad, 2 Constanta, 1 Cluj, 1 Bacau and 5 Bucharest En-route sectors. The 5 Bucharest sectors will be configured as appropriate for the traffic flow and volume and will be based on the use of 8 system sectors combined as required. (The airspace decisions were made prior to the Kosovo Crisis and are therefore unrealistic in the Kosovo context. This 6th objective was therefore given a low priority).

3.2 BULGARIA-ROMANIA JOINT SIMULATION OBJECTIVES

The joint simulation allowed more in-depth study of the objectives of the Romania 99 simulation and also addressed the following specific objectives:

1. To evaluate the civil Romanian/Bulgarian Interface including revised handover conditions for traffic destination Istanbul & Varna, and reduced cross-border radar separation.
2. To evaluate OLDI/SYSCO system and procedures across the Romanian/Bulgarian border.

4. SIMULATION CONDUCT

4.1 AIRSPACE

The simulated airspace included the entire Bucharest FIR/UIR and parts of the Budapest, Lvov, Kishinev, Odesa, Simferopol, Varna, Sofia, and Belgrade FIR/UIRs.

The simulated airspace was divided into either “Measured” or “Feed” sectors. Measured sectors represented the study airspace of the simulation and were simulated as realistically as possible. Feed sectors provided a realistic interface with the surrounding airspace without representing in full the actual sectorisation.

The airspace of the Bucharest FIR/UIR within the area of responsibility of Bucharest ACC was simulated by measured sectors. Airspace within the area of responsibility of Arad, Bacau, Cluj and Constanta ACC’s was simulated by either measured or feed sectors depending on the organisation simulated. All other simulated airspace was represented by feed sectors.

In the Bulgaria/Romania Joint Simulation, Sofia and Varna airspace was realistically represented by measured sectors. Brief details of the simulated airspace are included below. Full details can be found in the Bulgaria/Romania Joint Simulation Facility Specification Part 1 – Operational (Ref. 8) and the Romania 99 Simulation Facility Specification Part 1 – Operational (Ref. 9).

4.1.1 Route Structure

During the simulation preparation the Kosovo crisis occurred, with route structure changes occurring on an almost weekly basis. A pragmatic approach had to be adopted for the simulation and therefore the temporary Kosovo situation was ignored and the route structure from 1998 and a potential future route structure was simulated. The future route structure was based on ARN V.3 Phase 2 and two alternative unidirectional traffic flows were simulated for UL618 and UL622.

4.1.2 Terminal Airspace

The Bucharest TMA was simulated with its current geographical and vertical (2000ft – FL175) dimensions and also in an enlarged version extending to the Varna FIR boundary in the south and vertically up to FL245.

RNAV SIDs and STARs were defined for the enlarged TMA and the use of these formed the basis of a parallel study by EUROCONTROL AMN Division.

The Bucharest TMA was divided into Approach (AP) and Final Director (AD) sectors. The area of responsibility of AD depended on the landing direction at Bucharest (Otopeni) airport and extended vertically to FL50 in the existing TMA and to FL70 in the enlarged TMA.

4.1.3 En-route Sectorisation

The simulated en-route sectorisation was based on “classical” Romanian sectors as simulated in the previous real-time simulation – Romania 97, and also on the results of studies conducted in Romania. The Romanian study proposed new geographical sector boundaries and the use of up to eight “system sectors” for Bucharest ACC which can be combined as required to create sectorisation adapted to particular traffic flows.

The detail of the simulated sectorisation is described in Section 4.3.

4.1.4 Military Sectorisation

Two military sectors were simulated in all Romania 99 organisations: Military West (MW) and Military East (ME). These sectors controlled Operational Air Traffic (OAT) in the east and west of Romania respectively and were complemented by a Military Co-ordinator (MC) position that had overall responsibility for military operations. During the joint simulation only the MC position was simulated.

4.1.5 Danger and Restricted Areas

Military Temporary Segregated Areas (TSA) were specified for use with the 1998 route structure and also for the simulated future scenario. Eight different TSA were specified for each scenario, with no more than two being activated at any one time.

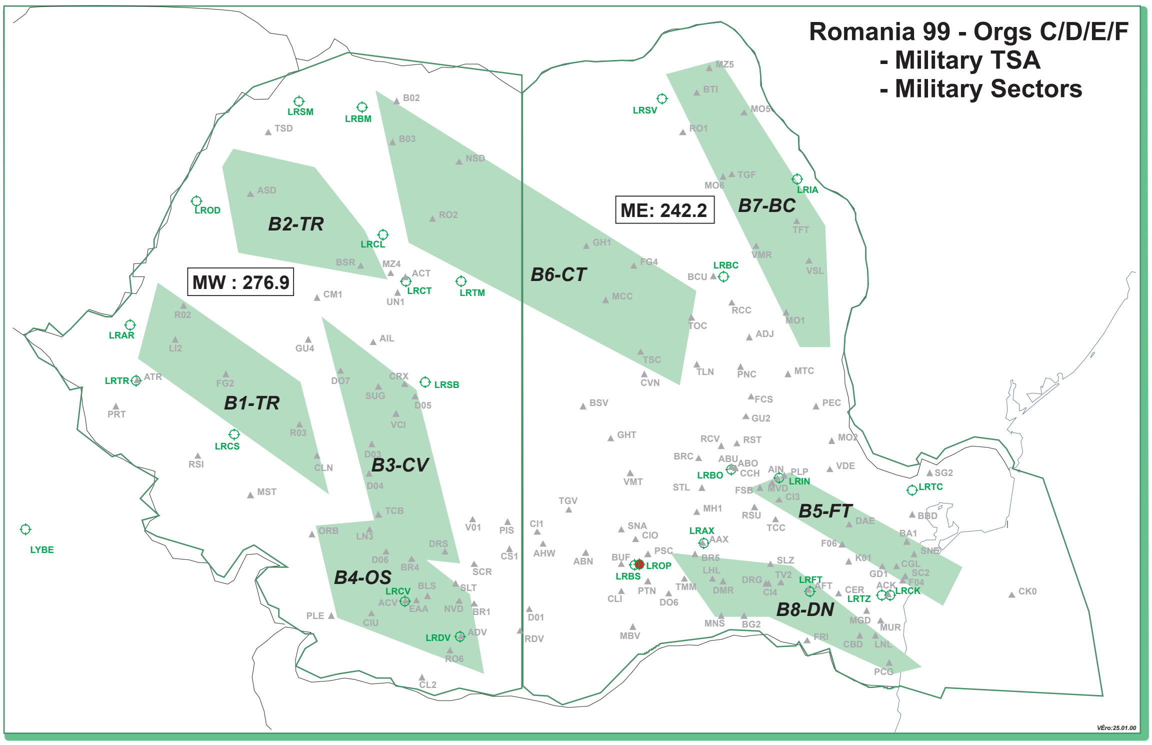

Fig. 4 - 1 : Map of Military Areas and Military Sectors

4.2 TRAFFIC

The traffic samples used during the simulation were based on traffic recordings from 1st August 1998 and adapted to the simulation requirements.

Baseline traffic samples were created for both early morning (predominantly westbound traffic flow) and early afternoon (predominantly eastbound traffic flow). Particular effort was devoted to ensuring that as many typical traffic situations as possible were represented. These traffic samples were considered to represent 100% for augmentation purposes.

Military flights were added to provide adequate traffic to achieve the simulation objectives.

For training purposes both baseline and traffic samples representing 66% of the baseline were used.

The measured exercises of the simulation included exercises using the 100% baseline traffic and also augmented traffic samples. As explained earlier, the simulation was conducted during the period of the Kosovo crisis and therefore it was difficult to predict the future traffic situation. It was decided to assume that there would be a rapid return normality following the end of the Kosovo crisis and that traffic flows would return to their original orientation. Traffic augmentations of 25% and 35% were therefore created by increasing the general number of flights on all routes by these amounts and making no specific assumptions concerning future traffic orientation.

It was decided not to take into account the introduction of Reduced Vertical Separation Minima (RVSM) in the preparation of the traffic samples. It was decided that RVSM was not necessary to achieve a successful simulation result. Using CVSM reduced preparation workload and risk.

4.2.1 Traffic Sample Analysis

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

BULGARIA-ROMANIA JOINT SIMULATION								
Sector	Organisation and traffic volume							
	A 100%		B 100%		B 125%		C 135%	
	F	**P**	**F**	**P**	**F**	**P**	**F**	**P**
ES	29	13	35	14	59	25	68	29
N	35	22	52	21	71	27	71	29
S	39	20	48	21	78	30	76	32
C	24	13	28	14	48	17	58	26
AP	23	12	29	14	36	16	36	13
AD	15	5	10	6	12	8	16	8

F = Mean hourly traffic flow

P = Peak number of aircraft on frequency

ROMANIA 99 SIMULATION
Organisation and traffic volume

Sector	A 100%		E 100%		F 100%		C 125%		D 125%		E 125%		F 125%		E 135%		F 135%	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
AS	27	18																
AN	32	11																
AU	43	15																
A1			14	6	35	14	16	5	30	17	24	16	47	21	26	12	54	18
A2			15	7	34	12	22	7	27	9	22	13	46	13	26	10	52	15
A3			77	24	44	12	79	23	36	9	86	26	52	15	91	33	56	18
ES	54	25																
NA	43	23																
NB	55	23																
SA	45	20																
SB	30	14																
B1					54	15			38	16			71	20			80	25
B23					50	17			30	13			67	21			79	23
B123			40	14			40	15			59	20			64	28		
B4			65	20	37	13	71	25	22	11	80	23	65	18	83	27	67	19
B5			52	17			55	20			58	22			60	21		
B57					55	20			42	14			78	32			87	29
B67			43	13			50	17			61	19			70	21		
B68					51	15			67	20			67	23			74	20
B8			28	8			35	13			37	12			43	14		
CN	29	11																
CS	36	11																
C1			23	10	25	7					34	13	31	7	41	16	34	9
C2			34	10	44	15					46	13	56	18	51	16	66	20
CL							61	25	50	30								
BC							25	15	35	24								
AP	32	12	31	12	30	12	38	13	25	12	37	17	34	13	40	15	37	13
AD	19	7	19	8	16	7	21	11	17	7	22	11	17	7	26	13	19	8
ME	7		7		7		11		9		9		8		9		9	
MW	5		5		5		6		6		6		6		7		6	

F = Mean hourly traffic flow

P = Peak number of aircraft on frequency

For military sectors (ME and MW) the figure shown is the average number of aircraft on the frequency.

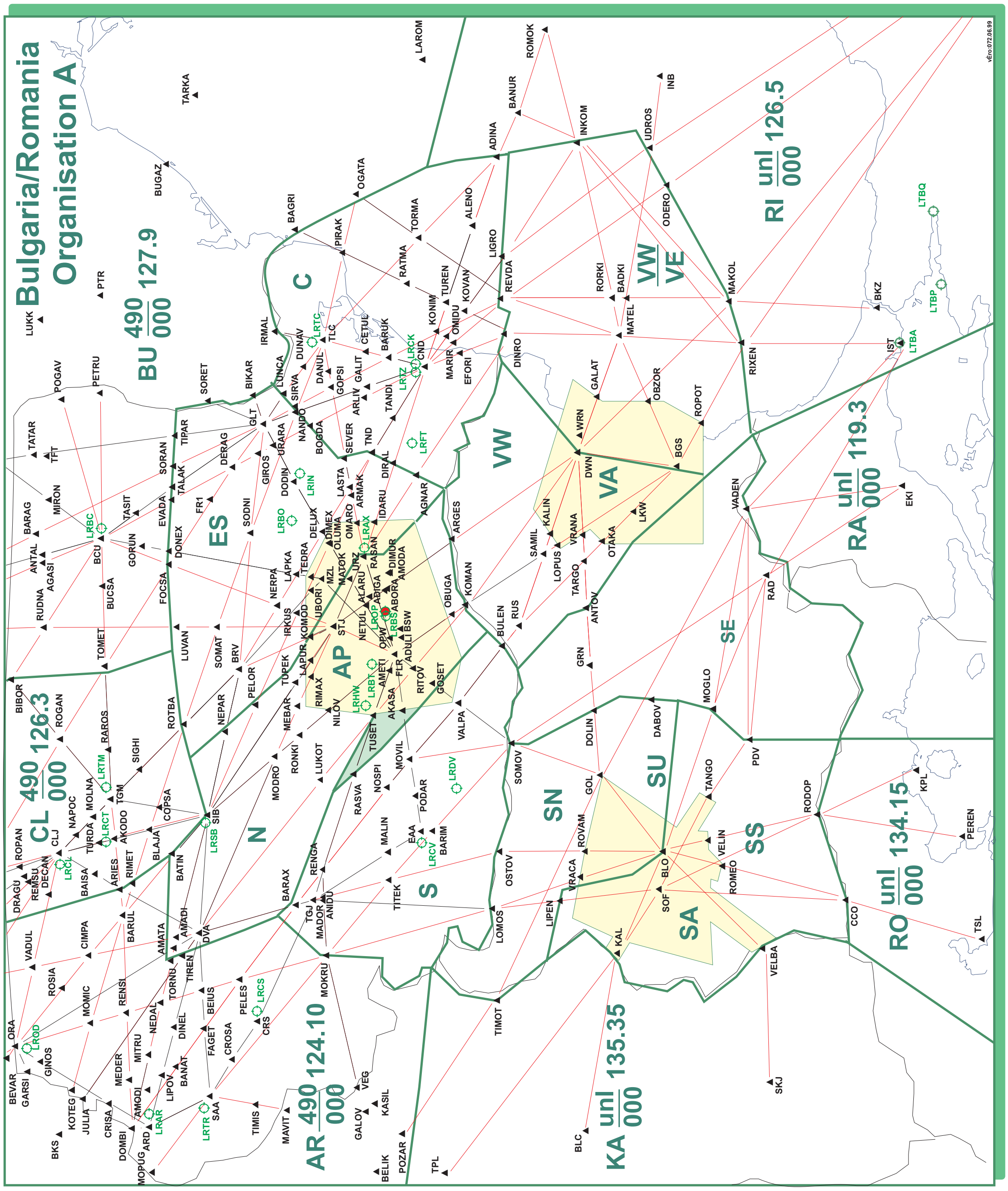

Fig. 4 - 2 : Bulgaria/Romania Joint Simulation - Map of Simulated Area

4.3 ORGANISATION

To achieve the simulation objectives, five organisations were foreseen for the Romania 99 simulation and three for the Bulgaria/Romania Joint Simulation.

The basic elements of the simulated organisations are described below.

4.3.1 Bulgaria/Romania Organisation A

4 Romanian en-route sectors were simulated: South, North, East and Constanta. The existing Bucharest TMA was simulated with an upper limit of FL175. The route structure and traffic flows were from 1998. UL618 and UL622 were simulated with existing traffic flow orientation.

4.3.2 Bulgaria/Romania Organisation B

The same en-route sectors were simulated as Org. A but with revised boundaries to correspond with the simulated enlarged Bucharest TMA up to FL245 and the use of route structure ARN V3 Phase 2, with UL618 northbound and UL622 southbound.

4.3.3 Bulgaria/Romania Organisation C

As Organisation B but with alternative minor revisions to airspace boundaries.

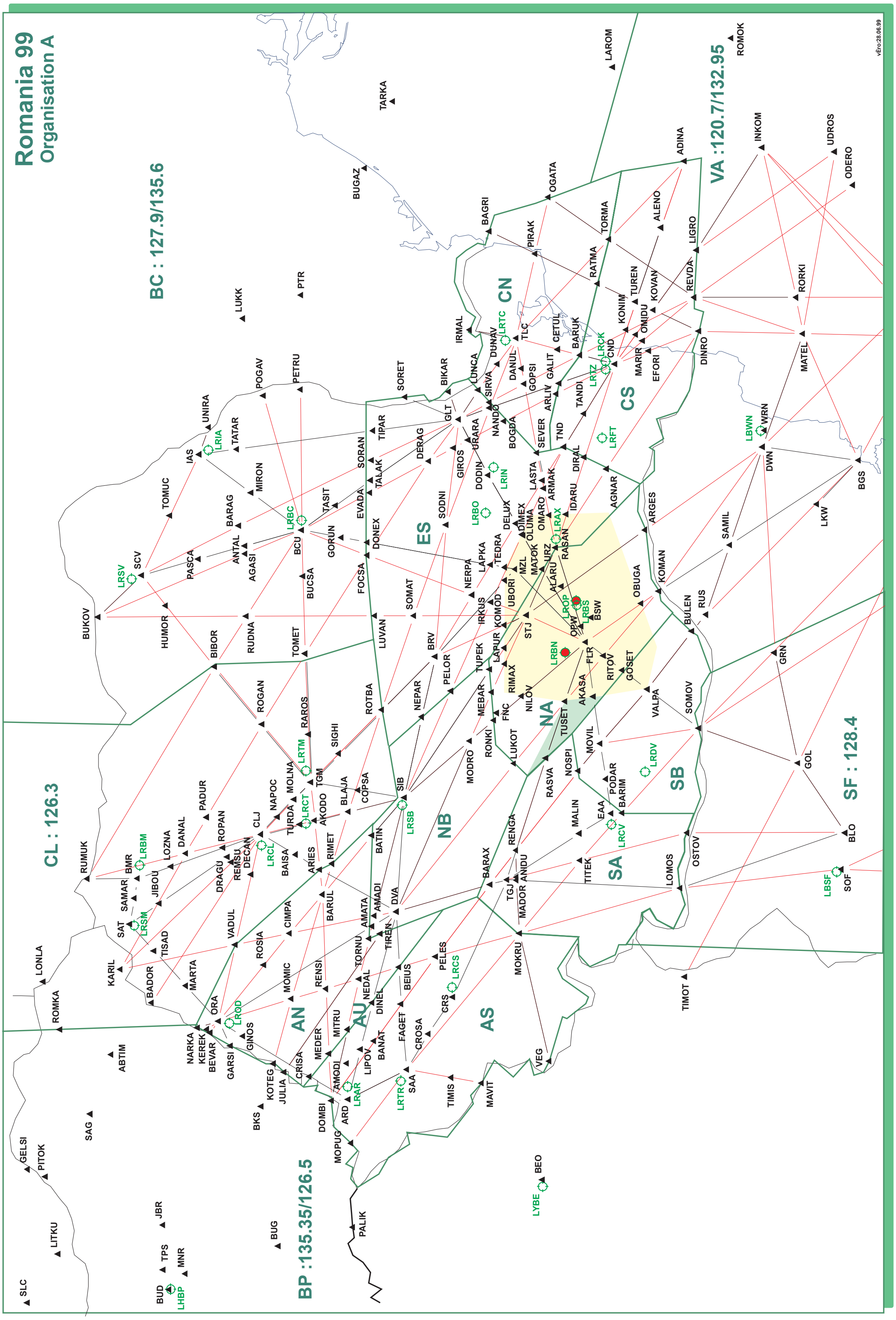

Fig. 4 - 3 : Map of Romania 99 - Organisation A

4.3.4 Romania 99 Organisation A

This organisation simulated the “classical” Romanian sectors as simulated in the previous real-time simulation – Romania 97 with 2 Arad lower sectors, 1 Arad upper sector above FL345, Bucharest North A and B, Bucharest South A and B, Bucharest East and Constanta North and South sectors. The existing Bucharest TMA was simulated with an upper limit of FL175. The route structure and traffic flows were from 1998.

The surrounding airspace of Cluj, Bacau, Budapest, Ukraine, Bulgaria and Yugoslavia was managed by feed sectors. Bucharest Otopeni and Baneasa Towers were also managed by a feed sector.

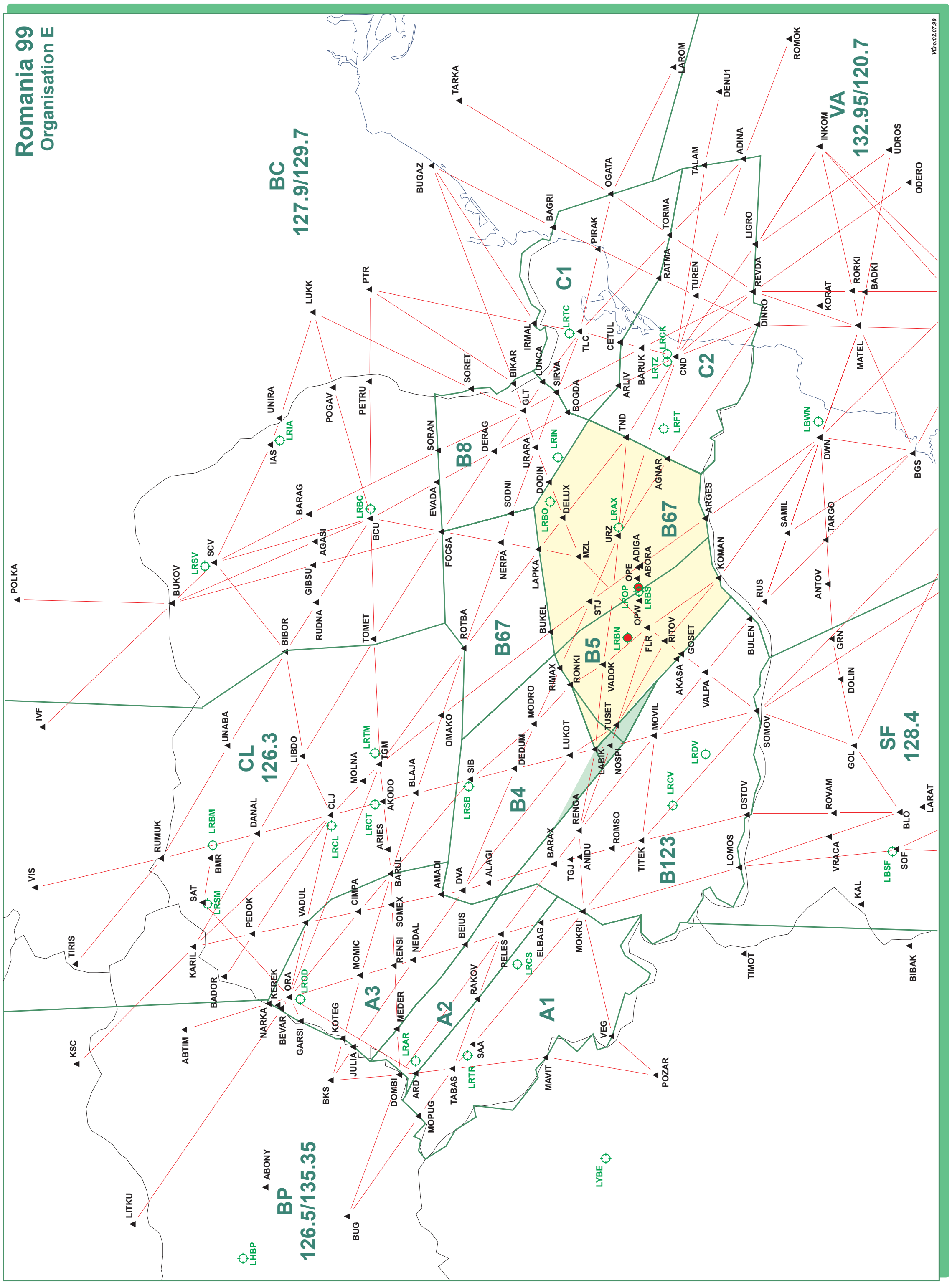

Fig. 4 - 4 : Map of Romania 99 - Organisation E

4.3.5 Romania 99 Organisation B

Organisation B was not simulated but represented the 8 Bucharest “system sectors” (B1-B8) which were grouped together to form 5 sectors for organisations C, D, E and F.

4.3.6 Romania 99 Organisation C

This organisation included Bucharest sectors adapted to early morning (predominantly westbound) traffic. Cluj and Bacau were simulated as single measured sectors and Constanta was a single feed sector. Other feed sectors were as Org A.

In Organisations C, D, E and F the enlarged Bucharest TMA was simulated up to FL245 with an increased area of responsibility for AD. The runways in use at Bucharest were 26 and 25.

Route structure was ARN V3 Phase 2, with UL618 northbound and UL622 southbound.

4.3.7 Romania 99 Organisation D

This organisation included Bucharest sectors adapted to early afternoon (predominantly eastbound) traffic. Cluj and Bacau were simulated as single measured sectors and Constanta was a single feed sector. Other feed sectors were as Org A. The runways in use at Bucharest were 08 and 07.

Route structure was ARN V3 Phase 2, with UL618 northbound and UL622 southbound.

4.3.8 Romania 99 Organisation E

This organisation included Bucharest sectors adapted to early morning (predominantly westbound) traffic. Constanta was split north/south into 2 measured sectors and Cluj and Bacau were feed sectors. Other feed sectors were as Org A. The runways in use at Bucharest were 26 and 25.

Route structure was ARN V3 Phase 2, with UL618 southbound and UL622 northbound.

A revised version of Organisation E was created during the simulation to test a revised boundary between Constanta North and South sectors.

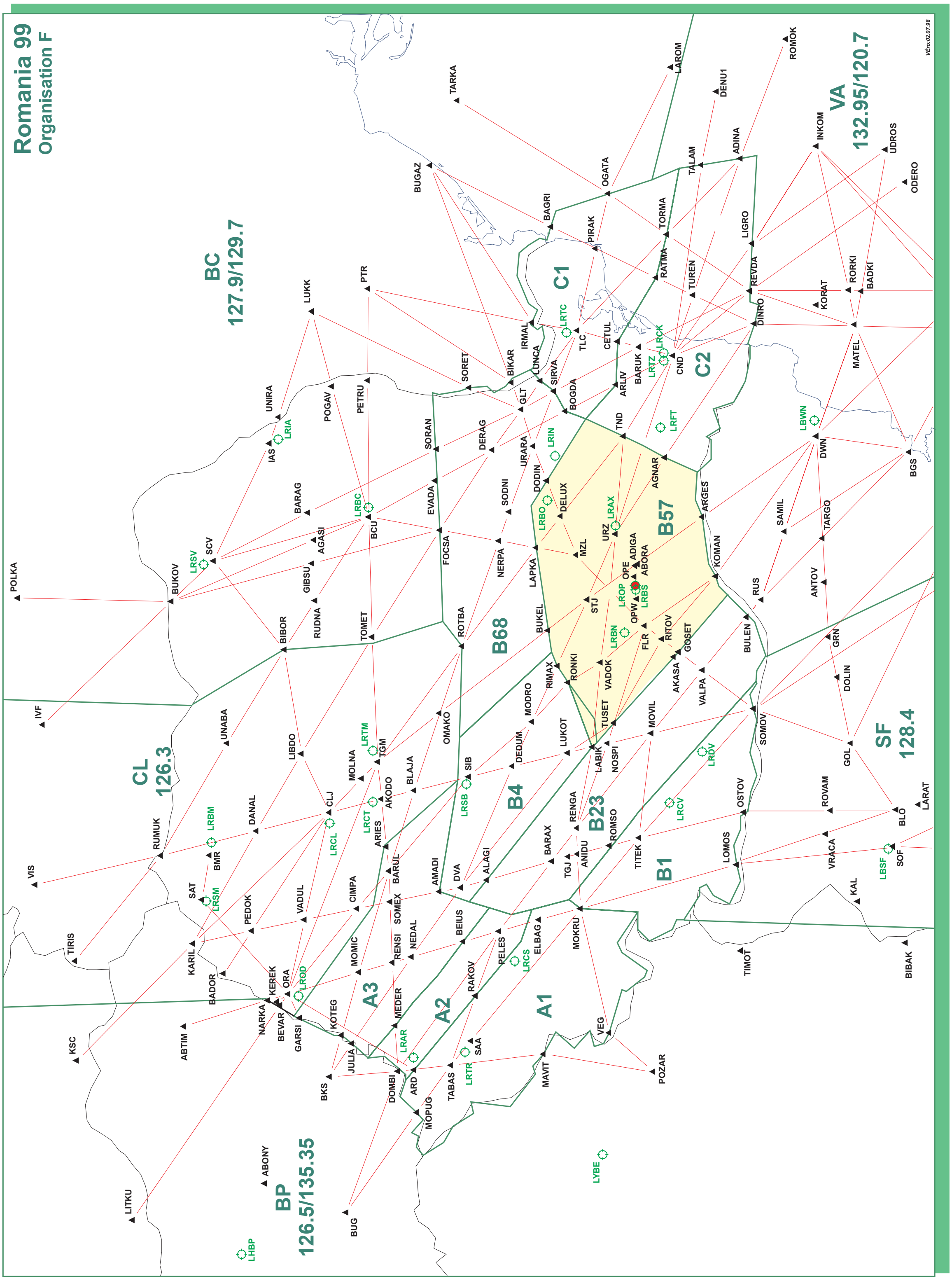

Fig. 4 - 5 : Map of Romania 99 - Organisation F

4.3.9 Romania 99 Organisation F

This organisation included Bucharest sectors adapted to early afternoon (predominantly eastbound) traffic. Constanta was split north/south into 2 measured sectors and Cluj and Bacau were feed sectors. Other feed sectors were as Org A. The runways in use at Bucharest were 08 and 07.

Route structure was ARN V3 Phase 2, with UL618 northbound and UL622 southbound.

4.4 PROGRAM OF EXERCISES

Three simulation exercises were conducted each day, with a main debriefing period scheduled after the final exercise of the day.

Exercises were of 1hr 15mins duration that started with an initial traffic charge which gradually grew during the first 15mins after which the next 1hr was conducted at the appropriate traffic level.

The tables below show the programs of exercises that were eventually completed.

<table>
<tr><th colspan="5">Bulgaria/Romania Joint Simulation Exercise Program</th></tr>
<tr><th>Week</th><th>Org</th><th>N° of Exercises</th><th>Traffic Level</th><th>Notes</th></tr>
<tr><td rowspan="4">1</td><td rowspan="3">A</td><td>4</td><td>66%</td><td rowspan="2">Training</td></tr>
<tr><td>2</td><td rowspan="4">100%</td></tr>
<tr><td>3</td><td rowspan="5">Measured</td></tr>
<tr><td rowspan="3">B</td><td>5</td></tr>
<tr><td rowspan="3">2</td><td>1</td></tr>
<tr><td>6</td><td>125%</td></tr>
<tr><td>C</td><td>6</td><td>135%</td></tr>
<tr><td colspan="2"></td><td>Total 27</td><td colspan="2">Representing 33 hours of simulation time</td></tr>
</table>

<table>
<tr><th colspan="5">Romania 99 Exercise Program</th></tr>
<tr><th>Week</th><th>Org</th><th>N° of Exercises</th><th>Traffic Level</th><th>Notes</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">A</td><td>4</td><td>66%</td><td rowspan="2">Training</td></tr>
<tr><td>3</td><td rowspan="2">100%</td></tr>
<tr><td>6</td><td rowspan="11">Measured</td></tr>
<tr><td rowspan="5">2</td><td>F</td><td>3</td><td rowspan="2">100%</td></tr>
<tr><td>E</td><td>3</td></tr>
<tr><td>F</td><td>3</td><td rowspan="2">125%</td></tr>
<tr><td>E</td><td>3</td></tr>
<tr><td>F</td><td>3</td><td rowspan="2">135%</td></tr>
<tr><td rowspan="4">3</td><td>E</td><td>3</td></tr>
<tr><td>C</td><td>3</td><td rowspan="2">125%</td></tr>
<tr><td>D</td><td>3</td></tr>
<tr><td>New E</td><td>3</td><td>135%</td></tr>
<tr><td colspan="2"></td><td>Total 40</td><td colspan="2">Representing 55 hours of simulation time</td></tr>
</table>

The staffing of sectors followed a strict rotation which took into account controller's qualifications and which ensured that each controller experienced each variation of organisation from as many different control positions as possible.

4.5 SIMULATED ATC SYSTEM

The ROMBULPO simulator configuration was based on the experience gained at the EEC during previous simulations of advanced ATC systems. The objective was to simulate common underlying functionality in all the simulations that is likely to become the basis of industry provided ATC systems within the next 5 years. This basic functionality was as follows:

- **Basic Electronic Co-ordination**: Notification, co-ordination and transfer of control in line with OLDI V2.2 (Ref. 5).
- **Advanced Electronic Co-ordination**: Civil – Military Crossing Request in line with OLDI draft V3 (Ref. 6).
- **Quick Information Access**: Rapid access to a dynamic flight leg and additional information windows.
- **Electronic List Data**: The system provided entry and exit information in list format allowing entry and exit conditions to be verified, modified or electronically co-ordinated.
- **Notebook Functions**: The controller could electronically note assigned headings, levels, speeds and direct routings that would normally be written on strips.
- **Flight Status**: Common flight status logic was used with the main states being Pending, Assumed, Concerned and Unconcerned.
- **Medium Term Conflict Detection**: The system provided en-route controllers with up to 30 minutes warning of potential conflicts.
- **Safety Nets**: The system provided a 2 minute warning of potential loss of radar separation (Short Term Conflict Alert – STCA), infringement of restricted airspace (Area Proximity Warning – APW) and infringement of minimum sector altitude (Minimum Sector Altitude Warning – MSAW).

Each of the states had specific Human Machine Interface (HMI) requirements and these were catered for on an individual basis without affecting the common functionality. The Bulgaria/Romania Joint Simulation featured 2 very different HMIs in the same simulation whilst sharing the same common underlying functionality.

4.5.1 The ROMATSA HMI

ROMATSA have conducted an ongoing series of prototyping exercises and have the experience of a previous EEC simulation conducted in 1997. This has allowed them to evaluate their detailed system specifications and develop a CWP prototype that formed the basis of the simulated CWP. The ROMATSA CWP prototype was installed at the EEC to assist in the preparation of the simulated HMI and also for demonstration purposes during the simulation periods.

The main features of the ROMATSA HMI are as follows:

- **Interactive Radar Label**: An advanced label format providing a lot of information in a very compact format with several controller options.
- **Data Input by Elastic Vector**: All values are input via elastic vector that is locked on a vertical axis for level inputs.
- **Touch Input Device**: Provided as an alternative and complementary input device to the mouse.
- **Minimal List Information**: A design objective was minimise the use of data list information with the maximum of graphical and radar image based information.
- **Electronic Co-ordination**: The use of colour to differentiate between outgoing and incoming co-ordination the ROMATSA HMI negates the need for “Message-in” and “Message-out” windows.

Details of the simulated HMI are provided in the Romania 99 System Handbook (Ref. 2) and for a full technical specification of the simulation facility the reader is invited to contact the EEC.

4.5.2 Operations Room Configuration

The operations room was configured as required for the various organisations of the Bulgaria/Romania Joint simulation and Romania 99.

- Bulgaria/Romania Joint Simulation

The operations room was configured with 24 measured CWPs as follows:

Sofia ACC . . . . 4 Sectors (8 CWP)
Varna ACC . . . . 2 Sectors (4 CWP)
Bucharest ACC . . . . 4 Sectors (8 CWP)
Bucharest APP . . . . 2 sectors (3 CWP)
Military Co-ordinator . . . . 1 CWP

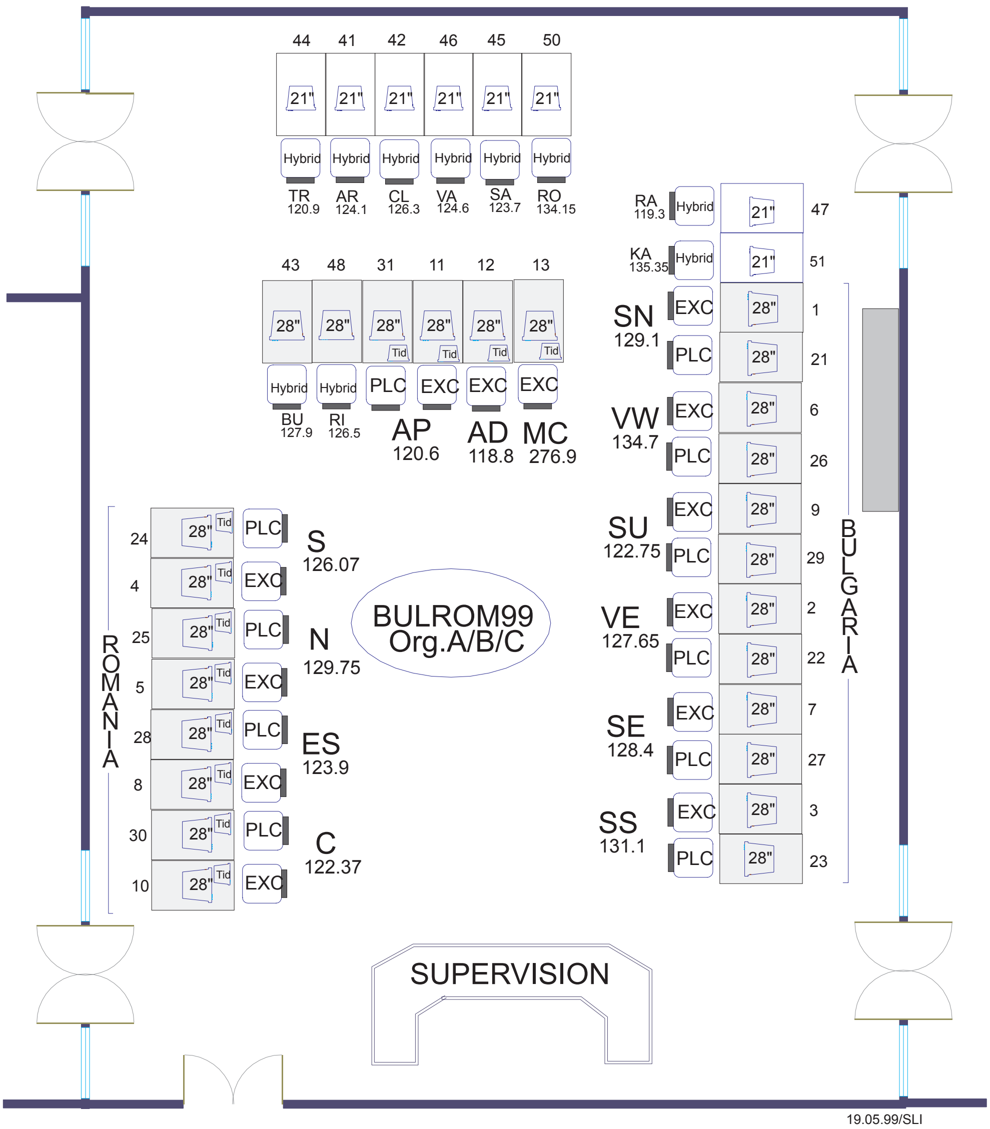

Fig. 4 - 6 : Bulgaria/Romania Joint Simulation Ops Room Layout

- Romania 99 Simulation

The operations room was configured with 26 measured CWPs as follows:

Bucharest ACC . . . . 5 Sectors (10 CWP)
Other Romanian ACCs . . 5 Sectors (10 CWP)
Bucharest APP . . . . 2 sectors (3 CWP)
Military . . . . 2 Sectors (3 CWP)

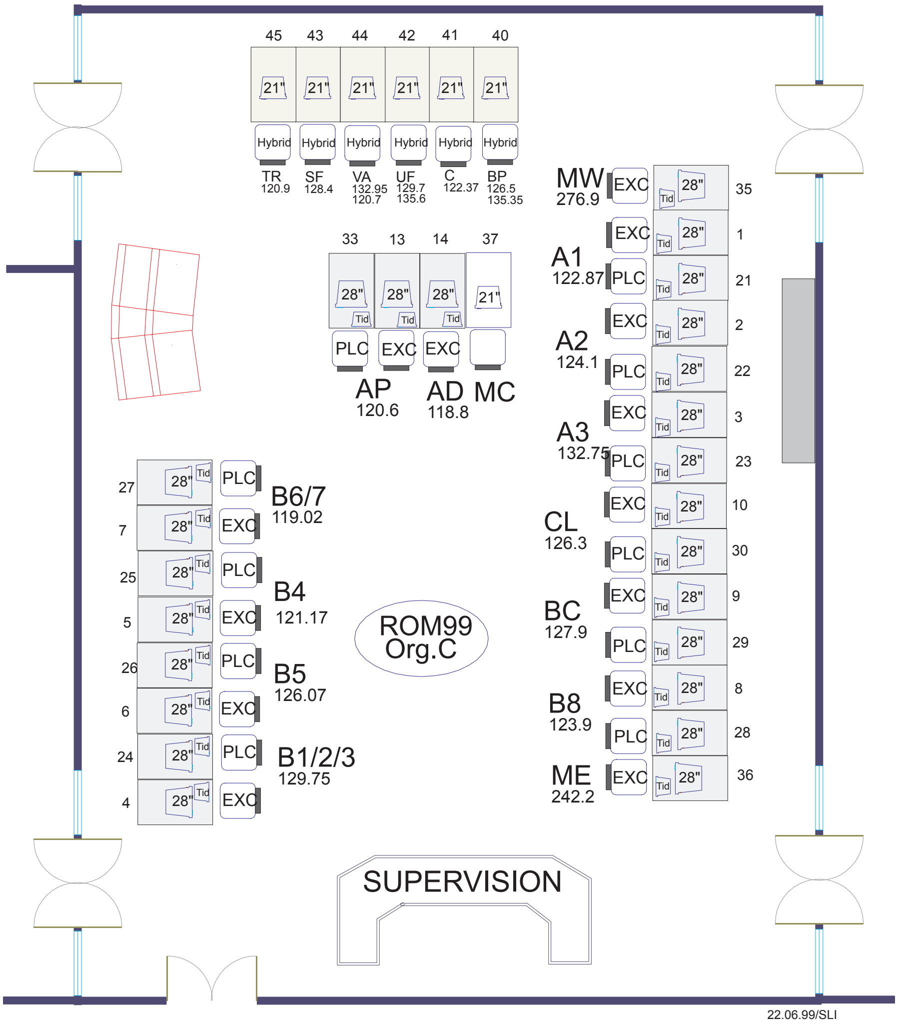

Fig. 4 - 7 : Romania 99 Simulation Ops Room Layout

The Measured Controller Working Position consisted of:

- 28'' square colour display, used to provide a multi-window working environment
- Main Processor and display driver
- 3 button mouse
- 14'' Touch Input Device
- A simulation telecommunication system with headset, footswitch, and panel-mounted push to talk facility

The measured sectors were comprised of identical CWPs configured as either Executive (EXC) or Planning (PLC) positions. Each CWP provided access to the same facilities; controllers had the capability to determine display preferences depending on the control task. Only the MTCD was specifically configured – only MTCD warnings referred by the PLC were displayed to the EXC.

Each CWP included a subjective workload panel (Instantaneous Self-Assessment – ISA) used by the controller for periodic input throughout the measured exercise.

Feed Sectors were provided with a specific interface known as the «hybrid feed sector» which incorporated a piloting function which interprets controller inputs also as pilot inputs allowing the sector to operate autonomously without the need for a dedicated pilot operator.

4.5.3 ATC Procedures and Controller Tasks

The controller tasks and procedures for the Romanian control environment were largely determined by the results of previous simulation experience.

Details of these controller tasks and procedures are contained in the Romania 99 Controller Information booklet (Ref. 3)

4.6 METHODOLOGY

The simulation results contained in this report were compiled from the notes taken at simulation de-briefing sessions, questionnaire responses and the observations of the project team.

Simulator recordings of controller inputs, pilot inputs and aircraft flight paths were analysed to provide further supporting evidence for the results.

The Instantaneous Self-Assessment (ISA) method was used to assess controller workload. Participants were asked to respond to a prompt every 2 minutes by pressing a button appropriate to their perceived workload at the time; Very High, High, Fair, Low or Very Low.

5. RESULTS - OBJECTIVE 1

To evaluate the new ROMATSA Controller Working Position, specifically:

- ***the Human Machine Interface including, colour, text, radar labels, data windows and graphic information presentation***
- ***the 3 button mouse for data access and input including extensive use of «elastic vectors»***
- ***the ROMATSA TID for data input and co-ordination purposes including specifically:***
  - ***data selection***
  - ***speed of access and input compared with the mouse***
  - ***specific uses including multiple inputs and approach tasks***
  - ***ergonomic aspects including location and parallax***
- ***controller aids including MTCD and Safety Nets***

The simulated ROMATSA Controller Working Position (CWP) was created to resemble as close as possible the ROMATSA prototype that has been the subject of considerable development in recent years. The ROMATSA prototype could not be directly integrated into the simulation for technical reasons. The prototype interface was created using the InterMAPhics™ graphical package and therefore all simulated features had to be recreated using ODS Toolbox which is the basis of the graphical interface of the EEC simulator - EONS. However, although this represented a considerable amount of work, the translation of features into EONS was very successful with only minor limitations preventing an identical CWP to be created. The points of incompatibility were in presentation priority that prevented the ROMATSA elastic vector input device being displayed over certain windows and also in the presentation of colour transparency. An adequate solution to these shortcomings could not be implemented due to the limited resources and time available but this had very little impact on the realisation of the simulation objectives.

Thanks to the co-operation of ROMATSA and the Gallium Corporation it was possible to install the ROMATSA prototype at the EEC several months before the simulation. A Romanian software engineer was seconded to the EEC for 9 months to assist in the preparation of the simulation. These two factors played a major role in the success and realism of the simulation. The ROMATSA prototype was also displayed in the operations room during the simulation periods which allowed visitors to gain hands-on experience of the new interface. The prototype was additionally used to demonstrate colour transparency and an alternative colour scheme to the one simulated.

The result of the study of the simulated CWP was very positive. The simulated CWP provided an efficient working environment that made maximum use of graphical aids and interaction via the radar label. The results of the simulation suggest mainly minor changes to what is a well-developed prototype.

The results in relation to this primary objective are presented in the order described in the wording of the objective. Results generally apply to all control positions. Where specific results apply to En-route, Approach or Military positions this is indicated.

Romania 99 - Typical Controller Working Position

5.1 MAIN DISPLAY FEATURES

The primary component of the simulated HMI was the 28” Monitor. This section will deal with the results concerning the features displayed on this screen. Other CWP components are reported on later in this section.

5.1.1 Colour

The colour scheme used throughout the simulation is described in detail in the Romania 99 System Handbook (Ref.2). The main colours used were as follows:

Background – Shades of pale grey
Pending Flight Data – Beige
Assumed Traffic Data – Lilac
Concerned Traffic Data – Lilac Callsign, remaining data grey
Unconcerned Traffic Data – Grey
Co-ordination Data – White
Warnings – Yellow and Orange

A typical display can be seen in the screen image below.

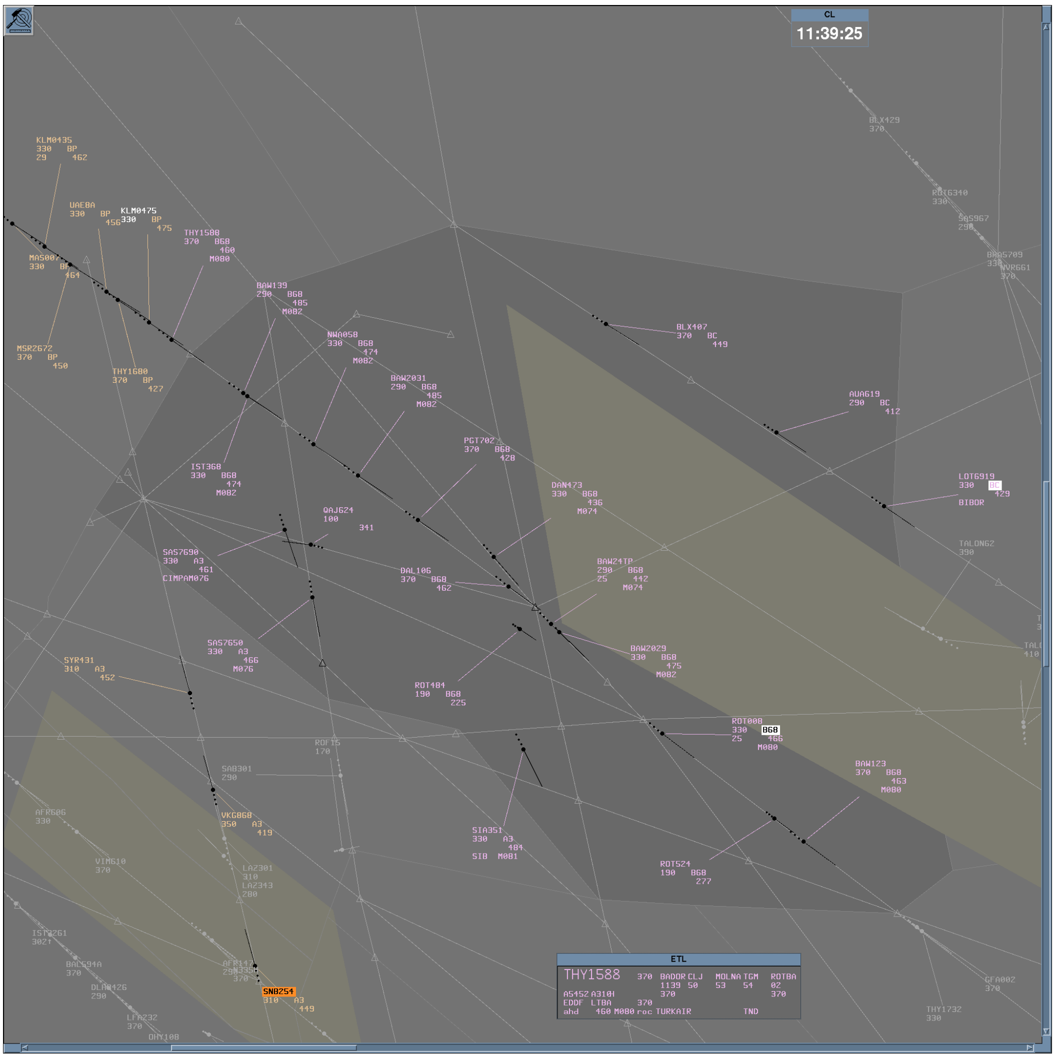

Fig. 5 - 1 : Typical Screen Image - Romania 99 Sector

The simulation participants fully endorsed the colour logic employed but considered that the exact choice should be the subject of further refinement.

97% of participants felt that the use of colour to indicate flight status helped them to «regularly or always» prioritise their actions. They also endorsed the general choice of colour with over 95% responding that they were never or rarely confused by the use of colour but comments were made about the use of specific colours. The colour used for «Assumed» was criticised by 30% of controllers who commented that it did not contrast enough with the background and they would prefer to see beige, black or even light blue used as assumed colour. “Unconcerned” colour was also criticised with almost 20% of controllers being dissatisfied with the grey colour used. The lack of contrast between the unconcerned grey and the background grey meant that data was difficult to read, in particular the AFL. Lack of contrast was also cited as a cause of discomfort and controllers appreciated the colour intensity controls which were only available on the ROMATSA prototype.

The ROMATSA interface specified extensive use of background colour change to highlight information. Subtle change of background colour was very successfully used to cross-highlight all data associated with a particular flight. For example, when the mouse cursor came to rest on a radar label not only was the Extended Track Label (ETL) updated with the appropriate flight details but the corresponding Sector List (SEL) and TID data was also presented with a slightly lighter background. The background colour change for this type of highlighting was just sufficient to ensure that the data could be easily located but legibility of text was not affected. Controllers greatly appreciated the effectiveness of this feature.

Logical colour highlighting was successfully used to reduce the need for additional text and also to indicate outgoing and incoming co-ordination without the need for “message windows”. Highlight using background colour was used to indicate incoming co-ordination. Data subject to co-ordination was displayed in white on the proposing sector whilst on the receiving sector the corresponding data was displayed with a white background. It was immediately found that certain foreground colours became illegible when displayed on a white background, the beige pending colour for example. The solution implemented was to display co-ordination items in black text whenever the white background colour was used. The 2 radar labels below show the effect of this.

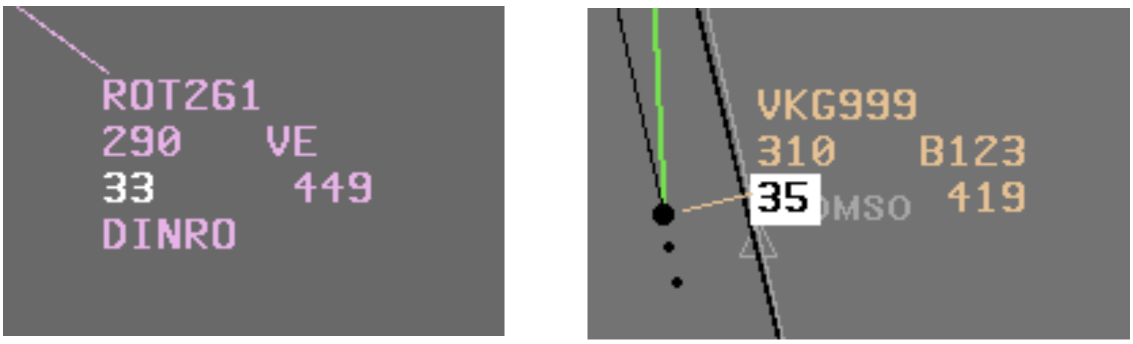

Fig. 5 - 2 : Screen image of outgoing and incoming co-ordination displayed in radar labels

Combining this use of colour with the use of specific mouse buttons (Button 1 – accept, Button 2 – reject, Button 3 – counter proposal) meant that co-ordination in/out windows became redundant and they were not included in the simulation. It was found, however, that all possible co-ordination items should be clearly displayed to the controller. One example concerned direct route co-ordination. A proposal for direct route was originally displayed only in the radar label. In the event that the radar label was not within the displayed range of the receiving controller he did not notice the co-ordination.

The implemented solution was to additionally display the direct co-ordination alongside the appropriate flight data in the Sector List (SEL).

Another area of potential difficulty in the use of background colour highlight arose when the same item could potentially be displayed in the same colour as the background colour. This obviously rendered the item invisible. This occurred with the Request On Frequency (ROF) function. A flight in “transfer in” status was displayed with the callsign in white. If the next downstream sector simultaneously made a ROF input the background to the callsign was displayed in white, resulting in white callsign on white background. Appropriate solutions should be devised for this and other similar possibilities.

Other comments concerning colour included the background grey used in the SEL which was considered too dark. The military tracks on civil sectors were displayed in unconcerned colour and controllers felt a dedicated colour should be used to allow this traffic to be more easily identified. The choice of colour for route centrelines should ensure that the speed prediction vector remains clearly visible.

Choice of colour is very subjective and there will always be differences of opinion. A majority of the participating controllers expressed a wish to be involved in the final choice of colour, but felt it was important that the use of colour was standard throughout the system and was the result of consultation and debate.

5.1.2 Text

The choice of font was as small as possible to enable the radar label data block and list data to remain as small as possible whilst remaining fully readable from the normal sitting position in front of the display.

The controllers were generally satisfied with the choice of text but did request some control over text size at the display. They also made several specific comments:

- Certain characters could be confused – for example the group O, 0 and D and also the letter B and the number 8
- The text of the range and bearing tool was considered too small

5.1.3 Radar Labels

The ROMATSA radar label format is the result of their prototyping and previous simulation experience. The current format is well developed and provides the maximum of information whilst occupying the minimum of display area.

Minimum information display rules ensure that superfluous data is never presented. Values are shortened following logical rules to ensure they occupy as little space as possible. The controller has control over several options in the label, the only permanent data is callsign, SSR Mode C level and the attitude indicator if climbing or descending. The option is given to display ground speed and the content of a special information field which may contain destination (first two letters of ICAO destination if outside Romania, last two if within Romania), next sector or exit point shortened to 2 letters.

The 4th line of the label containing assigned heading (ahd) assigned speed (asp) and rate (roc) data can be selected on/off. If data is present in line 4 when “off” has been selected a * symbol is displayed in line 3. Simply moving the cursor onto the track displays the Selected Label Window (SLW) in which all fields are visible.

A full description of the radar label is provided by the Romania 99 System Handbook (Ref. 2) but a selection of labels are shown below:

Fig. 5 - 3a : Radar Label - Callsign, Mode C, next sector and * indicating line 4 data present

Fig. 5 - 3b : Radar Label - Callsign, Mode C, next sector, ground speed and assigned Mach number

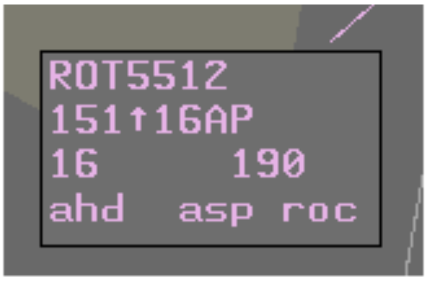

Fig. 5 - 3c : Selected Label Window (SLW) - Callsign, Mode C, attitude indication, CFL, next sector, XFL, ground speed plus assigned heading, speed and rate fields

All controllers considered the data content and layout of the radar label was complete for the operational requirements. The only comments made were as follows:

- The minimum information logic should take into the Supplementary Flight Level (SFL) value. As simulated only the XFL was compared with AFL and CFL to determine whether XFL should be displayed. When SFL has been input, it may be wise to continue to display XFL until the AFL is within the band SFL-XFL.
- In the pending label the XFL is not presented in the radar label. In the event of XFL co-ordination concerning a flight which is still in pending status on the receiving sector the ROMATSA specification calls for a forced display of XFL in the EFL field surrounded by a line frame. Controllers considered that this highlight might not be sufficient to avoid the risk of confusion.
- It was the opinion of the participants that the inclusion of both EFL and XFL in the pending label would lead to an unacceptably large data block especially in the presence of SFL data. The simulated radar label format was considered optimal and that an alternative solution may have to be found to highlight outstanding XFL co-ordination for a pending flight.
- The leader line linking the radar label to the track should be extendable to at least 8cm.

As with all display systems of this type, radar label overlap was an issue. The controllers appreciated the various methods available to resolve overlaps with manual resolution via the “drag and drop” feature being far and away the most popular method. Although this involved some considerable work, controllers said that they refreshed their mental traffic picture as they manually relocated labels and did not find it too tiresome.

The Extended Track Label (ETL) was effectively an electronic strip giving full flight details of any selected aircraft. The ETL was considered to be completely adequate and an example is shown below.

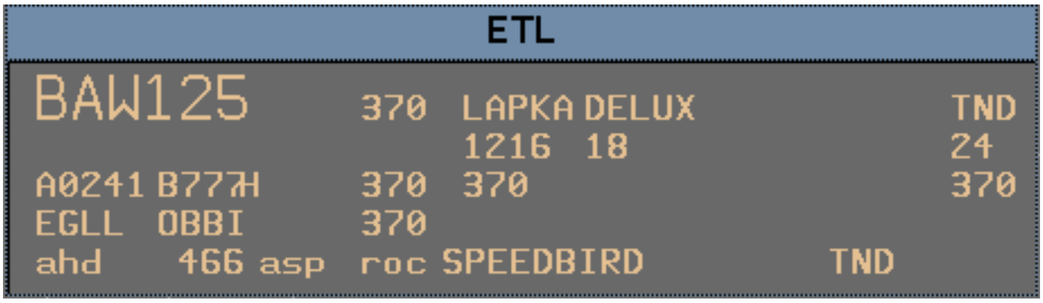

Fig. 5 - 4 : Screen image of Extended Track Label (ETL)

5.1.4 Data Windows

The ROMATSA data display is perhaps one of the least cluttered of this type of HMI currently under development and makes use of a minimum of additional data windows to those already described in the radar label section. The only data windows provided for civil controllers are the Sector List (SEL) containing entry and exit conditions for all pending, assumed and concerned flights and the Hold List containing brief data on flights which have been instructed to enter a holding pattern.

Sector List (SEL)

The SEL format was designed to enable entry and exit conditions to be checked by the comparison of traffic at point/level/time as is currently practised with paper strips. A “pack” feature arranged new data that initially appeared at the bottom of the list and sorted pending traffic by entry point, level and time. Assumed and concerned traffic was sorted by exit point, level and time.

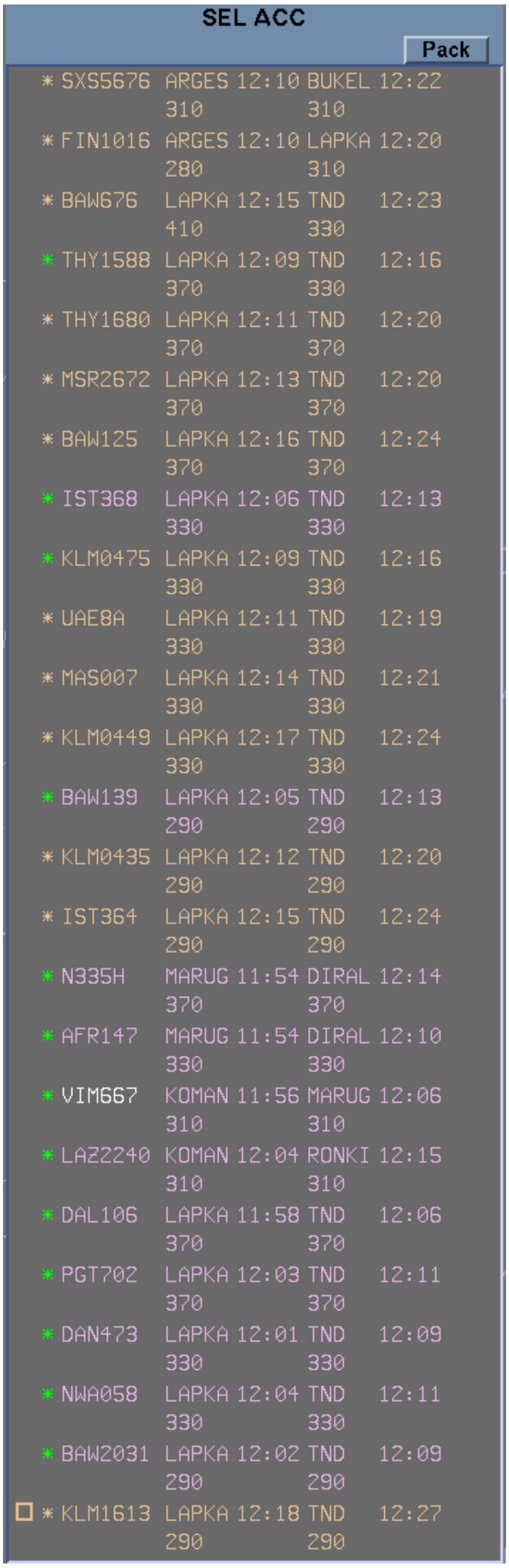

Fig. 5 - 5 : Screen image of Sector List (SEL)

The specification of the ROMATSA SEL seems to be a good compromise between the screen area covered and the usefulness of the data displayed with over 70% of controllers reporting that they used it "regularly" or "always". The data displayed in the SEL was generally considered adequate but certain observations were made concerning the SEL content and its features:

- Different sort criteria are required. Controllers had differing sort requirements and one feature that was seriously lacking was the ability to sort pending traffic by exit point.

- The SEL is the only place where data on all flights is permanently displayed therefore co-ordination data should always be visible in the SEL as it may not be visible elsewhere. During the simulation the SEL was modified to show direct route and military crossing co-ordination.

Hold List

En-route holding was not a feature of the simulation therefore the only sector to use the Hold List was Bucharest Approach. The format was as shown below:

The hold list fulfilled a useful function with no adverse comments recorded.

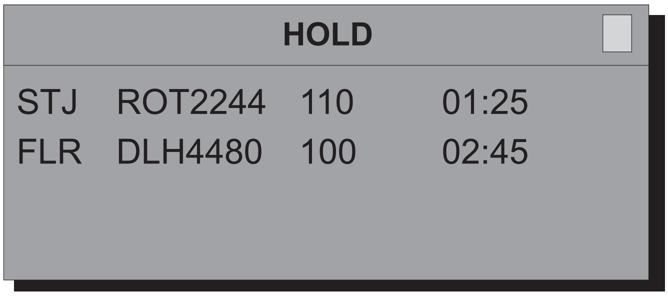

Fig. 5 - 6 : Hold List Window

5.2 GRAPHIC INFORMATION PRESENTATION

Results are in this section refer to other display features on the 28” monitor screen that have not been covered earlier.

5.2.1 Radar Control Panel

The Radar Control Panel provided access to the controls for the display and could be reduced to a small icon if required.

All required functions were present in the control panel with the only omission being an ability to save (memorise) a particular display centre point. The requirement for controller related preference settings was not addressed in the simulation but should be carefully considered for the operational system.

5.2.2 Callsign Menu

The callsign menu was designed to be as small as possible with less frequently used functions being located behind an “Advanced” button to prevent the primary menu being too large. Analysis of the use of the callsign menu functions during the last week of Romania 99 indicates that inputs were divided as follows:

Transfer/Assume inputs 89%
Forced ACT. 4%
Crossing Request . . . . 2.5% (accept/reject 2.5%)
Request on frequency 2%
All other inputs . . . . less than 0.3%

This analysis reveals that Transfer and Assume are by far the most common callsign menu inputs and provokes the question - “is menu selection really essential for these mutually exclusive inputs?”

5.2.3 Tracker and Range and Bearing Tool

The Tracker and Range and Bearing Tool closely followed ROMATSA specifications with activation being possible anywhere on the screen by use of button 3 of the mouse also known as the “Special Button” (SB). Certain limitations were imposed by the simulator systems and controllers insisted that these should not affect the operational system. One requirement that was not provided in the simulation was the ability to attach the tracker to any point on the screen and not necessarily to a waypoint symbol. Another observation was that when an R&B or Tracker input was being made the SLW feature should be deactivated as it often inhibited inputs.

As has been mentioned earlier the R&B text was considered too small. A more appropriate data format was also suggested with specific prefix letters to avoid confusion. For example:

R17
B125
T22.2

5.2.4 Integrity of System Determined Data States

Data states calculated by the system determined the appropriate colour and format of flight data. In most cases this was dependent on flight plan data updated by events such as sector exit. Prior to a state change to unconcerned, a crosscheck should be made with radar data to ensure the integrity of displayed data. The system should be designed to fail-safe with traffic remaining «concerned» unless there is clear assurance that the unconcerned state is appropriate.

During the simulation traffic was routed around active military areas and sometimes was forced to enter airspace that was not foreseen in the system calculated flight plan. The controllers had no manual control over the data state of flights which was managed by the system. Heading orders were not taken into account for the recalculation of sector sequence and therefore the controllers requested a feature to manually force data display to an adjacent sector. This could take the form of a «force concerned» input plus also a method of manually overriding the system calculated sector sequence. This requirement should be the subject of further debate prior to system specification agreement.

An additional question raised and not fully answered was display requirements for traffic that becomes uncorrelated. This traffic will not be governed by the usual data states because of the lack of flight plan association. Again radar data could be used to determine a special display status to ensure that the track does not become unconcerned.

5.2.5 Dynamic Flight Leg

The Dynamic Flight Leg (DFL) is an important part of a modern system and has development potential. One aim could be to reduce the time consuming use of the R&B tool. Features that were suggested during the simulation were:

- The DFL could be recalculated following heading input.
- The name of waypoints could be a display option to complement the ETO.
- The MTCD “look-ahead” could be indicated to show the extent of MTCD integrity.
- Time and distance to go to separation loss or closest point of conflict.
- Improvement in the display of conflicting traffic to provide less confusing data display.
- Approach controllers require such items as time/distance to touchdown and the names of intermediate points.

5.2.6 Squawk Ident

Squawk ident should force the display of a track through all filters

5.2.7 Mark

The Mark feature was regularly used for many purposes with the controllers being generally happy with the functionality although 27% said that they did not like the fact that either controller in the team deactivate the Mark, perhaps against the other's wishes.

Mark uses are stated in the Romania 99 Questionnaire Responses (Ref. 4)

5.2.8 Traffic Visualisation Tool

The Traffic Visualisation Tool highlighted all traffic at the same level (Press & Hold Button 2 on AFL) or all traffic between AFL and CFL (Press & Hold Button 2 on CFL). Practical experience in the simulation led to the highlight being expanded to show callsign, AFL and position symbol in green. A possible extension of this feature is to XFL where all aircraft between AFL and XFL could be highlighted. Green may not be the most appropriate colour as this tool provides a warning function.

5.2.9 Transfer Reminder

This was appreciated by some controllers but not others who found it annoying. Therefore it could be the subject of personal selection in the control panel. Additionally, the reminder could be suppressed when an aircraft is on heading or re-timed to go off at the sector boundary rather than the "2 minute before" parameter simulated. Approach controllers said that transfer reminder was inappropriate for them.

5.2.10 Level Deviation Alert

Level Deviation Alert was a useful feature added at the last minute to highlight aircraft that climb or descend without clearance. The CFL was shown in warning orange if the AFL deviated away from the CFL value.

5.2.11 Specific Approach Requirements

Approach controllers identified several specific HMI requirements:

- XFL/EFL is not appropriate within the approach/tower team. Removal would reduce label size
- Controller positions in the approach environment have specific requirements for the use of the concerned status. For example AP needs to see all AD traffic as concerned. Additional specific status may also be required for approach/tower
- CFL defaults should be carefully studied to enable more rapid inputs. The most appropriate level should be offered dependant on whether the flight is inbound or outbound taking into account the current CFL
- Heading, Speed and CFL inputs input by one approach team member should be visible to all the team
- The Mark feature should be extended to allow "marking" for other members of the approach team

5.2.12 Specific Military Requirements

Two types of military sectors were included in the simulation. Military Executives provided a control service to OAT whilst the Military Co-ordinator had overall responsibility for military operations and therefore required a composite display of all activity.

The participants identified several areas in which the interface could be modified to better serve military requirements.

- **Military Flight List**

This list was considered too big despite the fact that it was stated that additional data was desirable. The solution may be to provide display options in the window header to allow the controller to select the data he requires.

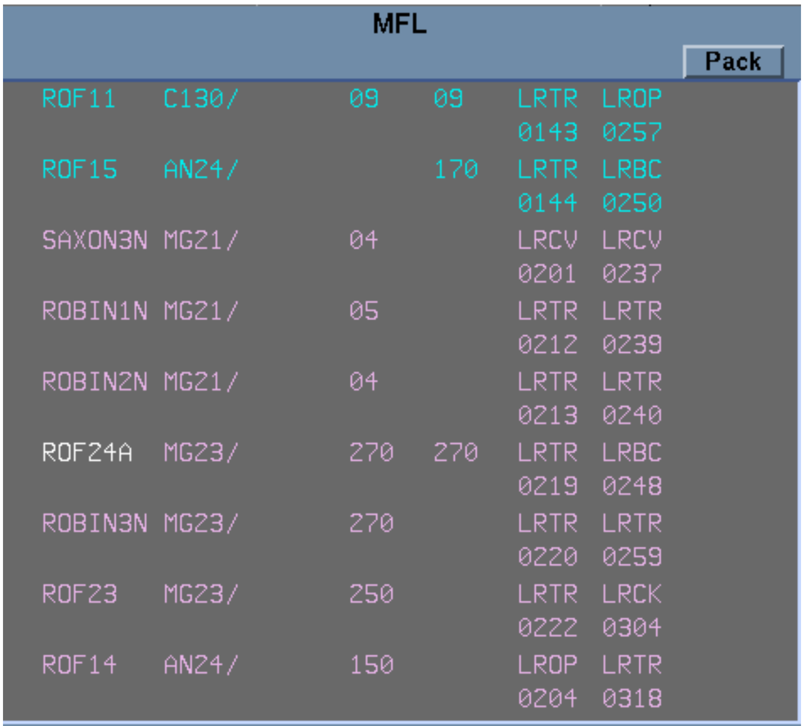

Fig. 5 - 7 : Military Flight List

- **Forced ACT**

FDP was suspended for military flights to allow the controller operational freedom to choose co-ordination partner as required. The Forced ACT allowed an ACT to be sent to any co-ordination partner, with whom the flight could then be co-ordinated and then transferred in the normal manner. This feature worked extremely well and allowed the required flexibility particularly with the Bucharest TMA where military flights started as GAT departing Bucharest Baneasa and Otopeni subsequently becoming OAT after transfer to the military.

- **Military Dynamic Flight Leg (MDFL)**

This feature did not work as required by the military due to the suspension of FDP for military flights. The suspension of FDP gave the military the required flexibility but meant that the route displayed on the MDFL was often in error. An operational requirement was expressed that the MDFL should accurately reflect the aircraft's route. This will be difficult to achieve but the following options may have merit. For routine navex or transport flights the MDFL could show the flight plan route as these flights rarely deviate from planned track. For high performance OAT on flexible flight plans a special speed vector could be provided in place of the DFL. This special speed vector could reflect the degree of certainty concerning the predicted trajectory and could be based on current heading, CFL, speed and rate of climb/descent. If the aircraft's intentions were unclear the speed vector presented could reflect this.

- **Callsign Menu**

The callsign menu offered main inputs in the top-level menu with less common inputs being provided in a second level menu. Less stages of input are desirable. It was suggested that if more options were available in the first level menu this might speed up the input process.

- **Military Crossing Request (XRQ)**

The HMI aspects of this feature are dealt with in Section 6 which reports on Civil-Military Co-ordination.

- **Military Area of Responsibility**

The military areas of responsibility were clearly shown to military controllers but not to civil controllers. This was an oversight that should be corrected in the operational system.

- **Contingency Highlighting**

The display of words such as JOKER and BINGO in line 4 of the label to indicate military states of urgency was considered insufficient. A coloured box surrounding the radar label was suggested to more quickly attract attention.

- **Military Co-ordinator (MC) Specification**

Prior to the simulation it proved difficult to imagine the HMI requirements for the Military Co-ordinator. The experience of the simulation enabled a clear list of requirements to be drawn up as follows. The MC needs:

- Free access to all military frequencies
- To see all traffic displayed including pending traffic for either military sector
- To see the CFL input on any military flight
- A Sector Indicator to see who is the current controller
- A copy of all XRQs
- Access to ETL data prior to departure
- Special warnings such as early warning of “low on fuel”

Above all, considerable effort should be placed on the specification of the MC position. It cannot just be a simple copy of a normal sector. The job description and military operational concept must be carefully developed prior to final HMI decisions.

5.3 THE 3 BUTTON MOUSE AND INPUT VIA ELASTIC VECTORS

ROMATSA have dedicated considerable effort to the study of input devices and their previous simulation experience and use of the prototype led to the specifications used during Romania 99. The mouse is considered as the primary data selection and input device for the Romanian HMI. The TID (explained in the next section) is considered as suitable alternative device and has particular specific uses.

5.3.1 Mouse Buttons

Previous studies have led to the configuration of the mouse buttons used in the simulation. The configuration is extremely logical and was a follows:

MOUSE BUTTON CONFIGURATION		
1 (LEFT)	**2 (CENTRE)**	**3 (RIGHT)**
"Action"	**"Information"**	**"Special"**
Co-ordination ACCEPT	Co-ordination REJECT	Co-ordination COUNTER-PROPOSAL
1. Data Input **2.** Activate/deactivate functions **3.** Standard window mgnt (size, drag and drop etc)	**1.** Access additional information **2.** Delete data **3.** To abandon input	**1.** Activate R&B and Tracker **2.** SFL value input **3.** Flip between mach and knots during speed input

This design has 3 key points:

- The co-ordination logic which is designed to negate the need for co-ordination message windows
- The use of right and left buttons to make SFL + XFL/EFL inputs (see below)
- The use of the right button to activate the R&B tool anywhere

The mouse was fully acceptable as the primary input device and no criticism of the implemented logic was forthcoming. The only comment being that consideration should perhaps be given to offering a reversed configuration on demand for left-handed controllers.

5.3.2 ELASTIC VECTOR DATA INPUT

Data input via elastic vector has been evaluated in several recent simulations with the primary use being for heading input. Romania have extended the use of elastic vector input to level, speed and rate of change values using a vector locked on a North-South axis. This method of input was initially tested in Romania on the ROMATSA ATC simulator. In particular, pilot positions were equipped with this input method and it was found that pilots could satisfactorily “keep up” with control orders. The Romania 97 simulation evaluated the use of the elastic vector for CFL input only and therefore allowed a back-to-back evaluation against the pop-up method.

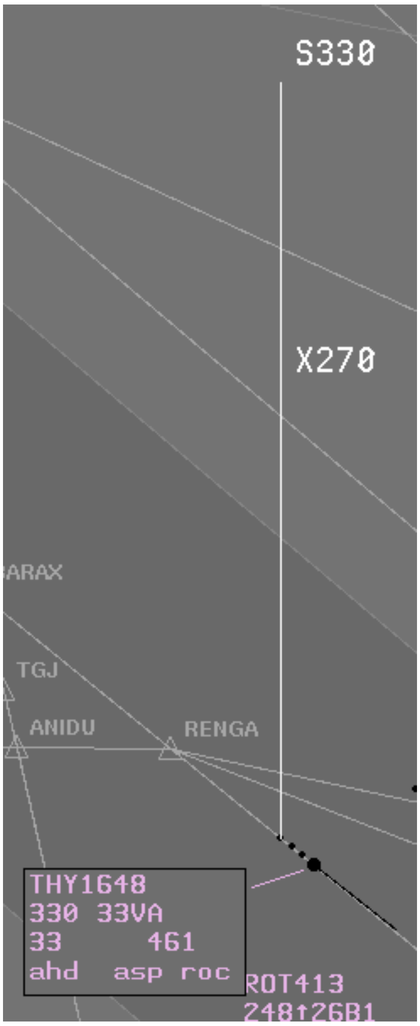

Fig. 5 - 8 : Elastic Vector Input of XFL combined with SFL

Input via elastic vector has several advantages. There is no pop-up window that unavoidably obscures data therefore requiring data such as callsign and order type to be shown in the header. The elastic vector is calibrated to present the same value at the same physical place each time. Therefore no matter where the data is displayed on the screen the required value is always in the same vertical position in relation to the top and bottom of the screen. For example; levels are offered with 1000ft at the bottom and FL450 at the top of the screen - therefore FL220 is always positioned half way up the screen.

The elastic vector inputs available were as follows:

ELASTIC VECTOR INPUTS	
Input	Method
Heading	Click AB on position symbol or «ahd» field Click AB when desired value displayed at end of vector
Direct	Click AB on position symbol or «ahd» field Click AB on a waypoint of route displayed on the video map
CFL	Click AB on CFL field - values offered preceded by letter C Click AB when desired value displayed
XFL/EFL	Click AB on XFL or EFL field Click SB when desired value of SFL displayed Click AB when desired value of XFL or EFL displayed (values preceded by E, X or S as appropriate)
Speed	Click AB on «asp» field Click SB flips between Mach and knots - values preceded by M or K as appropriate Click AB when desired value displayed
Rate	Click AB on «roc» field Click AB when desired value displayed

A full description can be found in the Romania 99 System Handbook (Ref. 2)

The controllers were very satisfied with the elastic vector as a means of input to the system. In particular they liked the fact that data was never obscured and there was no scrolling or paging was required.

It was observed that the elastic vector should have priority over all other display objects. Time and effort were not available to resolve a graphical problem in EONS where the elastic vector was obscured behind certain windows (ETL for example). This problem is not present on the ROMATSA prototype.

System response time must also be of high standard when vectors are used in this way because if the system «hesitates» even slightly, perhaps during a radar update, the elastic vector appears to «stick» frustratingly.

5.4 THE ROMATSA TID

The ROMATSA TID is described in the Romania 99 System Handbook (Ref. 2) and further details are available from ROMATSA.

The TID was a 14” touch sensitive screen placed at an angle below the Sony screen in the CWP. The main functions as specified by ROMATSA were represented to provide a valid evaluation the utility of the device.

The primary TID display presented callsigns on 2 pages - Pending and Assumed. Touching a button marked EXC or PLC as appropriate allowed the alternative page to be selected. Touching a callsign gave access to flight data in similar format to the radar label format for either information or modification.

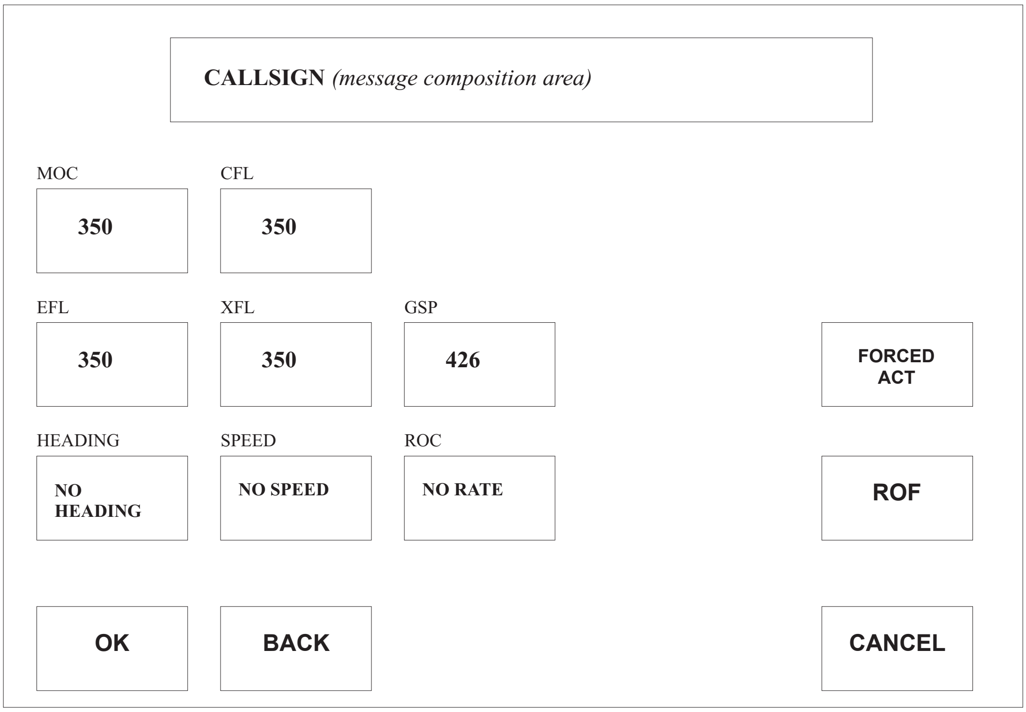

Fig. 5 - 9 : Touch input Device Flight Data Panel

Touching a value displayed on the Flight Data page of the TID gave access to appropriate input pages which offered certain default values and allowed access to other values via a «telephone type» number pad. One particular advantage of the TID was the ability to enter combined orders: heading, speed and CFL for example in the approach environment. A major disadvantage of the TID is that the eye has to be diverted form the main display; this may be undesirable in busy periods.

Several improvements were made to the TID during the simulation:

- Cross highlighting of callsign in line with the rest of the highlighting logic
- Transfer, ROF and co-ordination states shown on the TID
- Callsign automatically transferred to the assumed page when in transfer-in status

The TID was considered an excellent complement to the mouse with over 90% of the participants feeling that a combination of mouse and TID should be available. It was not questioned that the mouse should remain the primary input device because of its speed and ease of use, but that the TID had specific advantages for specific situations. PLCs often used it for co-ordination purposes.

The specific advantages of the TID were observed as follows:

- The TID was an excellent back-up to the mouse in the event of mouse or main screen graphics failure (several occasions occurred when the mouse was blocked due to system problems)
- In the event of one screen of a two controller team failing the controller who had lost his screen may be able to share the remaining screen whilst having his own input device in the TID
- Direct routing input to a point outside the displayed radar range (elastic vector was the only alternative to the TID)

- Multiple inputs
- Flight re-routing
- Military controllers felt that there may be several specific inputs required for military flights that may be better handled by the TID
- The TID provided a rapid method to Assume or respond to a ROF due to successful callsign highlighting
- Following further training/experience some TID inputs may become almost second nature and turn out to be quicker than the mouse due to the predictability of data location

The controllers made several additional suggestions for TID improvements:

- Pack by time sequence as opposed to alphabetic
- Pack on SEL or TID should pack all data everywhere
- Refined default values for approach (the TID has the advantage over the mouse of being able to display multiple defaults)
- Heading input via the TID for approach use was far from ideal and the specification of this function should be reviewed
- The colour scheme should be reviewed
- As a back up system it should provide all input possibilities
- Flight leg selection should be possible via the TID
- The TID should be positioned on the left of the console to ease left-handed use as the mouse is predominantly held in the right hand

5.5 CONTROLLER AIDS - MTCD AND SAFETY NETS

5.5.1 Medium Term Conflict Detection (MTCD)

A common MTCD logic was used during all the ROMBULPO simulations. Each state chose its own interface with the underlying system. Romania specified a simple conflict list with no additional graphic information except the display of conflict zones on the Dynamic Flight Leg.

The MTCD logic is fully described in the Romania 99 System Handbook (Ref. 2). The basis of the system was the horizontal trajectory updated by time deviations and controller input direct orders up to 30 minutes ahead of the aircraft. A search for conflicts in the horizontal plane was made and the result was refined by the use of specific vertical filters based on known values. No attempt was made to predict a vertical climb/descent profile. This provided a basic but reliable system which was considered a pragmatic approach taking into account the difficulties being experienced by more complex MTCD studies.

The ROMATSA Conflict List was presented to both EXC and PLC controllers but conflicts were initially presented only to the PLC. The list gave an indication of time to loss of separation and the predicted minimum distance. It also had a feature that allowed the PLC to acknowledge, remove or refer a conflict to the EXC. A filter was also provided to refine the vertical search to the levels between AFL and CFL - so called “True” conflicts. Other conflicts based on planning levels such as EFL and XFL were referred to as «Risks» and could be filtered out by use of the Risk filter.

Fig. 5 - 10 : Screen Image of Conflict List

The controllers were happy with the Conflict List as a means of presenting conflict pairs to the controller. The vertical filtering of conflicts was considered acceptable for sectors with a large proportion of traffic in stable flight at high level. It was suggested that the filtering of conflicts should be the subject of further work to try to provide more reliable and accurate information.

It was observed that many controllers used the conflict list as an aide-memoire for outstanding problems and then reverted to R&B use to verify the predicted separation. This may be force of habit, but prompted the suggestion that the DFL should provide additional information to reduce R&B use. It was observed that the “refer” function was little used - the EXCs therefore working without the benefit of MTCD.

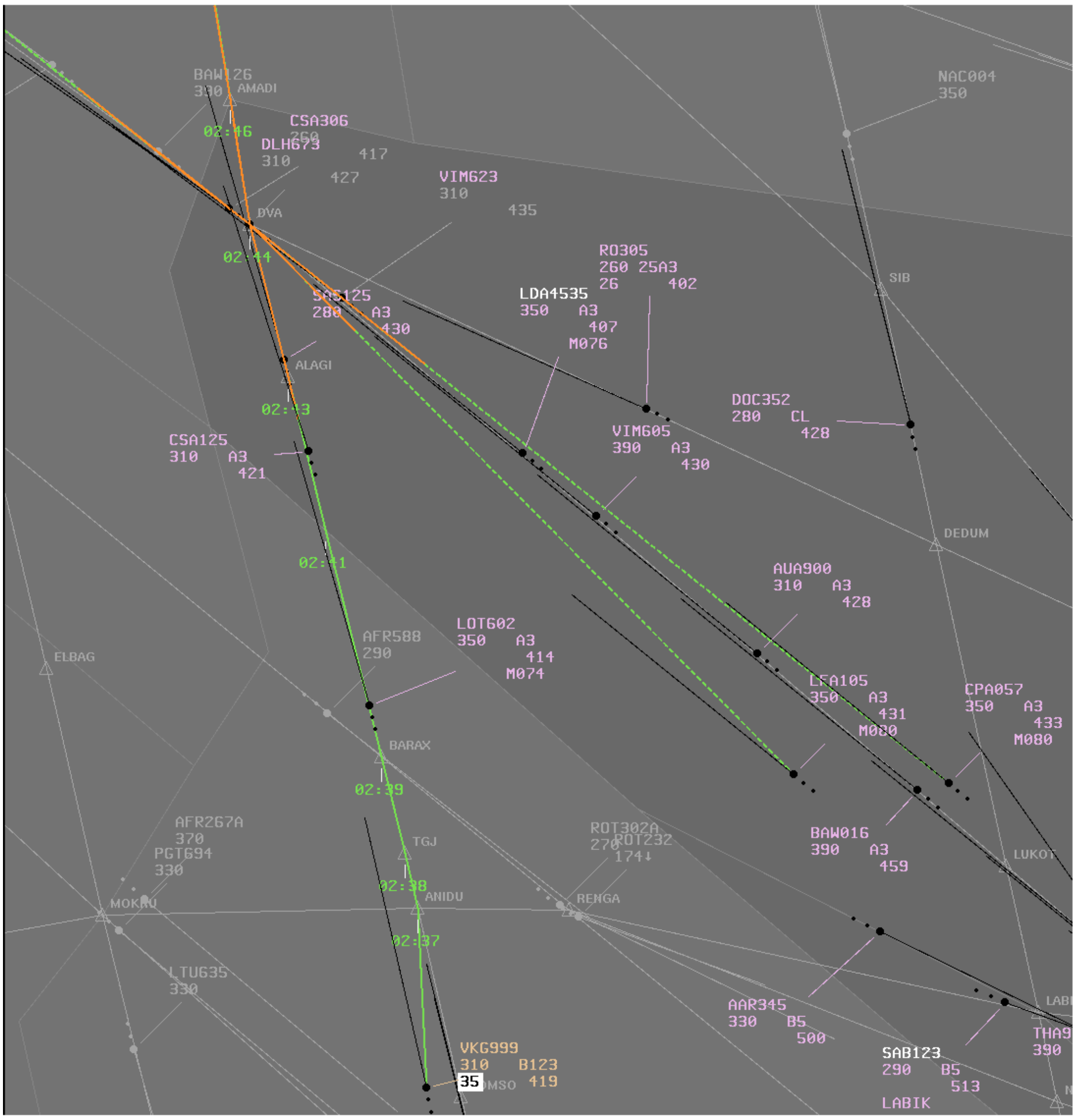

Fig. 5 - 11 : Screen image showing MTCD displayed on Dynamic Flight Legs

The MTCD clearly displays that the proposed EFL of FL350 fir VKG999 is unacceptable due to conflict with LFA105 and CPA57 in the vivinity of DVA.

5.5.2 Short Term Conflict Detection (STCA)

The simulated STCA included an orange line around the concerned labels and a yellow dotted line linking position symbols. The STCA was activated 2 minutes before predicted loss of separation based on radar trajectory and CFL was taken into account.

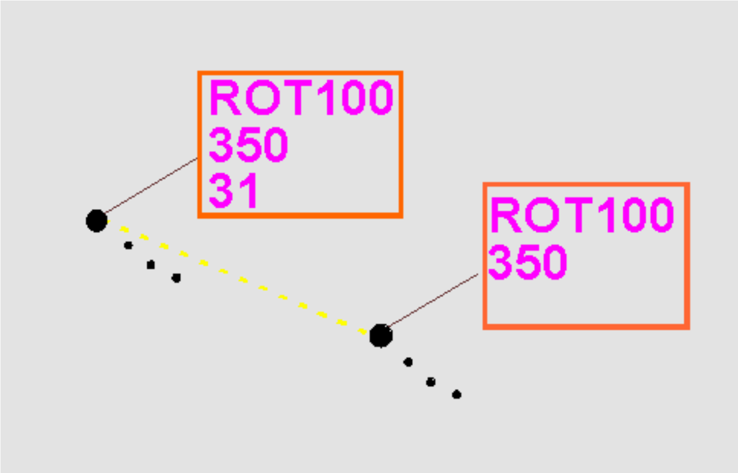

Fig. 5 - 12 : Short Term Conflict Alert (STCA)

The STCA adequately attracted attention and provided a clear indication of the nature of the problem without any additional data display in the radar label block. No adverse comments were received.

5.5.3 Area Proximity Warning (APW)

The APW was effective in attracting the controller's attention by the use of an orange background to the callsign. There was some discussion as to whether APW should be suppressed after it had caught the controllers attention but it was finally agreed that it should stay on as the concerned flight should perhaps be the subject of special attention whilst within the vicinity of restricted airspace. It was suggested that in the operational system APW should be linked dynamically to video map selection controlled centrally, probably by the supervisor.

Military participants commented that specific functionality would be required for military use. The military may wish to suppress APW for a particular zone within which they are operating and would require an alternative specific form of alert for the various types of areas - Danger, Restricted as well as TSA.

5.5.4 Minimum Safe Altitude Warning (MSAW)

A simple form of MSAW was provided to approach controllers to warn of approaching high ground by use of an orange background to AFL.

No adverse comments were recorded for this HMI feature except that as in all other cases where a background colour is used to highlight data the possibility should be considered of temporarily changing the colour of the text to ensure legibility.

5.6 CONTROLLER TASK DISTRIBUTION IN THE SIMULATION

With the exception of MTCD, the simulated system allowed full flexibility of tasks and roles. Operational procedures were agreed in advance to try to ensure a balance of workload within the control team.

5.6.1 Enroute Sectors

It was observed that PLCs occasionally reported higher workload than their EXC colleagues. Using the simulated system features the PLC was able take a considerable load off the EXC by trying to ensure pre-separated traffic flows. As reported earlier the use of R&B involved considerable effort and there was also a natural tendency to try to solve as many conflicting situations as possible prior to sector entry. This slight imbalance of workload favouring the EXC did of course allow the EXC to have a little spare capacity as he was often left with a mainly monitoring role allowing some capacity to manage unexpected events.

5.6.2 Approach Sectors

At very high traffic levels the AP EXC was often unable keep pace with the required inputs.

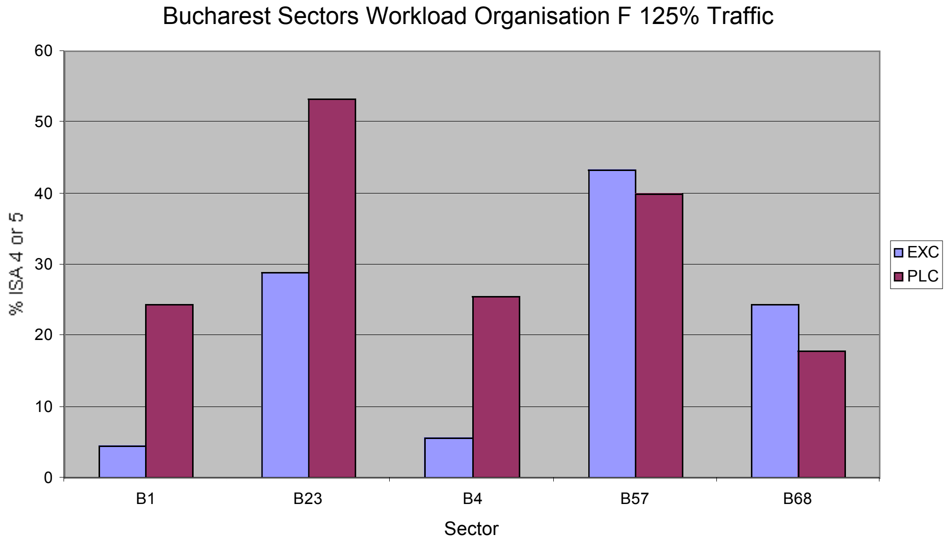

Fig. 5 - 13 : EXC workload compared with PLC workload

The PLCs often had to help out, which is a far from satisfactory situation. It was suggested that a review of roles and responsibilities within the approach team might lead to a reduction in AP EXC workload. The participating approach controllers felt that the simulation had given them the necessary experience to assist in this task.

6. RESULTS - OBJECTIVE 2

To evaluate new Civil-Military Co-ordination procedures

The simulation was designed to evaluate the concept of Civil and Military controllers operating in a shared airspace environment. The two military sectors managed military traffic over the entire Romanian airspace and operated in close co-operation with their civil colleagues operating within the same airspace. Most exercises were conducted without the activation of military Temporary Segregated Airspace (TSA) but during the 4th and final exercise of each organisation TSA were activated to gauge their impact on the civil sectors involved. The activation of selected TSA also allowed the military participants to evaluate the dimensions, location and suitability of the simulated TSA plus the transit requirements of military flights to and from the military bases.

6.1 ELECTRONIC CROSSING REQUEST

6.1.1 Description

The civil-military co-ordination procedures were based on implementation of the electronic civil-military crossing request as provided for in OLDI draft V3 (Ref. 6) and as simulated in graphical form in the EATCHIP series of simulations. Electronic crossing request was simulated in both directions, i.e. from military to civil requesting crossing of civil air route(s) or the Bucharest TMA and also from civil to military requesting crossing of an active TSA.

The electronic crossing request functionality is described in the Romania 99 System Handbook (Ref. 2). It included the XRQ message, which could be accepted or rejected, and the XCM message that was used to cancel an XRQ that was no longer required. No possibility of electronic counter-proposal was provided, controllers were asked to revert to telephone co-ordination should the first attempt at an electronic request fail or in the event of a modification of the crossing conditions. The system automatically detected the correct sector to which the crossing request should be sent by interpretation of the co-ordinates and level of the point at which the crossing was to be initiated, enabling a simple and rapid input procedure.

The graphical input of XRQ resulted in the display of the requested trajectory of the crossing request on both concerned sectors. The level (or band of levels) was displayed in the radar label of the concerned aircraft plus the callsign and levels displayed as a supplementary label at each end of the crossing segment. All this data was displayed in co-ordination colour prior to acceptance and subsequently displayed in warning colour after acceptance.

6.1.2 Crossing Request - General Results

The simulated electronic crossing request was very well received by a large majority of controllers with over 80% considering that it was frequently useful. Only 11% considered that it was rarely useful.

The XRQ initiation was accomplished via pop-up menus prior to the graphical route input using elastic vector. Controllers considered that the XRQ input would be easier to input if it was fully integrated into the Romanian HMI concept and used the elastic vector for level value inputs rather than a pop-up. This would be a logical development and reinforces the case for HMI design to be considered as a whole and not a collection of individual functions. As simulated, the XRQ input involved too many clicks according to the controllers and should be simplified. The Romanian HMI logic of “AB accept, IB reject, SB counter proposal”, should be integrated into the crossing request design. From the HMI point of view two other requirements were identified - a dotted line joining the radar label was appreciated to help in identifying the concerned aircraft and also a request was made to highlight the callsign of the concerned aircraft in co-ordination colour. This would be completely logical as the response to an incoming XRQ was via the callsign.

The controllers regretted that the system did not permit counter-proposition. This was considered during the simulation preparation but was considered to be excessively complex due to the inclusion of route and level information in the XRQ message. Any counter proposal logic would have to consider the three possibilities - counter propose route, level or both.

Once a crossing request had been approved controllers had differing requirements regarding data display. It was requested and implemented during the simulation that the radar label data and the graphical data including the additional labels situated at each end of the crossing segment should be separated to allow deletion of either at the controllers discretion. This meant that if required the graphical route could be agreed and then suppressed leaving just radar label data and an uncluttered display. Clutter was a problem especially with multiple requests for a stream of traffic. This could occur when a stream of military flights followed the same route or as frequently occurred during the simulation when a stream of civil aircraft required crossing of an active TSA.

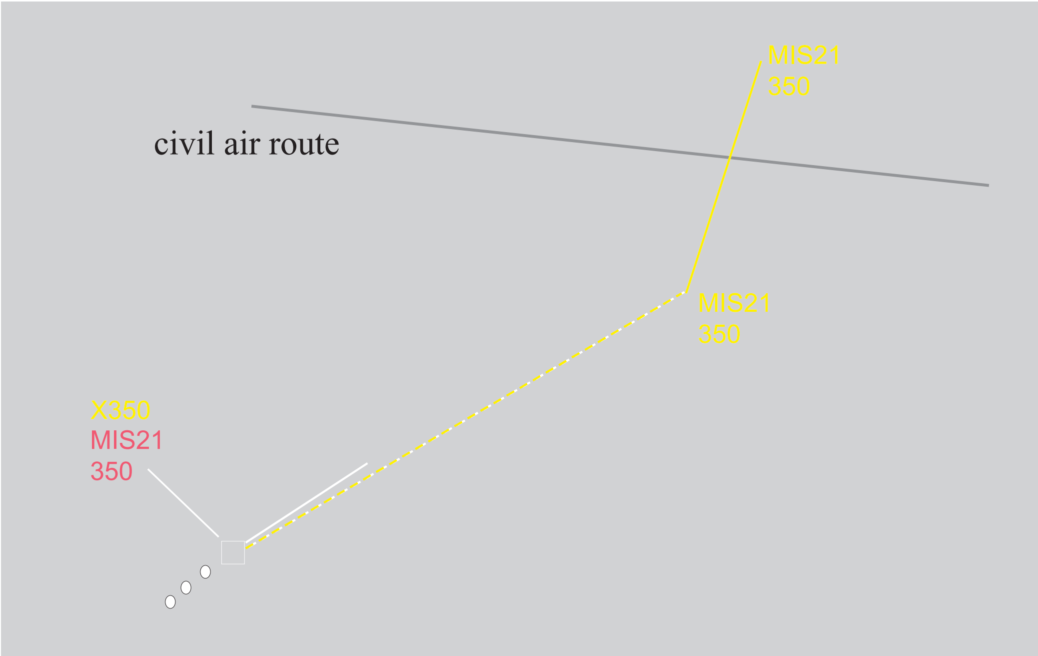

Fig. 6 - 1 : Graphical Presentation of Crossing Request

The requirement was also identified to request a modification of crossing conditions after initial approval had been received. The simulated system did not allow revision of the crossing level(s) or route.

A Military Co-ordinator (MC) was simulated. It was identified that it may be an operational requirement for either the sector or the MC to initiate the crossing request with the other being provided with a copy.

6.1.3 TSA Crossing by Civil Flights

It was identified that strict procedures are required in the case of civil requests to the military. Several issues must be addressed such as - what is the pre-warning time required by the military? The military pre-warning time may require that the crossing request be initiated by the civil sector prior to assume of control. It may be a requirement to copy the approved crossing to the sector currently controlling the flight. Procedures are also required to cover the eventuality that the military TSA affects 2 or more civil sectors - it was felt that one civil sector should be given responsibility for initiating the crossing request whilst the other(s) are provided with copies of the approved crossing.

The simulation of civil to military crossing requests also identified the requirement for multiple or “block crossing”. This would be a very useful feature, however further development of the HMI would be required.

Certain military TSA spread across the boundary between the two military sectors. This led to some confusion among the civil controllers as to which military sector was the controlling authority. Clear procedures would resolve this problem.

6.2 MILITARY ROUTE INFORMATION

Military and Civil controllers were dependant on the display of accurate route information concerning each others flights. Route information was essentially provided by the Dynamic Flight Leg (DFL). This was satisfactory for civil flights and routine military flights such as navigation exercises, but was unsatisfactory for military OAT flights following flexible flight plans. It was suggested that in the case of a requirement to show route information on an OAT flight a development of the speed vector could be used in place of the DFL. This special speed vector could reflect the degree of certainty concerning the predicted trajectory and could be based on current heading, CFL, speed and rate of climb/descent. If the aircraft’s intentions were unclear the speed vector presented could reflect this.

6.3 MILITARY TSA ACTIVITY

One set of Military TSA were specified for Organisation A and second set were specified for Organisations C, D, E and F. The simulation concentrated on the future situation represented by Organisations C, D, E and F therefore results are presented for these areas only. A map showing the simulated military areas is presented in Section 4 - Simulation Conduct.

Avoidance routes were prepared for the civil controllers to enable them to have a pre-designed alternative route that could be used to avoid an active area. Prior to re-routing a civil aircraft controllers were requested to attempt to arrange a crossing, first via electronic means or if this failed - verbally on the telephone.

AREA B1_TR

This area was very disruptive to Arad sector A1. When it was activated a major re-routing of civil flights was required. It was suggested that when B1_TR is active the sectors A1 and A2 should be amalgamated to reduce the co-ordination associated with the necessary avoiding action. Most of the military activity in this area was above FL350 therefore civil crossing requests at FL290 and FL330 were regularly approved.

AREA B2_TR

This area affected the Arad sector A3 but was not considered too disruptive to civil operations. This was mainly because the military traffic using this area remained at high level. Accommodating the return to base proved a little tricky for A3 but could be solved by procedures including a descent within the area prior to setting course. This TSA also affected the Cluj sector but Cluj were able to re-route traffic successfully as required.

AREA B4_OS

This area had a serious impact on Bucharest sector B1. Traffic had to be vectored the long way round to the south remaining in B1 or alternatively re-routed via sector B23 to the north. As simulated this traffic was “unconcerned” to B23 and a system function is therefore required to re-route traffic to include B23 in the sector sequence or at least display this traffic in “concerned” colour.

AREA B5_FT

This area affected both Constanta sectors with some vectoring required when crossing requests were not approved.

AREA B6_CT

No comments recorded.

AREA B7_BC

This area proved to be successful as it was very conveniently located for the military and had good dimensions. It was found that the few civil crossing requests could usually be accommodated.

AREA B8_DN

This area affected the southerly Constanta sector - C2 who was able to successfully avoid using direct routings or limited use of headings.

6.4 OVERALL CONCLUSION

The results presented above indicate the close working relationship that developed between civil and military during the simulation. The simulation represented a major step forward towards even closer co-operation and the efficient sharing of airspace.

7. RESULTS - OBJECTIVE 3

To further evaluate new co-ordination procedures between ACC sectors, ACC and APP sectors, and APP and TWR sectors.

A first evaluation of co-ordination procedures for a fully electronic stripless environment was conducted during Romania's previous real-time simulation - Romania 97 (Ref. 1). The simulations in 1999 were designed to build on the results of Romania 97 both in terms of HMI, (see Section 5) the procedures used and the implementation of OLDI principles detailed in the EUROCONTROL OLDI Standard V2.2 (Ref. 5) and draft V3 (Ref. 6).

As in OLDI documentation this subject is broken down into Notification, Co-ordination and Transfer of Control.

7.1 NOTIFICATION

The current notification period used in Romania is 13 minutes. This is the time prior to sector/unit exit at which the ACT message is sent. This parameter was used throughout the simulation with the exception of between Romania and Bulgaria where 8 minutes was used at the request of the Bulgarians.

The notification period is currently the most appropriate time at which strips should be printed and is close enough to exit time for this time to be accurate and not likely to be revised.

There was no evidence in the simulation that the 13 minutes parameter should be changed for the new environment. In the future, the accuracy of time data will become less relevant as the receiving unit will be probably already processing radar data based on correlation established on receipt of the ABI message. In the environment simulated the flight data was displayed in pending colour on receipt of the ACT and it was at this time that the PLC started to evaluate the flight data and check that sector entry and exit conditions were satisfactory.

In the electronic environment the controller is provided with simple means to modify both entry and exit conditions as soon as the ACT is received. This means that the notification period should be set at an appropriate time based on the following operational factors:

- The point at which the PLC requires data can be analysed by operational experts taking into account the time required for the PLC to analyse and react to the new data. This includes the possible need to re-negotiate entry conditions especially if conflict points are located close to the sector entry point.
- Optimal list data display requirements - list windows may become unreasonably large if flight data is displayed too early.

7.2 ENROUTE CO-ORDINATION

Co-ordination between en-route sectors and between en-route sectors and approach sectors was limited to level and direct route information. In the downstream direction all revisions were considered as referred revisions (RRV) and in the upstream direction co-ordination messages (CDN) were simulated.

The main findings of the simulation were regarding the limitation of the OLDI standard to two co-ordination partners - sending and receiving. It was also suggested that co-ordination should be expanded to include heading and speed information.

7.3 DIRECT ROUTE CO-ORDINATION

Sensible precautions were included in the HMI specifications to attempt to limit direct route co-ordination to just two co-ordination partners. It had been found in previous EUROCONTROL simulations (Lisboa 98 - Ref. 7) that unlimited use of the direct input order could cause undesirable side effects with multiple sectors being involved. In Romania 99 (and the other ROMBULPO simulations) the direct input order was limited to points up to and including the sector exit point prior to ACT time. Following transmission of the ACT, points within the next sector became available for direct input order - selection of a point within the next sector generated a RRV message. Route re-calculation was performed on receipt of the acceptance message. This logic worked well in the downstream direction.

In the upstream direction the situation is a little more complex. Once the ACT had been received a direct routing order could be proposed to the preceding sector. A problem occurred when the receiving sector was not yet in control of the aircraft and was not in a position to agree or implement the proposed direct routing.

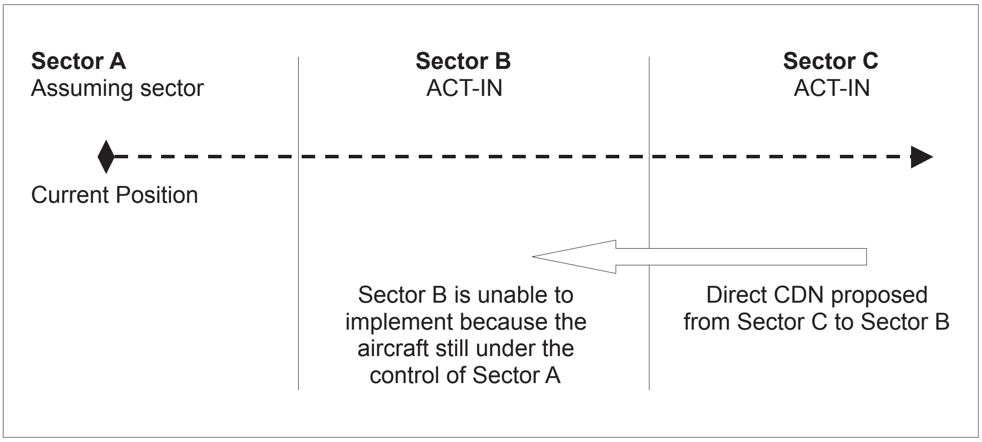

Fig. 7 - 1 : Upstream direct route co-ordination affecting 3 sectors

As you can see in the above graphic the co-ordination between Sector C and Sector B must remain on standby until co-ordination is effected between Sector B and Sector A. This could be achieved by use of the telephone or more suitably - by the use of a second CDN message. The simulated HMI and ATC system did not permit 2 outstanding co-ordinations at the same time. Neither did it allow the selection of co-ordination partner. In the example above sector B has two potential co-ordination partners for route revision/co-ordination - Sector A or Sector C. These requirements should be seriously considered for an operational system.

The system did not permit counter-proposal to a direct routing CDN or RRV. This possibility was considered logical and desirable for an operational system.

7.4 TRANSFER LEVEL CO-ORDINATION

Controllers were provided with the possibility of co-ordinating transfer levels that were displayed as Entry Flight Level (EFL), Exit Flight Level (XFL) and also Supplementary Flight Level (SFL) that could be combined with either EFL or XFL. For example FL210 (SFL) climbing FL310 (XFL) was displayed as 21↑ 31. Only the EFL or XFL value was considered for profile re-calculation, the SFL was considered as purely text for information.

Previous simulations have identified situations where 3rd sectors can be implicated in level co-ordination (see Lisboa 98 Report Ref. 7). In the Romania 99 simulation particular problems were encountered between vertically unlimited sectors that were adjacent to vertically split sectors.

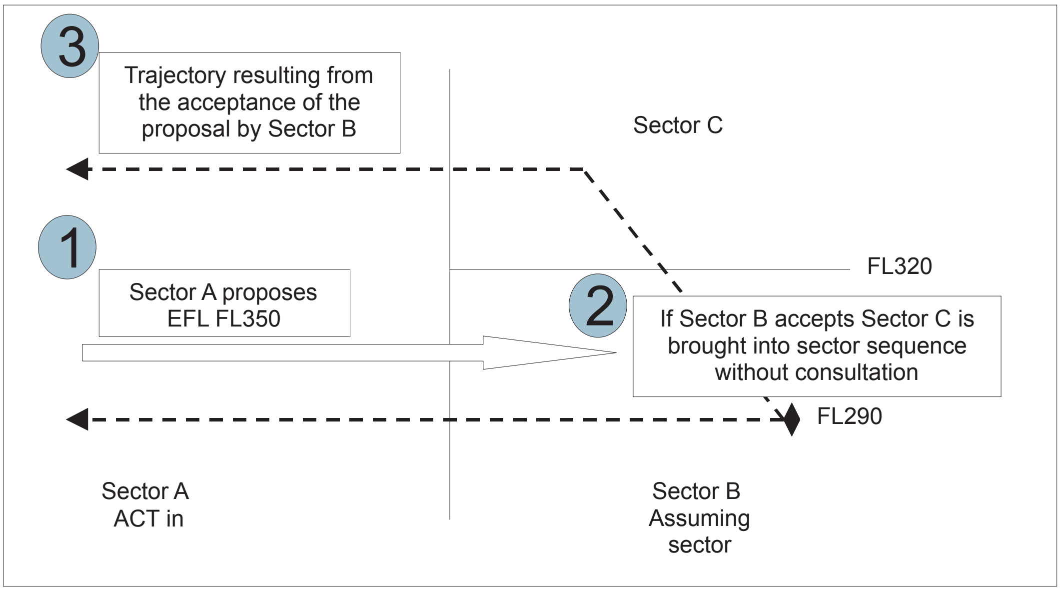

Fig. 7 - 2 : Upstream level co-ordination affecting 3 sectors

The graphic above shows the impact of a co-ordination proposal from Sector A to Sector B. By simply accepting the proposal Sector C is brought into the sector sequence without any consultation. As with the direct co-ordination example the initial co-ordination proposal must remain on standby whilst Sector B co-ordinates with Sector C electronically or verbally. Again, this must be considered in system design for the operational system.

7.5 APPROACH CO-ORDINATION

It was identified that co-ordination between the sectors that comprised the approach team must be handled very differently to the en-route situation. The approach controllers said that the approach area should be considered as one sector for electronic co-ordination purposes. There may be no need for data revision (either referred or automatically accepted) within the approach team. The identified requirement was for a distribution of data within the approach team so that each controller could see the CFL, heading and speed entered by any other controller. This type of data distribution was considered ideal for the approach environment where controllers work as a very closely integrated team. Distribution of data in this way would minimise verbal co-ordination and allow controllers to plan their actions based on a knowledge of the input orders of the other members of the team.

Therefore the Approach PLC, Approach EXC and Final Director need to be considered as a 3-controller team, not as 2 distinct sectors within the TMA.

The electronic co-ordination between the tower feed and the approach team which provided information and clearance request possibilities was endorsed as fulfilling the operational requirements.

7.6 TRANSFER OF CONTROL

The ROMBULPO simulations did not feature the Transfer Initiation Message (TIM). Only the Change of Frequency (COF) and Manual Assume (MAS) messages were simulated for Romania (other ROMBULPO simulations included release and handover functions not required by Romania).

Controllers said that they would have appreciated the implementation of a TIM message particularly to provide heading and speed information a few minutes prior to the transfer of control to enable them to plan more effectively. It was considered that input Mach would be very useful information.

The timing of the TIM message should be carefully considered as the controllers also requested to be able to co-ordinate heading and speed information. A “Request on Heading/Speed” message was suggested that could be treated either as a CDN message or simple request at the last minute prior to transfer which may not necessarily require a response from the transferring sector.

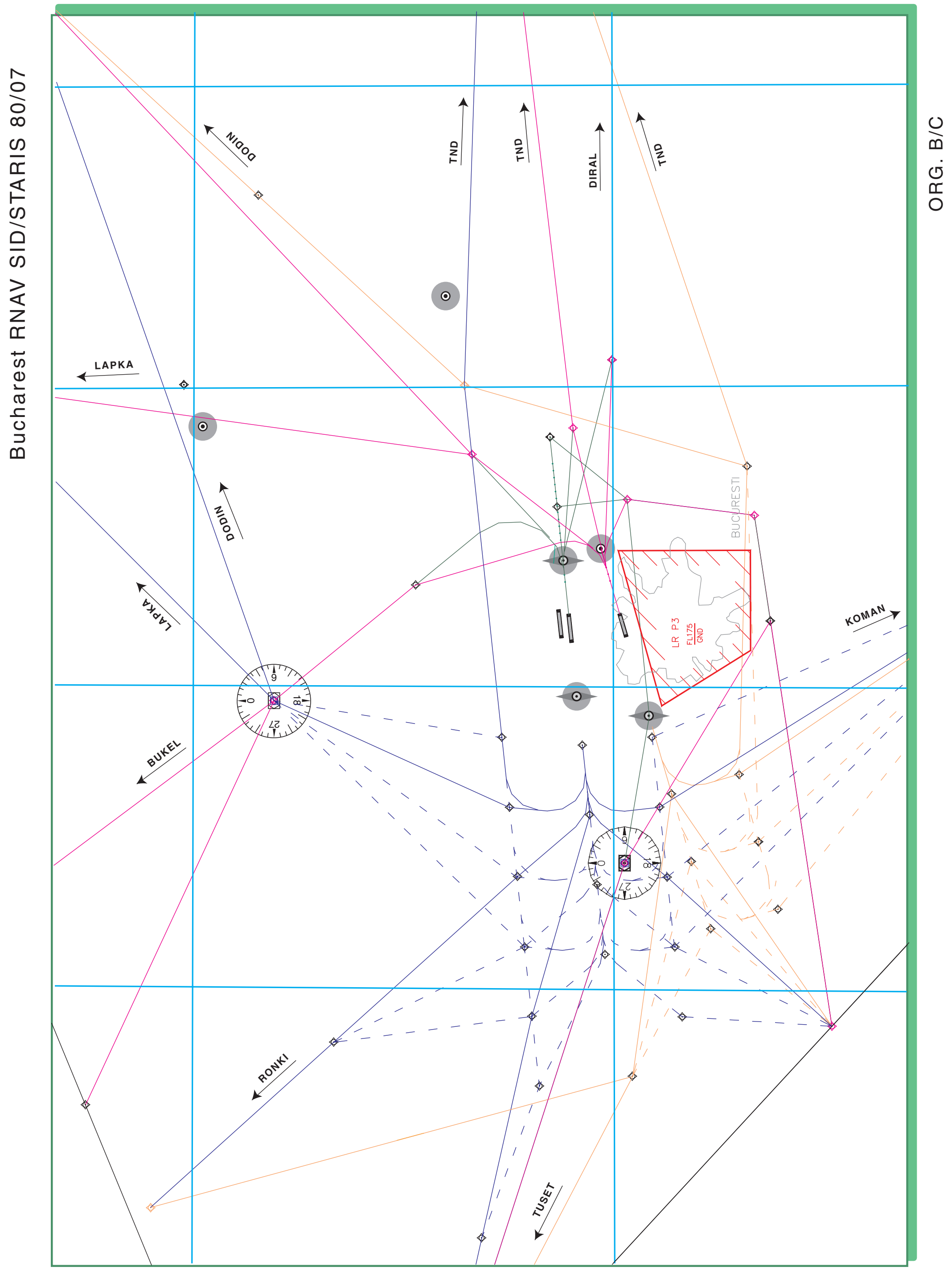

Fig. 8 - 1 : Typical RNAV Arrival and Departure routings for Bucharest (Otopeni) Runway 08

8. RESULTS - OBJECTIVE 4

To evaluate the use of RNAV arrival and departure routes for Bucharest and associated ATC and aircrew procedures.

8.1 INTRODUCTION

The enhanced accuracy and better performance made possible by the improved quality of the new generation of navigation and other avionics equipment being fitted to modern aircraft fleets has prompted EUROCONTROL to initiate studies aimed at evaluating the more efficient and widespread use of these systems throughout all phases of flight.

The first advance came in April 1998 with the implementation throughout ECAC airspace of Basic Area Navigation (B-RNAV). Previously, routes had to be aligned with ground-based navigation aids, thereby causing bottlenecks in the En-Route System. However, by substituting waypoints, the position of which can be located virtually anywhere, this restriction has been eliminated, as evidenced by the success of Version 3 (V.3) of the EUR-ANP. The flexibility in route planning allowed by B-RNAV has reduced the number of bottlenecks and improved the delay situation significantly.

The body responsible for B-RNAV implementation, the EUROCONTROL Airspace and Navigation Team (ANT), decided to explore the possibility of extending the potential benefits of RNAV to Terminal Airspace. It devolved this responsibility to the Terminal Area RNAV Applications Task Force (TARA) which had as its prime objective the definition of requirements for a cost-effective application of RNAV in Terminal Airspace.

Whilst there was a considerable amount of data which could be used to evaluate the use of RNAV from an aircraft operator’s perspective, it was recognised that there was very little quantifiable information relevant to ATS provision. TARA was therefore pleased to accept the offer of the three States (Bulgaria, Poland and Romania) participating in the ROMBULPO simulations to include RNAV aspects in their scenarios. Therefore, with the willing co-operation of the Operational Services staff of the EUROCONTROL Experimental Centre at the EEC, a comprehensive evaluation programme was developed by the Terminal Airspace specialists of the Airspace Management and Navigation Unit at EUROCONTROL HQ in Brussels.

8.2 EVALUATION DEVELOPMENT

Romania 99 was the last of the ROMBULPO series of simulations and, having previously simulated the Lateral Navigation (L-NAV) or 2-D option and basic 3-D L-NAV with vertical profile, the next step in the process was to evaluate concurrent mixed-mode (3-D and non-RNAV) operations with added scenarios which included exception handling (e.g. radio failure).

Arrival and departure RNAV procedures were produced for both runway configurations at Bucharest Otopeni and Baneasa airports. More detailed information on these procedures can be obtained from AMN, EUROCONTROL).

8.3 CONDUCT OF THE SIMULATION

Several weeks before the simulation commenced, participating controllers were given an introductory presentation on RNAV operations from an ATC perspective. A Quick Reference Guide, which included the phraseology to be used when handling RNAV aircraft, and face-to-face briefings were given to the controllers at the EEC before the commencement of the exercises which included RNAV operations.

Traffic samples for the overall simulation organisations were divided between the 26/25 and 08/07 runway configurations at the two airports. There were 18 exercises with a 3-D RNAV element, divided into traffic samples with 30% or 70% RNAV equipped aircraft.

The controllers were asked to allow, as far as practicable, the aircraft which were 3-D capable to self-navigate on to the ILS along the prescribed tracks and to fly their own profiles, whilst integrating the non-RNAV traffic as efficiently as possible. In addition to the aircraft generated from within the main simulation facility and handled by the pseudo-pilots, the Multi-Cockpit Simulator (MCS), flown by line pilots from TAROM - Romanian Airlines, was integrated into the exercises.

Fig. 8 - 2 : The Multi-Cockpits Simulator (MCS)

Both RNAV SIDs and STARs were flown and air traffic control specialists from AMN and Support to States (StS) carried out observations on the effect of the procedures. In addition, questionnaires were tailored for the controllers and the airline pilots as appropriate. For the controllers, the questionnaires probed such parameters as understanding of and confidence in the procedures, ease of use, appropriateness of phraseology and separation and sequencing issues. Pilots were asked similar questions but were also asked whether they considered that the RNAV tracks and vertical profiles flown made their flights more efficient, whether self-navigation enabled better management of the final stages of flight as well as whether they thought that RNAV operations were worthwhile.

In addition, much data has been gathered by the EEC with regard to radio frequency loading, track mileage, fuel burn, controller workload and so on. This data formed the basis of the final RNAV report made to TARA at the end of 1999. Detailed findings of the questionnaires were also included in the final report.

8.4 INTERIM FINDINGS

Controllers and pilots alike reported a reasonable understanding of the RNAV procedures. Nonetheless, uncertainty over the meaning of certain items of phraseology led to some confusion in the instructions given to pilots and pseudo-pilots and the different ways in which these instructions were interpreted. This became less of a problem, however, as the participants gained experienced in RNAV operations.

The quality of the simulator enabled the non-MCS traffic to fly consistently accurate tracks, and controllers quickly gained confidence in their predictability. The technique of using of RNAV waypoints instead of radar vectors was quickly mastered although controllers were not convinced that their use was more efficient than vectoring.

When handling RNAV traffic without positive intervention, controllers experienced a reduction in workload, both generally and in RTF usage. However, they felt that, when they were required to intervene, workload was slightly higher than when handling traffic conventionally.

It was considered that there was some priority given to RNAV-equipped traffic over non-RNAV aircraft. This may be due to controllers finding that it was easier to use conventional techniques such as radar vectoring to integrate the traffic, rather than using the more unfamiliar ways of adjusting RNAV tracks or profiles. Exception handling seemed to produce no more difficulty than would be anticipated in a more conventionally based system.

Overall, the controllers considered that the introduction of RNAV into Terminal Airspace might give some benefits to the ATS operation, but that much further study was required before this could be proved.

The MCS functionality was less reliable than the main simulator and, although not affecting the validity of the overall exercise, some MCS runs were abridged. The airline pilots were very enthusiastic about the possibilities afforded by the use of RNAV in this airspace, in particular commenting that the profiles flown could be better managed when tracks were predictable. However, they considered that the number of waypoints should be reduced, especially as the aircraft moved closer to the more critical final approach segment, where pilots have higher priority tasks and would not wish to be concentrating on this particular navigation function. In fact, these pilots suggested that, should an extended downwind leg be required, then this should be done by use of the heading select facility, rather than by proceeding to a waypoint.

8.5 INTERIM CONCLUSIONS

It was very encouraging to note the co-operation of the controllers, the TAROM pilots and the EEC pseudo-pilots participating in these evaluations. In particular, their input during debriefing sessions was invaluable.

As stated earlier, these findings will be augmented by substantial data now being collated by the EEC, but results so far indicate that this exercise has proved very useful in increasing the knowledge and experience of RNAV operations from the ATS viewpoint.

Combined with the output from the other simulations in the ROMBULPO series, it is anticipated that much valuable evidence will have been gathered for TARA to make its recommendations to ANT about the future use of RNAV in Terminal Airspace.

9. RESULTS - OBJECTIVE 5

To evaluate the dimensions and operating procedures for an enlarged Bucharest TMA and associated civil/military co-ordination.

The dimensions of the revised Bucharest TMA were large which meant that there was a risk of a high traffic load for the approach team. This disadvantage is offset by the advantages of freedom to manoeuvre and provide direct routings.

It was considered that the flexibility provided by the large TMA would be a significant advantage for several years to come prior to an increase in traffic volume that might make alternative airspace division desirable.

Clear operating procedures were considered essential because off the large volume of airspace and the freedom this provided to the controllers. The simulation has provided ROMATSA with much additional information on which to base these procedures by further development work involving the simulation participants.

Standard silent transfer levels were specified for all inbound and outbound traffic. The only level that was considered to be inappropriate was FL200 at LAPKA for inbound traffic. It was considered that FL170 would bee more appropriate.

It was a concern that the enlarged TMA would result in a higher co-ordination workload between approach and military controllers. This proved not to be the case with effective use being made of the military crossing request for military transit traffic which cut across the corners of the TMA. Electronic co-ordination was also very effective in ensuring that military flights operating to and from the Bucharest airports were efficiently handled. The impact of the activation of military TSAs in the vicinity of the TMA was also minimised by the electronic co-ordination possibilities offered by the civil to military XRQ.

The new TMA was directly adjacent to the Varna FIR which meant that traffic was co-ordinated and transferred directly to and from Bulgaria by the approach team. No problems were reported with this situation in the fully electronic environment simulated.

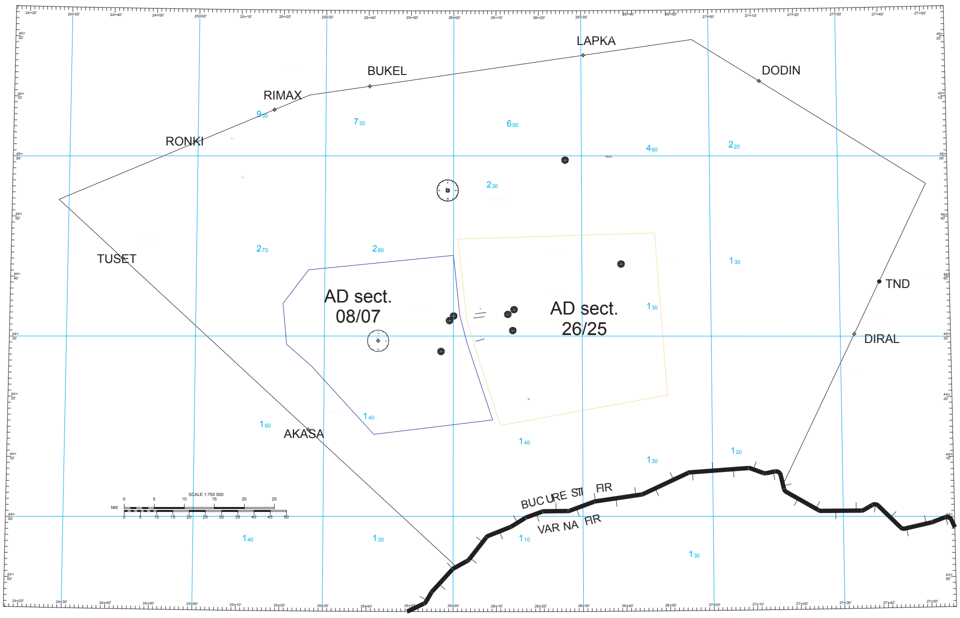

Fig. 9 - 1 : Enlarged Bucharest TMA

10. RESULTS - OBJECTIVE 6

To evaluate sectorisation and route structure by the comparison of existing (August 1998) route structure combined with a sectorisation including 3 Arad, 2 Constanta, 1 Cluj, 1 Bacau and 5 Bucharest En-route sectors. The 5 Bucharest sectors will be configured as appropriate for the traffic flow and volume and will be based on the use of 8 system sectors combined as required.

The airspace decisions were made prior to the Kosovo Crisis and are therefore unrealistic in the Kosovo context. This 6th Romania 99 objective was therefore given a low priority. However, much information was gathered and the results below provide interesting pointers towards improved Romanian airspace and route structure design.

Organisation A represented the August 1998 sectorisation. This acted as purely as a reference situation and it is therefore not intended to report on this organisation specifically as it is already history.

The remaining Organisations C, D, E and F represent various combinations of sectors used to achieve the aims of Objective 6. Various traffic volumes and flows were simulated and the results are presented by Centre and by Sector and reflect the impact of all these variables.

10.1 ARAD SECTORISATION

Three Arad sectors were simulated in all organisations.

In Organisation A two lower sectors (Arad South - AS and Arad North - AN) were simulated up to FL345. Above these sectors a large Arad Upper sector (AU) was simulated.

In all other organisations 3 vertically unlimited sectors were simulated (A1, A2 and A3). A1 and A2 retained essentially the same dimensions but A3 was modified using 2 versions of geographical dimensions. In Organisation E A3 was expanded north-eastwards into traditional Cluj airspace to more easily manage the northbound traffic on UL622 in this organisation. In the Organisations C, D and F when UL622 was southbound the northeastern boundary of A3 was revised so that the ORA-BARUL track reverted to Cluj control.

General Comments

The Arad sectorisation simulated in Organisations C, D, E and F was not well received by the controllers. For both eastbound and westbound traffic flows 77% of the controllers felt that the sector dimensions could be improved.

Westbound traffic seemed to pose the greatest problems with 88% of the controllers feeling that the route structure could be improved and 77% responding that the configuration of conflict points could be improved.

The controllers felt that the simulated sectorisation necessitated too much co-ordination. Again 77% felt that co-ordination requirements could be improved, this was particularly noted with a northbound UL618.

Opinion was equally divided on the subject of the orientation of UL618 and UL622. Neither orientation of one-way traffic proving better than the other. For Arad the key to the management of these traffic flows seems to lie in sector configuration rather than a preferred traffic orientation.

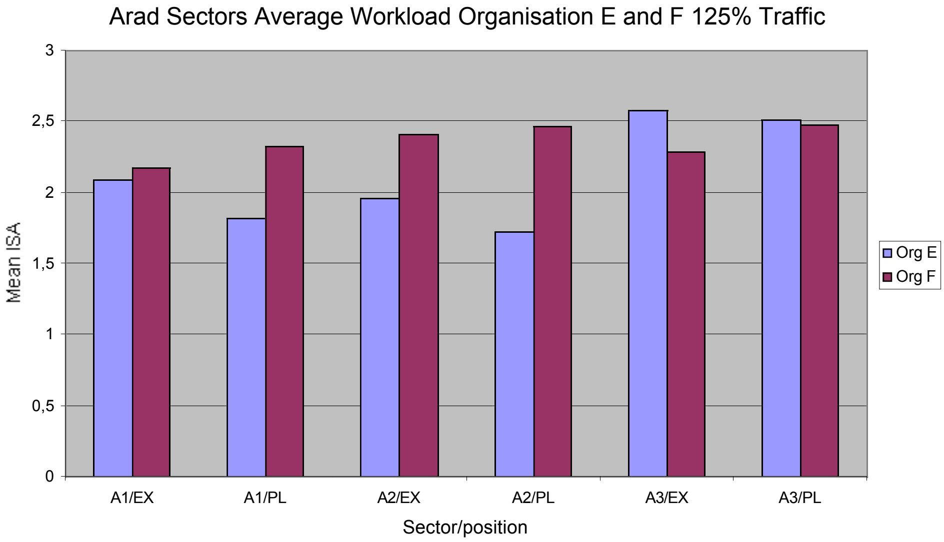

Fig. 10 - 1 : Mean ISA Workload for Arad Sectors In Org E and F at 125% Traffic

The chart above shows the slightly higher average workload recorded in sector A3 compared with A1 and A2.

Arad Sector A1

This sector had generally little to do and it was a generally felt opinion that A1 should be collapsed with A2 to create a more useful sector.

Arad Sector A2

It was felt that this sector was too narrow and as with A1 had relatively low workload due to the lack of space in which to do anything useful. Crossing problems in A2 had to be resolved by adjacent sectors because A2 had such little space to manoeuvre. As mentioned above, it was felt that A2 should be collapsed with A1.

Arad sector A3

This sector was simulated with 2 alternative sets of dimensions as explained earlier. The larger set of dimensions was preferred by the controllers as this helped to improve the management of traffic on the KARIL - OSTOV track. It was also considered preferable to include the crossing point ORA in A3 and therefore retain traffic on the LOMOS - NARKA traffic all the way to NARKA.

With predominantly westbound traffic and northbound UL618 problems were experienced integrating traffic flows at NEDAL and MOMIC.

It was generally felt that A3 should be split vertically. This corresponds with the suggestion to collapse A1 and A2 and would still leave the Arad airspace managed by 3 sectors.

10.2 BUCHAREST SECTORISATION

5 Bucharest sectors were simulated in all organisations. These sectors were created by combining the 8 Bucharest "system sectors" in two different combinations to suit predominantly eastbound or predominantly westbound traffic. The boundary between Bucharest and Arad was also adjusted in relation to the orientation of UL618 and UL622.

General Comments

The sector configuration used for westbound traffic (B123, B4, B5, B67, B8) was considered slightly better designed than the sector configuration for eastbound traffic (B1, B23, B4, B57, B68). 72% of controllers felt that the westbound configuration was "good" or at least "satisfactory" whilst this percentage fell to 60% for the eastbound configuration, all others felt that the sectorisation could be improved.

For eastbound traffic the controllers felt that one of the main problems was the configuration of the conflict points with 66% feeling that this could be improved. This was almost the opposite of the westbound configuration where 78% felt that the configuration of conflict points was "good" or "satisfactory".

The orientation of UL618/UL622 was considered unimportant for the eastbound traffic with 47% feeling that it made no difference whilst opinion was split amongst the others. However, there was a strong preference expressed for northbound UL618 (87%) with westbound traffic.

The SIB-SOMOV track was particularly disliked for southbound traffic with controller comments ranging from "unacceptable" and "a conflict provider" to the unprintable!

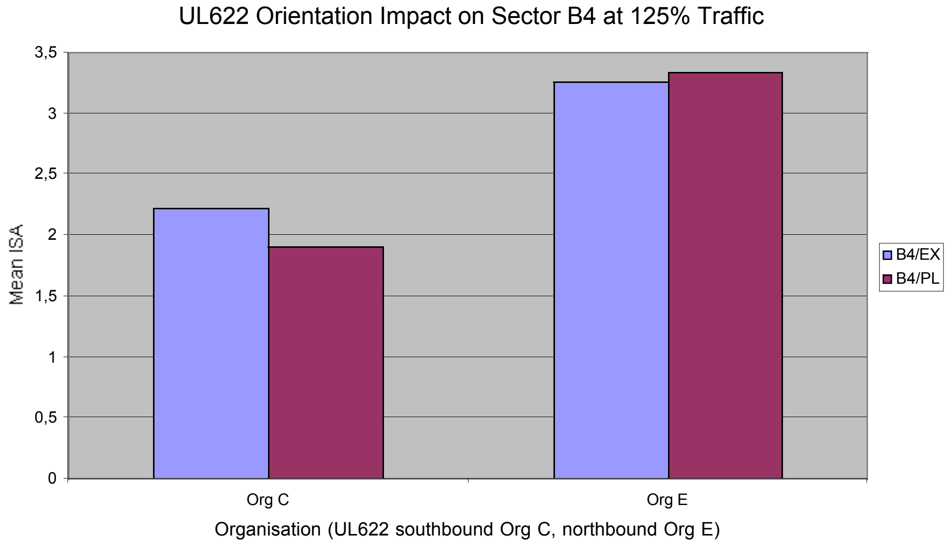

Fig. 10 - 2 : Sector B4 Workload Comparison Depending on UL622 Orientation

The chart above shows the greatly increased average workload recorded in sector B4 when UL622 was northbound.

Bucharest Sectors B1, B23 and B123

The split of B123 into B1 and B23 was not generally liked. When split, B1 had traffic on the SOMOV-VALPA track for just a few seconds and could not help B23 with conflict problems at VALPA.

Delegated airspace between RENGA and RASVA for Bucharest inbounds worked well with no adverse comments.

Some of the controller comments conflicted. For example sector B23 was generally disliked and it was said that it was too busy to accept military crossing requests. However other comments said that B23 should be collapsed with B1 to re-create the classical South sector. This combined sector could potentially get very busy and therefore an alternative split should be sought.

Bucharest B4

The orientation of UL622 had a strong influence on B4. When UL622 was northbound two flows had to be integrated at DVA. This sector had traffic on the frequency for a very short time around LABIK.

Other Bucharest Sectors

No particular comments noted.

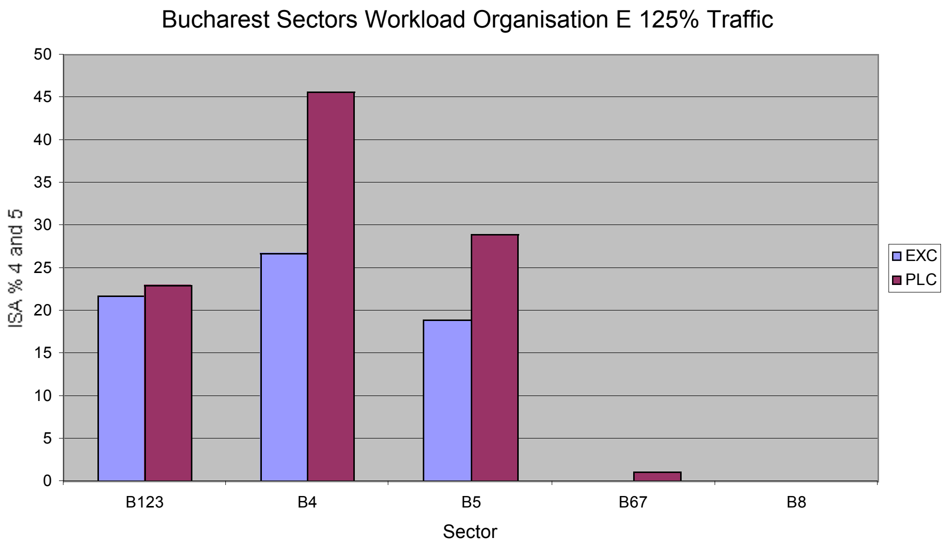

Fig. 10 - 3 : Bucharest Sectors Workload Org E

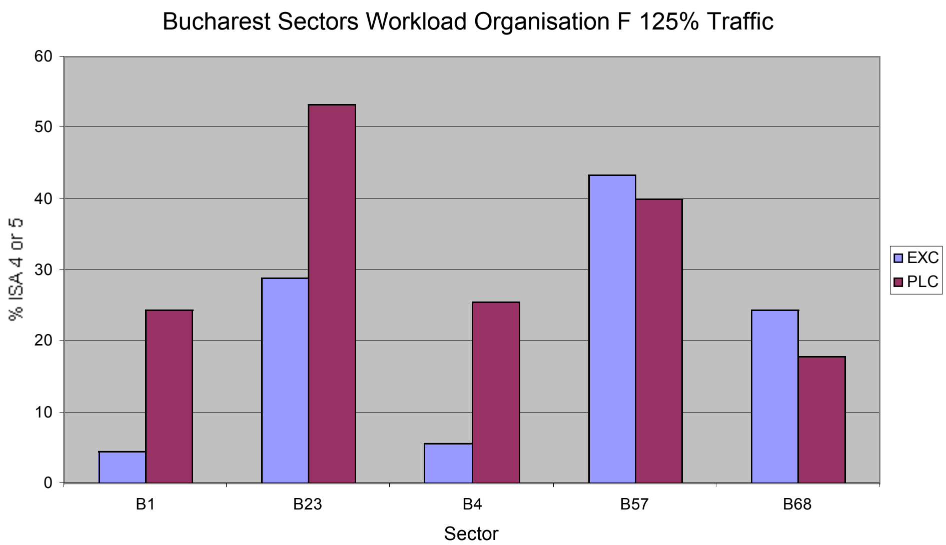

Fig. 10 - 4 : Bucharest Sectors Workload Org F

The charts above show the % of ISA 4 or 5 (High or Very High) workload recorded in Bucharest sectors during Org E and Org F exercises at 125% traffic. The imbalance is clear to see, particularly in Org E designed for the heavy westbound traffic period.

10.3 CONSTANTA SECTORISATION

The Constanta sectors as simulated were considered to be unbalanced. A revised split was devised and this was successfully simulated during a short series of Organisation E exercises. Changing the geographical limits of C1 and C2 for 135% traffic caused C1 traffic flow to increase from 39 to 42 aircraft per hour and for C2s traffic to fall from 54 to 47 aircraft per hour. Recorded workload was little changed but controllers said that the revised arrangement was more comfortable.

Romania 99
Constanta Sectors in Organisation E1

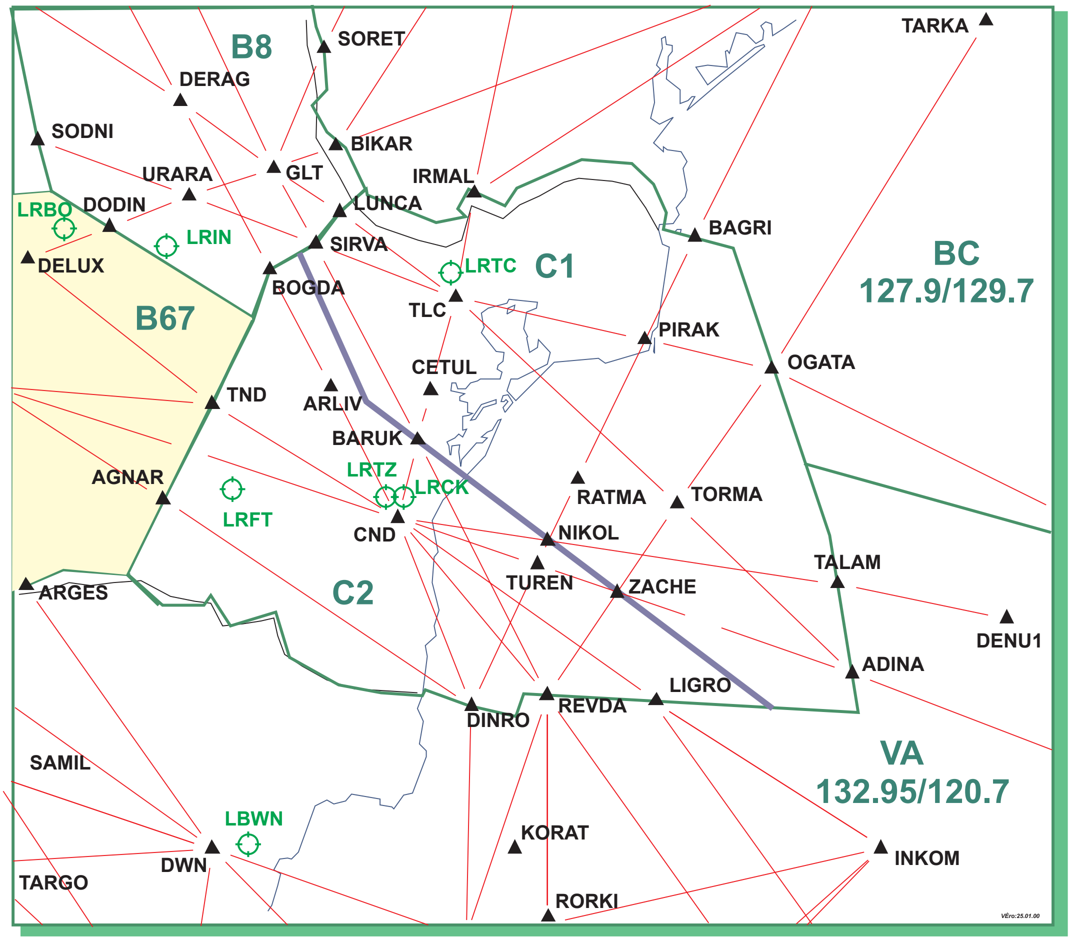

Fig. 10 - 5 : Map of Revised Constanta Sectors

The geographical sector split was the only major Constanta problem, all other aspects were generally acceptable; route structure, co-ordination requirements and distribution of conflict points.

10.4 BACAU SECTOR

The single Bacau sector was a measured sector in Organisations C and D.

The Bacau sector appears to have worked well with no adverse comments and the dimensions and route structure considered good.

Mean Bacau workload measured by ISA was Low (2) and slightly higher in Org D compared with Org C.

10.5 CLUJ SECTOR

The single Cluj sector was a measured sector in Organisations C and D.

The controllers who manned the Cluj sector felt that the sector dimensions could be improved with the suggestion that the route CIMPA - SIB should remain with Cluj area of responsibility. They felt that the route structure generally could be improved but no specific suggestions were made.

Mean Cluj workload measured by ISA was Fair (3) in both Org. C and Org. D.

10.6 RADAR SEPARATION

The radar separation standard used was found to have a major impact on operations. As traffic rose controllers found it more and more difficult to cope with the limited manoeuvring space provided in some of the more narrow sectors.

The decision was made to reduce en-route radar separation from 10 to 5 miles in the exercises at 135%. This was very well received by the controllers who reported that vectoring problems were eased.

11. RESULTS - BULGARIA-ROMANIA JOINT SIMULATION

1. To evaluate the civil Romanian/Bulgarian Interface (including revised handover conditions for traffic destination Istanbul & Varna, and reduced cross-border radar separations.

2. To evaluate OLDI/SYSCO system and procedures across the Romanian/Bulgarian border.

The objectives listed above are objectives specific to the Bulgaria-Romania Joint Simulation. Other common objectives with the Romania 99 Simulation are reported on in previous sections of this report where the findings include the combined results of both simulations.

11.1 HANDOVER CONDITIONS AND CROSS-BORDER SEPARATION

11.1.1 Separation Standards

Cross-border longitudinal separation was reduced from 15nm to 10nm for the period of the simulation. This was simulated in conjunction with full radar coverage.

This reduction in separation was found to have a major impact on workload. 50% of the participants felt that the reduced separation had a considerable impact on workload, whilst another 30% felt that it had either “some” or “very little” positive impact. No significant problems were reported although controllers stressed that the simulated environment was very different from the current situation. Reducing separation may be dependent on the introduction of new reliable future systems including all the advantages of the simulated system.

The reduction in longitudinal separation should also be considered in the context of the simulated electronic co-ordination reported on below. This feature transformed communication between the two countries.

11.1.2 Letters of Agreement

Descent agreements were tested for traffic inbound to the Varna FIR and Istanbul. All this traffic was descended to FL330 or below before being transferred from Bucharest to Constanta. This was designed to reduce workload close the Bulgarian border. Traffic destination Varna FIR was then further descended to FL290 by DINRO. Traffic destination Varna FIR coming directly from Bucharest Sectors was descended to FL270 by BULEN.

These levels were found to be fully satisfactory with no adverse comments being recorded.

11.1.3 Military Areas and Re-routing

On several occasions military TSA were activated close the Bulgaria/Romania border on either side.

The display systems only had the capability of displaying appropriate video maps of national areas; therefore Romanian controllers were not able to display video maps of active Bulgarian areas. As many of the military areas in the cross-border area have a significant impact on civil air routes it was suggested that the possibility should be provided for Romanian sectors to display active Bulgarian TSA and vice-versa.

Active TSA in the cross-border area affecting civil air routes often caused temporary re-routing to be required. It was suggested that a practical system be developed for the dynamic re-routing of flights around active military areas. This would be a useful subject for future Romanian-Bulgarian co-operation.

11.2 ELECTRONIC CO-ORDINATION IN THE CROSS-BORDER VICINITY

The provision of OLDI V2.2 electronic co-ordination between simulated Romanian and Bulgarian sectors transformed the co-ordination task. Currently telephone co-ordination is often difficult and there is always a risk of misunderstanding with voice communication. The electronic system provided a reliable and very swift method to co-ordinate either level or direct route information in both the down-stream and up-stream direction.

All controllers felt that the provision of electronic co-ordination simplified the co-ordination task. 73% felt that it «always» simplified the task whilst the remaining 27% felt that it «regularly» or «sometimes» simplified the task.

The advanced features of the simulated systems prompted the controllers from both countries to say: “the border between Romania and Bulgaria could be considered as any other sector boundary in the simulated environment”.

12. CONCLUSIONS

The simulations conducted for Romania by the EEC during 1999 confirm that the future Romanian HMI has reached an advanced level of development and acceptability. Many detail results will enable ROMATSA to further refine their specifications.

Results are presented below in relation to each objective of both simulations.

12.1 ROMANIA 99 SIMULATION CONCLUSIONS

Objective 1 : To evaluate the new ROMATSA Controller Working Position, specifically:

- ***the Human Machine Interface including, colour, text, radar labels, data windows and graphic information presentation***
- ***the 3 button mouse for data access and input including extensive use of «elastic vectors»***
- ***the ROMATSA TID for data input and co-ordination purposes including specifically:***
  - ***data selection***
  - ***speed of access and input compared with the mouse***
  - ***specific uses including multiple inputs and approach tasks***
  - ***ergonomic aspects including location and parallax***
- ***controller aids including MTCD and Safety Nets***

The Simulated CWP - General

The result of the study of the simulated CWP was very positive. The simulated CWP provided an efficient working environment that made maximum use of graphical aids and interaction via the radar label. The results of the simulation suggest mainly minor changes to what is a well-developed prototype.

A very large majority of participants felt that the use of colour to indicate flight status helped them to «regularly or always» prioritise their actions. They also endorsed the general choice of colour saying that they were never or rarely confused by the use of colour but several comments were made about the use of specific colours.

The ROMATSA interface specified extensive use of background colour change to highlight information. Subtle change of background colour was very successfully used to cross-highlight all data associated with a particular flight.

Logical colour highlighting was successfully used to reduce the need for additional text and also to indicate outgoing and incoming co-ordination without the need for «message windows». Data subject to co-ordination was displayed in white on the proposing sector whilst on the receiving sector the corresponding data was displayed with a white background. Combining this use of colour with the use of specific mouse buttons (Button 1 – accept, Button 2 – reject, Button 3 – counter proposal) meant that co-ordination in/out windows became redundant and they were not included in the simulation. It was found that modifications to the display system were required to ensure that data subject to co-ordination was always visible to the controller.

Choice of colour is very subjective and there will always be differences of opinion. A majority of the participating controllers expressed a wish to be involved in the final choice of colour, but felt it was important that the use of colour was standard throughout the system and was the result of consultation and debate.

All controllers considered the data content and layout of the radar label was complete for the operational requirements with some minor modification being suggested.

The controllers appreciated the various methods available to resolve overlaps with manual resolution via the «drag and drop» feature being far and away the most popular method. Although this involved some considerable work, controllers said that they refreshed their mental traffic picture as they manually relocated labels and did not find it too tiresome.

The ROMATSA HMI includes a minimum of list data and a maximum of graphical data presentation, this principle was fully accepted by the participants. The main data window is the Sector List (SEL) which was generally considered adequate but proposals were made for different sorting criteria and some additional data.

All required functions were present in the display control panel with the only omission being an ability to save (memorise) a particular display centre point. The requirement for controller related preference settings was not addressed in the simulation but should be carefully considered for the operational system.

The Dynamic Flight Leg (DFL) is an important part of a modern system and has development potential. One aim could be to reduce the time consuming use of the R&B tool. Several additional features were suggested during the simulation.

Approach controllers identified several specific HMI requirements due to the specific nature of teamwork in the approach environment.

Data States

Data states calculated by the system determined the appropriate colour and format of flight data. In most cases this was dependent on flight plan data updated by events such as sector exit. Prior to a state change to unconcerned, a crosscheck should be made with radar data to ensure the integrity of displayed data. The system should be designed to fail-safe with traffic remaining «concerned» unless there is clear assurance that the unconcerned state is appropriate.

During the simulation traffic was routed around active military areas and sometimes was forced to enter airspace that was not foreseen in the system calculated flight plan. Controllers requested a «force concerned» input plus also a method of manually overriding the system calculated sector sequence. This requirement should be the subject of further debate prior to system specification agreement.

An additional question raised and not fully answered was display requirements for traffic that becomes uncorrelated. This traffic will not be governed by the usual data states because of the lack of flight plan association. Radar data could be used to determine a special display status to ensure that the track does not become unconcerned.

Military Flight Management

FDP was suspended for military flights to allow the controller operational freedom to choose co-ordination partner as required. The Forced ACT allowed an ACT to be sent to any co-ordination partner, with whom the flight could then be co-ordinated and transferred in the normal manner. This feature worked extremely well and allowed the required flexibility particularly in the Bucharest TMA where military flights started as GAT departing Bucharest Baneasa and Otopeni subsequently becoming OAT after transfer to the military.

Prior to the simulation it proved difficult to imagine the HMI requirements for the Military Co-ordinator. The experience of the simulation enabled a clear list of requirements to be drawn up. The job description and military operational concept must be carefully developed prior to final HMI decisions.

Input Devices

The mouse was fully acceptable as the primary input device and no criticism of the implemented logic was forthcoming. The only comment being that consideration should perhaps be given to offering a reversed configuration on demand for left-handed controllers.

The controllers were very satisfied with the elastic vector as a means of input to the system. In particular they liked the fact that data was never obscured and no scrolling or paging was required. System response time must also be of high standard when vectors are used in this way because if the system “hesitates” even slightly, perhaps during a radar update, the elastic vector appears to “stick” frustratingly.

The TID was considered an excellent complement to the mouse with over 90% of the participants feeling that a combination of mouse and TID should be available. It was not questioned that the mouse should remain the primary input device because of its speed and ease of use, but that the TID had specific advantages for specific situations. The controllers made several suggestions for TID improvements.

MTCD and Safety Nets

The controllers were happy with the Conflict List as a means of presenting conflict pairs to the controller. The vertical filtering of conflicts was considered acceptable for sectors with a large proportion of traffic in stable flight at high level. It was suggested that the filtering of conflicts should be the subject of further work to try to provide more reliable and accurate information.

The STCA adequately attracted attention and provided a clear indication of the nature of the problem without any additional data display in the radar label block. No adverse comments were received.

It was suggested that in the operational system APW should be linked dynamically to video map selection controlled centrally. Military participants commented that specific functionality would be required for military use.

Teamwork and Task Sharing

It was observed that PLCs occasionally reported higher workload than their EXC colleagues did. Using the simulated system features the PLC was able take a considerable load off the EXC by trying to ensure pre-separated traffic flows. There was a natural tendency to try to solve as many conflicting situations as possible prior to sector entry. This slight imbalance of workload favouring the EXC did of course allow the EXC to have a little spare capacity, as he was often left with a mainly monitoring role allowing some capacity to manage unexpected events.

At very high traffic levels the Approach EXC was often unable keep pace with the required inputs. The PLC often had to help out, which is a far from satisfactory situation. It was suggested that a review of roles and responsibilities within the approach team might lead to a reduction in Approach EXC workload. The participating approach controllers felt that the simulation had given them the necessary experience to assist in this task.

Objective 2: ***To evaluate new Civil-Military Co-ordination procedures***

Electronic Co-ordination

The simulated electronic crossing request was very well received by a large majority of controllers with over 80% considering that it was frequently useful. Only 11% considered that it was rarely useful.

The XRQ initiation was accomplished via pop-up menus prior to the graphical route input using elastic vector. Controllers considered that the XRQ input would be easier to input if it was fully integrated into the Romanian HMI concept and used the elastic vector for level value inputs rather than a pop-up.

The controllers regretted that the system did not permit counter-proposition. This was considered during the simulation preparation but was considered to be excessively complex. The requirement was also identified to request a modification of crossing conditions after initial approval had been received. It was identified that it may be an operational requirement for either the sector or the Military Co-ordinator to initiate the crossing request with the other being provided with a copy.

The civil controllers made extensive use of the XRQ to request crossing of active TSA. Several specific requirements were identified.

Route Data

The Dynamic Flight Leg (DFL) was satisfactory for civil flights and routine military flights such as navigation exercises, but was unsatisfactory for military OAT flights following flexible flight plans. It was suggested that in the case of a requirement to show route information on an OAT flight a development of the speed vector could be used in place of the DFL.

Temporary Segregated Areas

Results were obtained concerning the usability of a set of military TSA. The report includes details of their acceptability to civil and military participants.

Generally

The results indicate the close working relationship that developed between civil and military during the simulation. The simulation represented a major step forward towards even closer co-operation and the efficient sharing of airspace.

Objective 3: ***To further evaluate new co-ordination procedures between ACC sectors, ACC and APP sectors, and APP and TWR sectors***

Notification

There was no evidence in the simulation that the current 13 minutes notification parameter should be changed for the new environment. The point at which the PLC requires data can be assessed by operational experts taking into account the time required for the PLC to analyse and react to the new data. It should be noted that list windows might become unreasonably large if flight data is displayed too early.

Co-ordination

The main findings of the simulation of electronic co-ordination were regarding the limitation of the OLDI standard to two co-ordination partners - sending and receiving. It was also suggested that co-ordination should be expanded to include heading and speed information.

The simulation identified sector configurations that will need special management in the operational system. This should be combined with pragmatic limitations to controller inputs of level and direct routing co-ordination.

It was identified that co-ordination between the sectors that comprised the approach team must be handled very differently to the en-route situation. The approach controllers said that the approach area should be considered as one sector for electronic co-ordination purposes. Therefore the Approach PLC, Approach EXC and Final Director need to be considered as a 3-controller team, not as 2 distinct sectors within the TMA.

Transfer of Control

Controllers said that they would have appreciated the implementation of a TIM message particularly to provide heading and speed information a few minutes prior to the transfer of control to enable them to plan more effectively.

Objective 4: ***To evaluate the use of RNAV arrival and departure routes for Bucharest and associated ATC and aircrew procedures.***

This objective will be the subject of a separate report by EUROCONTROL AMN Division to the Terminal Area RNAV Applications Task Force (TARA).

It was very encouraging to note the co-operation of the controllers, the TAROM pilots and the EEC pseudo-pilots participating in these evaluations. In particular, their input during debriefing sessions was invaluable.

The findings will be augmented by substantial data collated by the EEC, but results so far indicate that this exercise has proved very useful in increasing the knowledge and experience of RNAV operations from the ATS viewpoint. Overall, the controllers considered that the introduction of RNAV into Terminal Airspace might give some benefits to the ATS operation, but that much further study was required before this could be proved.

Combined with the output from the other simulations in the ROMBULPO series, it is anticipated that much valuable evidence will have been gathered for TARA to make its recommendations to ANT about the future use of RNAV in Terminal Airspace.

Objective 5: ***To evaluate the dimensions and operating procedures for an enlarged Bucharest TMA and associated civil/military co-ordination.***

The dimensions of the revised Bucharest TMA were large which meant that there was a risk of a high traffic load for the approach team. This disadvantage is offset by the advantages of freedom to manoeuvre and provide direct routings. It was considered that the flexibility provided by the large TMA would be a significant advantage for several years to come prior to an increase in traffic volume that might make alternative airspace division desirable.

It was a concern that the enlarged TMA would result in a higher co-ordination workload between approach and military controllers. This proved not to be the case with effective use being made of the military crossing request for military transit traffic that cut across the corners of the TMA.

Objective 6: ***To evaluate sectorisation and route structure by the comparison of existing (August 1998) route structure combined with a sectorisation including 3 Arad, 2 Constanta, 1 Cluj, 1 Bacau and 5 Bucharest En-route sectors. The 5 Bucharest sectors will be configured as appropriate for the traffic flow and volume and will be based on the use of 8 system sectors combined as required.***

Arad

The Arad sectorisation simulated in Organisations C, D, E and F was not well received by the controllers. For both eastbound and westbound traffic flows 77% of the controllers felt that the sector dimensions could be improved. Opinion was equally divided on the subject of the orientation of UL618 and UL622. Neither orientation of one-way traffic proving better than the other. For Arad the key to the management of these traffic flows seems to lie in sector configuration rather than a preferred traffic orientation.

Bucharest

The Bucharest sector configuration used for westbound traffic was considered slightly better designed than the sector configuration for eastbound traffic. 72% of controllers felt that the westbound configuration was “good” or at least “satisfactory” whilst this percentage fell to 60% for the eastbound configuration, all others felt that the sectorisation could be improved. There was a strong preference expressed for northbound UL618 (87%) with westbound traffic. Workload recordings show significant imbalance for the Bucharest sectors in both east and westbound configurations.

Constanta

The Constanta sectors as simulated were considered to be unbalanced. A revised geographical split was devised and this was successfully simulated during a short series of exercises.

Bacau

The Bacau sector appears to have worked well with no adverse comments and the dimensions and route structure considered good.

Cluj

The controllers who manned the Cluj sector felt that the sector dimensions could be improved with the suggestion that the route CIMPA - SIB should remain with Cluj area of responsibility.

Radar Separation

The radar separation standard used was found to have a major impact on operations. As traffic levels rose controllers found it more and more difficult to cope with the limited manoeuvring space provided in some of the more narrow sectors. The decision was made to reduce en-route radar separation from 10 to 5 miles in the exercises at 135%. This was very well received by the controllers who reported that vectoring problems were eased.

12.2 BULGARIA/ROMANIA JOINT SIMULATION CONCLUSIONS

Objectives:

1. ***To evaluate the civil Romanian/Bulgarian Interface (including revised handover conditions for traffic destination Istanbul & Varna, and reduced cross-border radar separations.***
2. ***To evaluate OLDI/SYSCO system and procedures across the Romanian/Bulgarian border***

The reduction in longitudinal separation from 15nm to 10nm was found to have a major impact on workload. No significant problems were reported although controllers stressed that the simulated environment was very different from the current situation. Reducing separation may be dependent on the introduction of new reliable future systems including all the advantages of the simulated system. The reduction in longitudinal separation should also be considered in the context of the simulated electronic co-ordination. This feature transformed communication between the two countries.

The provision of OLDI V2.2 electronic co-ordination between simulated Romanian and Bulgarian sectors transformed the co-ordination task. Currently telephone co-ordination is often difficult and there is always a risk of misunderstanding with voice communication. The electronic system provided a reliable and very swift method to co-ordinate either level or direct route information in both the down-stream and up-stream direction.

Revised letters of agreement were evaluated for Istanbul and Varna traffic which were found to be fully acceptable.

Many of the military areas in the cross-border area have a significant impact on civil air routes it was suggested that the possibility should be provided for Romanian sectors to display active Bulgarian TSA and vice-versa. Active TSA in the cross-border area affecting civil air routes often caused temporary re-routing to be required. It was suggested that a practical system be developed for the dynamic re-routing of flights around active military areas. This would be a useful subject for future Romanian-Bulgarian co-operation.

The advanced features of the simulated systems prompted the controllers from both countries to say: «the border between Romania and Bulgaria could be considered as any other sector boundary in the simulated environment».

RÉSUMÉ

En 1999, EUROCONTROL a mené deux simulations en temps réel pour le compte de la Roumanie. Le présent rapport récapitule les résultats de ces deux simulations.

Les simulations en temps réel Roumanie 99 et Bulgarie-Roumanie ont été réalisées au Centre expérimental d'EUROCONTROL entre le 21 juin et le 30 juillet 1999. Dans le cadre de la simulation Roumanie 99, 48 contrôleurs roumains, assistés de contrôleurs bulgares et hongrois, ont participé à 40 exercices de simulation. Pendant la simulation conjointe Bulgarie-Roumanie, 47 contrôleurs bulgares et roumains, ainsi que des contrôleurs des secteurs turcs situés en amont (“feed controllers”) ont pris part à 27 exercices de simulation.

La simulation Roumanie 99 a permis d'évaluer l'intégralité du système ATC civil en route roumain ainsi que la TMA et le contrôle d'approche de Bucarest, de même que 3 postes militaires assurant un service de contrôle à la circulation opérationnelle militaire (COM) dans un environnement d'espace aérien partagé. Dans le cadre de la simulation conjointe Bulgarie-Roumanie, les secteurs situés de part et d'autre de la frontière internationale ont été simulés de manière réaliste. La plus grande configuration simulée comportait 15 secteurs englobant 26 postes de travail de contrôleur ainsi que 6 secteurs en amont (“feed sectors”). La simulation a porté sur le futur système ATC roumain, qui est entièrement électronique et n'utilisera plus les bandes de progression de vol sur papier.

Ces exercices s'inscrivaient dans la série de simulations ROMBULPO, menées pour le compte de la Roumanie, de la Bulgarie et de la Pologne. Un configuration de simulation commune a été utilisée pour l'ensemble des exercices, faisant intervenir des fonctionnalités de base identiques, mais avec une interface contrôleur (HMI) spécifique à chaque État. Le système mis en œuvre présentait les caractéristiques suivantes : simulation des communications électroniques intersecteurs et intercentres selon la norme OLDI 2.2, coordination électronique entre civils et militaires dérivée des études d'EATCHIP, et dispositif de détection des conflits à moyen terme (MTCD) et filets de sauvegarde tels que le système d'alerte aux conflits à court terme (SCTA) et le dispositif d'avertissement de proximité de zone (APW).

Le poste de travail de contrôleur roumain avait déjà fait l'objet d'une évaluation dans le cadre de la simulation en temps réel Roumanie 97 (Rapport CEE n° 320). Les simulations menées en 1999 ont eu pour principal objet d'évaluer la dernière version du prototype de poste de travail de contrôleur et de compléter les résultats obtenus en 1997. Un des objectifs, en particulier, résidait dans l'évaluation de l'écran tactile, qui n'avait pu être testé en 1997. Les résultats des simulations indiquent que l'interface contrôleur roumaine est à présent au point, et acceptée par une large majorité de contrôleurs. Si l'écran tactile est jugé utile en tant qu'instrument de saisie secondaire, la souris demeure l'outil privilégié.

Au cours de la simulation, des relations de travail étroites se sont établies entre les contrô-

leurs civils et militaires, qui ont pu mettre en place une coordination électronique bilatérale efficace dans un environnement d'espace aérien partagé. La simulation aura donc été une étape décisive sur le plan du renforcement de la coopération et du partage efficace de l'espace aérien.

Des procédures RNAV dans la TMA de Bucarest ont été évaluées dans le contexte d'une étude parallèle menée conjointement avec l'Unité «Gestion de l'espace aérien et navigation» d'EUROCONTROL. Les résultats de cette étude ont constitué une source précieuse d'informations pour l'Équipe spéciale “Applications RNAV en zone terminale” (TARA).

Dans le cadre de la simulation conjointe Bulgarie-Roumanie, la coordination électronique et la couverture radar intégrales ont permis d'évaluer des minimums réduits de séparation longitudinale ; les participants ont indiqué que la frontière entre la Roumanie et la Bulgarie pouvait être assimilée à n'importe quelle autre limite de secteur dans l'environnement simulé.

1. INTRODUCTION

La simulation en temps réel Roumanie 99 et la simulation en temps réel conjointe Bulgarie-Roumanie ont été réalisées au Centre expérimental d'EUROCONTROL entre le 21 juin et le 30 juillet 1999, pour le compte de l'Administration roumaine des services de la circulation aérienne (ROMATSA) et de l'Administration bulgare des services de la circulation aérienne (ATSA).

Le présent rapport rend compte des résultats de la simulation Roumanie 99 ainsi que des conclusions de la simulation conjointe Bulgarie-Roumanie touchant au système roumain.

La ROMATSA est arrivée à un stade avancé des travaux de définition du futur système ATC roumain et a mis au point un prototype détaillé de poste de travail de contrôleur qui comprend notamment un écran tactile à l'appui des fonctions d'écran gérées par la souris. Le poste de travail de contrôleur roumain avait déjà fait l'objet d'une évaluation dans le cadre d'une précédente simulation en temps réel d'EUROCONTROL, intitulée Roumanie 97 (Réf. 1 - Rapport CEE n° 320). Les simulations menées en 1999 ont eu pour principal objet d'évaluer la dernière version du prototype de poste de travail de contrôleur et de compléter les résultats obtenus en 1997. Un des objectifs, en particulier, résidait dans l'évaluation de l'écran tactile, qui n'avait pu être testé lors de la simulation de 1997.

Les simulations ont également porté sur l'évaluation de procédures RNAV SID et STAR dans la TMA de Bucarest, en collaboration avec l'Unité “Gestion de l'espace aérien et navigation” (AMN) d'EUROCONTROL.

La simulation Roumanie 99 a inclus l'activation de secteurs militaires, avec coordination électronique bidirectionnelle intégrale entre contrôleurs civils et militaires, et l'application du concept d'utilisation flexible de l'espace aérien (FUA).

2. OBJECTIFS

2.1 OBJECTIFS DE LA SIMULATION ROUMANIE 99

1. Évaluer le nouveau de poste de travail de contrôleur de la ROMATSA, en particulier :
- l'interface contrôleur, notamment les couleurs, les textes, les étiquettes radar, les fenêtres de données et la présentation des informations graphiques ;
- la souris à trois boutons, pour l'accès aux données et leur saisie, y compris le recours étendu à des «vecteurs élastiques» ;
- l'écran tactile ROMATSA, pour la saisie et la coordination des informations, notamment :
  - la sélection des données ;
  - la vitesse d'accès et de saisie comparée à celle de la souris ;
  - les utilisations spécifiques, telles que saisies multiples et tâches d'approche ;
  - les aspects ergonomiques tels que l'emplacement et la parallaxe ;
- les aides aux contrôleurs, parmi lesquelles la MTCD et les filets de sauvegarde.

2. Évaluer de nouvelles procédures de coordination entre civils et militaires.

3. Poursuivre l'évaluation de nouvelles procédures de coordination entre secteurs CCR, entre secteurs CCR et APP ainsi qu'entre secteurs APP et TWR.

4. Évaluer l'utilisation de routes RNAV d'arrivée et de départ vers et depuis Bucarest, ainsi que les procédures connexes pour l'ATC et les équipages de conduite.

5. Évaluer les dimensions et les procédures d'exploitation d'une TMA de Bucarest élargie, ainsi que la coordination connexe entre civils et militaires.

6. Évaluer la sectorisation et la structure de routes par comparaison avec la structure existante (août 1998), associée à une sectorisation incluant 3 secteurs de contrôle de route dépendant d'Arad, 2 de Constanta, 1 de Cluj, 1 de Bacau et 5 de Bucarest. Les 5 secteurs de Bucarest sont dotés de la configuration appropriée pour le flux et le volume du trafic, qui se fonde sur l'utilisation de 8 secteurs système, combinés selon les besoins. (Les choix quant à l'espace aérien ont été effectués avant la crise du Kosovo, ce qui les rend irréalistes dans le contexte de cette dernière. Ce 6e objectif ne bénéficie donc pas une d'une priorité élevée).

2.2 OBJECTIFS DE LA SIMULATION CONJOINTE BULGARIE-ROUMANIE

La simulation conjointe a permis une étude plus approfondie des objectifs de la simulation Roumanie 99, ainsi que la poursuite des objectifs spécifiques suivants :

1. Évaluer l'interface civile entre la Roumanie et la Bulgarie (y compris les conditions modifiées de transfert de contrôle pour le trafic à destination d'Istanbul et de Varna, et la réduction des séparations radar transfrontalières).

2. Évaluer le système et les procédures OLDI/SYSCO pour le franchissement de la frontière entre la Roumanie et la Bulgarie.

3. CONCLUSIONS

Les simulations menées en 1999 par le CEE pour le compte de la Roumanie confirment que la future interface contrôleur roumaine a atteint un stade avancé de développement et d'acceptabilité. Bon nombre de résultats détaillés permettront à la ROMATSA d'affiner ses spécifications.

Les résultats sont présentés ci-après, en relation avec chacun des objectifs des deux simulations.

3.1 CONCLUSIONS DE LA SIMULATION ROUMANIE 99

Objectif 1: ***Évaluer le nouveau poste de travail de contrôleur de la ROMATSA, en particulier :***

- ***l'interface contrôleur, notamment les couleurs, les textes, les étiquettes radar, les fenêtres de données et la présentation des informations graphiques ;***
- ***la souris à trois boutons, pour l'accès aux données et leur saisie, y compris le recours étendu à des «vecteurs élastiques» ;***
- ***l'écran tactile ROMATSA, pour la saisie et la coordination des informations, notamment :***
  - ***- la sélection des données ;***
  - ***- la vitesse d'accès et de saisie comparée à celle de la souris ;***
  - ***- des utilisations spécifiques, telles que saisies multiples et tâches d'approche ;***
  - ***- les aspects ergonomiques tels que l'emplacement et la parallaxe ;***
- ***les aides aux contrôleurs, parmi lesquelles la MTCD et les filets de sauvegarde***

Le poste de travail de contrôleur simulé - Généralités

Les résultats de l'étude du poste de travail de contrôleur simulé sont très positifs. Le poste simulé offre un environnement de travail efficace, qui tire le meilleur parti possible des aides graphiques et des interactions par le biais de l'étiquette radar. Les conclusions de la simulation font essentiellement état de modifications mineures à ce qui s'avère un prototype largement au point.

Une grande majorité de participants considère que l'utilisation de couleurs pour indiquer le statut du vol les aide “régulièrement, voire toujours” à sérier leurs actions. Les participants approuvent aussi, en règle générale, le choix des couleurs, affirmant qu'ils n'ont jamais, ou alors rarement, été perturbés par l'emploi de ces dernières ; on note toutefois plusieurs observations à propos de l'utilisation de certaines tonalités.

L'interface de la ROMATSA prévoit un large recours au changement de la couleur d'arrière-plan pour mettre des informations en évidence. Les variations subtiles de la couleur d'arrière-plan pour faire ressortir toutes les données associées à un vol particulier ont été exploitées avec succès.

La mise en évidence logique à l'aide de la couleur a permis de réduire la nécessité de texte supplémentaire et aussi d'indiquer la coordination à l'entrée et à la sortie sans devoir recourir à des “fenêtres de message”. Les données faisant l'objet d'une coordination apparaissent en blanc sur le secteur qui la propose, tandis que les données correspondantes apparaissent sur fond blanc sur le secteur à qui elle est proposée. Grâce à l'utilisation combinée de la couleur et des boutons spécifiques de la souris (bouton 1 – acceptation, bouton 2 – refus, bouton 3 – contre-proposition), les fenêtres de coordination entrée/sortie sont devenues superflues et n'ont plus été intégrées à la simulation. Il s'est révélé nécessaire de modifier le système d'affichage afin que le contrôleur puisse voir en permanence les données faisant l'objet d'une coordination.

Le choix des couleurs est très subjectif, et il y aura toujours des divergences d'opinion. La majorité des contrôleurs ayant pris part à la simulation a émis le souhait d'être associée au choix définitif des couleurs, tout en jugeant essentiel que leur utilisation soit uniformisée dans l'ensemble du système, et soit le fruit de consultations et de débats.

Tous les contrôleurs jugent les données contenues dans l'étiquette radar et la présentation de cette dernière conformes aux besoins opérationnels ; ils n'ont suggéré que des modifications mineures.

Les contrôleurs apprécient les diverses méthodes de résolution des chevauchements, la procédure manuelle au moyen de la fonction “glisser-relâcher” (“drag and drop”) étant, de loin, la plus appréciée. Bien qu'elle entraîne une charge de travail importante, les contrôleurs affirment que cette méthode leur permet de rafraîchir leur image mentale de la situation du trafic à mesure qu'ils déplacent manuellement les étiquettes, et qu'elle ne génère pas une fatigue excessive.

L'interface contrôleur de la ROMATSA affiche un minimum de données de listes et un maximum d'informations graphiques, principe qui a été pleinement accepté par les participants. La principale fenêtre de données est la liste des secteurs (SEL), généralement considérée comme adéquate; des propositions ont toutefois été émises portant sur l'adoption d'autres critères de tri et l'ajout de données supplémentaires.

Toutes les fonctions requises sont présentes sur le panneau de contrôle d'affichage, à l'exception d'une fonction permettant de sauvegarder (mémoriser) un point d'affichage spécifique (“display centre”). La simulation n'a pas examiné la possibilité, pour chaque contrôleur, de fixer ses paramètres de préférence, mais il conviendra de l'envisager avec soin pour le système opérationnel.

Le tronçon de vol dynamique (DFL) constitue un élément important de tout système moderne, et offre des perspectives de développement. Un objectif pourrait être le moindre recours à l'outil R&B, d'un emploi fastidieux. Plusieurs fonctions supplémentaires ont été proposées au cours de la simulation.

Les contrôleurs d'approche ont recensé plusieurs besoins particuliers pour l'interface contrôleur, liés à la nature spécifique du travail en équipe dans un environnement de contrôle d'approche.

Statuts des pistes

Les statuts des pistes définies par le système déterminent la couleur et le format appropriés des données de vol. Dans la plupart des cas, ce processus est lié à l'actualisation des données de plan de vol suite à des événements, comme par exemple la sortie d'un secteur. Avant de modifier le statut d'un vol en «unconcerned», il convient d'effectuer un recoupement avec les données radar afin de s'assurer de l'intégrité des données affichées. Le fonctionnement du système devrait être à toute épreuve, tout trafic conservant le statut “concerned” tant qu'il n'y a pas certitude que le statut “unconcerned” se justifie.

Pendant la simulation, le trafic a été acheminé autour de zones militaires actives et a parfois même été forcé d'entrer dans un espace aérien qui n'était pas prévu dans le plan de vol calculé par le système. Les contrôleurs ont demandé à disposer d'une fonction de saisie «forced concerned» ainsi que d'une méthode permettant de transgresser manuellement la séquence de secteurs calculée par le système. Cette demande doit être examinée de manière approfondie avant d'être intégrée dans la spécification du système.

Un autre point soulevé et non entièrement résolu concerne les besoins d'affichage du trafic qui ne fait plus l'objet d'une corrélation. Ce trafic ne pourra se voir conférer aucun des statuts usuels, faute d'association avec un plan de vol. On pourrait utiliser les données radar pour définir un statut d'affichage spécial qui empêche que la piste ne passe pas en statut “unconcerned”.

Gestion des vols militaires

Le FDP a été suspendu pour les vols militaires afin de laisser au contrôleur la liberté de choisir son partenaire de coordination en fonction des besoins. La possibilité d'imposer un message d'activation (Forced ACT) a permis d'envoyer un ACT à n'importe quel contrôleur, avec lequel la coordination et le transfert du vol pouvaient ensuite se faire selon la procédure normale. Cette fonction s'est avérée très efficace et a ménagé la flexibilité requise, en particulier dans la TMA de Bucarest, où les vols militaires décollent en CAG de Baneasa et Otopeni (Bucarest) pour ensuite passer en COM après leur transfert aux contrôleurs militaires.

Il n'était guère aisé de cerner les besoins en matière d'interface contrôleur pour le coordinateur militaire préalablement à la simulation. L'expérience acquise à l'issue de l'exercice a permis de dresser une liste précise de ces besoins. La description de la fonction et le concept militaire opérationnel doivent être soigneusement mis au point avant d'arrêter définitivement les spécifications de l'interface contrôleur.

Instruments de saisie

Les contrôleurs ont tous adopté la souris comme instrument principal de saisie de données, et aucune critique n'a été formulée quant à la logique utilisée. La seule observation se rapportait à la mise au point éventuelle d'une configuration inversée pour les contrôleurs gauchers.

Les contrôleurs étaient très satisfaits du vecteur élastique en tant que moyen de saisie dans le système. Ils ont apprécié en particulier le fait que les données ne sont jamais masquées, et que la fonction ne requiert aucun défilement ni pagination. Par ailleurs, le temps de réponse du système doit être très court lorsque les vecteurs sont utilisés de cette façon, car si le système “hésite”, fût-ce un instant, pendant une actualisation des données radar par exemple, le vecteur élastique donne la désagréable impression de “coller”.

L'écran tactile est considéré comme un excellent complément de la souris : plus de 90 % des contrôleurs estiment que ces deux instruments de saisie devraient être disponibles simultanément. S'il ne fait aucun doute que la souris restera l'instrument de saisie privilégié en raison de sa vitesse et de sa facilité d'emploi, l'écran tactile présente des avantages spécifiques dans certaines situations. Les contrôleurs ont émis plusieurs propositions d'amélioration de l'écran tactile.

MTCD et filets de sauvegarde

Les contrôleurs sont satisfaits de la «Liste de conflits» comme moyen de présentation des paires de conflits. Le filtrage vertical des conflits est jugé acceptable pour les secteurs présentant une grande proportion de trafic en phase de vol stable à haute altitude. Il a été suggéré d'affiner encore le filtrage des conflits dans la perspective d'améliorer la fiabilité et la précision des données fournies.

Le STCA a suscité l'attention voulue et fourni une indication claire de la nature du problème sans nécessiter le moindre affichage supplémentaire dans le bloc d'étiquette radar. Le système n'a fait l'objet d'aucune critique.

Il a été proposé que, dans le système opérationnel, l'APW soit dynamiquement associée à la sélection de cartes vidéo, dont le contrôle serait régi de manière centralisée. Les contrôleurs militaires ont fait observer qu'une fonctionnalité spécifique serait requise pour les besoins militaires.

Travail en équipe et partage des tâches

On a pu observer que les contrôleurs de planification (PLC) étaient soumis par moments une charge de travail supérieure à celle de leurs collègues contrôleurs exécutifs (EXC). A l'aide des fonctions du système simulé, le contrôleur de planification était en mesure de réduire considérablement la charge de travail du contrôleur exécutif par son action préventive au niveau de la séparation des flux de trafic.

La tendance naturelle était de tenter de résoudre le plus grand nombre possible de situations conflictuelles préalablement à l'entrée des aéronefs dans le secteur. Ce léger déséquilibre de la charge de travail en faveur du contrôleur exécutif permettait à ce dernier de disposer d'une petite marge de manœuvre pour gérer les situations imprévues, son rôle se limitant essentiellement à assurer le suivi des vols.

Lorsque les niveaux de trafic étaient très élevés, le contrôleur exécutif d'approche se trouvait fréquemment dans l'impossibilité de saisir les données à la cadence voulue. Le contrôleur de planification devait alors lui prêter main forte, situation qui est loin d'être satisfaisante. L'idée a été émise qu'un réexamen des rôles et responsabilités au sein de l'équipe de contrôle d'approche pourrait déboucher sur une diminution de la charge de travail du contrôleur exécutif d'approche. Les contrôleurs d'approche ayant pris part à la simulation ont estimé avoir acquis de la sorte suffisamment d'expérience pour pouvoir contribuer à cette redistribution des rôles et responsabilités.

Objectif 2 : Évaluer de nouvelles procédures de coordination entre civils et militaires.

Coordination électronique

La demande automatique de franchissement, telle que simulée, a été très bien accueillie par une large majorité de contrôleurs ; plus de 80 % d'entre eux l'ont jugée souvent utile et 11 % seulement rarement utile.

L'émission de la XRQ se faisait via des menus instantanés, préalablement à la saisie de la route graphique au moyen du vecteur élastique. Les contrôleurs ont estimé que la saisie de la XRQ serait plus aisée si elle était pleinement intégrée dans la conception de l'interface contrôleur roumain et si la saisie des niveaux s'opérait au moyen du vecteur élastique plutôt que d'un menu instantané.

Les contrôleurs ont regretté que le système ne permette pas de faire des contre-propositions. Cette possibilité avait été envisagée pendant la préparation de la simulation, mais elle a été jugée excessivement complexe. Une autre nécessité est de pouvoir demander une modification des conditions de franchissement après la réception de l'autorisation initiale. Par ailleurs, les besoins de l'exploitation commandent que le responsable du secteur ou le coordinateur militaire qui émet la demande de franchissement en adresse une copie à l'autre.

Les contrôleurs civils ont fréquemment eu recours à la XRQ pour demander l'autorisation de franchir une TSA active. Plusieurs besoins spécifiques ont été identifiés.

Données de route

Le tronçon de vol dynamique (DFL) s'est avéré satisfaisant pour les vols civils et les vols militaires de routine tels que les exercices de navigation, mais insuffisant pour les vols militaires COM opérant selon des plans de vol flexibles. En cas de nécessité d'afficher des informations de route sur un vol COM, on pourrait utiliser un développement du vecteur vitesse à la place du DFL.

Zones de ségrégation temporaire

Le potentiel d'utilisation d'une série de TSA militaires a été examiné. Le rapport donne des précisions quant à leur acceptabilité pour les participants civils et militaires.

Conclusions générales

On retiendra essentiellement les relations de travail étroites qui se sont établies entre les contrôleurs civils et militaires au cours de la simulation. Cette dernière aura été une étape décisive sur le plan du renforcement de la coopération et du partage efficace de l'espace aérien.

Objectif 3 : ***Poursuivre l'évaluation de nouvelles procédures de coordination entre secteurs CCR, entre secteurs CCR et APP ainsi qu'entre secteurs APP et TWR***

Notification

La simulation n'a apporté aucun élément de nature à démontrer que l'actuel paramètre de notification de 13 minutes devrait être modifié dans le nouvel environnement. Les experts opérationnels sont en mesure de déterminer à quel moment le contrôleur de planification doit disposer des informations, en se fondant sur le temps nécessaire à ce dernier pour analyser les nouvelles données et prendre les mesures qui s'imposent. Il convient de noter que la taille des fenêtres de listes risque de devenir déraisonnablement grande si les données de vol sont affichées prématurément.

Coordination

Les principales conclusions de la simulation de la coordination électronique concernent la limitation de l'application de la norme OLDI à deux partenaires de coordination – expéditeur et récepteur. Il a également été proposé d'élargir la coordination aux informations relatives au cap et à la vitesse.

La simulation a permis d'identifier des configurations de secteur qui nécessiteront un mode de gestion particulier dans le cadre du système opérationnel, combiné à des limitations pragmatiques de la saisie des niveaux et de la coordination des itinéraires directs.

La coordination entre secteurs incluant l'équipe de contrôle d'approche doit être gérée de manière très différente de la coordination entre secteurs de route. Les contrôleurs d'approche considèrent que la zone d'approche forme un secteur à part entière aux fins de la coordination électronique. Aussi le contrôleur de planification d'approche, le contrôleur exécutif d'approche et le contrôleur final d'approche doivent-ils être considérés comme constituant une équipe de 3 contrôleurs, et non 2 secteurs distincts au sein de la TMA.

Transfert du contrôle

Les contrôleurs auraient apprécié l'envoi, quelques minutes avant le transfert de contrôle, d'un message TIM, destiné plus particulièrement à fournir des informations sur le cap et la vitesse, afin de leur permettre de planifier plus efficacement.

Objectif 4 : ***Evaluer l'utilisation de routes RNAV d'arrivée et de départ vers et depuis Bucarest, ainsi que les procédures connexes pour d'ATC et les équipages de conduite.***

Cet objectif fera l'objet d'un rapport distinct de l'Unité AMN d'EUROCONTROL à l'Équipe spéciale sur les applications RNAV en zone terminale (TARA).

On notera avec satisfaction la coopération qui s'est instaurée entre les contrôleurs, les pilotes de la TAROM et les pseudo-pilotes du CEE pendant ces évaluations. Les commentaires émis par ces derniers lors des séances de debriefing se sont révélés particulièrement précieux.

Les conclusions seront étoffées par un volume important de données compilées par le CEE, mais il ressort des résultats obtenus jusqu'ici que la simulation a été très utile en ce qu'elle a permis d'acquérir une plus grande connaissance et une expérience plus poussée des opérations RNAV sous l'angle de l'ATS. Globalement, les contrôleurs ont estimé que l'instauration de la RNAV dans l'espace aérien terminal pouvait, potentiellement, servir les opérations ATS, mais qu'il faudrait encore de nombreux travaux d'étude pour en obtenir la preuve définitive.

Ces résultats, combinés à ceux des autres simulations de la série ROMBULPO, devraient constituer une source précieuse d'informations, sur laquelle l'Équipe spéciale TARA pourra fonder ses recommandations à l'ANT quant à l'utilisation future de la RNAV dans l'espace aérien terminal.

Objectif 5 : ***Évaluer les dimensions et les procédures d'exploitation d'une TMA de Bucarest élargie, ainsi que la coordination connexe entre civils et militaires.***

Les dimensions de la TMA modifiée de Bucarest sont importantes, ce qui implique un risque important de charge de trafic élevée pour l'équipe de contrôle d'approche. Cet inconvénient est toutefois compensé par une plus grande liberté de manœuvre et par la possibilité de proposer des itinéraires directs. La flexibilité résultant de l'élargissement de la TMA est considérée comme un atout majeur pour les quelques années à venir, avant qu'une augmentation du volume du trafic ne rende souhaitable une nouvelle division de l'espace aérien.

On craignait que l'élargissement de la TMA n'entraîne une charge de travail plus élevée au niveau de la coordination entre contrôleurs d'approche et contrôleurs militaires. Cela n'a pas été le cas grâce à l'utilisation efficace du message de demande de franchissement pour les aéronefs militaires en transit coupant court à la périphérie de la TMA.

Objectif 6 : ***Évaluer la sectorisation et la structure de routes par comparaison avec la structure existante (août 1998), associée à une sectorisation incluant 3 secteurs de contrôle de route dépendant d'Arad, 2 de Constanta, 1 de Cluj, 1 de Bacau et 5 de Bucarest. Les 5 secteurs de Bucarest sont dotés de la configuration appropriée pour le flux et le volume du trafic, qui se fonde sur l'utilisation de 8 secteurs système, combinés selon les besoins.***

Arad

La sectorisation d'Arad simulée dans les organisations C, D, E et F a été jugée inadéquate. En ce qui concerne le trafic en direction de l'est et de l'ouest, 77 % des contrôleurs ont estimé que les dimensions du secteur pouvaient être améliorées. Les opinions étaient partagées quant à l'orientation de l'UL618 et de l'UL622, aucune des orientations retenues pour l'écoulement unidirectionnel du trafic ne s'avérant meilleure que l'autre. Pour Arad, la clé de la gestion de ces courants de trafic semble davantage résider dans la configuration des secteurs que dans une préférence quant à l'orientation du trafic.

Bucarest

La configuration des secteurs de Bucarest utilisée pour le trafic en direction de l'ouest a été jugée légèrement mieux conçue que celle pour le trafic vers l'est : 72 % des contrôleurs ont estimé que la configuration en direction de l'ouest était “bonne”, ou en tout cas “satisfaisante”, alors que ce pourcentage tombe à 60 % pour la configuration vers l'est, tous les autres contrôleurs considérant qu'elle peut être améliorée. Les contrôleurs ont exprimé une nette préférence pour une orientation vers le nord de l'UL618 (87 %) utilisée par le trafic vers l'ouest. Les enregistrements des charges de travail font apparaître un net déséquilibre pour les secteurs de Bucarest, tant dans la configuration vers l'est que vers l'ouest.

Constanta

Les secteurs de Constanta, tels que simulés, se sont avérés déséquilibrés. Une nouvelle répartition géographique a été définie et simulée avec succès pendant une brève série d'exercices.

Bacau

Le secteur de Bacau semble avoir donné satisfaction ; il n'y a pas eu de commentaires négatifs et la structure de routes a été jugée bonne.

Cluj

Les contrôleurs qui occupaient le secteur de Cluj ont estimé que les dimensions du secteur pouvaient être améliorées et ont suggéré de maintenir la route CIMPA – SIB dans la zone de compétence de Cluj.

Espacement radar

Il est apparu que l'espacement radar standard utilisé avait une incidence majeure sur les opérations. A mesure que les niveaux de trafic augmentaient, les contrôleurs éprouvaient de plus en plus de difficultés à gérer le trafic en raison du manque d'espace de manœuvre dans certains des secteurs plus étroits. Il a été décidé de réduire l'espacement radar en route de 10 à 5 miles dans les exercices à 135 %. Cette décision a été bien accueillie par les contrôleurs, qui ont fait état d'une atténuation des problèmes de guidage vectoriel.

3.2 CONCLUSIONS DE LA SIMULATION CONJOINTE BULGARIE-ROUMANIE

Objectifs :

1. ***Évaluer l'interface civile entre la Roumanie et la Bulgarie (y compris les conditions modifiées de transfert de contrôle pour le trafic à destination d'Istanbul et de Varna, et la réduction des séparations radar transfrontalières).***

2. ***Évaluer le système et les procédures OLDI/SYSCO pour le franchissement de la frontière entre la Roumanie et la Bulgarie.***

Il est apparu que la réduction de la séparation longitudinale de 15 à 10 miles nautiques avait une incidence majeure sur la charge de travail. Aucun problème notable n'a été relevé, bien que les contrôleurs aient souligné que l'environnement simulé était très différent de la réalité. La réduction des minima de séparation pourrait dépendre de l'introduction de nouveaux systèmes futurs fiables, qui comporteraient tous les avantages du système simulé. La réduction de la séparation longitudinale pourrait également être envisagée dans le cadre de la coordination électronique simulée. Cette dernière fonction a transformé les communications entre les deux pays.

La mise en place d'une coordination électronique de type OLDI V2.2 entre les secteurs roumains et bulgares simulés a métamorphosé la tâche de coordination. Actuellement, la coordination téléphonique est souvent difficile, et les communications vocales comportent toujours un risque de malentendu. Le système électronique mis en place fournit une méthode fiable et très rapide pour coordonner les niveaux de vol ou les données d'acheminement direct, tant avec l'amont qu'avec l'aval.

Des lettres d'accord révisées ont été évaluées pour le trafic en direction d'Istanbul et de Varna, et ont été jugées tout à fait acceptables.

Étant donné que bon nombre des espaces militaires dans la zone transfrontalière ont une incidence considérable sur les routes aériennes civiles, il a été suggéré que les secteurs roumains puissent afficher la TSA bulgare active et vice-versa. L'activation des TSA dans la zone transfrontalière a souvent nécessité des réacheminements temporaires. Il a donc été proposé de mettre au point un système pratique de réacheminement dynamique des vols autour des zones militaires actives. Il s'agirait d'un domaine utile de coopération future entre la Roumanie et la Bulgarie.

Les fonctions évoluées des systèmes simulés ont amené les contrôleurs des deux pays à considérer que la frontière entre la Roumanie et la Bulgarie pouvait être assimilée à n'importe quelle autre limite de secteur dans l'environnement simulé.