EUROPEAN ORGANISATION
FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL EXPERIMENTAL CENTRE

BULGARIA 99 REAL-TIME SIMULATION

EEC Report N°344
Project SIM-S-E1

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This report describes a EUROCONTROL real-time simulation study of the Bulgarian airspace conducted on behalf of ATSA Bulgaria. The study aimed to assist ATSA in preparing for the commissioning of a new Common National Air Traffic Control Centre in Sofia, equipped with an advanced ATM system. Part 1 of the study evaluated the impact of a fully electronic ATM system, which included the removal of paper flight strips, the provision of OLDI/SYSCO co-ordination, MTCD and Safety Net alerts in a vertically split sector environment. Part 2 of the study extended the first evaluation with a joint simulation with ROMATSA Romania focusing closely on cross border issues. The simulations were also designed to complement a previous Fast-time simulation (EEC Note No 4/99) which had evaluated a re-sectorisation of the Bulgarian airspace. All Enroute sectors, Sofia TMA and Military sectors were simulated. Traffic samples representing forecast levels for 2005-2007 were simulated.
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The Bulgaria 99 Real-time simulation (19th April 1999 - 7th May 1999) and the Bulgaria-Romania 99 Real-time simulation (21st June 1999 - 2nd July 1999), were the first real-time simulations commissioned by ATSA Bulgaria, as part of a programme to prepare for the establishment of a new Common National Air Traffic Control Centre (CNATCC) in Sofia.

Altogether, 2 ATSA management personnel, 27 civil controllers and 4 Military controllers participated in the Bulgaria 99 simulation. In Bulgaria-Romania 99, 22 Bulgarian civil controllers (12 of which were new), and 23 Romanian controllers were involved. The controllers gained hands-on experience during a total of 92 hours of simulator time provided during the acceptance, training and evaluation periods for both simulations.

In Bulgaria 99 the entire Bulgarian Civil Enroute ATC system was evaluated along with the Sofia TMA and Sofia Approach control. Two Military sectors provided a control service to military traffic and co-ordinated with civil controllers regarding the sharing of Bulgarian airspace in line with the EUROCONTROL ‘Flexible use of Airspace’ concept. Two different airspace organisations were tested with eight enroute sectors and one approach sector manned. Two pilots from Balkan Airlines also participated in the evaluation of Sofia Approach procedures using the EUROCONTROL Multi Cockpit Simulator.

In Bulgaria-Romania 99 two further airspace organisations were evaluated for the Bulgarian civil enroute airspace. In this joint simulation ROMATSA (Romania) participated fully, simulating four enroute sectors, Bucharest TMA and Approach control with a focus on the common border between Romania and Bulgaria.

In both simulations an advanced ATC environment was evaluated. It is proposed that the new Bulgarian system will incorporate many proposals from the EATCHIP programme in being fully electronic and will not employ paper strips.

Both simulations were designed to compliment the previous fast-time simulation carried out for ATSA Bulgaria (Model Of Bulgarian Airspace, EEC Note No 4/99), which tested new airspace configurations. Main features of the controller interface were the inclusion of electronic OLDI/SYSCO co-ordination in a vertically split sector environment, Medium Term Conflict Detection and Safety Nets such as Short Term Conflict Alert, Area Proximity Warning and Minimum Safe Altitude Warning.

To support the civil-military interaction, an electronic civil-military crossing procedure was implemented which proved highly successful in fully accommodating the requirements of both airspace users. Other information on the effective use of list information, track label interaction and the use of colour in an automated system was obtained and which will assist ATSA in more accurately specifying the features of the new Bulgarian ATM system.

Although initially considered a high priority, airspace organisation and route evaluation objectives were awarded less importance following the disruption to air traffic flows during the Yugoslavian 'Kosovo' Crisis which occurred shortly prior to the Bulgaria 99 simulation. The closure of routes over Yugoslavia and subsequent re-direction of traffic flows meant that the post Kosovo situation was far from clear. The simulation management in agreement with ATSA proceeded with the prepared analysis plan in the hope that the results obtained will later aid ATSA in establishing a suitable sectorisation and route structure, following the normalisation of traffic flows in the region.

Finally, the simulations were noted for the large number of distinguished visitors who attended the EEC. The steps ATSA Bulgaria has taken, to play a leading part in a fully integrated European ATM system were apparent and served well to promote Bulgaria’s important role in the region. It is hoped that the information presented in this report will further aid ATSA in the tasks necessary to prepare Bulgaria for Air Traffic Management in the next millennium.
ACKNOWLEDGEMENTS

The Bulgaria 99 and Bulgaria-Romania 99 project teams would like to thank the experts from ATSA (Air Traffic Services Authority) Bulgaria, namely Alexander Krastev, Tzvetomir Blajev, Roumen Tachkov, Major Nikolay Tintchev and Velin Pavlov, for their assistance, co-operation and hard work during the preparation and testing phases of the simulations.

Thanks are also due to the large team from the EUROCONTROL Experimental Centre who worked in producing the simulations. Particular mention must go to José Seixo and the technical team, for their effort in making the simulator a technical triumph, capable of running these simulations of previously unparalleled complexity and size. Undoubtedly the success of the simulations was a direct result of their commitment and dedication.

It is also necessary to thank DHMI Turkey for providing four controllers from Istanbul to staff the adjacent sectors in both simulations and also ROMATSA (Romania) for providing two Romanian controllers for adjacent sectors in Bulgaria 99 simulation. The participation of these controllers provided highly realistic traffic flows and essential cross-border co-ordination for the simulations.

Thanks must also go to Balkan Airlines who provided the use of two pilots for the Bulgaria 99 simulation and also for the Bulgaria-Romania 99 simulation, in order to more realistically evaluate RNAV Approach procedures to Sofia and Bucharest airports. The professional manner that the pilots displayed and their active participation meant that much useful data was captured which will aid development in the use of RNAV within Terminal airspace.

Finally, thanks must go to the Bulgarian civil and military controllers who attended for the Bulgaria 99 and Bulgaria-Romania 99 simulations. All the controllers showed motivation and enthusiasm and it is their valuable contribution that has made this report possible.
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INTRODUCTION

The Bulgaria 99 Real-time simulation (19th April 1999 - 7th May 1999) and the Bulgaria-Romania 99 Real-time simulation (21st June 1999 - 2nd July 1999) were real-time simulations commissioned by ATSA Bulgaria as part of a programme to prepare for the establishment of a new Common National Air Traffic Control Centre (CNATCC) in Sofia.

The joint EEC preparation project developed to meet the individual simulation requirements for ROMATSA (Romania), ATSA (Bulgaria), and PATA (Poland) was termed the ROMBULPO Project. At an early stage it became apparent that the requirements of three simulation client states were essentially similar. Bulgaria, Romania and Poland all wished to simulate advanced ATM systems but with different country-specific controller interfaces. It was decided to benefit from the joint development of these simulations by providing a common simulation, however providing a specific controller interface designed by the client for each simulation.

The ROMBULPO facility, upon which all simulations were based was derived from a recent EEC simulation\(^1\) and was therefore already at an advanced stage of development and testing. The use of this existing facility minimised the risk to the simulation clients and reduced the software work otherwise required to develop three completely new simulations. A further benefit of using a common simulator configuration was the increased time available for acceptance testing and debugging prior to the first simulation in the series, Bulgaria 99.

Each controller interface (HMI) took into account the objectives for each state and the amount of detailed specification already existing. For all states HMI specification was derived from the DSI\(^2\) HMI project, with individual changes carefully described in separate HMI delta documents.

A parallel ROMBULPO project existed as part of the assistance provided by EUROCONTROL Support to States (StS). A team of experts from StS provided advice and guidance to each state, regarding how to obtain most benefit from each real-time simulation, towards improvement of their planned future ATC systems.

A further feature of the ROMBULPO project was an initial investigation into the application of RNAV SIDs and STARs for each state. EUROCONTROL Airspace Management and Navigation (AMN) provided expert consultancy to each state. The evaluation probed several areas including Control Procedures, HMI and also included the use of line pilots from TAROM and Balkan Airlines using the EEC Multi-Cockpit Simulator to obtain a cockpit view of the procedures. Final results from these investigations are not yet published, however a summary of findings will be presented in this report.

Finally, the Bulgaria 99 Real-time Simulation conducted solely for ATSA Bulgaria and the Bulgaria-Romania 99 Real-time Simulation conducted jointly for ATSA and for ROMATSA (Romania) will each be addressed in this report. Section One will describe the Bulgaria 99 Real-time Simulation and Section Two will report on the additional objectives and data gathered from the joint simulation of particular interest to ATSA.

Note \(^1\): SweDen 98 – A joint Sweden and Denmark Real-time Simulation (S19) 06, 24 July 1998.

Note \(^2\): DSI (Denmark/Sweden Interface- I09) is a project in co-operation between EEC and Danish CAA (SLV) following OID IV, TE3C and the SweDen96 simulation. Sweden (LFV) joined the project on the basis of commonality with their System2000 project. The aim is to provide an interface platform to demonstrate the HMI requirements of Working Positions and associated functionality, which compliment new system specifications.
1. BULGARIA 99 - SIMULATION OBJECTIVES

1.1 GENERAL OBJECTIVES

A. Expose the controllers to a fully automated platform, including advanced features proposed for the EATCHIP III programme, and as far as possible as specified in the Technical Specifications for the new national ATCC.

B. Expose the controllers to an advanced HMI, including features proposed for the EATCHIP III programme, to assist in the HMI specification for the new national ATCC.

1.2 SPECIFIC OBJECTIVES

1) Training

Perform Advanced-System training and make an evaluation of the future training requirements for the operational system.

2) Controller Procedures

Assess the degree of change in the ATC procedures and task distribution between Planning Controller (PLC) and Executive Controller (EXC) in an automated system.

3) Controller Interface (HMI) Evaluation

Evaluate the use of the specified HMI, with specific focus on the following tools or features:

A. Label and Track information (including interaction)
B. Dynamic Flight Leg
C. Conflict and Risk Display
D. Vertical Aid Window
E. Sector List
F. Sector Inbound List, Arrival List, Departure List and other list presentations.

4) Airspace and Route Structure

Evaluate two airspace organisations and two route structures incorporating route modifications proposed for ARN 3 Phase II. Assess the impact of traffic evolution on the proposed airspace organisations.

5) Civil Co-ordination

Evaluate the use of OLDI/SYSCO supported co-ordination with adjacent sectors and ATC centres.

6) Civil-Military Co-ordination

Evaluate OLDI/SYSCO supported Civil-Military co-ordination between Civil and Military Controllers and the use of the EATCHIP ‘Flexible Use of Airspace’ concept, for possible application within Bulgarian airspace.

7) RNAV

To evaluate the use of RNAV arrival and departure routes for Sofia and associated ATC and airc-
rew procedures.
2. BULGARIA 99 - SIMULATION CONDUCT

2.1 TRAINING

Controller training played an important part in the preparation prior to conducting this 'advanced system' simulation. Even with significant resources applied to preparing the controllers, the EEC analysts still expected to observe a feature known as 'learning effect', where the controllers became more experienced and comfortable with the system as the simulation progressed, even though traffic levels may in fact have increased.

An assessment of the training required before the commissioning of an advanced ATC system and the suitability of the training undertaken for this simulation, were requested by ATSA in order to more effectively plan their future training needs.

The training program applied, consisted of three main elements.

1. Computer Based Training (CBT) delivered by EEC personnel familiar with the simulated system.

2. System Training Manuals, that explained the detailed functionality of the simulated system.

3. Training Exercises, at reduced traffic levels, with de-briefings and oral instruction.

2.2 ORGANISATIONS

Two organisations were simulated, Organisation A and Organisation B. (A third possible airspace configuration, Organisation C was reserved for evaluation during the Bulgaria-Romania 99 Real-time simulation, see Section 2 of this report).

The route structures described in Paragraph 2.3.1 were used with each organisation. Different Restricted Areas and Temporary Segregated Areas (TSA) were activated for each exercise, requiring separate control procedures and specific military traffic was prepared for each scenario.

Terminal Airspace for both Sofia FIR and Varna FIR remained unchanged during the simulation.

2.2.1 Organisation A

Organisation A proposed a revised sectorisation for the Sofia FIR, splitting the airspace into five sectors. Three low-level sectors (SN, SS, and SE), surface to FL340 were defined. For the upper airspace two high level sectors (UW and UE), FL340 to unlimited were defined. Sector UE had the same geographical dimensions as SE, while Sector UW shared the geographical dimensions of Sectors SN and SS combined.

The Varna FIR was split into three sectors. Varna West sector (VW) managed traffic in the western part of the Varna FIR with vertical limits from surface to unlimited. Varna East (VE) managed low level from surface to FL360, in the eastern part of the FIR, with Varna Upper (VU) sharing the same geographical dimensions as VE but superposed from FL360 to unlimited.
Figure 2: BULGARIA 99 Airspace-Organisation B
2.2.2 Organisation B

In Organisation B the Sofia Sectors remained unchanged. A second sectorisation of the Varna FIR was evaluated. A three-sector configuration was retained, however the sector boundary between Varna East (VE) and Varna West (VW) was re-defined, with Varna Upper (VU) still sharing the same geographical dimensions as VE. The same vertical sector limits were retained.

Route structure was modified with the changes specified in Paragraph 2.3.1

2.3 AIRSPACE

The simulated airspace included the entire Sofia and Varna FIRs (Bulgaria), parts of the Bucharest FIR (Romania), Simferopol FIR (Ukraine), Istanbul FIR (Turkey), Athinai FIR (Greece), Skopje FIR (Former Yugoslav Republic of Macedonia) and Beograd FIR (Yugoslavia).

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 Sofia FIR (with the exception of Plovdiv CTR) was simulated as measured sectors. Varna FIR was simulated as measured sectors with the exception of Varna and Burgas TMAs which acted as feed sectors. All other simulated airspace was represented by feed sectors.

Bulgarian military airspace was simulated as two measured sectors representing the eastern and western domains.

2.3.1 Route Structure

The basis for route structure was as defined for ARN3 Phase 1.

In Organisation A, the following routes were included:

<table>
<thead>
<tr>
<th>Route</th>
<th>Segment 1</th>
<th>Segment 2</th>
<th>Segment 3</th>
<th>Segment 4</th>
<th>Segment 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL610</td>
<td>IST</td>
<td>VADEN</td>
<td>DABOV</td>
<td>GOL</td>
<td>TIMOT</td>
</tr>
<tr>
<td>UL618</td>
<td>TGJ</td>
<td>LOMOS</td>
<td>LIPEN</td>
<td>SOF</td>
<td>RODOP</td>
</tr>
<tr>
<td>UL605</td>
<td>VALPA</td>
<td>BULEN</td>
<td>LKW</td>
<td>BGS</td>
<td>RIXEN</td>
</tr>
<tr>
<td>UL602</td>
<td>BAG</td>
<td>MAKOL</td>
<td>EMONA</td>
<td>DWN</td>
<td>KOMAN</td>
</tr>
<tr>
<td>UL619</td>
<td>KFK</td>
<td>MAKOL</td>
<td>EMONA</td>
<td>DWN</td>
<td>ARGES</td>
</tr>
</tbody>
</table>

In Organisation B, the following routes were amended from those simulated in Organisation A.

<table>
<thead>
<tr>
<th>Route</th>
<th>Segment 1</th>
<th>Segment 2</th>
<th>Segment 3</th>
<th>Segment 4</th>
<th>Segment 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN739</td>
<td>TPL</td>
<td>KAL</td>
<td>RODOP</td>
<td>KPL</td>
<td></td>
</tr>
<tr>
<td>UL605</td>
<td>VALPA</td>
<td>BULEN</td>
<td>BGS</td>
<td>RIXEN</td>
<td>BAG</td>
</tr>
<tr>
<td>UL602</td>
<td>BAG</td>
<td>MAKOL</td>
<td>DWN</td>
<td>KOMAN</td>
<td>DVA</td>
</tr>
<tr>
<td>UL619</td>
<td>KFK</td>
<td>MAKOL</td>
<td>DWN</td>
<td>ARGES</td>
<td>STJ</td>
</tr>
<tr>
<td>NEW ROUTE</td>
<td>BLO</td>
<td>VEZEN</td>
<td>ROZIN</td>
<td>GABAR</td>
<td>MILIN</td>
</tr>
</tbody>
</table>
Military routes were specifically defined for the simulation. These included routes to and from the active TSA's and also patrol routes that started and ended at the original military airport.
The active route for each flight was displayed in the flight plan data, for each military aircraft.

2.3.2 Terminal Airspace

The Sofia TMA and the Varna TMA were included in the simulation, although Varna Approach only acted as a feed sector for the Varna En-route Sectors.

The Varna TMA combined the current Varna TMA and the Burgas TMA. Additionally the eastern boundary of the Varna TMA was extended to the western boundary of the Varna East (VE) sector. This modification meant for flights routing through GALAT and OBZOR, Varna West (VW) sector was not brought briefly into the sector sequence.

The Sofia TMA was extended to the western FIR boundary to keep low level flights (below FL245) from having Sofia South (SS) sector brought briefly into the sequence. Plovdiv CTR was not simulated with the Tower Feed sector handling traffic to and from Sofia Approach sector.

2.3.3 En-route Sectorisation

The en-route sectorisation incorporated resulted from the EEC Fastime study [Reference 8].

Bulgaria 99 - Organisation A

In Organisation A, the Varna FIR was divided into three sectors. Varna West (VW) managed traffic in the western part of the Varna FIR from surface to unlimited. Varna East (VE) managed traffic in the eastern part of the Varna FIR from surface to FL340. Varna Upper (VU) was superposed over the Varna East sector, from FL340 to unlimited.

In the Sofia FIR a five sector configuration was evaluated. Sofia East (SE) operated in the eastern part of the Sofia FIR, from surface to FL340. Upper East (UE) was superposed over Sofia East from FL340 to unlimited.

In the western part of the Sofia FIR, Sofia North (SN) and Sofia South (SS) managed traffic from surface to FL340. Upper West (UW) was superposed over both lower sectors and operated from FL340 to unlimited.

Bulgaria 99 - Organisation B

Organisation B retained the same Sofia FIR sectorisation evaluated in Organisation A. The geographical boundaries of the Varna sectors were altered to meet over the DWN VOR rather than EMONA (refer airspace charts, Page 6). Additional direct routes were implemented from BLO - DWN and KAL - RODOP. The Entry level through SOMOV - GOL for traffic south-west bound from Romania was changed from FL280 to FL290, to avoid conflicting with traffic south-east bound through SOMOV - RAD.

Airspace maps showing the simulated sectors for Organisation A and B are shown on pages 4 & 6.
2.3.4 Military Sectorisation

The entire Bulgarian airspace was divided into two military control sectors, Military East (ME) and Military West (MW), which remained unchanged during the simulation. In the simulation scenario the Military controllers retained control of military OAT traffic and civil controllers retained control of all GAT traffic. Close co-operation was maintained however, and a feature of the simulation was the two-way co-ordination for civil airway crossings by military OAT traffic and for reserved airspace crossings by civil GAT traffic.

2.3.5 Danger, Restricted and Temporary Segregated Areas.

The following Temporary Segregated Areas were simulated:

- TSA A FL265 - FL390
- TSA B FL265 - FL390
- TSA C FL265 - FL390
- TSA D FL265 - FL390

The following Prohibited Area was simulated:

- LB P1 Surface - FL245

2.3.6 Surrounding Airspace

The feed sector configuration remained unchanged throughout the simulation.

The Romanian airspace was represented by two sectors Ostov (OS) and Dinro (DI). Rixen (RI) represented Ukrainian airspace and the north-eastern Turkish sectors. Radovets (RA) represented Turkish sectors west of Istanbul. Rodop (RO) represented Greek sectors and Kalotina (KA) represented the Former Yugoslav Republic of Macedonia and Yugoslavian sectors.

Full details of the simulated airspace can be found in the Bulgaria 99 Facility Specification - Part 1 Conduct and Analysis [Reference 1].

2.4 TRAFFIC

Traffic samples were initially based on a 24-hour period, from the 1 August 1998. Following analysis, two periods of traffic from the 24-hour sample were selected as suitable for the Bulgaria 99 simulation. As the predominant traffic flows experienced during the early morning period differ significantly from those experienced in the evening period, the two periods selected were referred to as AM (morning) and PM (afternoon) samples.

The initial (100%) samples were then increased to produce samples reflecting a 25% increase (125%), 35% increase (135%) and 45% increase (145%).
Predicted traffic growth was scrutinised having reached high levels of approximately 9% p.a. over the previous few years and then having sharply fallen to a slightly negative figure in 1998. Ultimately the crisis in Kosovo, involving the closure of Yugoslavian airspace and the severe disruption of traffic in the region has meant that all previous forecasts are now invalid. However if traffic increase stabilises at a 5% growth rate, the high traffic samples could be assumed to represent possible traffic figures for the years 2005 - 2007.

Military traffic was added to provide adequate traffic to achieve the simulation objectives.

Approach traffic for the periods selected for en-route evaluation, was not suitable for approach evaluation. For this reason, traffic landing at Sofia (LBSF) and Plovdiv (LBPD) was added to the enroute sample to more accurately investigate the Approach requirements. The number of flights added was statistically small and did not significantly distort the numbers in the en-route airspace.

Specific reduced traffic samples suitable for system training were created from the main samples at 66% (Organisation A) and 100% (Organisation B) levels for use in the training phase of the simulation.

2.4.1 Traffic Sample Analysis

The traffic sample analysis indicates the hourly traffic flow and peak traffic level for each sector in both Organisation A and B. The results are shown separately for the 125%, 135% and 145% traffic levels.

Flow describes the number of aircraft entering the setor during the measured hour while Peak indicates the maimun number of aircraft simultaneously under the control of the sector.

<table>
<thead>
<tr>
<th>Measured Sector</th>
<th>Organisation A</th>
<th>Organisation B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow</td>
<td>Peak</td>
</tr>
<tr>
<td>SA</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>SE</td>
<td>55</td>
<td>23</td>
</tr>
<tr>
<td>SN</td>
<td>62</td>
<td>27</td>
</tr>
<tr>
<td>SS</td>
<td>49</td>
<td>25</td>
</tr>
<tr>
<td>UE</td>
<td>25</td>
<td>14</td>
</tr>
<tr>
<td>UW</td>
<td>37</td>
<td>17</td>
</tr>
<tr>
<td>VE</td>
<td>42</td>
<td>16</td>
</tr>
<tr>
<td>VW</td>
<td>44</td>
<td>21</td>
</tr>
<tr>
<td>VU</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>ME</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>MW</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>
Bulgaria 99 Traffic Samples: 1998 + 35%

<table>
<thead>
<tr>
<th>Measured Sector</th>
<th>Organisation A</th>
<th>Organisation B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow</td>
<td>Peak</td>
</tr>
<tr>
<td>SA</td>
<td>27</td>
<td>10</td>
</tr>
<tr>
<td>SE</td>
<td>49</td>
<td>17</td>
</tr>
<tr>
<td>SN</td>
<td>51</td>
<td>20</td>
</tr>
<tr>
<td>SS</td>
<td>46</td>
<td>18</td>
</tr>
<tr>
<td>UE</td>
<td>31</td>
<td>11</td>
</tr>
<tr>
<td>UW</td>
<td>47</td>
<td>21</td>
</tr>
<tr>
<td>VE</td>
<td>43</td>
<td>12</td>
</tr>
<tr>
<td>VW</td>
<td>48</td>
<td>22</td>
</tr>
<tr>
<td>VU</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>ME</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>MW</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Bulgaria 99 Traffic Samples: 1998 + 45%

<table>
<thead>
<tr>
<th>Measured Sector</th>
<th>Organisation A</th>
<th>Organisation B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow</td>
<td>Peak</td>
</tr>
<tr>
<td>SA</td>
<td>37</td>
<td>17</td>
</tr>
<tr>
<td>SE</td>
<td>56</td>
<td>20</td>
</tr>
<tr>
<td>SN</td>
<td>55</td>
<td>18</td>
</tr>
<tr>
<td>SS</td>
<td>53</td>
<td>18</td>
</tr>
<tr>
<td>UE</td>
<td>35</td>
<td>12</td>
</tr>
<tr>
<td>UW</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>VE</td>
<td>50</td>
<td>14</td>
</tr>
<tr>
<td>VW</td>
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<td>20</td>
</tr>
<tr>
<td>VU</td>
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<td>11</td>
</tr>
<tr>
<td>ME</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>MW</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

2.5 EXERCISE PROGRAMME

An exercise program was constructed which allowed for three simulation exercises per day. After allowing for an Introduction Briefing and a Final Presentation and De-briefing session, forty-three simulation exercise slots were available. Eight exercise slots were allocated for familiarisation and system training and three exercise slots were retained as spares for contingency use.

The remaining thirty-two exercises were allocated for measured exercises. The exercise program was carefully constructed in order to address the simulation objectives. Each organisation was investigated with increasing amounts of traffic, different military scenarios, morning and afternoon traffic flows and for the benefit of the Sofia Approach evaluation, with Runway 09 or Runway 27 active.
As Runway 27 is the most active runway at Sofia, twenty-three of the forty scheduled exercises were allocated to Runway 27 and seventeen to Runway 09. This ratio in favour of Runway 27 was selected by the client in order to gain slightly more data on the most common runway configuration.

Bulgaria 99 Exercise Summary

<table>
<thead>
<tr>
<th>Week</th>
<th>Org.</th>
<th>N°. of exercises</th>
<th>Traffic level</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A</td>
<td>4</td>
<td>66%</td>
<td>Training (Two AM and Two PM)</td>
<td></td>
</tr>
<tr>
<td>1 B</td>
<td>4</td>
<td>100%</td>
<td>Training (Two AM and Two PM)</td>
<td></td>
</tr>
<tr>
<td>1 A</td>
<td>6</td>
<td>125%</td>
<td>Evaluation Org. A (Three AM and Three PM)</td>
<td></td>
</tr>
<tr>
<td>2 B</td>
<td>6</td>
<td>125%</td>
<td>Evaluation Org. B (Three AM and Three PM)</td>
<td></td>
</tr>
<tr>
<td>2 B</td>
<td>6</td>
<td>135%</td>
<td>Evaluation Org. B (Three AM and Three PM)</td>
<td></td>
</tr>
<tr>
<td>2 A</td>
<td>3</td>
<td>135%</td>
<td>Evaluation Org. A (Two AM and One PM)</td>
<td></td>
</tr>
<tr>
<td>3 A</td>
<td>3</td>
<td>135%</td>
<td>Evaluation Org. A, RNAV Training (One AM and Two PM)</td>
<td></td>
</tr>
<tr>
<td>3 A</td>
<td>4</td>
<td>145%</td>
<td>Evaluation Org. A, RNAV Evaluation (Two AM and Two PM)</td>
<td></td>
</tr>
<tr>
<td>3 B</td>
<td>4</td>
<td>145%</td>
<td>Evaluation Org. B, RNAV Evaluation (Two AM and Two PM)</td>
<td></td>
</tr>
</tbody>
</table>

Total 40 Representing 53 hours 20 minutes of simulation time.

Figure 3 : Bulgaria 99 Exercise Summary

The staff allocation to each sector was based on three separate controller rotations,

A. Varna Sectors (including Varna Approach feed sector).

B. Sofia En-route Sectors (including RO and KA feed sectors).

C. Sofia Approach Sector (including Sofia Tower feed Sector).

The staffing plan took into account each controller's qualifications and recent experience and ensured that each variation of organisation was evaluated from as many different control positions as possible.

2.6 SIMULATED ATC SYSTEM

The simulated ATC system was representative of an advanced "stripless" ATC system incorporating many features from the EATCHIP III development programme and requirements defined for the Bulgarian National Air traffic Control Centre (CNATCC).

The system employed an advanced Operator Display System (ODS) including extensive use of colour. A three-button mouse was the sole input and data access device, through which the controller interacted with the following facilities:
Screen Configuration

All screen configurations including range, filters, label orientation, selectable windows and displayed maps were set via an iconifiable on-screen control panel.

1.6.2 Interactive Track Labels

In this electronic system the track label became an integral tool for the controller. The label had three main functions. Labels,

- displayed essential flight plan information.
- provided interaction to enter controller inputs to the system.
- displayed Safety Net warnings when necessary.

Electronic Civil Co-ordination

The controller could negotiate sector entry levels (EFL) and sector exit levels (XFL) and direct routes via electronic means.

Electronic Military Co-ordination

Military controllers could electronically negotiate crossing requests for military aircraft to cross civil air routes and Civil controllers could negotiate crossing requests for civil aircraft to cross military reserved areas.

Electronic List Data

Electronic lists displayed sector entry and exit conditions for each flight, and allowed this information to be verified, modified or electronically co-ordinated.

Quick Information Access

The controller had instantaneous access to certain flight information, such as a Dynamic Flight Leg (DFL) and other flight display windows.

Notebook Functions

The controller could enter Assigned Headings, Assigned Speeds, and Assigned Rates of Climb/Descent as well as Direct Routes directly into the track label for display in place of marking the information on paper flight strips.

Medium Term Conflict Detection

The system provided en-route controllers with warnings of system calculated potential flight conflicts, up to 30 minutes before the start of each conflict.

Safety Nets

The system provided warnings relating to Short Term Conflict Alert (Loss of radar separation), Area Proximity Warning (military area incursion) and Minimum Safe Altitude Warning (ground proximity)
up to two minutes prior to the infringement.

Certain objectives concerning specific elements of the simulated system and controller interface are addressed in this report. However, a full description of the simulated system is contained within the Bulgaria 99 Facility Specification -Part 2 (Technical) [Reference 3].

2.7 CONTROLLER WORKING POSITION

The measured Controller Working Position consisted of:

- A Sony 20" square colour display, providing a multiple window, working environment.
- A Hewlett Packard™ processor and BARCO™ graphics card.
- A mouse device equipped with three input buttons.
- A digital communication system (Audio-LAN) with Headset, speaker, footswitch and panel mounted Push-to-talk facility.
- An Instantaneous Self-Assessment (ISA) subjective workload input device.

Where a sector had two positions, an Executive Controller position (EXC) and a Planning Controller position (PLC), the CWP provided to each position was identical with the same functionality. Only operational rules and the specified tasks of the two controllers prompted the setting of different screen configurations.

Military sectors were allocated an Executive CWP only.

Adjacent 'Feed' Sectors

Six 'Feed Sector' controllers were equipped with SONY™ 20" square monitors and two were provided with 21" Monitors. Special functionality was attached to a Feed Sector CWP, known as a 'Hybrid' Working position. The Hybrid incorporated a piloting function so that controller inputs were interpreted directly as pilot inputs, allowing the sector to operate without a dedicated pseudo-pilot.

2.7.1 Operations Room Configuration

The Operations room was configured with 28 Controller Working Positions as follows:

- Sofia ACC 5 Sectors (10 CWP)
- Sofia Approach 1 Sector (2 CWP)
- Varna ACC 3 Sectors (6 CWP)
- Bulgarian Military 2 Sectors (2 CWP)
- Feed Sectors 8 Sectors (8 CWP)

The Operations Room layout remained unchanged between Organisation A and Organisation B. The sector layout reflects the simulation requirement to measure electronic and telephone co-ordination. With the exception of the Military positions, adjacent sectors were not placed together, thereby limiting verbal and gesture style co-ordination methods that could not be effectively measured.
2.7.2 ATC Procedures and Controller Tasks

ATC Procedures applied during the simulation were as far as possible the same as in current operation (at the time of the simulation) at the ATC Centre of origin, either in Bulgaria or in the surrounding airspace.

In order to evaluate the task distribution between Executive Controller and Planning Controller, a defined set of tasks applicable to each control position were specified.

The task definition was based on the premise that the Planning Controller's main responsibility was 'Pending' flights, while the Executive Controller's prime responsibility was 'Assumed' flights. However, the task description did not restrict team co-operation and either controller was free to assist the other as required. Both control positions were identical in functionality, allowing the controller team (EXC and PLC) to evolve other working methods and re-distributing the sector tasks if desirable.

Detailed controller task definitions are provided under Objective 2, evaluating Controller Procedures in the simulation.

2.8 METHODOLOGY

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

The Instantaneous Self-Assessment (ISA) method was used to collect subjective data on controller workload. Participants were asked to respond to a visual prompt every two minutes during each measured exercise, by pressing one of five available buttons appropriate to their workload at the time; Under-utilised, Relaxed, Comfortable, High, or Excessive.
Figure 4: BULGARIA 99 Control Room Layout
3. RESULTS - OBJECTIVE 1

TRAINING

Perform Advanced-System training and make an evaluation of the future training requirements for the operational system.

3.1 TRAINING

The Training Programme developed for the Bulgaria 99 simulation consisted of three main elements.

The programme began with a presentation to the controllers in March 1999 outlining the aims of the real-time simulation, accompanied by a brief description of the simulation scenario and their contribution to the success of the programme. This was followed by the installation at the Sofia ACC of a Computer Based Training (CBT) package previously designed and developed at the EEC. Operational EEC staff familiar with the simulated system then explained each CBT module and fielded questions over a three-day period.

System Handbooks issued prior to the simulation explained the detailed functionality of the simulated ATM system. This was designed as a reference manual giving detailed information on the specific functionality of each HMI feature. The System Handbook was supported by a ‘Quick Reference Guide’ available at each operating position. This guide highlighted the main interactions available using the mouse to either input or display flight information.

The final phase of training involved a series of training exercises after arrival at the EEC on 19 April 1999. The first four exercises (using Organisation A at reduced traffic levels, 66% of the simulation baseline), acted as a familiarisation period and the second series of four exercises (using Organisation B samples without reduction) allowed the controllers to become more proficient with using the interface. Each exercise was accompanied by practical instruction from a team of operational staff familiar with the system, with further explanation being given during de-briefing sessions as required.

The measured evaluation then began on April 23, day four of the simulation schedule.

3.2 TRAINING RESULTS

The pre-simulation training provided was well received by the controllers. Of the twenty-five controllers canvassed in Bulgaria 99, twenty-four reported that they had received adequate information about the simulation prior to their arrival, with twenty-three responding that they were adequately briefed about their role in the experiment.

All twenty-five controllers considered the CBT course to be useful, while the handbooks were regarded as useful by twenty-four of the controllers.

The main area of comment regarding the training was not the value of the specific training elements, as each stage appears to have been of considerable benefit to more than 90% of the controllers, but rather the depth and extent of each section of the training.
The controllers emphasised the value of the CBT course, but noted that the package lacked a degree of realism. Others felt that more CBT training prior to the simulation might have been of even greater benefit. While it is difficult to achieve the 'look and feel' of working on a SONY™ 20” square screen with a CBT package operating on a personal computer, the value of such a training aid was clearly established.

Some controllers also expressed the opinion that pre-training for an advanced operational system should be a comprehensive package. The package should involve a full and in-depth Computer Based Training course, clear and detailed documentation and a series of simulation exercises beginning at low traffic levels with each scripted for a particular training objective.
4. RESULTS - OBJECTIVE 2

CONTROLLER PROCEDURES

Assess the degree of change in the ATC procedures and task distribution between Planning Controller (PLC) and Executive Controller (EXC) in an automated system.

ATC Procedures applied, were as far as possible the same as in current operation (at the time of the simulation) at the ATC Centre of origin, either in Bulgaria or in the surrounding airspace.

In order to evaluate the task distribution between Executive Controller (EXC) and Planning Controller (PLC), a defined set of tasks applicable to each control position was specified.

The task definition was based on the premise that the main responsibility for the PLC was 'Pending' flights, while the prime responsibility for the EXC was 'Assumed' flights. However, the task description did not restrict team co-operation and either controller was free to assist the other as required. Both control positions were identical in technical functionality, allowing the sector team (both EXC and PLC) to evolve other working methods and re-distribute the sector tasks if desirable.

4.1 BULGARIA 99 CONTROLLER TASK DESCRIPTION - (INITIAL MODEL)

Sector entry before the entry of the flight into the sector

Planning Controller
- Verified entry conditions for each new flight (SIL, SEL).
- Detected potential conflicts at sector entry - used MTCD & Dynamic Flight Legs.
- Resolved those conflicts as required (modification of EFL).

Executive Controller
- Read any new element displayed in SIL, SEL.
- Was responsible for any SKIP initiation.

Flight within the sector

Planning Controller
- Monitored the sector frequency and assisted the Executive controller in detecting and resolving conflict situations - used MTCD & Dynamic Flight Legs.
- Assisted the Executive controller with co-ordination Accept, Reject or Counter Proposal in Co-ordination-In window - used telephone if required.

Executive Controller
- Was responsible for Assume input (on first R/T contact).
- Was responsible for radio communication with pilots.
- Was responsible for providing the required separation between aircraft.
- Was responsible for conflict detection and resolution.
- Was responsible for tactical co-ordination radar to radar with adjacent sectors - used telephone if required.
- Was responsible for CFL, ahd, asp, arc, input orders.
Before the aircraft exited the sector

Planning Controller
● Determined, in co-operation with Executive controller, sector exit conditions - was responsible for XFL input.

Executive Controller
● Was responsible for ensuring that exit conditions were achieved.
● Was responsible for Transfer input.

4.1.1 Military and approach controllers

The military sectors were manned by an executive controller only. The operational requirements for the military control positions differed widely from the civil positions and some interface changes were made to support these different demands.

The task definition required for the Approach Sector (SA) was also significantly different from the En-route sectors, although the basic philosophy of a Planning Controller / Executive Controller team still applied. The addition of new SIDs and STARs, both Conventional and RNAV in the approach environment and the interaction with Sofia Tower and the Enroute Sectors meant that operational scenario was more complex with new procedures evolving.

Special consideration for defining an appropriate task division for the approach controllers will be necessary once the tasks themselves are determined. Task division is not a factor for the single manned military positions, however the position demanded specific procedures in order to interact with other military sectors concerning the transferring of military flights and with civil sectors for the handling of civil 'crossing requests'.

4.2 CONTROLLER PROCEDURES RESULTS

The controllers considered that the functionality of each control position should be identical to enable the controllers themselves to create an appropriate task division and not have one imposed by the system. This also allowed the controllers to modify the task division when traffic levels increased or decreased.

The controllers were supportive that Planning Controller and the Executive Controller were able to work together as a team and generally supportive that the procedures permitted this teamwork.
4.2.1 General Task Division

The general division of responsibility between Planning Controller and Executive Controller, where priority for the Planning Controller was 'Pending' aircraft (prior to Transfer-In) and the priority for the Executive controller was 'Assumed' aircraft (after Transfer-In), was generally accepted as basis for the task division.

The controllers reported that task allocation between Planning Controller and Executive Controller was not always clear. This may have been a result of allowing too much flexibility in the system configuration, or a result of the short simulation period in gaining familiarity with the roles. System recordings indicate that the Planning Controller was often carrying out tasks such as CFL input, specifically allocated to the Executive Controller. While some versatility was incorporated to allow for a distribution of workload, some actions although considered the key responsibility of one controller, were apparently shared between the two sector controllers. The impact of this indistinct task allocation was not apparent, however confusion over individual responsibilities did arise.

The two controllers continued to work together closely with 80% stating that they 'sometimes/frequently' discussed matters with the other controller.

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Did you consider that the PLC and the EXC were able to work together as a team in the management of the sector?

- Always: 40.00%
- Regularly: 56.00%
- Sometimes: 4.00%

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Did you discuss verbally with the other member of your control team?

- Frequently: 50.00%
- Sometimes: 30.77%
- Rarely: 19.23%
4.2.2 Transfer of Control and Transfer of Communications.

In the task description provided, the input of the ‘Assume Function’ was allocated to the Executive Controller on first R/T contact with the transferring aircraft (following the simultaneous actions by the upstream sector of ‘Transfer input’ and ‘Aircraft frequency change’). The expected benefit was that the Executive Controller was aware by label state, which aircraft had established R/T contact and which aircraft were in the process of changing communication.

This task sequence was contra to the current system employed in Bulgaria at the time of simulation. The current system required the down-stream controller to Assume the aircraft, prior to the upstream controller issuing the frequency change instruction. The premise was that if the downstream controller was too busy to make the Assume input, they were also too busy to establish communications and the frequency change should be delayed.

The drawback of the second system in the automated environment (simulated), was that after assume by the downstream sector the aircraft track label would become unconcerned (grey) for the upstream sector and could also be filtered from display on the screen. This would remove any prompt to the transferring controller reminding them to issue the aircraft frequency change instruction.

It is essential for the automated system to be compatible with the operational transfer of control and frequency change procedures in place, or for new procedures similar to those simulated to be developed and implemented, if problems between the two methods are to be avoided.

4.2.3 Exceptional Task Division

Although some tasks were explicitly allocated to the Executive Controller, at high traffic levels the responsibility for certain functions was occasionally accepted by the Planning Controller.

The case for such inter-operability has been made previously, however the controllers were divided on the procedure that should apply for ‘CFL input’ and ‘Assume Input’. Some controllers stated that only the Executive Controller should make these inputs. At issue was the amount each input (CFL or AOC) contributed towards maintaining the ‘radar picture’ and whether sharing of these tasks meant a degradation of the Executive Controller’s control and situational awareness.

Any restriction may be implemented using control procedures without the necessity for system limitations, thereby allowing a margin of flexibility while the full implications are evaluated.

4.2.4 Vertically Split Sectors

The controllers reported that the task allocation when applied in a 'vertically-split' sectorisation was inappropriate in certain situations.

It was found that where flights cross level boundaries (rather than geographical sector boundaries),
the procedure for co-ordination, default value and achievement of Entry Flight Level (EFL) and Exit Flight Level (XFL) required modification.

The full implication of a vertically-split sectorisation on an electronic co-ordination system is presented in the discussion of Objective 5, Civil Co-ordination. The result of the simulation however, suggested that although the Planning Controller could sometimes effectively plan an EFL/XFL for a flight in advance, in many instances the intervention of the two Executive Controllers immediately prior to the level change was necessary.

The controllers eventually concluded that the Planning Controller should avoid early co-ordination and that the default levels involved should require the minimum incursion into the next sector's airspace. The co-ordination of 'level change' and even more importantly 'time of level change' would be handled by the Executive Controllers concerned. (Special simulator functionality was developed in Bulgaria 99 to allow the co-ordination of these conditions which was then implemented in the Bulgaria-Romania 99 simulation).
Figure 5: Screen capture of Sofia North Planning Controller
5. RESULTS - OBJECTIVE 3

5.1 CONTROLLER INTERFACE (HMI) EVALUATION

Evaluate the use of the detailed HMI, with specific focus on the following tools or features:

A. Label and Track information
B. Dynamic Flight Leg
C. Conflict and Risk Display
D. Vertical Aid Window
E. Sector List
F. Sector Inbound List, Arrival List, Departure List and other list presentations.

The Human Machine Interface (HMI) in the automated system simulated for Bulgaria 99, was a complex display combining flight and radar information, airspace and aeronautical information, and system derived information on the projected trajectory for each flight. Interaction with the system through the HMI was an essential feature, which provided input to the system and feedback to the controller.

A full description of the Bulgaria 99 HMI (which was also used for the Bulgaria-Romania 99 Simulation) is available in the Bulgaria 99 Facility Specification - Part 2 Technical [Reference 3] and in the Bulgaria 99 System Handbook - [Reference 4].

The main elements of the HMI were, a large Air Situation Window (ASW), information windows with list and graphical data, and a three-button mouse input device. The use of colour played a key role in defining and prioritising information. Inter-sector telephone communication was available, however no paper flight strips were provided.
5.2 GENERAL HMI RESULTS

The HMI provided for the Bulgaria 99 simulation was well accepted by the participating controllers, with 96% identifying the windows-type display environment as a positive step for future ATC systems. The use of colour in the display of data was also very well received. While 20% of the controllers had no previous experience of mouse input devices or windows environments, they adapted quickly to the system. A large number (88%), agreed that the integration of multiple display and input windows into a single display was a good idea, supporting the direction proposed by ATSA prior to the simulation.

Over 90% of the controllers stated that the combination of the different tools and controller aids provided a satisfactory system that permitted the removal of paper strips.

"The combination of dynamic flight leg with conflict information, vertical aid window, interactive radar labels and lists provides a satisfactory system which permits the removal of paper strips."

5.2.1 Label and Track Information

The format and functionality of the track label was a key feature of the simulated HMI, with different labels provided for the En-route, Approach and Military positions. Approach controllers had further specialist label designs for Arriving and Departing flights. (A detailed description of the label formats is provided in the Bulgaria 99 Real-time Simulation System Handbook [Reference 4]).

Label format also reflected the Control State of the aircraft. For Unconcerned (and Concerned) flights a minimum label format was provided to all sectors.

A standard label format was provided for ‘Pending’ and ‘Assumed’ aircraft with the display of additional information necessary for the planning and control of the flight. (Example: En-route Pending).
A selected label format was displayed when the mouse cursor was moved over a standard label. In the Bulgarian HMI, the Selected label displayed all fields (cancelling the minimum information rule) and Line 4, containing the ahd, asp and arc fields, to enable values to be input. The next sector indicator was replaced by the next sector frequency (Example: En-route Assumed).

Finally an Extended Track label (ETL) was provided giving comprehensive details on the flight. This information was displayed in a separate window either at the track position for a “quick-look” or at a pre-set location on the screen as required. (Example: En-route Assumed).

Different colours were used to represent the aircraft control states:

- Unconcerned labels: Grey text
- Pending labels: Pink text
- Assumed labels: White text
- Concerned labels: Mustard text

The controllers could dialogue with the system through interactive fields in the label, using the mouse. Once the mouse cursor was placed over a field, a ‘single click’ or ‘press and hold’ action, with either the left, middle or right mouse button indicated an input to the system.

The left button was designated the ‘Action Button’ (for inputting data), the right button the ‘Information Button’, (for displaying data) and the middle button, the ‘Special Button’, reserved for additional functions.

**5.2.2 Label and Track Results**

The controllers indicated that the mouse was acceptable as a means of data input. However, 27% of the controllers did indicate that they sometimes experienced confusion over selecting which mouse button to use in certain circumstances. Selecting the correct label field was not highlighted as a problem, however window management was sometimes difficult. An extended period of use will aid the controllers in becoming skilled, however adherence to consistent mouse functionality in the different elements of the future Bulgarian system, is recommended to assist the controllers in becoming adept more quickly.
The controllers reported that the radar label format was suitable and indicated that only a few minor alterations need be considered. Several requested the sector exit point be removed from the standard label, and only shown in the selected label and others that the FIR exit point be displayed in the Extended Track Label. The label font used [Adobe 'Helvetica Bold' 14Pt (Proportional)] was not regarded as ideal. Evaluation of different fonts was not an objective of the simulation, however some controllers found the font used difficult to read and further research to select the most appropriate font is recommended. A further request by the controllers was to be able to show large or small text at the controller's discretion. The display of next sector frequency proved a useful feature and was very well received.

The controllers requested some other features not provided in the simulation. These included the ability to select label fields on/off, enabling a reduction in label size when busy. A facility to input and display a Mach Number restriction until a specified waypoint was also required. The controllers had a preference for positioning the Exit Point (XPT) below the Exit Flight Level (XFL) to promote easier association of the two items. A larger selectable area was desired, to make track symbol selection easier.

The minimum level information rule applied in the standard label dictated that the AFL, EFL/CFL and XFL levels were not all displayed if of equal value. If the aircraft was cleared to and cruising at its exit flight level, no action was required and only AFL was displayed. If any condition was not attained then the extra level was displayed, indicating action required for this aircraft (either monitoring or flight modification). The display of different level combinations therefore changed the shape of the data block and indicated quickly to the controller if interventions were still required. The different shape of the data blocks was effective for the controllers, with 75% indicating that it was 'regularly or always' useful.

The use of colour for labels was also successful, with over 90% of the controllers stating that the use of colour in labels and text assisted them in carrying out their ATC tasks. Several controllers commented that the Grey used for unconcerned labels was not sufficiently different from the White used for Assumed labels and that for vertically split sectors, where traffic above and below the sector was shown, the two shades could be confused when the sectors were busy.
The colour of labels indicating the control status of the flight (e.g. Assumed) was also successful in assisting the controllers to prioritise their work.

Controllers did state that the need to dialogue with the track label and keep the system updated 'occasionally or rarely' affected their execution of their principal controlling tasks. However the vast majority (90%) also reported that the workload in updating the system was 'occasionally or frequently' worthwhile given the resulting information from the system. The pop-up menus associated with data entry were also suitable with 96% of the group noting that they were happy with them as a means of input to the system.

The Extended Track Label layout was correct with 85% of the controller group considering it complete for their operational requirements.

Automatic label de-confliction was not available in the simulation. In the high traffic scenarios simulated label congestion did become a problem. The need for implementation of a well-developed and suitable label anti-overlap function was noted. While methods currently available in operational systems are not sufficiently well developed, research is progressing in this field and it is hoped that a suitably mature algorithm will eventually become available.

### 5.2.3 Supplementary Flight Level

The Supplementary Flight Level (SFL) was an additional level input to indicate a vertical condition applied to an aircraft climbing or descending to an XFL. Input was by selection in the Level Pop-up menu, following which the label or list data would show the SFL as a two figure group with the appropriate climb or descent arrow, adjacent to the XFL. (Example En-route - Assumed, FL270 climbing FL390)

**Figure 9: Supplementary Flight Level (SFL)**

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**Is the inclusion of the SFL in the system a useful feature?**

- **Yes** 92.00%
- **Not so sure** 8.00%
The SFL feature, enabling the input and display of conditional climbs and descents was found useful by 92% of the controllers. Of the group 76% preferred the system-supported input to a telephone co-ordination. A further question found that 74% of the controllers felt the SFL ‘rarely or never’ took up too much space in the track label or lists.

5.2.4 Safety Net Alerts

The simulated system supported the detection of Minimum Safe Altitude Warning (MSAW), Area Proximity Warning (APW) and Short Term Conflict Alert (STCA). Twenty-four of the twenty-five controllers reported that the displayed warnings (Line 0, Label Text) sufficiently attracted attention. Yellow text was used for MSAW and APW with red text reserved for STCA warnings.

The Bulgarian FIR contains high terrain with some areas reaching to over 8000 feet, while Sofia city is surrounded by mountains that impinge on the landing and departure procedures for the airport. The provision of an accurate and reliable MSAW feature was sought for those sectors handling low level traffic.

The MSAW simulated used a two minute look-ahead to determine if terrain clearance (based on defined terrain volumes) would be infringed and also took into account the Cleared Flight Level, suppressing warnings for aircraft expected to reach level flight without infringement.

The MSAW function was valued, although warnings were rarely generated due to the vigilance of the controllers. MSAW was considered of significant benefit for the low-level sectors of the Bulgarian FIR.

Area Proximity Warning (APW) provided warnings on civil incursions into Danger or Restricted Areas based on the same principle as MSAW. A two-minute look-ahead predicted the vertical and horizontal position of the aircraft, in relation to defined volumes of airspace and also recognised if a CFL value meant incursion would not occur. In all cases, if the CFL was broken (level bust) the warning would be re-applied. A large number the controllers considered APW a benefit with only 4% indicating the feature was never useful.

The Short Term Conflict Alert (STCA) feature was based on a projection of the aircraft radar track (unlike the Medium Term Conflict Detection (MTCD), which used updated flight plan information). A two-minute look ahead detected if two aircraft tracks would infringe a pre-determined separation minimum. STCA warnings were issued from the time the conflict was predicted until finally resolved. STCA also took CFL inputs into account to reduce false alerts. Again in all cases, if the CFL was broken (level bust) the warning would be re-applied. as for APW, the controllers indicated high support, with over 90% finding STCA useful.
5.2.5 Dynamic Flight Leg

The Dynamic Flight Leg displayed the aircraft route from the current radar track position until the end of the flight, as a solid green line with conflict sections marked in red. Forecast times at waypoints were displayed adjacent to each point. The controllers use of the Dynamic Flight Leg during the simulation indicated that it was potentially one of the most powerful elements of the HMI package. When the controllers were handling high traffic levels, the Dynamic Flight Leg continued to be used as a primary tool for providing route, sector sequence and conflict information when busy and reference to other tools and lists became difficult.
5.2.6 Dynamic Flight Leg Results

The Dynamic Flight Leg received strong support from the controllers, with over 90% stating in the questionnaire that it was ‘regularly or always’ useful and over 82% indicating that the display of conflict information ‘regularly’ or ‘always’ assisted them in performing their tasks. Discussion indicated that although potentially important tool, the DFL needed further development to improve benefit for the controller. Most controllers (70%) obtained route information from both the DFL and list data, however a considerable portion (30%) used the DFL only.

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Bar chart showing the responses to the question: **Was the Dynamic Flight Leg (DFL) facility useful?**

- **Always**: 34.62%
- **Regularly**: 57.69%
- **Sometimes**: 7.69%

Bar chart showing the responses to the question: **Did the display of conflict information on the DFL assist you in performing your task?**

- **Always**: 13.04%
- **Regularly**: 69.57%
- **Sometimes**: 13.04%
- **Rarely**: 4.35%
5.2.7 Improvements to the simulated DFL

Multiple (full-length) flight legs for conflicting flights were displayed simultaneously with the subject aircraft. This cluttered the display and as the subject DFL was in the same colour as the others, it was difficult to differentiate individual aircraft when the conflicting flight legs finally diverged. Times for different flight legs, at common waypoints were shown, however these were often displayed on top of each other making them unreadable. The controllers requested an ability to click with the mouse at any point along the DFL, to display a predicted time for the selected point along the route.

The controllers suggested that only the 'subject DFL' with conflict segments be initially displayed. The display of other conflicting DFLs could be made on controller request (e.g. single-click conflict segment). Another identified solution was to display only the conflict segment of the other flights DFL, reducing clutter on the screen. The essential requirement was to display the subject aircraft in a clear manner with other information only when required.

The controllers also requested that the subject aircraft DFL be displayed in a different colour to the other DFLs, further distinguishing it on the display. Other information that could be of important use for the controller and was not indicated was the MTCD look-ahead point on the DFL and the system predicted TOC (Top of Climb) and TOD (Top of descent) points. The MTCD look-ahead is important, as conflicts will not be displayed beyond this point, therefor the controller could erroneously interpret their absence as a conflict free flight segment.

5.2.8 Conflict and Risk Display

The Conflict and Risk Display (CRD) was a display element of the Medium Term Conflict Detection (MTCD) function during the simulation.

In an ATC system employing paper flight strips, the calculation and notification of future conflicts can be carried out by a controller, following comparison of reporting point estimates and flight levels for each aircraft crossing the sector. The calculation can be made in advance of the aircraft track being displayed on the radar screen, once flight information is received and recorded on the flight progress strips.

In the advanced 'stripless' environment simulated, the calculation of future conflicts was replaced by the MTCD function. This information was then notified to the controllers through indications on the Dynamic Flight Leg (DFL), in the Conflict and Risk Display (CRD) and in the Vertical Aid Window (VAW).

The MTCD logic replaced the reporting point estimates used to forecast the progress of each flight with a calculation using the horizontal element of the aircraft trajectory. When two aircraft were forecast to infringe a pre-determined separation distance, the horizontal conflict was further assessed to determine if vertical separation was also infringed.

The vertical analysis used values known to the system such as AFL and CFL to determine if the conflict was 'real'. If the planning levels for a conflict pair overlapped, the result was considered to show a 'risk of conflict'. The risk was used to assist the controller in planning the evolution of the two flights from sector entry level (EFL) to sector exit level (XFL).
A warning was determined to be a RISK if, Routes crossed and Level Band overlapped as defined below:

<table>
<thead>
<tr>
<th>Time Before Assume of Control:</th>
<th>The lowest of</th>
<th>SFL (if defined) otherwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFL, EFL, XFL.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The highest of</td>
<td>AFL, EFL, XFL.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SFL (if defined) otherwise</td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Time After Assume of Control:</th>
<th>The lowest of</th>
<th>AFL, EFL, XFL.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The highest of</td>
<td>AFL, EFL, XFL.</td>
<td></td>
</tr>
</tbody>
</table>

A warning was determined to be a CONFLICT if, Routes crossed and Level Bands overlapped as defined below:

<table>
<thead>
<tr>
<th>Time Before Assume of Control:</th>
<th>The lowest of</th>
<th>SFL (if defined) otherwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFL, EFL, XFL.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The highest of</td>
<td>AFL, EFL, XFL.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SFL (if defined) otherwise</td>
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</thead>
<tbody>
<tr>
<td>The highest of</td>
<td>AFL, EFL, XFL.</td>
<td></td>
</tr>
</tbody>
</table>

Conflicts were indicated in red and risks were indicated in yellow. The display could also be filtered to remove the display of risks. Following recommendation from the controller group in Bulgaria 99 (and in line with the concept of MTCD as a planning tool), in Bulgaria-Romania 99 the display of conflicts involving 2 assumed aircraft under the responsibility of the Executive controller, could also be suppressed, greatly reducing the number of conflicts presented.

Two horizontal separation parameters were simulated in the Bulgaria 99, representing the current procedures in Bulgarian airspace. For en-route aircraft within the Sofia and Varna FIRs, a separation minima of 8 NM (15 KM) was applied. For en-route aircraft being transferred to other ATC centres, a 15 NM minima was applied (within 15 NM of the FIR boundary). The use and display of the two separation standards was found to be undesirable in the Bulgaria 99 simulation therefore in Bulgaria-Romania 99, the decision was taken to use only one horizontal separation parameter of 10 NM for the MTCD function. This reduced the number of conflicts detected and also the complexity of the HMI presented to the controllers.
The CRD could be displayed (on or off) by selection of a specific button (MTCD) in the Control Panel.

5.2.9 Conflict and Risk Display Results

The CRD tool forms one element of the overall MTCD function presented to the controllers. Three elements of the MTCD function are currently being developed and are necessary for the tool to prove an effective controller aid. The accuracy of the aircraft trajectory must be assured as it forms the basis for the computation of tasks for Executive and Planning Controllers using the MTCD tool must be correctly distributed and finally and the requirement for information displayed to the Planner and Executive must be suitably defined.

An evaluation of the Conflict Risk Display also includes an evaluation of the other elements that make up the complete MTCD function. Although the simulations did not attempt an in-depth investigation of each of the separate MTCD elements, useful information was gained that will aid the further development of Medium Term Conflict Detection.
Overall the controllers supported the use of the CRD, although with reservations. The questionnaires found that 70% of the controllers found the CRD 'sometimes, regularly or always' useful. An important requirement for the tool is that controllers have confidence in the conflict predictions made. When asked if they considered the conflicts and risks displayed to be 'real', 35% indicated 'regularly' and 48% 'sometimes'. Comments indicated that controllers felt that the information presented, needed to be checked, supporting the view that improvements in the accuracy of information is still required.

Regarding the CRD display, 65% of the group reported that the information displayed was 'regularly' or 'sometimes' confusing. Specific comments indicated that too many conflicts were presented (although this was improved in the Bulgaria-Romania 99 simulation by filtering Assumed-Assumed conflict pairs) and that occasionally false or double-conflicts were shown. It is expected that some false conflicts will be detected due to prediction error however it is important that the rate is low to promote trust in the tool.

On the positive side, the controllers indicated that the CRD did reduce their workload and assisted them in better prioritising their tasks. With improvements in the accuracy of the detection, task allocation and information display the tool should achieve better acceptance and may prove a feature able to assist controllers handle the increasing traffic volumes forecast for the region.
5.2.10 Vertical Aid Window

The Vertical Aid Window (VAW) provided a vertical presentation of an individual flight through the sector, including relevant information such as predicted Top of Climb/Descent. Conflict and Risk information derived from the MTCD function was displayed with identification of the relevant aircraft. Entry co-ordination (EFL) and Exit co-ordination (XFL) could be initiated by selecting the new value from the displayed buttons.

The VAW was displayed following a single click with the information button on any level in the selected label. The display could be re-sized horizontally by using the time handle on the x-axis, or vertically by using the two sliders on the y-axis to span the desired level band.

Size and shape of the conflict zones described the length and configuration of the conflict. A conflict involving two opposite direction aircraft was displayed as a narrow zone, whereas a conflict between two aircraft in-trail was shown as a wider zone, depending on the duration of the separation loss.

The controllers did not prefer the Vertical Aid Window to the other tools available. At the end of the simulation period few of the controllers indicated regular use. During discussion several possible reasons were identified to explain why this tool was considered unsuitable. The vertical view or 'slice of airspace' presented in the VAW was a considerable change from the normal plan view display with which the controllers were more familiar. The display of trajectory information for a single aircraft rather than for a group of relevant aircraft also affected the controller's working method. Finally in the busy en-route traffic environment, which was a feature of the Bulgarian scenario, most flights were at cruise flight levels and conflicts generally involved the convergence of horizontal traffic flows rather than the crossing of aircraft in the vertical plane.

The results indicated that 65% of the controller group 'rarely or never' found the VAW useful.
However in line with the findings for the CRD, 26% 'regularly' and 52% 'sometimes' considered the various conflicts or risks to be real, suggesting the problem probably lay with presentation rather than the conflict/risk detection function.

5.2.11 Sector List (En-route Only)

Was the Vertical Aid Window (VAW) useful?

The Sector List was a tabular window combining entry and exit data with other relevant flight information, for Pending, Assumed and Concerned flights through the sector.

Information for each aircraft was displayed as a single line (strip) with the lines sorted in descending order according to Exit Point (XPT), Exit level (XFL) and Exit time (ETX). The strip was highlighted when the aircraft selected label was raised in the radar window, and inversely when the SEL line was selected, the aircraft selected label was displayed on the radar window (and in any other displayed list).

In order to reduce the size of the window 'Entry fields' and 'Supplementary fields' were displayable on/off by selection of two option buttons in the window header. Entry fields included Entry Point (EPT), Entry Time (ETE) and Entry Level (EFL). Supplementary fields included SSR code, Aircraft type and Departure/Destination Aerodromes. All interactive label fields remained interactive in the SEL.

The display colour of the text for each flight reflected the Label State in Pending, Assumed or Concerned colour, with information first displayed when the ACT was received from the previous sector. Entry fields were subsequently deleted on Assume Control and the complete line was removed after sector exit.
The information presented in the Sector List could provide entry flight data before a track label was visible in the radar window. Co-ordination could be initiated or received from the preceding sector by interacting with the aircraft list line. This facility was also available in the Sector Inbound Lists (SILs) and the simulation made a comparison between the two types of display. Of the two only the SEL provided display of sector exit information.

5.2.12 Sector List Results

The main problem associated with the SEL (as simulated) was the size of the window when the sector was busy. The width could be reduced by de-selecting option fields, however the height was not limited to a pre-set number of lines (with a ‘scroll bar’ provided when this was exceeded). This meant that the list could become excessively large and encroached on the radar window. The alternative was to enforce a limit, with the disadvantage being that all lines would not have been permanently visible. The desire to have the SEL sorting on exit conditions was also noted, however a more configurable sorting method allowing the controller to configure the sorting on demand was requested. Questionnaire results indicate that usefulness of the Sector List was not determined.

![Figure 14: Sector List](image)

The display of information in the SEL and the provision in the option fields appears to have been successful with 76% of the controllers stating that they were able to find the correct format for their requirements.

![Was the Sector List useful?](image)

The display of information in the SEL and the provision in the option fields appears to have been successful with 76% of the controllers stating that they were able to find the correct format for their requirements.
5.2.13 Sector Inbound Lists (En-route Only)

The main function of the Sector Inbound Lists (SILs) was to display flight data on aircraft before they were displayed in the radar window. As for the SEL, this enabled the controller to initiate or respond to co-ordination before the track label was visible.

Information was displayed for each pending flight as a single list line, sorted on Entry Point (EPT), Entry Time (ETE) and Entry Level (EFL). When the aircraft changed status from Pending to Assumed the information was deleted from the list. Additional information on sector exit conditions could be selected for display if required. The number of SILs required depended on the sector configuration, but usually featured four per sector. Sector Entry Points were often combined so that flights entering through the same geographical border were displayed only in one SIL (sorted by entry point).

In the simulation the SILs could be configured so that empty SILs (zero entering aircraft) were not displayed or so that all SILs were permanently displayed, selectable from the Control Panel window.

![Graph showing the ability to select the format of the information displayed in the Sector list.](Image)

**Figure 15: Sector Inbound List (SIL)**
5.2.14 Sector Inbound List Results

The controllers opinions were evenly spread on the usefulness of the SIL windows. Of the group 70% felt that the correct information was defined for the SIL, with 15% stating information was missing and 15% indicating some information was not necessary.

5.2.15 Preference Sector List (SEL) versus Sector Inbound Lists (SILs)

In comparing the SEL and SILs, a clear winner was not identified. At the end of the simulation an equal number of the controllers indicated a preference for the Sector List or for the Sector Inbound Lists. Several controllers also stated that they had enough information in the Track Label and Extended Track Label, without requiring information in advance of the aircraft radar display.

In discussion several issues were raised concerning the need to display flight information on entering traffic. This included the need to show entry data for a flight that may be squawking an incorrect SSR code. In certain circumstances the flight's track label would not be displayed ('Unconcerned' filter status) and no warning on the approaching traffic would be otherwise shown.

5.2.16 Arrival and Departure Lists (Approach Only)

The Arrival and Departure Lists were windows provided to the Sofia Approach Controllers to display flight data on aircraft landing, departing or transiting the Sofia TMA. Each aircraft was displayed as a single list line containing relevant flight data. The lists functioned using the SEL principle, in that information was only deleted on sector exit (rather than as for the SILs, on Assume of Control).

The Arrival List contained specific information on arriving aircraft sorted by entry time. Data included the allocated Standard Arrival Route (STAR), Entry Flight Level (EFL) and Cleared Flight Level (CFL), Aircraft Type/Weight category and a calculated estimate for the Final Approach Fix.

The Departure List was sorted on Estimated Time of Departure (ETD) and provided specific information on the Standard Instrument Departure (SID), Cleared Flight Level (CFL), Exit Flight level (XFL), Type/Weight Category and assigned SSR code.
Interaction was available with the lists. For the Arrival List, the STAR field (which was also shown in the label) was updated if an alternate STAR or landing runway was input. The Departure List allowed full electronic co-ordination with the aerodrome controller on the assigned SID for each departing aircraft.

As the Approach controller also handled flights inbound and outbound from Plovdiv (LBPD) data on these flights was also displayed. Aircraft transiting the Sofia TMA were displayed in the Arrival List.

### 5.2.17 Arrival and Departure Lists Results

The Arrival and Departure lists were only provided for the Approach controllers in the Bulgaria 99 simulation, which was a small group (5 controllers) in statistical terms. The task of the Approach control is highly specialised and supporting the requirements for the handling of the arriving and departing flights was an important feature of the simulation preparation.

The Approach controllers group stated different views on the usefulness of the Arrival List, with one person indicating that the list was 'never' useful, three others indicating that it was 'sometimes or regularly' useful and one person 'always' useful. The weight of argument supports the view that some benefit was gained from the information provided. No alternative SEL/SILs were provided for Approach Control and the Arrival list provided the only warning of arriving traffic before it was displayed in the radar window. Sorting of the flights in the Arrival List was found suitable.

![Figure 16: Arrival and Departure Lists](image-url)
The Departure List was more widely accepted, with all Approach Controllers stating that it was 'always or regularly' useful. The same number indicated that the list was sorted correctly for their requirements. One comment suggested combining the two lists, effectively creating a SEL as provided for the en-route controllers.

5.2.18 Hold List (Approach Only)

The Hold List was provided to Approach controllers for displaying information on aircraft instructed to Hold in either the BOZ or WAK holding patterns. The Hold List opened automatically when an aircraft was instructed to enter the hold and closed when the last aircraft was instructed to leave the hold (via the Callsign Menu). Information provided included Callsign, Actual Flight Level (AFL), Cleared Flight Level (CFL), Holding point and Expected Approach Time (EAT). Input through the Hold List was the sole means of displaying an EAT (previously written on a flight progress strip).

Most controllers stated the Hold List was 'regularly' useful, however the tool could not be properly evaluated in a very busy traffic environment, where runway capacity was exceeded as this scenario was not often experienced. No special events such as closing the runway were prescribed for the simulation. The Approach Controllers did however support the specification as defined.

5.3 THE MILITARY INTERFACE

The Military Control position developed for the Bulgaria 99 simulation provided the military officers with an initial evaluation of an advanced electronic colour display. Design features were incorporated which accommodated the existing special needs of military control in Bulgaria, with new display and co-ordination features made possible with the advanced system that was simulated.

5.3.1 Military Flight List

Each Military Control position was provided with a Military Flight List (MFL) to display relevant information on military flights both pending and active in the relevant sector. Fields provided data on Departure and Destination Aerodromes, Entry Level (EFL), Exit level (XFL), Military Route, Aircraft Type, Number in Formation, and Assigned SSR code.

The military participants identified the Military Flight List as suitable, with all responses showing it was 'regularly or always' useful.
5.3.2 Military Interface - Other features

5.3.3 Label display of Civil and Military Aircraft

For the Military controllers all aircraft were displayed regardless of altitude or 'sector of responsibility'. Military aircraft under the control of the sector were displayed in Assumed colour (White). Military aircraft under the control of the other military sector were displayed in Blue. Civil aircraft were shown Unconcerned (Grey) if outside the set height filter range and Concerned (Mustard) if within the set range.

5.3.4 Provision of Safety Nets

Due to the special nature of military missions, normal safety net information was not provided for military aircraft. An alert was issued if an STCA warning was received between a Civil and Military aircraft. In this case the alert was displayed to both civil and military controllers.

5.3.5 Transfer of Military Flights

The versatility required by military traffic precluded the definition of a fixed flight plan and fixed sector sequence. To obtain the necessary flexibility the military controller was able to select the next sector and send advance information (ACT) when required. This would change the colour state from ‘Other Military’ (Blue) to Pending (Pink) for the next military sector and copied the Cleared Flight value to the XFL/EFL field. Normal level co-ordination and transfer of control could then take place.

In all cases the functionality provided for the Bulgarian Military was found suitable. Further specific information on interaction between civil and military positions involving electronic crossing requests (XRQ), is provided in the section concerning Civil-Military Co-ordination.
6. RESULTS - OBJECTIVE 4

Airspace and Route Structure

Evaluate two airspace organisations and route structures incorporating modifications proposed for ARN3 Phase II implementation. Assess the impact of traffic evolution on the proposed airspace organisations.

Two airspace organisations were considered in Bulgaria 99, which incorporated different configurations for the Varna and Sofia sectors (Bulgaria-Romania 99 considered further variants discussed in Section 2 of this report). Organisations were assessed at increasing traffic levels (125%, 135%, and 145%).

6.1 AIRSPACE AND ROUTE STRUCTURE RATIONALE

The investigation planned for the Bulgaria 99 (and Bulgaria-Romania 99) simulation involved the evaluation of both route changes and appropriate sector modifications in order to accommodate forecast traffic growth, including westbound flows from Yugoslavia. Shortly before the start of the Bulgaria 99 simulation, following an exceptional political situation in the region, all air routes through Yugoslavia and the Former Yugoslav Republic of Macedonia were closed. The effect of this was to suppress westbound flows and to greatly increase southbound flows from Romania.

Insufficient time remained available to re-construct and validate a new series of traffic samples for the simulation, nor to design and build a new airspace configuration. In any event, the length of the crisis and outcome of the political situation were unknown, as was any projection of the eventual traffic model.

A decision was made by the project team to continue with the prepared traffic and airspace configuration, although the priority for the 'Airspace and Route Structure' objective was necessarily reduced. A subjective rather than exhaustive evaluation was made, with the results available to assist ATSA when considering airspace organisation at some future time. In order to aid ATSA in coping with the disrupted traffic flows, requiring immediate changes in sectorisation and procedures, an extension to the completed EEC Fastime Study [Reference 8] was prepared and conducted.

6.2 AIRSPACE AND ROUTE STRUCTURE RESULTS

6.2.1 Sofia FIR

The Sofia controllers reported a preference for Organisation A, as this route structure produced less conflicts for Sofia North (SN) compared with Organisation B, which included route (UN687) VELBA-BLO-DWN-MATEL-INKOM, which crossed all main traffic flows in the Bulgarian FIR.

Sofia South (SS) sector was identified as the most charged sector in the simulation, mainly due to the number of crossing traffic flows and the interference of vertically evolving aircraft. The sector was considered busy even at 125% traffic levels.

Upper West (UW) was also considered busy with a suggestion to move the altitude restriction (FL290/FL250) placed on the southbound flow through CCO, back to the Romanian boundary at
LOMOS, facilitating the descent of these aircraft. This would enable Upper West to handle only in-cruise traffic potentially reducing the workload considerably.

Sofia North (SN) was considered the third most difficult sector with workload in the eastern sectors Sofia East (SE) and Upper East (UE) considered high but manageable, without excessive conflicts.

6.2.2 Varna FIR

The Varna East (VE) controllers reported a preference for Organisation B, as the sector configuration was more suitable. In Organisation A, traffic on the MATEL-RIXEN route landing Istanbul required descent to FL250 at RIXEN. However traffic on the MAKOL-EMONA route often restricted these descents with insufficient room available for radar vectoring.

Problems were identified in Organisation A for Varna West (VW) with the convergence of flows MATEL-DWN and MAKOL-DWN with insufficient time after the Varna East (VE) sector boundary to effect separation.

Varna East and Varna West were considered equally busy with Varna Upper less loaded, however all were considered manageable even at 145% traffic levels.

6.2.3 Sofia Approach

Although the structure of the TMA was not a particular focus for the simulation, Sofia Approach controllers reported few problems with the airspace configuration. Comments did indicated that in a busy traffic environment a vertically split approach sector should be considered.
7. RESULTS - OBJECTIVE 5

Civil Co-ordination

Evaluate the use of OLDI/SYSCO supported co-ordination with adjacent sectors and ATC centres.

7.1 INTRODUCTION

Flights that are provided with an ATC service are transferred from sector to sector and from one ATC unit to the next, in a manner designed to ensure safety. In order to achieve this, data on the sector (or ATC unit) boundary is co-ordinated in advance. Control of the flight is then transferred when it is at the boundary. Where this communication is carried out by telephone, the passing of data on individual flights is a major support task, particularly at Area Control Centres.

The operational use of connections between Flight Data Processing Systems (FDPS), for the purpose of replacing such verbal messages, referred to as On-line Data Interchange (OLDI), began within Europe in the early nineteen-eighties.

Common rules and message formats for implementation were agreed and incorporated in EUROCONTROL Standard for On-line Data Interchange Edition 1, which was subsequently revised as Edition 2. The upgrade from OLDI Edition 1 to Edition 2 is generally known as System Assisted Co-ordination (SYSCO).

7.2 BULGARIA 99 ENVIRONMENT

The co-ordination environment provided in the Bulgaria 99 (and Bulgaria-Romania 99) simulation supported full electronic co-ordination between all internal and external partners. While it is accepted that not all countries bordering Bulgaria are likely to upgrade simultaneously to systems that support full electronic co-ordination, the objective of the simulation was to determine the benefit to be gained in such an automated environment.

For each flight an Activation Message (ACT) was transmitted eight minutes prior to the sector exit boundary, with all revisions after this treated as 'Referred Revisions', in that they had to be agreed by both controllers. The system supported Entry Flight Level (EFL), Exit Flight Level (XFL) and Direct (DCT) co-ordination as well as Transfer of Control and Request on Frequency (ROF) messages.

Co-ordination was possible to 'propose', 'counter-propose' or 'reject' a proposal. Messages were displayed in the Co-ordination Windows and also coded into the track label and list HMI.

Correct sector sequence and co-ordination partners were determined from the aircraft trajectory, which was modified following the controller input of data. If a controller input a new XFL or DCT, this updated the aircraft trajectory (and formulated a new sector sequence if required).
Input of a new XFL value (after ACT) was displayed as an EFL co-ordination at the next sector. When agreed the new value would update the aircraft trajectory. When two sectors are superposed such as Sofia East (SE) and Upper East (UE) were in Bulgaria 99, the boundary between the two sectors is found in the vertical plane. For these cases, special functionality was required. Firstly the display of XFL/EFL becomes problematic. Displaying the boundary level (FL340) for all aircraft was not operationally suitable; therefore the target level for the flight was treated as the XFL/EFL value.

Regularly the rule, 'Climb as soon as possible, descend as late as possible' is used to construct an aircraft's trajectory, as it represents the most economic profile for the aircraft. However, in the vertically split sector environment, the new XFL value must be applied immediately rather than at the end of the sector, to correctly reflect the profile of the aircraft and construct the new sector sequence.

The problems associated with vertically split sectors were increased in Bulgaria 99 with the superposing of Upper West (UW) over both Sofia North (SN) and Sofia South (SS).

If Upper West (UW) proposed a new XFL for descent to Sofia South (SS), while the aircraft was still flying over Sofia North (SN), the agreed XFL value was 'applied immediately' (Example A) updating the trajectory and bringing Sofia North (SN) ‘incorrectly’ into the sector sequence. If the XFL was
applied 'as late as possible' (Example B) then co-ordination was possible with Sofia South (SS), however Upper West (UW) was never able to propose a descent to Sofia North (SN).

7.4 RESULTS OF ELECTRONIC CO-ORDINATION IN THE VERTICAL PLANE

Co-ordination with adjacent sectors was effective with few problems encountered. However, co-ordination between vertically split sectors underlined several technical and operational shortcomings.

The displaying of a 'default XFL' value for flights to be transferred from the upper sector to the lower sector was discussed at length. If a 'Default XFL' (e.g. FL250, transfer level from SS to Athens Centre) was presented to the upper sector (UW), this allowed the controller to descend the aircraft to this level, without co-ordination. The descent would cross all levels in the lower sector (SS), from FL340 (the vertical boundary) to FL250, without the upper controller having knowledge of other conflicting aircraft.

Several options were considered, including presenting '???' in place of the default XFL value, therefore requiring the upper controller to input and co-ordinate each descent. This was rejected as being over burdensome. Finally the default XFL value was set at the first available level in the lower sector airspace (i.e. FL330). The aircraft was given descent to this level and then transferred to the lower sector, which then continued the aircraft's descent to FL250, separated from other relevant traffic.

The various difficulties posed by having a large upper sector over several lower sectors also featured in the exercise debriefings. The problem of whether to treat an XFL input immediately has been already highlighted, with the controllers requesting the ability to select the co-ordination partner for each descent (e.g. UW choosing either SN or SS), depending on the desired descent point. If sector SN was chosen the XFL would be treated 'immediately', if sector SS then the XFL would be treated 'as late as possible'.

Following agreement on an appropriate level, another requirement for the controllers was to be able to co-ordinate the actual moment of descent, through heavy flows of traffic. The controllers required a co-ordination message such as 'Change Level Now', which would be used by the two Executive Controllers to indicate to each other when descent was suitable (This functionality was developed and evaluated in Bulgaria-Romania 99, with the results described in Section 2 of this report).
7.5 ELECTRONIC CO-ORDINATION IN THE HORIZONTAL PLANE

As with controller inputs in the vertical plane, DIRECT inputs in the horizontal plane caused a re-calculation of the trajectory. As co-ordination takes place between two co-ordination partners, this could have the effect of bringing third sectors into the sequence, without their consent or option of refusal. In order to reduce this risk and to ensure co-ordination of route changes always took place, several rules were imposed on the DIRECT functionality.

The DIRECT input could be made to points within the current sector at any time. However, a DIRECT to points in the next sector could only be made if an Activation Message (ACT) had been sent, therefore ensuring the DIRECT was treated as a 'Referred Revision' requiring the approval of the next sector. If no ACT had been sent this could initiated before the scheduled time from the Callsign Menu (SEND ACT).

Additionally, the number of DIRECT points available for selection was limited to the next eight points, to reduce the risk of bringing a third sector into the sequence.

Sector design was found to be important when applying the DIRECT functionality as occasionally when a standard DIRECT was input, the sector boundary of an adjacent sector was inadvertently cut bringing that sector into the new sector sequence.

This occurred in Organisation A, for flights through Sofia South (SS) routing KAL-BLO-MOGLO. When Sofia South (SS) input DIRECT MOGLO (sometimes before the aircraft crossed KAL), the trajectory crossed a small segment of Sofia North (SN), causing the sector sequence to change from SS-SE, to SS-SN-SS-SE. This caused confusion for the sectors involved, including Sofia North, which had the label in 'Pending' state, although not concerned with the flight and problems for the experimental FDPS in having to manage a sector re-entry for Sofia South (SS) sector.

These problems were exacerbated if Sofia North input 'SKIP' (recommended practice) as the sector sequence became SS-SSSE with SS transferring to itself.

Figure 21: SOFIA SOUTH Direct Order with incursion of SOFIA NORTH
7.6 RESULTS OF ELECTRONIC CO-ORDINATION IN THE HORIZONTAL PLANE

Careful sector design is required to avoid flights cliplng small segments of adjacent airspace and to allow standard DIRECT routes to be applied without generating sector sequence anomalies. While large sectors with straight-line boundaries are preferred, sector design must also accommodate traffic flows, national boundaries and sector capacity limitations, sometimes inhibiting ideal design.

7.6.1 Co-ordination Interface

Two windows were provided to enable co-ordination messages to be sent and received. The Co-ordination OUT window displayed messages sent to others sectors. The Co-ordination IN window displayed messages received from other sectors, awaiting a response. The windows were only displayed when a message was present and resized to display additional messages. Messages were sorted in time order with the earliest message at the top.

<table>
<thead>
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<table>
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<tr>
<th>COORDINATION IN</th>
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<td>02:17</td>
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Figure 22: Co-ordination Lists

The Co-ordination windows allowed changes for flights to be proposed. Proposals to be accepted or rejected and if necessary counter-proposals to be sent. Co-ordination was possible on Entry Flight Level (EFL), Exit Flight Level (XFL), Direct (DCT) [and for Civil/Military Crossing requests (XRQ)].

Proposed data sent to other sectors was displayed in green and proposed data received from other sectors was displayed in blue, to assist the controllers in identifying which co-ordinations were awaiting a response. A co-ordination message was displayed in the Co-ordination window, with the data element also shown in the track label and other lists (i.e. SIL/SEL/ARR/DEP) in the appropriate co-ordination colour.

7.6.2 Co-ordination Interface Results

The controllers found the windows useful, although commented that the black text used to indicate sector identification and nature of the proposal was difficult to see on the dark background of the window. The different colour of incoming and outgoing co-ordination values (blue/green) was stated to be successful.

A portion of the controllers (31%) did sometimes miss the initial posting of a co-ordination message. A timely response to each request is important for facilitating the control of aircraft and also for keeping the system updated. Of the controllers, 42% 'regularly' and 27% 'sometimes' reported difficulty in interpreting the messages. The messages themselves must be short and concise in order to keep the window size small, and yet sufficiently clear and explanatory to allow quick interpretation.
7.7 General Co-ordination Results

Although the provision of vertically split sectors in the Bulgaria 99 simulation raised several pertinent issues; the controllers strongly supported the use of system-assisted electronic co-ordination. Compared with the current Bulgarian system, 23% stated that it 'always', 65% 'regularly' and 12% 'sometimes' assisted with their ATC tasks. Comments from the controllers identified benefits such as reduced telephone communication, faster, more silent co-ordination and a reduction in ATC task load.

*Did the availability of electronic co-ordination assist you in your ATC tasks when compared to the existing Bulgarian system?*
8. RESULTS - OBJECTIVE 6

Civil - Military Co-ordination

Evaluate OLDI/SYSCO supported Civil-Military co-ordination between Civil and Military Controllers and the use of the EATCHIP 'Flexible Use of Airspace' concept, for possible application within Bulgarian airspace.

8.1 INTRODUCTION

The EATCHIP 'Flexible Use of Airspace' concept (FUA) was introduced as a basis for Airspace Management (ASM) in the time frame 1995-2005, with an aim to increasing the capacity and efficiency of Air Traffic Management within the ECAC area.

The basis for the concept is that airspace should no longer be designated as either military or civil airspace, but should be considered as one continuum, used flexibly on a day-to-day basis.

It is anticipated the application of FUA will lead to:

- An increase in ATC capacity and a tangible reduction in GAT (General Air Traffic) delays.
- More efficient ways to separate OAT (Operational Air Traffic) and GAT (General Air Traffic).
- Improved real-time civil-military co-ordination and a significant reduction in airspace segregation needs.
- The use of temporary segregated areas being brought more closely into line with military operational requirements.

Three levels of ASM are defined 'Strategic', 'Pre-Tactical' and 'Tactical'. At the Tactical level, the FUA concept allows a maximum joint-use of airspace, through appropriate tactical Civil/Military co-ordination. Systems support is required to assist controllers in performing co-ordination in an efficient manner and to reduce the workload of the data exchange and co-ordination tasks.

8.2 BULGARIA 99 MILITARY ENVIRONMENT

The Civil and Military air traffic systems in Bulgaria currently operate as independent entities.

Service is provided to GAT (General Air Traffic) by ATSA, using civil air traffic controllers while the Bulgarian Airforce military controllers manage OAT (Operational Air Traffic). In the new ATC centre for Sofia, both services are planned to be co-located. The controller working positions will use similar colour displays and share flight information and data communication systems.

In the Bulgaria 99 simulation the airspace was divided into two military sectors Military East (ME) and Military West (MW), controlling military traffic from 'ground to unlimited'. These two military sectors shared Bulgarian airspace with eight civil en-route sectors and two civil approach sectors.

Military aircraft flew missions from six military airports, while international arrivals and departures from four civil airports were simulated.
In each simulation exercise different combinations of four Temporary Segregated Areas (TSA) were activated from FL265 - FL390. The important contribution made by agriculture within the Bulgarian economy means crop protection is given high priority. The TSAs can be activated at short notice, to permit ‘Cloud-Shooting’ activity, controlled by the Bulgarian military. ‘Cloud-Shooting’ refers to high altitude rockets being exploded inside Cumulo-Nimbus clouds, reducing the risk of hail precipitation and potential crop damage.

When adverse meteorological conditions exist, significant volumes of Bulgarian airspace can be closed affecting air routes and busy flows of traffic. The airspace restriction also increases traffic density in unaffected airspace, resulting in additional conflicts and extra internal and external coordination tasks for the civil controllers.

8.3 CROSSING REQUEST INTRODUCTION

The ‘FUA’ concept allows for the exchange of data between civil and military controllers. The simulation incorporated the tactical co-ordination of ‘crossing requests’ for individual civil aircraft, with ‘crossing clearance’ allowing transit of segregated airspace, even during an active airspace restriction. Crossing requests were also tactically co-ordinated for military aircraft transiting civil airways, with the aim of improved traffic awareness and enhanced safety where military routes intersected civil air routes.

8.3.1 Crossing Request Functionality

Before a Crossing Request Message could be sent a series of data inputs were required defining the requirements. A civil controller initiated a ‘Crossing Request’ for ‘Pending or Assumed’ aircraft by selecting ‘CROSS’ from the aircraft’s ‘Callsign Menu’.

Figure 23: BULGARIA 99 Military Airspace
Once selected the controller input the crossing level(s) from a Level Menu pop-up. An elastic-vector line then linked the aircraft track symbol to a target cursor and the start point (origin) of the 'crossing' was input.

When the 'start point' had been defined, the elastic-vector line attached the start point to the target cursor and displayed the proposed 'crossing'. The 'end point' (extremity) of the crossing was then selected.

From the 'start point' and selected 'crossing level' the system calculated the correct (military) partner for the co-ordination. The crossing request (XRQ message) was then sent to the military sector. The sending civil sector displayed X[level] in the track label in 'outgoing co-ordination colour', along with the crossing line and level information at the transit points.

For the Military controller the aircraft label changed to 'Concerned '(mustard). The co-ordination was displayed in 'incoming co-ordination colour', as a track label indication (e.g. X350), with the crossing line displayed, and also as a text message in the Co-ordination-IN window. To simplify the specification, the military controller could only 'Accept' or 'Reject' the proposal, while operational instructions for a 'reject' required a telephone explanation to be passed. Counter-proposal for levels and/or routes was considered a desirable next development, once the functionality was validated.

Once accepted, the line and label text changed colour (yellow) indicating approval to both civil and military sectors. If necessary the crossing could be cancelled (XCM) by selection from the callsign menu.

At the request of the civil controllers, the HMI indication could be cancelled individually for either the Label indication (e.g. X350), or the 'crossing line' and text indication (e.g. AZA7696/350).

The need for this functionality was identified when stream of aircraft required crossing approvals and a series of crossing requests were co-ordinated for the same air-route and TSA. The label indication was important for each approved aircraft, however the display of multiple crossing lines in the same place were redundant and cluttered the display.
The same procedure operated for the military controllers requesting civil airway crossing approval for OAT traffic, with the system calculating the correct civil co-ordination partner from the 'start point' and 'flight level' input by the military controller.

(Example: Sector UE has requested and obtained 'TSA C' crossing approval for AZA7696 (N.B.: the yellow crossing line has been suppressed). AVZ112 is proposed for crossing to Military East (ME) at FL350 and is displayed in Outgoing Co-ordination Green).

### 8.4 CIVIL - MILITARY CO-ORDINATION RESULTS

The provision of electronic co-ordination between the Military and Civil controllers in Bulgaria 99 was regarded as extremely successful by both the civil and military controllers. This was the first evaluation of the HMI and system functionality, and several design points were noted.

The number of steps to input a 'crossing request' message was considered too many. The number of input selections required was minimum six steps (or seven, if a level band was required).

<table>
<thead>
<tr>
<th>Input No.</th>
<th>Function</th>
<th>Action</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Select CROSS</td>
<td>Single Click (AB) CROSS from Callsign Menu</td>
<td>Raised XRQ/XCM menu</td>
</tr>
<tr>
<td>3.</td>
<td>Select XRQ/XCM/XIN menu (N.B. XIN not used)</td>
<td>Single Click (AB) XRQ.</td>
<td>Raised Level Input window</td>
</tr>
<tr>
<td>4.</td>
<td>Select crossing level(s)</td>
<td>Single Click (AB) Level (or SC Special Button (SB) [first level] plus SC AB [second level] to input level band).</td>
<td>Changed cursor to target cursor, elastic vector (dashed-yellow) linked to track symbol.</td>
</tr>
<tr>
<td>5.</td>
<td>Input 'Start Point'</td>
<td>Single Click (AB) at origin.</td>
<td>Input point, elastic-vector from origin point (solid-yellow).</td>
</tr>
<tr>
<td>6.</td>
<td>Input 'End Point'</td>
<td>Single Click (AB) at extremity</td>
<td>Input point, cursor returned to normal, crossing line to outgoing co-ordination colour (green), XRQ message sent.</td>
</tr>
</tbody>
</table>

The number of steps could have been reduced to five by removal of [Step 3] the XRQ/XCM/XIN menu. Crossing Intention message (XIN) was not applied in Bulgaria 99 and the Crossing Cancellation Message (XCM) was only required if an XRQ had been already sent. CROSS [Callsign Menu] could be displayed for flights without an active crossing or be replaced by CAN-CEL CROSS [Callsign Menu], if a crossing was active.
The possibility to input multiple point crossings was requested by the controllers along with the ability to counter-propose a received crossing request. Initially this could be limited to 'level' counter-proposal only, as combining 'level and route' counter-proposal may introduce unmanageable complexity.

Initially crossing request functionality was enabled for 'Assumed' aircraft only. During the simulation it became apparent that functionality should also be extended to 'Pending' aircraft. Often the sector boundary was close to the TSA boundary and insufficient time was available for planning and requesting the TSA crossing approval. The functionality was amended during the simulation correcting the problem.

The ability to cancel display of the label indication (e.g. X350), separately from the crossing line indication was appreciated by the controllers. As a stream of civil aircraft approached an active TSA, multiple crossing approvals were sought. After approval the label indication was retained as it distinguished aircraft with approval from those without, however the multiple crossing lines over the TSA were deleted to reduce clutter. This was suitable for 'civil' crossings on both civil and military displays. However, military aircraft tended not to fly in 'streams' and so the problem was not apparent.

During the final week of the Bulgaria 99 Real-time simulation over 300 crossing requests were passed between Civil and Military controllers. The controllers indicated that the 'Flexible Use of Airspace' environment simulated was successful in promoting improved co-operation between civil and military sectors, a better level of service for civil aircraft, and enhanced traffic information for the military controllers. The efficiency of seamless, silent, co-ordination between civil and military systems indicated that significant benefits could be gained from exploiting a closer liaison between the civil and military establishments.
9. RESULTS - OBJECTIVE 7

RNAV Approach Evaluation

Evaluate the use of RNAV arrival and departure routes for Sofia Airport and associated ATC and aircrew procedures.

9.1 RNAV 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 Brétigny, a comprehensive evaluation programme was developed by the Terminal Airspace specialists of the Airspace Management and Navigation Unit at EUROCONTROL HQ in Brussels.

9.2 EVALUATION DEVELOPMENT

Bulgaria 99 was the first of the Rombulpo series of simulations and it was therefore decided, as a first step in the RNAV studies, to evaluate the effect on air traffic control operations of aircraft self-navigating on pre-defined routes within the Sofia TMA. This navigation option is known as 2-D (Lateral Navigation [LNAV]).

PANS-Ops expertise was used to construct, for simulation purposes only, arrival and departure RNAV(4,3),(996,993)
9.3 SIMULATION CONDUCT

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 set at 125%, 135% and 145% of current levels. It was decided that, for maximum benefit, the eight RNAV measured exercises would be carried out at 145% and the training would comprise three exercises at 135%.

All aircraft for the RNAV exercises were 2-D capable and the controllers were asked to allow them, as far as practicable, to self-navigate on to the ILS along the prescribed tracks. In addition to the aircraft generated from within the main platform and handled by the pseudo-pilots, the Multi-Cockpit Simulator (MCS), flown by line pilots from Balkan, was integrated into the exercises.
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 line 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 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 is being collated and is intended to form the basis of the final RNAV report to be made to TARA in December 1999. Detailed findings of the questionnaires will also be included in the final report.

9.4 INTERIM RESULTS

Controllers and pilots alike reported a good understanding of the RNAV procedures. However, there was early confusion over the meaning of some of the phraseology. This problem, exacerbated by different interpretations of that phraseology by controllers, pilots and pseudo-pilots, necessitated an on-the-spot review and redrafting of the words used and their meaning.

The stability of the main platform 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.

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 platform and, although not affecting the validity of the overall exercise, some MCS runs were abridged. The line 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. In fact, they were so confident about the compatibility of aircraft systems with these procedures, that they had time to reflect on what they thought were the difficulties liable to be faced by controllers, such as the lack of computer-aided sequencing tooling.
9.5 INTERIM CONCLUSIONS

It was very encouraging to note the willingness of the Bulgarian controllers, the Balkan pilots and the EEC pseudo-pilots to participate wholeheartedly 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 (Poland 99, Bulgaria-Romania 99 and Romania 99), 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.

Figure 26: Screen Capture SOFIA APPROACH Executive Controller
REPORT SECTION 2

BULGARIA - ROMANIA 99
10. BULGARIA-ROMANIA 99 - BULGARIAN OBJECTIVES

10.1 GENERAL OBJECTIVES

A. Expose the controllers to a fully automated platform, including advanced features proposed for the EATCHIP III programme, and as far as possible as specified in the Technical Specifications for the new national ATCC.

B. Expose the controllers to an advanced HMI, including features proposed for the EATCHIP III programme, to assist in the HMI specification for the new national ATCC.

10.2 SPECIFIC OBJECTIVES

10.2.1 Controller Interface (HMI)

Evaluate use of the HMI with specific focus on the following tools or features changed from the Bulgaria 99 simulation:

A. Change Level Co-ordination and Default XFL values.

B. MTCD Parameters and Filters.

10.2.2 Airspace and Route Structure

Evaluate a further version of airspace organisation (En-route sectorisation derived from Model of Bulgarian Airspace - EEC Note No 4/99) and a revised route structure derived using possible application of ARN3 Phase II developments. Assess the impact of traffic evolution on the proposed airspace organisations.

10.2.3 Reduced En-route Separation

Evaluate reduced inter-centre enroute separation (10NM) between Romania and Bulgaria, for the effect on controller procedures and workload.

10.2.4 Civil Co-ordination

Evaluate the use of OLDI/SYSCO supported co-ordination with adjacent sectors and ATC centres (with particular reference to interaction with Romania).
Figure 27 : BULGARIA-ROMANIA 99 Airspace Organisation A
11. BULGARIA - ROMANIA 99 SIMULATION CONDUCT  
(DETAILING CHANGES FROM BULGARIA 99)

11.1 TRAINING

As for Bulgaria 99, training consisted of three main elements, Computer Based Training (CBT), System Manuals and Training Exercises. Additionally six controllers from Bulgaria 99 were also allocated to Bulgaria-Romania 99, bringing with them experience of the system functionality and HMI interaction. The six experienced controllers were evenly distributed on the controller roster to ensure support was available to each new participant.

11.2 ORGANISATIONS

Three organisations were simulated, Organisation A, Organisation B and Organisation C.

The route structures described in Paragraph 11.3.1 were used with each organisation. Different Danger Areas and Temporary Segregated Areas (TSA) were activated for each exercise, requiring different control procedures.

11.2.1 Organisation A

Organisation A proposed a revised sectorisation for the Sofia FIR, splitting the airspace into four sectors. Two low-level sectors (SN, SS) from the surface to FL340 were included. One high level sector superposed above SN and SS was defined as Sofia Upper (SU), while Sofia East (SE) had vertical limits of surface to unlimited.

The Varna FIR was reduced to two sectors. Varna East (VE) managed from surface to FL360, in the eastern part of the FIR while Varna West (VW) managed traffic in the western part of the Varna FIR with vertical limits from surface to unlimited and also above VE from FL360 to unlimited.

UL618 and UL622 retained their current traffic flow orientation.

11.2.2 Organisation B

Organisation B for Bulgaria was identical to Organisation A, however several boundary changes were incorporated by Romania changing the adjacent sectors at the Bulgaria-Romania frontier. Principally for Bulgaria, the Bucharest TMA was extended to share a common boundary with VW sector, and the Romanian North (N) and East (ES) sectors were modified.

UL618 and UL622 retained their current traffic flow orientation.

11.2.3 Organisation C

In Organisation C, the Varna Sectors retained the same configuration applied in Organisations A and B. The Sofia sectors simulated a revised boundary line between SN and SS, from an FIR boundary point north of KAL-TIMUR-ROMAM to a sector boundary point midway between DABOV and MOGLO.

UL618 and UL622 traffic flows were inverted.
Romania used a sectorisation essentially similar to organisation B, with some small boundary changes to accommodate the inversion of flows on UL618/UL622.

11.3 AIRSPACE

The simulated airspace included the entire Sofia and Varna FIRs (Bulgaria), Simferopol FIR (Ukraine), Istanbul FIR (Turkey), Athinai FIR (Greece), Skopje FIR (Former Yugoslav Republic of Macedonia) and Beograd FIR (Yugoslavia). As Romania played was a full participant in the simulation, all Romanian sectors bordering Bulgaria were simulated realistically.

The Sofia and Varna FIRs were simulated as measured sectors with the exception of Sofia Approach and Varna Approach that acted as feed sectors. All adjacent Romanian Sectors were simulated and measured as part of the ROMATSA experiment, however all other airspace was represented by feed sectors.

No Bulgarian military sectors were included in Bulgaria 99, although some Danger and Restricted airspace was included, particularly where Bulgaria-Romania cross border issues were of interest.

11.3.1 Route Structure

The basis for route structure was ARN3 Phase II, however some elements of the proposed changes were incorporated in different configurations to assess their likely impact.

In Organisation A and B, the current orientation of UL618 and UL222 was retained. In organisation C, the orientations of UL618 and UL 622 were inverted, with a reversal of the present flows.

11.3.2 En-route Sectorisation

The en-route sectorisation incorporated results from the EEC Fastime investigations [Reference 8].

In all organisations, Varna sectorisation was assessed in a two-sector configuration, rather than the three-sector arrangement evaluated in Bulgaria 99. In Bulgaria 99, the vertical level split for the Varna sectors was set at FL340. In Bulgaria-Romania 99, Varna East (VE) handled traffic up to FL360 in the eastern region of the Varna FIR, and Varna West (VW) not only handled traffic from ground to unlimited in the western region, but also above FL360 (over VE) in the eastern region.

In Organisations A and B, the Sofia en-route sectors were reduced from five (in Bulgaria 99) to four, amalgamating Upper East (UE) with Sofia East (SE) which now managed traffic from ground to unlimited. Sofia North (SN) and Sofia South (SS) sectors retained the same vertical limits, from ground to FL340, with the superposed sector renamed Sofia Upper (SU) rather than Upper west (UW). The boundary between SN and SS was the same as in Bulgaria 99.

Organisation C, incorporated the same vertical dimensions for the Sofia sectors, however the boundary line between SN and SS was re-drawn from an FIR boundary point north of KAL -TIMUR-ROVAM to a sector boundary point between DABOV and MOGLO. This change in Organisation C coincided with the inversion of traffic flows on UL618/UL622.
Figure 29: BULGARIA-ROMANIA 99 Airspace Organisation C
11.3.3 Danger and Temporary Segregated Areas.

The following Temporary Segregated Areas were simulated:

TSA B FL265 - FL375
TSA D FL265 - FL375

The following Danger Areas were simulated:

LB D6 Surface - FL265
LB D7 Surface - FL265
LB D8 Surface - FL265

11.3.4 Surrounding Airspace

The feed sector configuration remained unchanged throughout the simulation.

Rixen (RI) represented the north-eastern Turkish sectors. Radovets (RA) represented Turkish sectors west of Istanbul. Rodop (RO) represented Greek sectors and Kalotina (KA) represented the Former Yugoslav Republic of Macedonia and Yugoslav sectors.

Full details of the simulated airspace can be found in the Bulgaria-Romania 99 Facility Specification - Part 1 Conduct and Analysis [Reference 2].

11.4 TRAFFIC

Traffic samples were initially based on the same 24-hour period used for Bulgaria 99 and taken from the 1 August 1998. The traffic validation phase for Bulgaria-Romania 99 was complicated by the need to address the requirements of both ATSA Bulgaria and ROMATSA Romania, with changes in one country impacting on sector traffic levels and aircraft flows in the other. Common samples that were generally suitable to both clients were eventually developed.

The initial (100%) samples were then increased to produce additional samples reflecting a 25% increase (125%) and 35% increase (135%). Specific reduced traffic samples suitable for system training were created from the main samples at 66% and 100% levels for use in the training phase of the simulation.

1.4.1 Traffic Sample Analysis

The traffic sample analysis indicates the hourly traffic flow and peak traffic level for each sector in Organisations A, B and C. The results are shown separately for the 125% and 135% traffic levels.
### Bulgaria - Romania 99 Traffic Samples: 1998 + 0%

<table>
<thead>
<tr>
<th>Bulgaria Measured Sector</th>
<th>Organisation A</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>Flow 29</td>
<td>Peak 13</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>Flow 23</td>
<td>Peak 10</td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>Flow 27</td>
<td>Peak 12</td>
<td></td>
</tr>
<tr>
<td>SU</td>
<td>Flow 14</td>
<td>Peak 11</td>
<td></td>
</tr>
<tr>
<td>VE</td>
<td>Flow 20</td>
<td>Peak 15</td>
<td></td>
</tr>
<tr>
<td>VW</td>
<td>Flow 26</td>
<td>Peak 17</td>
<td></td>
</tr>
</tbody>
</table>

### Bulgaria - Romania 99 Traffic Samples: 1998 + 25%

<table>
<thead>
<tr>
<th>Bulgaria Measured Sector</th>
<th>Organisation B</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>Flow 44</td>
<td>Peak 18</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>Flow 32</td>
<td>Peak 12</td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>Flow 30</td>
<td>Peak 15</td>
<td></td>
</tr>
<tr>
<td>SU</td>
<td>Flow 26</td>
<td>Peak 16</td>
<td></td>
</tr>
<tr>
<td>VE</td>
<td>Flow 29</td>
<td>Peak 12</td>
<td></td>
</tr>
<tr>
<td>VW</td>
<td>Flow 36</td>
<td>Peak 15</td>
<td></td>
</tr>
</tbody>
</table>

### Bulgaria - Romania 99 Traffic Samples: 1998 + 35%

<table>
<thead>
<tr>
<th>Bulgaria Measured Sector</th>
<th>Organisation C</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>Flow 76</td>
<td>Peak 26</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>Flow 54</td>
<td>Peak 17</td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>Flow 50</td>
<td>Peak 23</td>
<td></td>
</tr>
<tr>
<td>SU</td>
<td>Flow 42</td>
<td>Peak 20</td>
<td></td>
</tr>
<tr>
<td>VE</td>
<td>Flow 58</td>
<td>Peak 25</td>
<td></td>
</tr>
<tr>
<td>VW</td>
<td>Flow 58</td>
<td>Peak 21</td>
<td></td>
</tr>
</tbody>
</table>
1.5 EXERCISE PROGRAMME

An exercise program was constructed which again allowed for three simulation exercises per day. After allowing for an Introduction Briefing and a Final Presentation, twenty-seven simulation exercise slots were available. Six exercise slots were allocated to familiarisation and system training and one exercise slot was retained as a spare for contingency use. The remaining twenty exercises were allocated to measured exercises.

<table>
<thead>
<tr>
<th>Week</th>
<th>Org.</th>
<th>Number of exercises</th>
<th>Traffic level</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>4</td>
<td>66%</td>
<td>Training (Two AM and Two PM)</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>2</td>
<td>100%</td>
<td>Training (One AM and One PM)</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>3</td>
<td>100%</td>
<td>Evaluation Org. A (Three PM)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5</td>
<td>100%</td>
<td>Evaluation Org. B (Three AM and Two PM)</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>1</td>
<td>100%</td>
<td>Evaluation Org. B (One PM)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>6</td>
<td>125%</td>
<td>Evaluation Org. B (Three AM and Three PM)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>6</td>
<td>135%</td>
<td>Evaluation Org. C (Three AM and Three PM)</td>
</tr>
</tbody>
</table>

Total 27 Representing 36 hours of simulation time.

The staff allocation to each sector was based on two separate controller rotations;

A. Varna Sectors (including Varna Approach feed sector).

B. Sofia En-route Sectors (including RO, KA and SA feed sectors).

11.6 SIMULATED ATC SYSTEM

The simulated ATC system operated as that developed for the Bulgaria 99 simulation, however some small changes were incorporated to take into account interim results from the Bulgaria 99 evaluation. Romanian positions operating with the same underlying functionality but were configured with a completely different controller interface separately designed by ROMATSA. Both the Bulgarian HMI and the Romanian HMI were presented concurrently in the EEC Operations Room, which was divided into Bulgarian and Romanian sections.

The following changes were made to the Bulgarian HMI for the Bulgaria-Romania 99 simulation:

11.6.1 Separation Standard

A separation of 10NM between radar tracks was applied at the Romanian border replacing the current separation standard of 15NM.

11.6.2 Medium Term Conflict Detection

One separation parameter was applied throughout the measured en-route sectors of 10NM. The CRD was provided with an ‘Assumed-Assumed’ display filter.
11.6.3 Co-ordination

For inter-sector co-ordination between vertically split sectors, an additional facility was included allowing co-ordination of the ‘moment of climb/descent’ for which an XFL/EFL was agreed.

Full electronic co-ordination was included between Bulgarian sectors and Romanian sectors, providing a more fully realistic environment for the evaluation of cross border co-ordination issues.

11.7 ATC PROCEDURES AND CONTROLLER TASKS

ATC Procedures applied during the simulation were as far as possible the same as in current operation (at the time of the simulation) at the ATC Centre of origin, either in Bulgaria or in the surrounding airspace. Due to the inversion of traffic flows on UL618/UL622 in Organisation C, the current level procedures involving Romania and Greece were adjusted to accommodate the new traffic flows.

The controller task definition remained the same as specified for Bulgaria 99 with more emphasis being placed on evaluating the particular problems faced by vertically split sectors (all sectors excluding SE) in the simulation.

11.8 OPERATIONS ROOM LAYOUT

The Operations room layout was required to accommodate the Bulgarian and Romanian complement of CWPs. The Bulgarian positions were placed in the right section of the Operations Room with the Romanian positions occupying the left and end sections. As in Bulgaria 99 some adjacent sectors were positioned at some distance to each other, to ensure co-ordination was carried out using electronic or telephone means and therefore measured.

The Operations room was configured with 28 Controller Working Positions as follows:

- Sofia ACC  
  4 Sectors  (8 CWP)
- Varna ACC  
  2 Sectors  (4 CWP)
- Romanian ACC  
  4 Sectors  (8 CWP)
- Romanian Approach and Tower  
  2 Sectors  (3 CWP)
- Romanian Military  
  1 Sector  (1 CWP)
- Feed Sectors  
  10 Sectors  (10 CWP)
Figure 31: BULGARIA-ROMANIA 99 Control Room Layout
12. BULGARIA-ROMANIA 99 RESULTS - OBJECTIVE 1

12.1 CONTROLLER INTERFACE (HMI) EVALUATION

Evaluate use of the detailed HMI with specific focus on the following tools or features changed from the Bulgaria 99 simulation:

A. Change Level Co-ordination.
B. MTCD Filters.

The HMI provided for the Bulgaria-Romania 99 real-time simulation matched that provided for the Bulgaria 99 simulation, however several small changes were incorporated reflecting the results of the earlier evaluation. Additionally as no Bulgarian military sectors were included in Bulgaria - Romania 99 the military aspects of the HMI were not re-assessed.

Although Bulgaria Romania 99 was conducted over a two-week period (compared with Bulgaria 99, which was a three-week simulation) the HMI results have been found to be generally similar, providing validation of the findings from the first controller group.

This report (Section 2 - Bulgaria-Romania 99) therefore concentrates on the new features incorporated or where the results diverged and further clarification is warranted. A full description of the HMI is contained in the Bulgaria-Romania System Handbook - Bulgaria Version [Reference 5] and analysis of the controller questionnaires in Bulgaria - Romania Questionnaire Analysis - Bulgaria [Reference 12].

12.2 CHANGE LEVEL CO-ORDINATION.

Objective 5 from Bulgaria 99 evaluated the impact of electronic co-ordination. It was found that although the functionality was generally suitable for adjacent sectors (in the horizontal plane), for vertically split sectors, issues concerning 'the default XFL' and 'the moment of level change' arose. When one high-level sector was superposed over two low-level sectors the selection of correct co-ordination partner became difficult.

In Bulgaria- Romania 99, for vertically split sectors the default XFL values continued to be set at the first level in the receiving sector. This restrained the transferring controller from issuing a CFL through other levels in the receiving sector (with possibly conflicting aircraft), and was found to be the best solution in the circumstances.

Co-ordination of 'the moment of level change' was important where a climb or descent took an aircraft from one sector to another (as between vertically split sectors). This was because although the XFL/EFL (GOTO level) had been co-ordinated, the conflicting traffic changed depending on the time and point the actual level change took place.

A solution to co-ordination of the 'moment of level change' was proposed in Bulgaria 99, followed by some initial evaluation. In Bulgaria-Romania 99 an effective HMI and co-ordination system was developed and tested.

12.2.1 Change Level Co-ordination Functionality

Selection of this function (for appropriate aircraft) sent a text co-ordination message 'CHG LVL' to the sector identified as the co-ordination partner (SI). The colour of the text was coded to indicate the status of the message and displayed in Label Line 0.
Message Type  | Text     | Displayed to      | Colour                      
---               | ---      | ---                | ---                         
Proposal Message | CHG LVL  | Sender             | Co-ordination OUT Green.   
Proposal Message | CHG LVL  | Receiver           | Co-ordination IN Cyan.     
Accepted Message | CHG LVL  | Sender and Receiver| Warning Yellow.             
Rejected Message | (empty field) | Sender and Receiver | (empty field)              

Initial input was via the Callsign Menu. The additional button 'CHG LVL' was available in the last line of the callsign pop-up, for both PENDING and ASSUMED aircraft, and for both EXC and PLC positions. This allowed the sending of the CHG LVL text as a proposal from either the upstream or downstream sector.

Once selected from the Callsign Menu the 'CHG LVL' text was displayed in co-ordination colour (Green for the proposer and Cyan for the receiver) in Line 0 of the label. A Single Click Action Button could accept the co-ordination, which then changed the text to yellow for both sectors indicating the message had been acknowledged. If the CHG LVL co-ordination was rejected a Single Click Information Button deleted the text from both sectors. Following the execution of the level change, the message was automatically deleted on TRANSFER/ASSUME of the aircraft.

12.3 CHANGE LEVEL CO-ORDINATION RESULT

The controllers operating in those sectors with (vertical) level boundaries (all except SE) reported that the function was both useful and efficient. It enabled the tactical co-ordination of the descent without the excessive need for verbal co-ordination. In some instances where a heading was required a telephone co-ordination was necessary, however the number of instances was significantly reduced.

As advanced stripless systems attempt to accommodate current airspace configurations, the need to better accommodate vertical sector boundaries and develop correct co-ordination mechanisms has become more important. Other issues such as the relevance of Entry Point (EPT), Exit Point (XPT), Entry Flight Level (EFL), Exit Flight Level (XFL) and how they operate with vertical sector boundaries have already been identified.

12.4 MTCD FILTERS

In Bulgaria 99 the Conflict Risk Display (CRD) displaying MTCD information was described as a planning tool. The task definition for Executive (EXC) and Planning (PLC) Controllers emphasised this with the PLC having prime responsibility for planning the transit of flights through the sector, prior to Assume of Control. The inappropriateness of the CRD as a tactical tool was also explained. The MTCD calculations were based on Flight Plan profiles, and although updated by Direct orders and level inputs, the calculations did not take account of aircraft headings. The cyclical update for MTCD (each 5 minutes or at aircraft input order) was also insufficient for tactical purposes.

Figure 32 : Conflict Risk Display (CRD) (II)
The MTCD function however was found to display too many conflicts/risks. The PLC had to check each conflict for validity and either implement a solution or defer action, counting on the Executive controller to provide a tactical solution. The controller group from Bulgaria 99 commented that the display of conflicts between two assumed aircraft, both under tactical control, was not in line with the concept of MTCD as a planning tool and needlessly cluttered the Conflict Risk Display. The example (right) shows a screen capture from Bulgaria 99. Of the fourteen conflicts and risks displayed, only three are relevant for the PLC. In Bulgaria-Romania 99 the display was provided with a button to suppress these conflicts/risks. This filtered the information and provided a relevant presentation that could be quickly and easily interpreted by the PLC.

12.4.1 MTCD Filters - Result

The controllers supported the reduced display with all choosing to suppress Assumed-Assumed conflicts/risks. In Bulgaria-Romania 99 the separation parameter was standardised at 10nm throughout the simulation area (rather than the 8nm separation and 15nm separation parameters used for different volumes in Bulgaria 99). This also simplified the analysis of the MTCD presentation. The controllers still questioned the accuracy of the conflicts displayed, re-iterating the need to improve the quality of the aircraft trajectories; if the conflict information displayed is to correctly reflect the actual traffic scenario. Task division between Executive and Planning Controllers remained blurred. As in the results for Bulgaria 99, a suitable task definition which adequately distributes the controller workload and which correctly supports the planning and tactical roles is required to achieve the most benefit from the MTCD tool.

12.5 HMI RESULTS SUMMARY

The controllers in Bulgaria - Romania 99 were generally very supportive of the HMI investigated, with 83% agreeing that 'the integration of multiple display/input interfaces into a single display and input interface is a very good idea'. Altogether 94% stated that a "windows" style environment is a positive step for future ATC systems. The number stating that the simulated system permitted the removal of paper strips was lower at 72% (Bulgaria 99, 91%) with 28% unsure, however this still represents a sizeable majority and was drawn following one less week of simulation.

"The use of a "windows" style environment is a positive step for future ATC systems."

![Bar chart showing 94% agree and 6% not so sure about the use of a "windows" style environment.](image)
The CRD was better received in this simulation (73% responding that it was ‘Always’ or ‘Regularly’ useful versus 39% in Bulgaria 99) possibly reflecting the changes made since Bulgaria 99. Other requests common with the earlier simulation were to be able to overcome an incorrect next sector by manual intervention, and an ability to input ‘request direct’.
13. BULGARIA-ROMANIA 99 RESULTS - OBJECTIVE 2

Airspace and Route Structure

Evaluate a further version of airspace organisation and a revised route structure derived using possible application of ARN3 Phase II developments. Assess the impact of traffic evolution on the proposed airspace organisations.

13.1 AIRSPACE AND ROUTE STRUCTURE RESULTS

As in Bulgaria 99, the significance of investigating proposed new route structures and associated sectorisations was greatly reduced following the announcement of the political crisis in Kosovo and Yugoslavia. The effect of the crisis was to close all air routes over Yugoslavia and the Former Yugoslav Republic of Macedonia and severely distort the main traffic flows east and south bound through Bulgaria. As in Bulgaria 99, the project team made the decision to continue with the traffic according to the original simulation plan and reduce the importance of this objective. The analysis was therefore again based on subjective comments made by the controllers.

13.1.1 Organisations A and B

Organisations A and B were essentially the same for Bulgaria with the key feature in Organisation B being the re-design of the Bucharest TMA to share a common frontier with the Varna East (VE) sector. Recurring conflicts were a problem between the Varna north-west bound departures and the Otopeni (Bucharest) north-bound arrivals, with the Varna departures able to climb above FL245 at the border with Romania.

Figure 33: SOFIA NORTH and SOFIA SOUTH Sector - Zoom - Organisation B
13.1.2 Organisation C

Organisation C was designed to test the inversion of routes UL618/622 with a proposed re-secto-
risation of Sofia Sectors SS and SS to suit the new route structure. The controllers liked the route
inversion, however found the design did not allocate enough sector time before intersections of
crossing flows at BLO.

For Sofia South (SS) the transfer point for southbound traffic from Sofia North (SN) at ROVAM was
too late to effect changes to resolve conflicts before BLO. It was not possible to co-ordinate early
descent with the Sofia North (SN) controller because of restrictions imposed by the flow north-west
bound GOL- TIMOT. One solution proposed by the controllers involved moving BLO further south
from the SS/SN boundary.

All Varna sectors coped well with the 135% traffic growth with the controllers indicating that the sec-
tors were reasonably balanced for workload. Sofia North indicated that the overall workload remai-
ned the same as in Organisation A & B, with Sofia South indicating the overall workload was redu-
ced in Organisation C.

Figure 34 : SOFIA NORTH and SOFIA SOUTH Sector-Zoom-Organisation C
14. BULGARIA-ROMANIA 99 RESULTS - OBJECTIVE 3

Reduced En-route Separation

Evaluate reduced inter-centre separation (10NM) between Romania and Bulgaria, for the effect on controller procedures and workload.

14.1 REDUCED EN-ROUTE SEPARATION

The current separation standard imposed between aircraft being transferred between Romania and Bulgaria is 15 NM. The simulation assessed the impact of reducing this separation to 10 NM. This change was expected to produce positive results reducing the sector workload.

14.2 REDUCED EN-ROUTE SEPARATION RESULT

The controllers reported no problems with the reduction in separation. No requirement for additional procedures to facilitate the new standard was determined. The Romanian controllers were also supportive of the reduction. Romanian comments were that solid radar cover, reliable equipment and SYSCO co-ordination were required for implementation. All indications are that applying the new standard (10 NM) will produce a significant decrease in cross border workload.
15. BULGARIA-ROMANIA 99 RESULTS - OBJECTIVE 4

Civil Co-ordination

Evaluate the use of OLDI/SYSCO supported co-ordination with adjacent sectors and ATC centres (with particular reference to interaction with Romania).

15.1 CIVIL CO-ORDINATION

As in Bulgaria 99, the provision of electronic messages to replace common telephone co-ordination between civil sectors was a key feature of the simulation. In Bulgaria 99 the electronic co-ordination was extended to the surrounding feed sectors, however as these sectors were not realistically simulated, the effect of replacing the normal telephone communication could only be surmised.

In Bulgaria - Romania 99 as well as continuing the assessment of internal electronic co-ordination, it was possible to fully evaluate a seamless electronic border with the Romanian sectors of the Bucharest FIR.

The provision of OLDI/SYSCO in the Bulgaria-Romania 99 simulation remained unchanged from Bulgaria 99, however as no Bulgarian Military sectors were included, the Civil-Military co-ordination element was not evaluated. Temporary Reserved Airspace was activated and displayed, particularly where this activation had an impact on operations at the common Bulgarian/Romanian border, however no activity was in fact simulated. No military control authority for the TRAs was provided and no 'Crossing Clearance' (XRQ) through restricted airspace was available.

15.2 CIVIL CO-ORDINATION RESULTS

As in Bulgaria 99, the controllers supported the introduction of electronic co-ordination indicating it significantly reduced the controller's workload. Problems with selecting the correct co-ordination partner in a 'vertically-split sector environment' persisted, however the introduction of 'CHG LVL' co-ordination (see Bulgaria- Romania 99, Objective 1 - Controller interface) assisted the Executive Controllers.

The controllers stated that they were in favour of the system as simulated, where all revisions before ACT were 'not referred' and all revisions after ACT 'were referred'. This simplified system was clear to the controllers and reflected in the HMI regarding aircraft states.

Controllers from both states regarded the provision of full external co-ordination between Bulgaria and Romania as very successful. The questionnaire responses showed that 84% of Bulgarian controllers felt that the use of OLDI/SYSCO with the adjacent Bulgarian/Romanian airspace 'always or regularly' simplified the co-ordination task. A revealing comment from the controllers was that the provision of full electronic co-ordination between Bulgaria and Romania rendered the international frontier "just like any other sector boundary".
15.2.1 ACT Times

In the Bulgaria-Romania 99 simulation the Activation Message (ACT) was sent at a pre-defined time parameter before next sector entry. For Bulgarian system this parameter was 8 minutes before next sector entry and for Romanian system this was set at 13 minutes before next sector entry, in order to cope with each country’s particular requirements.

However, as both countries share a common boundary these different parameters had an impact on the provision of ACT messages across the border. For flights from Romania to Bulgaria, the Bulgarian sector received ACT information 13 minutes prior to sector entry rather than the normal 8 minutes. However, for flights from Bulgaria to Romania, the Romanian sectors received ACT information only 8 minutes before sector entry rather than the normal 13 minutes.

Interestingly the controllers reported that this was not considered a problem, with the data provided at a time considered not excessively late by Romania and not excessively early by Bulgaria. As the issue of ACT provision will arise when both centres are suitably equipped, the reduced significance of each country's specific ACT parameter should assist in harmonising the common interface.

15.2.2 Reserved Airspace Maps and Flight Plan Deviation

As described in Section 1 of this report for Bulgaria 99, the imposition of reserved airspace in the region of the Bulgaria/Romania border can severely impact on the flow of air traffic. Sector workload increases, principally because the requirement for additional cross-border co-ordination and the need to apply new tactical routes.

The 'Flexible Use of Airspace' concept evaluated in Bulgaria 99, showed that the sharing of the airspace use between Military and Civil authorities could greatly reduce disruption, however it must be expected that on certain occasions the reserved airspace may be closed.

When this was simulated in Bulgaria-Romania 99, the controllers had no means to tactically modify an aircraft route, except using the DIRECT command, which was not always suitable or did not
avoid the airspace restriction. The controllers requested a facility to edit an aircraft trajectory, avoiding the reserved airspace, and rejoining the flight plan at a later point. This would create a new entry point and entry route for the Romanian sector that would be displayed as a co-ordination for acceptance.

While this facility was not available in the simulations, the concept and requirement was identified. The controllers also requested the provision of Reserved Airspace Video Maps, for the Romanian airspace be displayable on the Bulgarian HMI during the period of Romanian activity, allowing the Bulgarian controllers to provide more suitable deviations for aircraft.

15.2.3 'Request Direct' Functionality

A feature requested in Bulgaria 99 was the ability for a controller to request a 'Direct Route' for a pending aircraft. A co-ordination would be proposed for routing the aircraft from its current position in the preceding sector, 'Direct' to a selected point in the controller's sector. In Bulgaria-Romania 99 the controllers indicated that this 'Request Direct' facility should also be available across the common border to co-ordinate such requests with the Romanian sectors.
16. CONCLUSIONS AND RECOMMENDATIONS

Bulgaria 99 and Bulgaria-Romania 99 were successful simulations that achieved the main objectives set out at the project conception in 1998. Although the airspace evaluation was limited by uncertainty regarding eventual traffic flows in the region, the information gained will remain useful for planning an appropriate configuration when the situation stabilises.

The simulations were notable for the motivation and professionalism of the participating controllers, who have gained valuable experience working in an advanced stripless environment. They will continue to be an asset to ATSA in the coming program. Another important feature was the strong support shown for the project by both ATSA management and the Bulgarian military, which undoubtedly played a key role in the successful outcome.

The two high-level objectives for both simulations were to expose the controllers to a fully automated platform including advanced features and an advanced HMI, both containing proposals from the EATCHIP III programme. This was achieved with thirty-nine civil controllers and four military controllers participating in the two simulations.

A summary of the conclusions in relation to the detailed objectives is provided below:

16.1 BULGARIA 99 - OBJECTIVE 1

Training

Perform Advanced-System training and make an evaluation of the future training requirements for the operational system.

The pre-simulation training provided was well received by the controllers. The controllers considered the Computer Based Training (CBT) course and the handbooks to be useful. They did comment that while the CBT did assist them in preparing for the simulation it lacked a degree of realism only found on the larger screen.

For the controllers the value of system training was clearly established. They stated that for an advanced operational system this should be a comprehensive package. The package should involve a full and in-depth CBT course, clear and detailed documentation and a series of simulation exercises beginning at low traffic levels, each scripted for a particular training objective.

16.2 BULGARIA 99 - OBJECTIVE 2

Controller Procedures

Assess the degree of change in the ATC procedures and task distribution between Planning Controller (PLC) and Executive Controller (EXC) in an automated system.
Regarding the interface provided to the PLC (Planning Controller) and EXC (Executive Controller), the controllers considered that the functionality of each control position should be identical in the operational system to enable the controllers themselves to create an appropriate task division and not have one imposed by the system. The flexibility provided in the simulation allowed the working methods to evolve, but might have contributed to a feeling of unclear role distinction.

The controllers did feel that the two controllers were able to work together as a team and generally agreed that the defined roles permitted this teamwork. Findings show that the two controllers continued to work together closely with 80% stating that they 'sometimes/frequently' discussed matters with the other sector controller.

Although several tasks were explicitly allocated to the Executive Controller, at high traffic levels the responsibility for certain functions was occasionally accepted by the Planning Controller.

However, the controllers were divided on the procedure that should apply for particular actions such as 'Cleared Flight Level' (CFL) input and 'Assume of Control' (AOC) input. Several controllers stated that only the Executive Controller should make these inputs. At issue was the amount each input (CFL or AOC) contributed towards maintaining the 'radar picture' and whether sharing of these tasks meant a degradation of the Executive Controller's control and situational awareness.

Further consideration is recommended before placing any restriction on the system functionality. Any limitation may be implemented using controller procedures thereby allowing flexibility while the implications are fully evaluated.

Finally, the controllers reported that the defined task allocation when applied for a 'vertically split sector' was inappropriate in certain situations. They eventually concluded that the PLC should avoid early co-ordination of level changes with sectors above or below the current sector and that any default exit levels (XFLs) should involve the minimum incursion into the next sector's airspace.

The co-ordination of 'level change' and even more importantly 'time of level change' should be handled by the Executive Controllers concerned. (Special simulator functionality was developed during Bulgaria 99 to allow the co-ordination of these conditions, which was then implemented and evaluated in Bulgaria-Romania 99).

16.3 BULGARIA 99 - OBJECTIVE 3

Controller Interface (HMI) Evaluation

Evaluate the use of the specified HMI, with specific focus on the following tools or features;
A. Label and Track information (including interaction)
B. Dynamic Flight Leg
C. Conflict and Risk Display
D. Vertical Aid Window
E. Sector List
F. Sector Inbound List, Arrival List, Departure List and other list presentations.
The results indicate that the move proposed by ATSA towards an EATCHIP III style interface is sound with the interface being well accepted by the participating controllers, 96% identifying the windows-type display environment as a positive step for future ATC systems. They further agreed that the integration of multiple display and input windows into a single display was a good idea.

Resounding support was noted for the simulated interface with over 90% of the controllers stating that the combination of the different tools and controller aids provided a satisfactory system that permitted the removal of paper strips.

16.3.1 Label and Track Information

The controllers indicated the mouse was acceptable as a means of data input. However, a number of the controllers did indicate that they sometimes experienced confusion over selecting which mouse button to use in certain circumstances. Using the mouse to select the correct label field was not highlighted as a problem, however window management was sometimes difficult. An extended period of use will aid the controllers in becoming proficient, however adherence to consistent mouse button functionality is recommended to assist the controllers in becoming adept more quickly.

The controllers reported that the radar label format was suitable and indicated that only a few minor alterations need be considered. Several requested the sector exit point be removed from the standard label, and only shown in the selected label and others that the FIR exit point be displayed in the Extended Track Label.

The label font used [Adobe 'Helvetica Bold' 14Pt (Proportional)] was not regarded as ideal. Evaluation of different fonts was not an objective of the simulation, however some controllers found the particular font used difficult to read and further study to select the most appropriate font is recommended. Another request by the controllers was to be able to show large or small text at the controller's discretion. The display of next sector frequency in the selected label proved a useful feature and was very well received.

Additionally, the controllers requested some features not provided in the simulation. These included the ability to select label fields on/off, enabling a reduction in label size when busy. A facility to input and display a Mach Number restriction until a specified waypoint was also required. The controllers had a preference for positioning the Exit Point (XPT) below the Exit Flight Level (XFL) to promote easier association of the two items. A larger track symbol was desired, to make cursor selection easier, although any increase in size should be balanced against any track congestion that may result.

The use of the 'Minimum Level Information' rule resulted in the reduction of duplicate level information and a specific label block shape depending on remaining tasks to be performed. This indicated quickly to the controller if interventions were still required. The different shape of the data blocks was found to be effective with 75% of the controllers indicating that it was 'regularly or always' useful.

The use of colour for labels was also successful, with over 90% of the controllers stating that the use of colour in labels and text assisted them in carrying out their ATC tasks. Several controllers commented that the 'Grey' used for unconcerned labels was not sufficiently different from the 'White' used for assumed labels. For vertically split sectors, where traffic above and below the sector was shown, the two shades could be confused when the sectors were busy.
Controllers did state that the need to dialogue with the track label and keep the system updated sometimes affected their execution of their principal controlling tasks. However the vast majority also reported that the workload in updating the system was worthwhile given the resulting information from the system. The controllers indicated that they were happy with pop-up menus as a means of input to the system.

The Extended Track Label (ETL) layout was considered complete for the controllers' operational requirements.

16.3.2 Supplementary Flight Level

The SFL feature, enabling the input and display of conditional climbs and descents was found useful by nearly all the controllers. Of the group 76% preferred the system-supported input of SFL information to a current telephone co-ordination. The same number also felt that the provision the SFL field did not take up too much space in the track label or lists.

16.3.3 Safety Nets

The MSAW function was valued, although warnings were not often generated due to the vigilance of the controllers. MSAW was considered of significant benefit to low-level sectors of the Bulgarian FIR, however had no application in the upper airspace. Nearly all the controllers considered APW a benefit with only 4% indicating the feature was never useful.

STCA while also generated rarely was considered very useful. The controllers indicated high support for the STCA function, with over 90% finding it useful.

All three safety net features took CFL inputs into account, only generating an APW, MSAW or STCA warning if the aircraft failed to level at its assigned level. This significantly reduced the display of false alerts and encouraged more confidence in the system.

16.3.4 Dynamic Flight Leg

The controllers use of the Dynamic Flight Leg (DFL) during the simulation indicated that it was potentially one of the most powerful elements of the HMI package. When the controllers were handling high traffic levels, the Dynamic Flight Leg continued to be a primary tool for providing route, sector sequence and conflict information when reference to other tools and lists became difficult.

The Dynamic Flight Leg received strong support from the controllers, with nearly all indicating that it was regularly useful and most indicating that the display of conflict information assisted them in performing their tasks. Discussion indicated that although potentially an important tool, further development was needed to improve the benefit for the controller. Most controllers obtained route information from both the DFL and list data, however a considerable portion used the DFL only.

One suggested improvement was that only the 'subject aircraft' DFL with conflict segments be initially displayed. The display of other legs for conflicting aircraft could be displayed on controller request. The conflict search was set at 30 minutes ahead of the aircraft position, however the DFL was displayed for all the remaining flight. This meant that a portion of the DFL could be displayed as 'conflict free' when conflicts may in fact exist. The section of the displayed DFL, where conflict search has not been made, should be indicated.
16.3.5 Conflict and Risk Display

Overall the controllers supported the use of the CRD, although with reservations. The results found that 70% of the controllers found the CRD at times useful. An important requirement for the tool is that controllers have confidence in the conflict predictions made. Comments indicated that controllers felt that the information presented, needed to be checked, supporting the view that improvements in the accuracy of data is still required.

Regarding the display, a large number still found the information confusing. Specific comments indicated that too many conflicts were presented (although this was improved in the Bulgaria-Romania 99 simulation by filtering Assumed-Assumed conflict pairs) and that occasionally false or double-conflicts were shown. It is expected that some false conflicts will be detected to allow for prediction error however it is important that the rate is low to promote trust in the tool.

On the positive side, the controllers indicated that the CRD did reduce their workload and assisted them in better prioritising their tasks. With improvements in the accuracy of the detection, task allocation and information display the tool should achieve better acceptance and may prove a feature able to assist controllers handle increasing traffic volumes.

16.3.6 Vertical Aid Window

The controllers stated that they rarely found the VAW too useful. At the end of the simulation period few of the controllers indicated regular use. Discussion did not indicate a single clear reason for the rejection of this tool, however it may be related to the display of flights by vertical profile rather than the more familiar plan view. Other possible factors include the VAW focus on a single trajectory rather than group of concerned aircraft and the fact that the majority of traffic flows in Bulgarian airspace are at cruise levels rather than in climbing or descending phases of flight.

16.3.7 Sector List and Sector Inbound Lists (Enroute Only)

In comparing the SEL and SILs, a clear choice was not identified. At the end of the simulation an equal number of the controllers indicated a preference for the Sector List or for the Sector Inbound Lists. Several controllers also stated that they had enough information in the Track Label and Extended Track Label, without requiring information in advance of the aircraft radar display. The desire to have the SEL sorting on exit conditions was also noted, however a more configurable sorting method allowing the controller to configure the sorting on demand was requested.

The main problem associated with the SEL (as simulated) was the size of the window when the sector was busy. The main problem with SILs was the number displayed per sector.

The result of the simulation indicates that the individual controllers consider their requirements to be different. The choice of either a SEL or SILs that can be displayed following controller selection may accommodate all requirements and allow each controller to some preference in their chosen working method.
16.3.8 **Arrival List and Departure List (Approach Only)**

The Approach controllers had different views on the usefulness of the Arrival List, with one person indicating that the list was 'never' useful, three others indicating that it was 'regularly' useful and one person 'always' useful. The weight of argument supports the view that some benefit was gained from the information provided. Sorting of the flights in the Arrival List was found suitable.

The Departure List was found more acceptable with all approach controllers indicating it was useful and sorted correctly.

16.3.9 **Hold List (Approach Only)**

Most controllers stated the Hold List was regularly useful, however the tool was not fully evaluated in a very busy traffic environment, as runway capacity was not often exceeded during the simulation.

The Approach controller group did however support the specification as defined.

16.3.10 **Specific Military Data Display (Military only)**

In all cases the functionality and data display provided for the Bulgarian Military was found suitable including the Military Flight List (MFL). For further specific information see Bulgaria 99 Objective 6 (Civil-Military Co-ordination).

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### 16.4 BULGARIA 99 - OBJECTIVE 4

**Airspace and Route Structure**

Evaluate two airspace organisations and two route structures incorporating route modifications proposed for ARN 3 Phase II. Assess the impact of traffic evolution on the proposed airspace organisations.

#### 16.4.1 Airspace and Route Structure Results

**Sofia FIR**

The Sofia controllers reported a preference for Organisation A, as this route structure produced less conflicts for Sofia North (SN) sector compared with Organisation B, which included route (UN687) VELBA-BLO-DWN-MATEL-INKOM, which crossed all main traffic flows in the Bulgarian FIR.

Sofia South (SS) sector was identified as the most heavily loaded sector in the simulation, mainly due to the number of crossing traffic flows and the interference of vertically evolving aircraft. The sector was considered busy even at 125% traffic levels.

Upper West (UW) was also considered busy with a suggestion to move the altitude restriction (FL290/FL250) placed on the southbound flow through CCO, back to the Romanian boundary at LOMOS, facilitating the descent of these aircraft. This would enable Upper West to handle only in-cruise traffic potentially reducing workload considerably.

Sofia North was considered the third most difficult sector with workload in both eastern sectors, Sofia East (SE) and Upper East (UE) high but manageable.
Sofia North (SN) was considered the third most difficult sector with workload in the eastern sectors Spfia Est (SE) and Upper East (UE) considered high but manageable, without excessive conflicts.

16.4.2 Varna FIR

The Varna East (VE) controllers reported a preference for Organisation B, as the sector configuration was more suitable. In organisation A, traffic on the MATEL-RIXEN route landing Istanbul required descent to FL250 at RIXEN. However, traffic on the MAKOL-EMONA route often restricted these descents with insufficient room available for radar vectoring.

Problems were identified in Organisation A for Varna West (VW) with the convergence of flows MATEL-DWN and MAKOL-DWN with insufficient time after the Varna East (VE) sector boundary to effect separation.

Varna East (VE) and Varna West (VW) were considered equally busy with Varna Upper less loaded, however all were considered manageable even at 145% traffic levels.

16.5 BULGARIA 99 - OBJECTIVE 5

Civil Co-ordination

Evaluate the use of OLDI/SYSCO supported co-ordination with adjacent sectors and ATC centres.

Electronic co-ordination with adjacent sectors was found to be very effective with few problems encountered. However, co-ordination between vertically split sectors underlined several technical and operational shortcomings.

Vertically split sectors offer many challenges to electronic co-ordination and the problems normally associated with co-ordination involving vertically split sectors were increased in Bulgaria 99 with the superposing of a large single sector, Upper West (UW) over both Sofia North (SN) and Sofia South (SS).

Default XFLs for vertically split sectors were regarded as unsuitable by the controllers. It was finally decided that the default XFL value should be set at the first available level in the next sector airspace. The aircraft was given climb/descent to this level and then transferred to the next sector, which then continued the aircraft’s climb/descent clear of other traffic.

Difficulties posed by having a large upper sector over several lower sectors also featured in the exercise debriefings. The problem existed of how to select the correct co-ordination partner for each descent (e.g. UW choosing either SN or SS), depending on the desired descent point. This problem was not resolved and will continue to exist while a generic rule regarding climb and descent must be applied to aircraft profiles.

Following agreement on an appropriate transfer level, another requirement for the controllers was to be able to co-ordinate the actual ‘instant’ of descent, sometimes through heavy flows of traffic. The controllers requested a co-ordination message such as ‘Change Level Now’, which could be used by the two Executive Controllers to indicate to each other when descent was suitable (This functionality was later developed and evaluated in Bulgaria-Romania 99).
Additionally, sector design was found to be important when applying the DIRECT functionality as occasionally when a standard DIRECT was input, the sector boundary of an adjacent sector was inadvertently cut bringing that sector into the new sector sequence.

Careful sector design is required to avoid flights clipping small segments of adjacent airspace and to allow standard DIRECT routes to be applied without generating sector sequence anomalies.

The controllers found the co-ordination windows suitable, although commented that the black text used to indicate sector identification and nature of the proposal was difficult to see on the dark background of the window. The different colour of incoming and outgoing co-ordination values (blue/green) was stated to be particularly useful.

Finally, although the provision of complex vertically split sectors in the Bulgaria 99 simulation raised several pertinent co-ordination issues; the controllers strongly supported the use of system-assisted electronic co-ordination. Compared with the current Bulgarian system, 23% stated that it 'always', 65% 'regularly' and 12% 'sometimes' assisted with their ATC tasks. Controllers identified benefits such as reduced telephone communication, faster, more silent co-ordination and a reduction in ATC task. The provision of electronic co-ordination in an automated system should reduce the controllers' peripheral workload and allow them more time to deal with the actual traffic problems.

16.6 BULGARIA 99 - OBJECTIVE 6

Civil-Military Co-ordination

Evaluate OLDI/SYSCO supported Civil-Military co-ordination between Civil and Military Controllers and the use of the EATCHIP 'Flexible Use of Airspace' concept, for possible application within Bulgarian airspace.

The provision of electronic co-ordination between the Military and Civil controllers in Bulgaria 99 was regarded as extremely successful by both the civil and military controllers. This was the first evaluation of the HMI and system functionality, and several design points were noted.

Controllers identified a method to reduce from 6 to 5 the input steps required for an airspace crossing request. The possibility to input multiple point crossings was requested by the controllers along with the ability to counter-propose a received crossing request.

In Bulgaria 99 the crossing request was initially enabled for 'Assumed' aircraft only. During the simulation it became apparent that functionality should also be extended to 'Pending' aircraft to allow the pre-planning of airspace crossings for aircraft not yet under control and where the reserved airspace was close to the sector boundary.

The ability to cancel display of the track label data separately from the graphical radar screen display was appreciated by the controllers. As a stream of civil aircraft approached an active TSA, multiple crossing approvals were sought and the display of these produced unwanted screen clutter.

During the final week of the Bulgaria 99 Real-time simulation over 300 crossing requests were passed between Civil and Military controllers. The controllers indicated that the 'Flexible Use of Airspace' environment simulated was successful in promoting improved co-operation between civil
and military sectors, a better level of service for civil aircraft, and enhanced traffic information for the military controllers. The efficiency of seamless, silent, co-ordination between civil and military systems showed that significant benefits could be gained from exploiting a closer liaison between the civil and military units.

**16.7 BULGARIA 99 - OBJECTIVE 7**

**RNAV**

To evaluate the use of RNAV arrival and departure routes for Sofia and associated ATC and air crew procedures.

Bulgaria 99 as the first of the ROMBULPO series of simulations evaluated the effect on air traffic control operations of aircraft self-navigating on pre-defined routes within the Sofia TMA. This navigation option is known as 2-D (Lateral Navigation [LNAV]). PANS-Ops expertise was used to construct (for simulation purposes only) arrival and departure RNAV procedures for both runways at Sofia airport.

The results of the simulation indicated that the controllers and pilots alike had a good understanding of the RNAV procedures. However, there was early confusion over the meaning of some of the defined phraseology. 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 radar 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.

The Balkan line 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. In fact, they were so confident about the compatibility of aircraft systems with these procedures, that they had time to reflect on what they thought were the difficulties liable to be faced by controllers, such as the lack of computer-aided sequencing tools.

In summary, it was very encouraging to note the willingness of the Bulgarian controllers, the Balkan pilots and the EEC pseudo-pilots to participate wholeheartedly in these evaluations. In particular, their input during debriefing sessions was invaluable. 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 (Poland 99, Bulrom 99 and Romania 99), 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.
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.

### 16.8 BULGARIA - ROMANIA 99 - OBJECTIVE 1

**Controller Interface (HMI)**

Evaluate use of the HMI with specific focus on the following tools or features changed from the Bulgaria 99 simulation:

(a) Change Level Co-ordination and Default XFL values.
(b) MTCD Parameters and Filters

Although Bulgaria - Romania 99 was conducted over a two-week period (compared with Bulgaria 99, which was a three-week simulation) the HMI results were found to be generally similar, providing validation of the findings from the first controller group.

These conclusions concentrate on the new features incorporated or where the results diverged and further clarification is required.

#### 16.8.1 Change Level Co-ordination

Bulgaria 99 evaluated the impact of electronic co-ordination. It was found that although the standard functionality was suitable for adjacent sectors (in the horizontal plane), for vertically split sectors, issues concerning 'the default XFL' and 'the moment of level change' arose.

Co-ordination of 'the moment of level change' was important where a climb or descent took an aircraft from one sector to another (as between vertically split sectors). This was because although the XFL/EFL (GOTO level) had been co-ordinated, the conflicting traffic changed depending on the time and point the actual level change took place.

A solution to co-ordination of the 'moment of level change' was proposed in Bulgaria 99, followed by some initial evaluation. In Bulgaria-Romania 99 an effective HMI and co-ordination system was developed and tested.

The controllers operating in sectors with (vertical) level boundaries (all except SE) reported that the function was both useful and efficient. It enabled the tactical co-ordination of the climb/descent without the excessive need for telephone co-ordination. In some instances where a heading was required a telephone co-ordination was still necessary, however the number of instances was significantly reduced.

As advanced stripless systems attempt to accommodate current airspace configurations, the need to better accommodate vertical sector boundaries and develop correct co-ordination mechanisms has become more important.

#### 16.8.2 Medium Term Conflict Detection

In Bulgaria-Romania 99 it was decided to provide a filter which allowed the controllers to deselect the display of Assumed-Assumed conflicts in the CRD. The controllers supported the reduced display with all choosing to suppress Assumed-Assumed conflicts.

Additionally, the separation parameter was standardised at 10nm throughout the simulation area.
(rather than the 8nm separation and 15nm separation parameters used for different volumes in Bulgaria 99). This also simplified the controller understanding of the MTCD presentation.

The controllers still questioned the accuracy of the conflicts displayed, re-iterating the need to improve the quality of the aircraft trajectories. The conflict information displayed should correctly reflect the real traffic situation. Task division between the Executive and the Planning Controller for handling of conflicts remained blurred. As in the results for Bulgaria 99, a suitable task definition which adequately distributes the controller workload and which correctly supports the planning and tactical roles is required to achieve the most benefit from the MTCD tool.

16.8.3 HMI General Summary

The controllers in Bulgaria - Romania 99 were generally very supportive of the controller interface, with 83% agreeing that 'the integration of multiple display/input interfaces into a single display and input interface is a very good idea'. Again nearly all stated that a "windows" style environment is a positive step for future ATC systems. The number stating that the simulated system permitted the removal of paper strips was slightly lower than for the earlier Bulgaria 99 simulation with 28% remaining unsure, however a sizeable majority supported the future direction proposed.

The CRD was better received in this simulation (73% responding that it was 'Always' or 'Regularly' useful versus 39% in Bulgaria 99) possibly reflecting the changes made since Bulgaria 99. Other requests common with the earlier simulation were to be able to overcome an incorrect next sector by manual intervention, and an ability to input 'request direct'.

16.9 BULGARIA - ROMANIA 99 - OBJECTIVE 2

Airspace and Route Structure

Evaluate a further version of airspace organisation (En-route sectorisation derived from Model of Bulgarian Airspace - EEC Note No 4/99) and a revised route structure derived using possible application of ARN3 Phase II developments. Assess the impact of traffic evolution on the proposed airspace organisations.

16.9.1 Organisations A and B

Organisations A and B were essentially the same for Bulgaria with the key feature in Organisation B being the re-design of the Bucharest TMA to share a common frontier with the Varna East (VE) sector. Recurring conflicts were a problem between the Varna north-west bound departures and the Otopeni (Bucharest) north-bound arrivals, with the Varna departures able to climb above FL245 at the border with Romania.

16.9.2 Organisation C

Organisation C was designed to test the inversion of routes UL618/622 with a proposed re-sectorisation of Sofia Sectors SS and SS to suit the new route structure. The controllers liked the route inversion, however found the design did not allocate enough sector time before intersection of crossing flows at BLO.
For Sofia South (SS) the transfer point for southbound traffic from Sofia North (SN) at ROVAM was too late to effect changes to resolve conflicts before BLO. It was not possible to co-ordinate early descent with the Sofia North (SN) controller because of restrictions imposed by the flow north-west bound GOL- TIMOT. One solution proposed by the controllers involved moving BLO further south from the SS/SN boundary.

All Varna sectors coped well with the 135% traffic growth with the controllers indicating that the sectors were reasonably balanced for workload. Sofia North indicated that the overall workload remained the same as in Organisation A & B, with Sofia South indicating the overall workload was reduced in Organisation C.

16.10 BULGARIA - ROMANIA 99 - OBJECTIVE 3

Reduced En-route Separation

Evaluate reduced inter-centre enroute separation (10NM) between Romania and Bulgaria, for the effect on controller procedures and workload.

The controllers reported no problems with the reduction in separation. No requirement for additional procedures to facilitate the new standard was determined. The Romanian controllers were also supportive of the reduction. Romanian comments were that solid radar cover, reliable equipment and SYSCO co-ordination were required for implementation. All indications are that applying the new standard (10 NM) will produce a significant decrease in cross border workload.

16.11 BULGARIA - ROMANIA 99 - OBJECTIVE 4

Civil Co-ordination

Evaluate the use of OLDI/SYSCO supported co-ordination with adjacent sectors and ATC centres (with particular reference to interaction with Romania).

As in Bulgaria 99, the controllers supported the introduction of electronic co-ordination indicating it significantly reduced the controller's workload. Problems with selecting the correct co-ordination partner in a 'vertically-split' sector environment persisted, however the introduction of 'CHG LVL' co-ordination (see Bulgaria-Romania 99, Objective 1 - Controller Interface) assisted the Executive Controllers.

The controllers stated that they were in favour of the system as simulated, where all revisions before ACT were 'not referred' (without co-ordination) and all revisions after ACT transmission were 'referred' (with co-ordination). This simplified system was clear to the controllers and reflected in the HMI regarding aircraft states.

Controllers from both states regarded the provision of full external co-ordination between Bulgaria and Romania as very successful. The questionnaire responses showed that 84% of Bulgarian controllers felt that the use of OLDI/SYSCO with the adjacent Bulgarian/Romanian airspace 'always or regularly' simplified the co-ordination task. A revealing comment from the controllers was that the provision of full electronic co-ordination between Bulgaria and Romania rendered the international frontier "just like any other sector boundary".
16.11.1 ACT Times

The controllers reported that the use of different ACT times across the common border was not considered a problem, with the data provided at a time considered not excessively late by Romania and not excessively early by Bulgaria. As the issue of ACT provision will arise when both centres are suitably equipped, the reduced significance of each country's specific ACT parameter should assist in harmonising the common interface.

16.11.2 Aircraft Deviation around Reserved Airspace

When reserved airspace was active, the controllers reported they had no means to tactically modify an aircraft route, except using the DIRECT command, which was not always suitable or did not avoid the airspace restriction.

The controllers requested a facility to edit an aircraft trajectory, avoiding the reserved airspace, and rejoining the flight plan at a later point. This would create a new entry route for the Romanian sector that could be displayed as a co-ordination for acceptance.

The controllers also requested that Reserved Airspace Video Maps for Romanian airspace be displayable on the Bulgarian HMI during the period of Romanian activity, allowing the Bulgarian controllers to provide more suitable aircraft deviations taking into account the Romanian restrictions.

16.11.3 'Request Direct' Functionality

A feature requested in Bulgaria 99 was the ability for a controller to request a 'Direct Route' for a pending aircraft. A co-ordination would be proposed for routing the aircraft from its current position in the preceding sector, 'Direct' to a selected point in the controller's sector. In Bulgaria-Romania 99 the controllers indicated that this 'Request Direct' facility should also be available across the common border to co-ordinate such requests with the Romanian sectors.

Au total, 2 membres du personnel de gestion de l'ATSA, 27 contrôleurs civils et 4 contrôleurs militaires ont participé à la simulation Bulgarie 99. L'exercice Bulgarie-Roumanie 99 s’est, quant à lui, déroulé avec la participation de 22 contrôleurs civils bulgares (dont 12 nouveaux) et de 23 contrôleurs roumains. Ces contrôleurs ont acquis une expérience sur le tas pendant un total de 92 heures de temps de simulateur programmées pour les phases de réception, de formation et d'évaluation des deux simulations.

La simulation Bulgarie 99 a permis d'évaluer l'intégralité du système ATC civil en route bulgare ainsi que la TMA et le contrôle d'approche de Sofia. Deux secteurs militaires ont fourni un service de contrôle au trafic militaire et assuré la coordination avec les contrôleurs civils pour ce qui est du partage de l'espace aérien bulgare, en application du concept EUROCONTROL d'utilisation flexible de l'espace aérien. Deux organisations de l'espace aérien ont été testées, avec huit secteurs en route et un secteur d'approche. Deux pilotes de la compagnie Balkan Airlines ont également participé à l'évaluation des procédures d'approche de Sofia au moyen du simulateur multihabitacle d'EUROCONTROL.

Dans le cadre de la simulation Bulgarie-Roumanie 99, deux organisations supplémentaires ont été évaluées pour l'espace aérien civil en route bulgare. La ROMATSA (Roumanie) a participé activement à cet exercice conjoint en simulant quatre secteurs en route ainsi que la TMA et le contrôle d'approche de Bucarest, l'accent étant mis sur la frontière entre la Roumanie et la Bulgarie.

Dans les deux cas, un environnement ATC de pointe a été évalué. Le nouveau système bulgare proposé intégrera bon nombre de propositions du programme EATCHIP dans la mesure où il sera entièrement électronique et n'utilisera plus les bandes de progression de vol sur papier.

Les deux simulations ont été conçues pour compléter la simulation en temps accéléré précédemment réalisée pour le compte de l'ATSA bulgare (Modèle de l'espace aérien bulgare, Note CEE n° 4/99), qui avait permis de tester de nouvelles configurations d'espace aérien. Les principaux apports effectués au niveau de l'interface contrôleur ont été l'inclusion de la coordination électronique OLID/SYSCO dans un environnement composé de secteurs scindés dans le plan vertical, de la détection des conflits à moyen terme et d'une série de filets de sauvegarde tels que le système d'alerte aux conflits à court terme, le dispositif d'avertissement de proximité de zone et l'avertisseur d'altitude minimale de sécurité.

Une procédure électronique de franchissement de zones a été mise en œuvre à l'appui de la coordination entre civils et militaires ; elle s'est révélée particulièrement efficace pour la prise en compte des besoins des deux catégories d'usagers. D'autres éléments d'information, relatifs à l'utilisation efficace des données de listage, à l'interaction étiquettes-pistes et à l'utilisation de la couleur dans le cadre d'un système automatisé ont été obtenus, qui permettront à l'ATSA de définir plus précisément les caractéristiques du nouveau système ATM bulgare.

Bien qu'initiallement considérés comme prioritaires, les objectifs en matière d'organisation de l'espace aérien et d'évaluation des routes se sont vu attribuer une importance moindre suite aux perturbations des courants de trafic engendrées par la crise du Kosovo, qui a éclaté peu avant le début de la simulation Bulgarie 99. De fait, la fermeture des routes au-dessus de la Yougoslavie et
le réacheminement corollaire des vols ont eu pour effet de rendre particulièrement aléatoires les projections quant à la situation d'après-crise. En accord avec l'ATSA, les responsables de la simulation s'en sont donc tenus au plan d'analyse initial, dans l'espoir que les résultats obtenus permettront aux autorités bulgares d'instaurer une sectorisation et une structure de routes adéquates dès le retour à la normale du trafic dans la région.

Le projet préparatoire commun du CEE élaboré aux fins de répondre aux besoins en matière de simulation de la ROMATSA (Roumanie), de l'ATSA (Bulgarie) et de la PATA (Pologne) a été baptisé Projet ROMBULPO.

Très vite, il est apparu que les trois Etats clients partageaient les mêmes besoins fondamentaux. La Bulgarie, la Roumanie et la Pologne souhaitaient, toutes trois, simuler des systèmes ATM évo- lués, mais avec des interfaces contrôleur spécifiques à chaque pays. Il a été décidé de tirer parti du développement conjoint de ces simulations en proposant une simulation commune qui ferait intervenir, dans les trois cas, une interface contrôleur spécifique conçue par le client pour chaque exercice.

L'installation ROMBULPO devant servir à l'ensemble des simulations a été développée à partir de celle d'une récente simulation du CEE et était donc déjà bien au point. Le fait de recourir à une installation existante a permis de minimiser les risques pour les clients et de s'épargner une partie des travaux de programmation qu'aurait nécessité la mise au point de trois simulations entièrement nouvelles. L'adoption d'un simulateur commun a également permis de disposer de davantage de temps pour procéder aux essais de réception et au débogage avant la première simulation de la série, à savoir la simulation Bulgarie 99.

Chacune des interfaces contrôleur (HMI) a été développée en tenant compte des objectifs particuliers de chaque Etat et des spécifications détaillées dont on disposait déjà. Dans les trois cas, on s'est servi des spécifications de base issues du projet HMI DSI, les différentes particularités des HMIs étant ensuite consignées dans le détail dans des documents distincts.

Un projet ROMBULPO parallèle a été mené dans le cadre de l'assistance fournie par l'Unité "Appui aux Etats" (SIS) d'EUROCONTROL. Une équipe d'experts de la SIS a conseillé chacun des trois Etats intéressés sur la manière de tirer le meilleur parti de chaque simulation en temps réel pour améliorer la planification de son futur système ATC.

Le projet ROMBULPO a permis en outre une étude préliminaire de l'application de SID et de STAR RNAV dans chaque Etat. Ces travaux ont été menés avec le concours d'experts-conseils de l'Unité "Gestion de l'espace aérien et navigation" (AMN) d'EUROCONTROL. L'évaluation a notamment porté sur les procédures de contrôle et l'interface homme-machine ; elle a également fait intervenir des pilotes de ligne de la TAROM et de Balkan Airlines aux commandes du simulateur multihabitacle du CEE de manière à obtenir leur avis sur les procédures utilisées. Les résultats définitifs de ces investigations n'ont pas encore été publiés, mais on trouvera une synthèse des conclusions d'étude dans le présent rapport.

La simulation en temps réel Bulgarie 99, réalisée pour le seul compte de l'ATSA bulgare, et la simulation en temps réel Bulgarie-Roumanie 99, effectuée conjointement pour l'ATSA et la ROMATSA (Roumanie), font, chacune, l'objet d'un chapitre distinct du présent rapport. La Section 1 décrit la simulation en temps réel Bulgarie 99, la Section 2 passe en revue les objectifs supplémentaires ainsi que les résultats de la simulation conjointe qui présentent un intérêt particulier pour l'ATSA.
1. BULGARIE 99 – OBJECTIFS DE LA SIMULATION

1.1 OBJECTIFS GENERAUX

A. Familiariser les contrôleurs avec le fonctionnement d'une plateforme entièrement automatisée, intégrant les fonctions évoluées proposées pour le programme EATCHIP III et répondant dans toute la mesure possible aux spécifications techniques du nouvel ATCC national.

B. Familiariser les contrôleurs avec le fonctionnement d'une HMI de conception avancée, intégrant les fonctions évoluées proposées pour le programme EATCHIP III, dans l'optique de faciliter la spécification de l'interface homme-machine du nouvel ATCC national.

1.2 OBJECTIFS SPECIFIQUES

1) Formation

Dispenser une formation à l'utilisation de systèmes de pointe et évaluer les besoins futurs en formation pour le système opérationnel.

2) Procédures de contrôle

Evaluer l'ampleur des changements au niveau des procédures ATC et de la répartition des tâches entre le contrôleur de planification (PLC) et le contrôleur exécutif (EXC) dans un environnement automatisé.

3) Evaluation de l'interface contrôleur (HMI)

Evaluer l'utilisation de l'interface spécifiée en accordant une attention particulière aux outils et fonctions ci-après :

A. Données d'étiquettes et de pistes (y compris leur interaction)
B. Tronçon de vol dynamique (DFL)
C. Affichage des conflits et des risques
D. Fenêtre d'assistance verticale
E. Liste des secteurs
F. Liste des entrées dans les secteurs, listes des arrivées et des départs et autres types de liste.

4) Organisation de l'espace aérien et structure de routes

Evaluer deux organisations de l'espace aérien et deux structures de routes intégrant les modifications proposées pour la phase II de l'ARN 3. Evaluer l'incidence de l'évolution du trafic sur les organisations de l'espace aérien proposées.

5) Coordination civile

Evaluer le recours à la coordination automatisée (OLDI/SYSCO) avec les secteurs et les centres ATC adjacents.

6) Coordination civile-militaire

Evaluer la coordination automatisée (OLDI/SYSCO) entre contrôleurs civils et militaires ainsi que l'utilisation du concept EATCHIP d"utilisation flexible de l'espace aérien", en vue de son application éventuelle dans l'espace aérien bulgare.

7) RNAV

Evaluer l'utilisation de routes RNAV d'arrivée et de départ vers et depuis Sofia, ainsi que les procédures connexes pour l'ATC et les équipages de conduite.
2. BULGARIE-ROUMANIE 99 – OBJECTIFS DE LA BULGARIE

2.1 OBJECTIFS GENERAUX

A. Familiariser les contrôleurs avec le fonctionnement d'une plateforme entièrement automatisée, intégrant les fonctions évolutées proposées pour le programme EATCHIP III et répondant dans toute la mesure possible aux spécifications techniques du nouvel ATCC national.

B. Familiariser les contrôleurs avec le fonctionnement d'une HMI de conception avancée, intégrant les fonctions évolutées proposées pour le programme EATCHIP III, dans l'optique de faciliter la spécification de l'interface homme-machine du nouvel ATCC national.

2.2 OBJECTIFS SPECIFIQUES

2.2.1 Interface contrôleur (HMI)

Evaluer l'utilisation de la HMI en accordant une attention particulière aux outils ou caractéristiques modifiés par rapport à la simulation Bulgarie 99 :

A. coordination du changement de niveau et valeurs XFL par défaut ;

B. paramètres et filtres MTCD.

2.2.2 Organisation de l'espace aérien et structure de routes


2.2.3 Séparation réduite dans l'espace en route

Evaluer les incidences, sur les procédures ATC et la charge de travail des contrôleurs, d'une réduction des normes de séparation (10NM) dans l'espace en route entre centres, entre la Roumaine et la Bulgarie.

2.2.4 Coordination civile

Evaluer le recours à la coordination automatisée (OLDI/SYSCO) avec les secteurs et les centres ATC adjacents (sous l'angle plus particulier des interactions avec la Roumanie).
3. CONCLUSIONS ET RECOMMANDATIONS


On retiendra en particulier la motivation et le professionnalisme des contrôleurs participants, qui ont acquis une expérience précieuse du travail dans un environnement de conception avancée, caractérisé par l'absence de bandes de progression de vol. Ces contrôleurs seront pour l'ATSA un atout de poids dans la suite du déroulement du programme. Toute aussi notable a été l'ampleur de l'appui fourni au projet par la direction de l'ATSA et les autorités militaires bulgares, ce qui a indubitablement joué un rôle déterminant dans la réussite de l'entreprise.

Les deux simulations avaient pour objectifs majeurs de familiariser les contrôleurs au fonctionnement d'une plateforme de pointe entièrement automatisée et d'une HMI de conception avancée, intégrant, chacune, des propositions du programme EATCHIP III. Pour ce faire, trente-neuf contrôleurs civils et quatre contrôleurs militaires ont été associés aux deux simulations.

On trouvera ci-après une synthèse des conclusions pour chacun des objectifs spécifiques :

3.1 BULGARIE 99 – OBJECTIF 1

Formation

Dispenser une formation à l'utilisation des systèmes de pointe et évaluer les besoins futurs en formation pour le système opérationnel.

La formation dispensée préalablement à la simulation a été favorablement accueillie par les contrôleurs. Ces derniers ont qualifié d'utiles les cours ainsi que les manuels de formation assistée par ordinateur (CBT). Ils ont toutefois fait observer que si la CBT les avait effectivement aidés au niveau de la préparation à la simulation, celle-ci n'offrait pas tout le réalisme voulu en raison de l'absence d'écrans de grandes dimensions.

Pour les contrôleurs, la pertinence de la formation à l'utilisation des systèmes est clairement établie. Cette formation devrait même faire l'objet d'un module pédagogique complet pour tout système opérationnel de conception avancée. Un tel module comprendrait un cours CBT complet et approfondi, une documentation claire et détaillée et une série d'exercices de simulation avec des charges de trafic croissantes, chacun de ces exercices correspondant à un objectif spécifique de la formation.

3.2 BULGARIE 99 - OBJECTIF 2

Procédures de contrôle

Evaluer l'ampleur des changements au niveau des procédures ATC et de la répartition des tâches entre le contrôleur de planification (PLC) et le contrôleur exécutif (EXC) dans un environnement automatisé.

En ce qui concerne l'interface mise à leur disposition, les contrôleurs de planification (PLC) et les contrôleurs exécutifs (EXC) ont estimé que les fonctions de chaque poste de travail devraient être identiques au niveau du système opérationnel, de telle sorte que les contrôleurs puissent organiser eux-mêmes la répartition des tâches au lieu de devoir se conformer à un modèle imposé par le système.

Si la souplesse accordée dans le cadre de la simulation a permis de faire évoluer la méthode de travail, il est possible qu'elle ait engendré une impression de flou quant à la distinction des rôles.
Les participants ont estimé que les deux contrôleurs étaient en mesure de fonctionner en tandem et que les rôles, tels que définis, permettaient un tel travail d'équipe. Les résultats montrent que les deux contrôleurs ont continué à travailler en étroite collaboration, 80 % des participants indiquant avoir eu des contacts occasionnels à fréquents avec l'autre contrôleur du secteur pour régler certaines questions.

Nonobstant le fait qu'une série de tâches aient été explicitement dévolues au contrôleur exécutif, il est arrivé, lorsque le niveau de trafic atteignait des pointes, que le contrôleur de planification prenne en charge certaines fonctions.

On relève toutefois des divergences de vues quant à la procédure à appliquer pour certaines actions spécifiques telles que la saisie du niveau de vol autorisé (CFL) ou du message de prise en charge du contrôle (AOC). Une partie des contrôleurs a estimé que seul le contrôleur exécutif devrait être habilité à opérer ces saisies. La question en l'espèce était de savoir dans quelle mesure chaque nouvelle saisie (CFL ou AOC) contribuait au maintien de l'image radar et si le partage de ces tâches n'était pas de nature à nuire à la façon dont le contrôleur exécutif assure le contrôle et perçoit la situation générale.

Un examen plus approfondi de la question s'impose avant d'envisager la moindre restriction au niveau des fonctionnalités du système. Des limitations peuvent être instaurées par la voie de procédures de contrôle de façon à ménager une certaine souplesse dans l'attente d'une évaluation complète des incidences.

Enfin, les contrôleurs ont signalé que le mode d'attribution des tâches pouvait, lorsqu'il était appliqué à un secteur scindé dans le plan vertical, se révéler inadéquat en certaines circonstances. Ils ont conclu que le PLC devrait s'abstenir de coordonner trop tôt les changements de niveau de vol avec les secteurs supérieurs ou inférieurs et que tous les niveaux de sortie (XFL) par défaut devraient limiter au minimum l'incursion dans l'espace aérien du secteur suivant.

La coordination du changement de niveau et, plus important encore, de l'heure du changement de niveau devrait être du ressort du contrôleur exécutif compétent. (Une fonction spéciale a été mise au point sur le simulateur pendant l'exercice Bulgarie 99 à l'effet de permettre la coordination de ces paramètres ; cette fonction a ensuite été mise en œuvre et évaluée dans le cadre de la simulation Bulgarie-Roumanie 99.)

3.3 BULGARIE 99 - OBJECTIF 3

Evaluation de l'interface contrôleur (HMI)
Evaluer l'utilisation de l'interface spécifiée en accordant une attention particulière aux outils et fonctions ci-après :
A. Données d'étiquettes et de pistes (y compris leur interaction)
B. Tronçon de vol dynamique (DFL)
C. Affichage des conflits et des risques
D. Fenêtre d'assistance verticale
E. Liste des secteurs
F. Liste des entrées dans les secteurs, listes des arrivées et des départs et autres types de liste.

Les résultats démontrent la pertinence du choix opéré par l'ATSA en faveur d'une interface du type EATCHIP III. Cette dernière a été bien acceptée par les contrôleurs participants, 96 % d'entre eux considérant le fenêtrage d'écran comme une évolution positive pour les futurs systèmes ATC. Ces mêmes contrôleurs ont par ailleurs estimé que l'intégration des multiples fenêtres d'affichage et de saisie sous la forme d'un affichage unique était une bonne idée.

L'interface simulée a reçu un appui massif de la part des contrôleurs : 90 % d'entre eux ont indi-
qué que la combinaison des différents outils et aides au contrôleur donnait pleinement satisfaction et permettait d’envisager la suppression des bandes de progression de vol.

3.3.1 Données d’étiquettes et de pistes

La souris a été jugée acceptable en tant qu’instrument de saisie de données. Un certain nombre de contrôleurs ont toutefois indiqué avoir parfois hésité quant au choix du bouton à utiliser dans certaines circonstances. Le fait d’employer la souris pour sélectionner le champ d’étiquette n’a pas été perçu comme un problème ; en revanche, la gestion des fenêtres s’est révélée ardue par moments. Une période d’utilisation prolongée aidera les contrôleurs à se “faire” au système, mais il est recommandé que les contrôleurs s’astreignent à utiliser systématiquement les fonctions associées aux boutons de la souris de manière à se familiariser plus rapidement.

Les contrôleurs ont jugé adéquat le format de l’étiquette radar, seules quelques modifications mineures devant être envisagées. Certains ont demandé que le point de sortie de secteur soit retiré de l’étiquette standard pour n’apparaître que dans l’étiquette sélectionnée, d’autres ont souhaité que le point de sortie de FIR soit affiché dans l’étiquette de piste étendue.

La police de caractères de l’étiquette [Adobe ‘Helvetica Bold’ 14 Pt (Proportional)] a fait l’objet de critiques. L’évaluation de différentes polices de caractères ne constituait pas un des objectifs de la simulation, mais certains contrôleurs ayant fait état de difficultés à déchiffrer la police choisie, des travaux complémentaires sont recommandés à l’effet de sélectionner le caractère le plus adéquat. Un autre souhait exprimé par les contrôleurs était de pouvoir modifier à volonté la taille des caractères d’écran. L’affichage de la fréquence du secteur suivant dans l’étiquette sélectionnée s’est avéré une fonction utile et particulièrement appréciée.

Par ailleurs, les contrôleurs ont demandé l’inclusion d’une série de fonctions non prévues dans la simulation. On citera notamment la possibilité de sélectionner des champs d’étiquettes par simple activation/désactivation ("on/off"), de manière à pouvoir réduire la taille des étiquettes en période de pointe, ou bien encore la faculté d’encoder et d’afficher une restriction du nombre de mach applicable jusqu’à un point de cheminement donné. Les contrôleurs ont indiqué qu’ils préféreraient voir apparaître le point de sortie (XPT) sous le niveau de vol de sortie (XFL), ce qui facilite l’association de ces deux paramètres. Ils se sont également prononcés en faveur d’un symbole de piste plus grand afin de faciliter la sélection au moyen du curseur. Il convient cependant de faire en sorte que l’adoption d’un symbole plus grand ne brouille pas l’affichage des pistes.

L’adoption de la règle de l’information minimale concernant les niveaux de vol s’est traduite par une diminution des données redondantes et l’affichage de blocs de données d’étiquettes aux contours variables en fonction du nombre de tâches restant à exécuter. Le contrôleur pouvait ainsi savoir en un clin d’œil s’il devait encore intervenir. Ces blocs de données à géométrie variable ont fait la preuve de leur efficacité, 75 % des contrôleurs considérant qu’ils étaient “régulièrement, voire toujours” utiles.

Le recours à la couleur dans les étiquettes et les zones de texte a également été bien accueilli, plus de 90 % des contrôleurs estimant que cela facilitait l’exécution de leurs tâches. Plusieurs contrôleurs ont fait observer que le gris des étiquettes qui ne les concernait pas ne se distinguait pas suffisamment du blanc utilisé pour les étiquettes des vols pris en charge. Dans le cas de secteurs scindés dans le plan vertical, avec affichage du trafic évoluant au-dessus et en-dessous du secteur considéré, les deux teintes risquaient d’être confondues en période de forte activité des secteurs.

Les contrôleurs ont fait observer que le fait de devoir dialoguer avec l’étiquette de piste et actualiser le système nuisait parfois à l’exécution de leurs tâches de contrôle principales. La vaste majorité d’entre eux a cependant estimé que la charge de travail qu’impliquait la mise à jour du système se justifiait au vu des informations obtenues en retour du système. Les participants se sont déclarés satisfaits des menus instantanés utilisés pour saisir les données dans le système.
Le format de présentation de l'étiquette de piste étendue (ETL) a été jugé conforme aux besoins opérationnels des contrôleurs.

3.3.2 Niveau de vol supplémentaire (SFL)

La fonction SFL, qui permet d'encoder et d'afficher des montées et des descentes conditionnelles, a été qualifiée d'utile par la presque totalité des contrôleurs. Soixante-six pour cent d'entre eux ont préféré recourir à la saisie système des données SFL plutôt qu'à la coordination courante par voie téléphonique. Le même pourcentage a également estimé que l'affichage du champ SFL ne prenait pas trop de place sur l'étiquette de piste, ni sur les listes.

3.3.3 Filets de sauvegarde

La fonction MSAW a été appréciée bien que peu d'avertissements aient été générés en raison de la vigilance des contrôleurs. Il a été établi que le MSAW était porteur d'avantages considérables dans les secteurs inférieurs de la FIR bulgare, mais qu'il ne trouvait en revanche aucune application dans l'espace aérien supérieur. La quasi totalité des contrôleurs a considéré que l'APW présentait des avantages, seuls 4 % d'entre eux jugeant ce dispositif inutile.

La STCA a été qualifiée de très commode bien qu'elle ait été très peu sollicitée. Cette fonction a recueilli le soutien de plus de 90 % des contrôleurs.

Les trois fonctions de filet de sauvegarde ont tenu compte des données CFL saisies pour ne générer des avertissements APW, MSAW ou STCA que lorsque l'aéronef ne respectait pas le niveau de croisière qui lui avait été assigné. Il en est résulté une diminution sensible du nombre de fausses alertes et, partant, une confiance accrue dans le système.

3.3.4 Tronçon de vol dynamique (DFL)

Il ressort de l'utilisation faite, par les contrôleurs, de la fonction DFL que cette dernière constitue potentiellement l'un des outils les plus puissants du progiciel HMI. Confrontés à des niveaux de trafic élevés, les contrôleurs ont continué à se servir de la fonction DFL en tant qu'outil de base pour obtenir des données sur les routes, la séquence des secteurs et les conflits, le recours aux autres outils et listes devenant plus problématique.

La fonction DFL a reçu le soutien marqué des contrôleurs, la presque totalité d'entre eux indiquant y avoir eu recours régulièrement et la grande majorité affirmant que l'affichage des données de conflit les avait aidés dans l'exécution de leurs tâches. Il est ressorti des discussions que l'outil, nonobstant son importance potentielle, nécessitait certains affinements pour mieux servir encore le contrôleur. Si la plupart des contrôleurs ont eu recours à la fois au DFL et aux données de listes pour obtenir des informations de route, une proportion considérable d'entre eux s'est limitée au DFL.

Il a été suggéré, entre autres, que seul le DFL de l'aéronef cible, avec les segments conflictuels, soit initialement affiché, l'affichage d'autres tronçons aux fins de localisation des aéronefs en conflit pouvant se faire à la demande du contrôleur. Bien que la fonction de recherche de conflits ait été programmée sur 30 minutes avant l'arrivée sur la position, le système affichait le DFL pour toute la suite du vol. Cela signifie donc qu'une portion du DFL pouvait apparaître comme étant exempte de conflits alors qu'en fait des conflits étaient susceptibles de survenir. Il conviendrait que soit indiquée la partie du DFL affiché pour laquelle aucune recherche de conflit n'a été effectuée.
3.3.5 Affichage des conflits et des risques (CRD)

Globalement favorables au CRD, les contrôleurs ont toutefois émis certaines réserves à son égard. Soixante-dix pour cent d’entre eux l’ont qualifié de ponctuellement utile. Il importe, pour la crédibilité de l’outil, que les contrôleurs aient confiance dans les prévisions de conflits. Or il ressort de leurs commentaires que les contrôleurs jugent nécessaire de vérifier l’information présentée, ce qui tend à confirmer que des améliorations sont encore requises au niveau de la précision des données.

Sur le plan de l’affichage, nombre de participants ont estimé que les informations prêtaient encore à confusion. Il a notamment été reproché au système d’afficher un trop grand nombre de conflits (problème partiellement résolu dans le cadre de la simulation Bulgarie-Roumanie 99 grâce au filtrage des paires de conflits du type "Assumed-Assumed") et de signaler sporadiquement de faux conflits ou des conflits doubles. On prévoit que certains faux conflits seront détectés de façon à déduire l’erreur de prévision ; il importe cependant que ce taux d’erreur soit faible pour favoriser la confiance dans l’outil.

En revanche, les contrôleurs ont concédé que le CRD avait effectivement réduit leur charge de travail et leur avait permis de mieux situer les priorités. Moyennant une série d’améliorations au niveau de la précision de détection, de l’attribution des tâches et de l’affichage des données, l’outil devrait être mieux accepté et s’avérer susceptible d’aider les contrôleurs à prendre en charge de volumes de trafic croissants.

3.3.6 Fenêtre d’assistance verticale (VAW)

La VAW a été qualifiée de rarement utile. À l’issue de la simulation, peu de contrôleurs ont déclaré y avoir eu recours de manière régulière. Les discussions n’ont pas permis de mettre en évidence un motif particulier pour expliquer ce rejet ; celui-ci pourrait être lié au fait que la fonction utilise un mode d’affichage des vols par profil vertical au lieu de l’affichage panoramique, plus traditionnel. Parmi les autres motifs possibles, on peut avancer le fait que la VAW se focalise sur une trajectoire unique plutôt que sur un groupe d’aéronefs spécifiques et que les courants de trafic dans l’espace aérien bulgare sont essentiellement constitués de vols en croisière plutôt que de vols en montée ou en descente.

3.3.7 Liste des secteurs (SEL) et listes des entrées dans les secteurs [de route uniquement] (SIL)

L’utilisation comparée de la SEL et des SIL n’a débouché sur aucun choix clair, les deux types de listes ayant recueilli un nombre égal de suffrages à l’issue de la simulation. Par ailleurs, plusieurs contrôleurs ont indiqué que l’étiquette de piste et l’étiquette de piste étendue leur donnaient suffisamment d’informations sans qu’ils doivent chercher à en obtenir d’autres préalablement à l’affichage des aéronefs sur l’écran radar. Si d’aucuns ont émis le souhait de pouvoir opérer, dans la SEL, un tri sur la base des conditions de sortie, c’est finalement vers une méthode permettant au contrôleur de configurer davantage le tri en fonction des besoins que s’est orientée la demande.

Le principal problème rencontré avec la SEL (telle que simulée) a été la taille de la fenêtre lorsque le secteur était chargé. Pour les SIL, il s’est agi du nombre d’entrées affichées par secteur.

Les résultats de la simulation montrent que chaque contrôleur considère avoir des besoins différents de ceux des autres. La possibilité d’afficher, sur simple sélection, la SEL ou les SIL serait de nature à couvrir tous les besoins et laisserait au contrôleur une certaine latitude dans le choix de sa méthode de travail.
3.3.8 Listes des arrivées et des départs (approche uniquement)

Les contrôleurs ont des avis divergents quant à l'utilité de la liste des arrivées, un contrôleur déclarant que cette dernière ne lui avait jamais servi, trois autres la qualifiant de régulièrement utile et le dernier la jugeant utile en toutes circonstances. Le poids des arguments avancés tend à démontrer qu'un certain profit a pu être tiré des informations fournies.

Le tri des vols sur la liste des arrivées a été jugé adéquat.

La liste des départs a davantage fait l'unanimité, tous les contrôleurs d'approche l'ayant jugée utile et correctement ordonnancée.

3.3.9 Liste des attentes (approche uniquement)

La plupart des contrôleurs ont estimé que la liste des attentes était régulièrement utile, encore que cet outil n'ait pu faire l'objet d'une évaluation complète dans un environnement de trafic très chargé, la capacité des pistes n'ayant pas été souvent dépassée au cours de la simulation.

Le groupe des contrôleurs d'approche a néanmoins approuvé la spécification définie.

3.3.10 Affichage spécifique des données militaires (militaires uniquement)

Dans tous les cas, l'affichage des fonctions et des informations réservées aux militaires bulgares a été jugé adéquat, y compris pour ce qui est de la liste des vols militaires (MFL). On se reportera, pour plus d'informations sur la question, à l'Objectif 6 (Coordination civile-militaire) de la simulation Bulgarie 99.

3.4 BULGARIE 99 - OBJECTIF 4

Organisation de l'espace aérien et structure de routes
Évaluer deux organisations de l'espace aérien et deux structures de routes incorporant les modifications proposées pour la phase II de l'ARN 3. Évaluer l'incidence de l'évolution du trafic sur les organisations de l'espace aérien proposées.

3.4.1 Résultats FIR de Sofia

Les contrôleurs de Sofia préfèrent l'Organisation A, qui génère moins de conflits dans le secteur Sofia North (SN) que l'Organisation B ; en effet, cette dernière inclut la route (UN687) VELBA – BLO – DWN – MATEL – INKOM, qui coupe tous les grands courants de trafic dans la FIR bulgare.

Le secteur Sofia South (SS) s'est révélé le secteur le plus chargé, principalement en raison de la multiplicité des courants de trafic sécants et de l'interférence des aéronefs en montée ou en descente. Il s'agit d'un secteur très chargé (niveaux de trafic de l'ordre de 125 %).

Le secteur Upper West (UW) est également considéré comme chargé ; il est proposé de replacer sur la frontière romaine, à LOMOS, la restriction d'altitude (FL 290/FL250) imposée aux courants qui traversent le CCO en direction du sud ; une telle modification faciliterait la descente de ces aéronefs et permettrait au secteur Upper West de ne prendre en charge que le trafic de croisière, ce qui pourrait entraîner une réduction considérable de la charge de travail.

Le secteur Sofia North apparaît comme le troisième secteur le plus difficile ; dans les deux secteurs orientaux, Sofia Est (SE) et Upper East (UE), la charge de travail, élevée, est jugée raisonnable et ne présente pas un nombre excessif de conflits.
3.4.2 FIR de Varna

Les contrôleurs de Varna East (VE) préfèrent l'Organisation B, dans laquelle la configuration de secteurs leur semble plus appropriée. Dans l'Organisation A, le trafic à destination d'Istanbul évoluant sur la route MATEL – RIXEN doit descendre au FL250 à RIXEN, mais le trafic évoluant sur la route MAKOL-EMONA impose souvent des restrictions à ces descents et l'espace nécessaire au guidage radar est insuffisant.

L'Organisation A engendre des problèmes dans le secteur Varna West (VW) en raison de la convergence des courants en descente MATEL-DWN et MAKOL-DWN, le temps disponible après le franchissement de la limite du secteur Varna East (VE) étant trop bref pour mettre en œuvre la séparation.

La charge des secteurs Varna East (VE) et Varna West (VW) est du même niveau et celle de Varna Upper est plus faible, mais ces trois secteurs demeurent gérables, même avec des niveaux de trafic de l'ordre de 145 %.

3.5 BULGARIE 99 - OBJECTIF 5

Évaluation de la coordination automatisée (OLDI/SYSCO) avec les centres ATC et les secteurs adjacents

La coordination électronique avec les secteurs adjacents s'est révélée très efficace et n'a engendré que peu de problèmes. Dans le cas de secteurs scindés dans le plan vertical, elle présente toutefois plusieurs carences d'ordre technique et opérationnel.

Les difficultés importantes que présente la coordination électronique dans les secteurs scindés dans le plan vertical ont été encore accrues dans la simulation Bulgarie 99 du fait de la superposition d'un grand secteur unique (Upper West) au-dessus de deux secteurs (Sofia North (SN) et Sofia South (SS)).

Les contrôleurs ont estimé que les valeurs XFL par défaut ne convenaient pas dans le cas de secteurs superposés. Il a finalement été décidé que la valeur XFL par défaut devrait être fixée au premier niveau disponible dans l'espace aérien du secteur suivant. Les aéronefs ont reçu l'instruction de monter/descendre à ce niveau, puis ont été transférés au secteur suivant, dans lequel ils ont poursuivi leur montée/descente à l'écart des autres vols.

Les difficultés liées aux superpositions d'un grand secteur supérieur au-dessus de plusieurs secteurs inférieurs ont également été mentionnées dans les briefings. Le problème réside dans le choix, pour chaque descente, du partenaire de coordination approprié (UW doit choisir SN ou SS, par exemple), selon le point de descente souhaité. Ce problème, non résolu, subsistera, alors qu'une règle générique de montée et de descente doit être appliquée aux profils d'aéronefs.

Une fois arrêté le niveau de transfert approprié, les contrôleurs se sont heurtés à une autre difficulté, celle de coordonner le "moment" de la descente, parfois à travers d'importants courants de trafic. Les contrôleurs ont demandé un message de coordination de type "Change Level Now", qui pourrait être utilisé par deux contrôleurs exécutifs pour se confirmer mutuellement le moment auquel il convient de faire descendre l'aéronef (cette fonctionnalité a été développée et évaluée dans le cadre de la simulation Bulgarie-Roumanie 99).

La configuration des secteurs est également importante en cas d'utilisation de la fonction "DIRECT" ; en effet, il arrive parfois qu'un aéronef mis sur une route directe standard franchisse par inadvertance la limite d'un secteur adjacent, laquelle se trouve ainsi intégrée dans la nouvelle séquence de secteurs.

Il importe donc de concevoir avec soin la configuration des secteurs, pour éviter que les vols sur routes directes n'empruntent de petits segments de l'espace aérien adjacent et ne génèrent ainsi
des anomalies dans la séquence de secteurs. Les contrôleurs ont estimé que les fenêtres de coordination étaient adéquates, mais qu'il n'était pas facile de déchiffrer, sur le fond sombre de la fenêtre, le texte en noir utilisé pour désigner le secteur et la nature de la proposition. Ils ont particulièrement apprécié l'emploi de couleurs différentes (bleu et vert) pour distinguer les valeurs de coordination des vols entrants et sortants. Enfin, malgré les nombreux problèmes liés à la superposition de secteurs complexes, les contrôleurs participant à la simulation Bulgarie 99 se sont dits très favorables à l'utilisation de la coordination électronique. 23 % d'entre eux ont jugé que, par rapport au système actuel, ce type de coordination les aidait "toujours" dans leur travail, 65 % "régulièrement" et 12 % "occasionnellement". Selon eux, il en résultera une diminution des communications téléphoniques, une coordination plus rapide et plus silencieuse et une réduction des tâches ATC ; dans un système automatisé, la charge de travail périphérique devrait s'en trouver réduite, les contrôleurs pouvant alors se concentrer davantage sur les problèmes de trafic.

3.6 BULGARIE 99 – OBJECTIF 6

Coordination civile-militaire
Évaluer la coordination électronique (OLDI/SYSCO) entre contrôleurs civils et militaires et l'exploitation du concept EATCHIP d’"utilisation flexible de l'espace aérien" en vue de son application éventuelle dans l'espace aérien bulgare. La coordination électronique entre contrôleurs civils et militaires a été jugée extrêmement satisfaisante par les contrôleurs tant civils que militaires. La simulation Bulgarie 99 constituant la première évaluation de la HMI et des fonctionnalités du système, plusieurs observations quant à la conception de ce dernier ont été émises. Les contrôleurs ont mis en évidence une méthode permettant de ramener de 6 à 5 le nombre d'entrées requises pour une demande de franchissement d'espace aérien. Ils souhaiteraient pouvoir introduire plusieurs points de franchissement et envoyer une contre-proposition après accusé de réception d'une demande de franchissement. Au départ, seuls les aéronef déjà pris en charge ("Assumed") pouvaient faire l'objet d'une demande de franchissement. Pendant la simulation, il est apparu que cette fonction devrait être étendue aux aéronefs "attendus" ("Pending"), afin de permettre la préplanification des franchissements d'espace aérien, notamment lorsque l'espace aérien réservé est proche de la limite de secteur. Les contrôleurs ont apprécié le fait de pouvoir supprimer l'affichage des données de piste séparément des autres données affichées sur l'écran radar graphique. Cette fonction est particulièrement utile lorsqu'un courant d'aéronefs civils approchent d'une TSA active et que de nombreuses demandes de franchissement sont introduites, encombrant l'écran de manière indésirable.

Pendant la dernière semaine de la simulation en temps réel Bulgarie 99, les contrôleurs civils et militaires ont traité plus de 300 demandes de franchissement. Ils ont indiqué que l'environnement FUA simulé permettait d'améliorer la coopération entre secteurs civils et militaires, le niveau des services fournis aux aéronefs civils et la qualité des informations de trafic pour les contrôleurs militaires. L'efficacité de cette coordination souple et silencieuse entre civils et militaires prouve qu'il y a beaucoup à gagner de l'instauration d'une liaison plus étroite entre centres civils et militaires.

3.7 BULGARIE 99 - OBJECTIF 7

RNAV
Évaluer l'utilisation de routes RNAV de départ et d'arrivée à Sofia, ainsi que les procédures connexes pour l'ATC et les équipages de conduite
La simulation Bulgarie 99, première dans la série ROMBULPO, a permis d'évaluer l'incidence, sur
les opérations ATC, de la navigation d'aéronefs évoluant en mode autonome sur des routes prédéfinies au sein de la TMA de Sofia. Ce mode de navigation est appelé 2-D (Navigation latérale [LNAV]). La mise au point (à des fins de simulation uniquement) de procédures RNAV de départ et d'arrivée pour les deux pistes de l'aéroport de Sofia s'est faite sur la base des connaissances spécialisées des PANS-Ops.

Il ressort de la simulation que contrôleurs et pilotes ont bien compris les procédures RNAV, malgré quelques confusions initiales au sujet de la signification de certaines expressions prédéfinies. L'utilisation de points de cheminement RNAV au lieu de vecteurs radar a été rapidement maîtrisée, mais les contrôleurs ne sont pas convaincus que cette technique soit plus efficace.

La prise en charge du trafic RNAV sans intervention active de la part des contrôleurs s'est traduite par une réduction de la charge de travail en général, et des communications RTF en particulier. Toutefois, lorsqu'une intervention s'est révélée nécessaire, la charge de travail était légèrement plus élevée qu'avec les procédures habituelles.

Les pilotes de la Balkan Airlines se sont montrés très enthousiastes au sujet des possibilités qu'offre l'utilisation de la RNAV dans leur espace aérien ; ils ont notamment estimé que les profils de vol pourraient être mieux gérés si les trajectoires étaient prévisibles. En fait, ils étaient si confiants dans la compatibilité des systèmes embarqués avec ces procédures qu'ils ont même pris le temps de réfléchir aux difficultés susceptibles, selon eux, d'être rencontrées par les contrôleurs (manque d'outils informatisés de mise en séquence, par exemple).

En synthèse, il est très encourageant de noter la motivation qu'ont manifesté les contrôleurs bulgares, les pilotes de la Balkan Airlines et les pilotes de simulation du CEE pendant ces évaluations. Les commentaires qu'ils ont émis lors des séances de debriefing sont particulièrement précieux.

Ces conclusions seront complétées par un volume important de données que collationne le CEE, mais il ressort des résultats obtenus jusqu'ici que la simulation a été très utile en ce qu'elle a permis aux services ATS d'augmenter leurs connaissances et leur expérience en matière d'opérations RNAV.

On escompte que ces résultats, combinés à ceux des autres simulations (Pologne 99, Bulrom 99 et Roumanie 99), constitueront une source précieuse d'informations sur laquelle l'Équipe de travail TARA pourra se fonder pour formuler ses recommandations à l'ANT quant à l'utilisation future de la RNAV dans l'espace aérien terminal.

Globalement, les contrôleurs ont estimé que l'instauration de la RNAV dans l'espace aérien terminal pouvait être utile à certains égards pour les opérations ATS, mais qu'il faudrait encore de nombreux travaux d'étude avant de pouvoir la mettre en œuvre.

3.8 BULGARIE- ROUMANIE 99 - OBJECTIF 1

Interface contrôleur (HMI)

Évaluer l'utilisation de la HMI en accordant une attention particulière aux outils ou caractéristiques modifiés par rapport à la simulation Bulgarie 99 :

(a) coordination du changement de niveau et valeurs XFL par défaut ;
(b) paramètres et filtres MTCD.

Bien que la simulation Bulgarie-Roumanie 99 ait été réalisée sur 2 semaines (et non sur trois comme la simulation Bulgarie 99), les résultats HMI se sont révélés globalement similaires, vali- dant ainsi les conclusions du premier groupe de contrôleurs.

Les présentes conclusions portent essentiellement sur les fonctionnalités nouvelles et sur les points de divergence des résultats, qui nécessitent un complément de précisions.
3.8.1 Coordination du changement de niveau

La simulation Bulgarie 99 a permis d'évaluer l'incidence de la coordination électronique. Il est apparu que si la fonctionnalité convenait bien pour les secteurs adjacents (dans le plan horizontal), des problèmes liés aux valeurs "XFL par défaut" et au "moment du changement de niveau" se posaient dans le cas de secteurs scindés dans le plan vertical. La coordination du moment du changement de niveau est importante lorsqu'un aéronef en montée ou descente passe d'un secteur à un autre (dans le cas de secteurs superposés, par exemple), car, malgré la coordination des niveaux XFL/EFL (niveau GO TO), les vols en conflit ne sont pas les mêmes selon le moment et le lieu où le changement se produit effectivement.

Une solution à ces problèmes de coordination du "moment du changement de niveau" a été proposée et a fait l'objet d'une première évaluation pendant la simulation Bulgarie 99. Une HMI et un système de coordination ont été développés et testés pendant la simulation Bulgarie-Roumanie 99. Les contrôleurs travaillant dans des secteurs superposés (c'est-à-dire tous les secteurs sauf SE) ont indiqué que la fonction était à la fois utile et efficace. Elle a permis la coordination tactique de la montée/descente sans usage excessif du téléphone. Dans les cas où il fallait indiquer un cap, la coordination a encore dû se faire par téléphone, mais le nombre de ces cas a sensiblement diminué.

Les systèmes évolués, sans bande de progression de vol, étant conçus pour maîtriser les configurations actuelles de l'espace aérien, la nécessité de mieux gérer les limites des secteurs dans le plan vertical et de développer des mécanismes de coordination adéquats s'impose sans cesse davantage.

3.8.2 Détection des conflits à moyen terme

Dans la simulation Bulgarie-Roumanie 99, il a été décidé d'installer un filtre permettant aux contrôleurs de désélectionner l'affichage des conflits de type Assumed-Assumed dans le CRD. Les contrôleurs se sont dits favorables à la réduction des données affichées et ont tous choisi de supprimer l'affichage desdits conflits.

De plus, la séparation a été fixée à 10 NM dans l'ensemble de la zone de simulation (au lieu des valeurs de 8 NM et 15 NM utilisées pour différents volumes dans la simulation Bulgarie 99). Cette simplification a également permis aux contrôleurs de mieux comprendre la présentation MTCD.

Les contrôleurs ont encore mis en cause la précision des conflits affichés, soulignant une nouvelle fois la nécessité d'améliorer la qualité des trajectoires des aéronefs. Les informations de conflit affichées devraient refléter fidèlement la situation de trafic réelle. La répartition des tâches entre contrôleur exécutif et contrôleur planification en matière de traitement des conflits reste floue. Comme les résultats de la simulation Bulgarie 99 l'indiquaient déjà, une définition correcte des tâches, garantissant une juste répartition de la charge de travail entre contrôleurs et un appui adéquat aux tâches de planification et de contrôle tactique, est indispensable à une exploitation optimale de l'outil MTCD.

3.8.3 HMI - Synthèse générale

D'une manière générale, les contrôleurs de la simulation Bulgarie - Roumanie 99 se sont dits très favorables à l'interface contrôleur, 83 % d'entre eux convenant que l'"intégration des diverses interfaces d'affichage et d'entrée en une interface unique était une excellente idée". Comme dans la simulation précédente, presque tous les contrôleurs ont affirmé qu'un environnement de style "fenêtres" était un progrès pour les systèmes ATC futurs. Le nombre de contrôleurs affirmant que le système simulé permettait l'abandon des bandes de progression de vol sur papier est légèrement inférieur à ce qu'il était dans la simulation Bulgarie 99, 28 % d'entre eux demeurant incertains ; une
majorité confortable se dit néanmoins favorable aux orientations proposées pour l'avenir.
La CRD a été mieux reçue pendant cette simulation (73 % ont répondu qu'elle était "toujours" ou "régulièrement" utile, contre 39 % dans la simulation Bulgarie 99), peut être en raison des modifications apportées dans l'intervalle. Comme dans la simulation précédente, les contrôleurs souhaiteraient pouvoir corriger à la main les erreurs d'indication du secteur suivant et introduire des demandes de route directe.

3.9 BULGARIE - ROUMANIE 99 - OBJECTIF 2

Organisation de l'espace aérien et structure de routes
Évaluer une autre organisation de l'espace aérien (sectorisation de l'espace en route dérivée du modèle de l'espace aérien bulgare – Note CEE n° 4/99) et une structure de routes révisée établie à partir des applications possibles des développements de la Phase II de l'ARN3. Évaluer l'incidence de l'évolution du trafic sur les organisations proposées de l'espace aérien.

3.9.1 Organisations A et B

Les Organisations A et B étaient essentiellement les mêmes pour la Bulgarie, la caractéristique principale de l'Organisation B étant la nouvelle conception de la TMA de Bucarest en vue de la doter d'une frontière commune avec le secteur Varna East (VE). Des conflits se sont produits de manière récurrente entre les vols en direction du nord arrivant à Otopeni (Bucarest) et les aéronefs décollant de Varna en direction du nord-ouest, ces derniers pouvant monter au-dessus du FL 245 à la frontière roumaine.

3.9.2 Organisation C

L'Organisation C visait à tester l'inversion des routes UL618/622 et la resectorisation proposée des secteurs SS et SN de Sofia comme suite à la nouvelle structure de routes. Les contrôleurs ont apprécié l'inversion des routes, mais ont jugé que le temps prévu dans le secteur avant l'intersection de BLO n'était pas suffisant.

Pour Sofia South (SS), le transfert du trafic en provenance de Sofia North (SN) et se dirigeant vers le sud (ROVAM) se produit trop tardivement pour que des mesures de résolution des conflits puissent être mises en œuvre avant BLO. En outre, il n'est pas possible de coordonner une descente précoce avec les contrôleurs de Sofia North (SN) en raison des restrictions qu'imposent les courants nord-ouest à destination de GOL-TIMOT. Les contrôleurs ont donc proposé de déplacer BLO plus au sud de la limite SS/SN.

Tous les secteurs de Varna ont pu absorber dans de bonnes conditions l'augmentation de 135 % du trafic et les contrôleurs ont indiqué que la charge de travail des secteurs était raisonnablement équilibrée. Pour Sofia North, la charge de travail globale demeure la même que dans les Organisations A et B ; pour Sofia South, elle diminue dans l'Organisation C.

3.10 BULGARIE - ROUMANIE 99 - OBJECTIF 3

Réduction de la séparation en route
Évaluer les incidences d'une réduction de la séparation en route (10 NM) lors des transferts entre centres, entre la Roumanie et la Bulgarie, sur les procédures et la charge de travail des contrôleurs.
Les contrôleurs n'ont signalé aucun problème lié à la réduction de la séparation. Aucune demande
de procédures supplémentaires n’a été formulée. Les contrôleurs roumains, également favorables à la réduction, ont déclaré que sa mise en œuvre nécessitait une solide couverture radar, des équipements fiables et une coordination automatique (SYSCO). Tout semble indiquer que l’application de la nouvelle norme (10 NM) entraînera une diminution significative de la charge de travail liée au franchissement de frontières.

3.11 BULGARIE - ROUMANIE 99 - OBJECTIF 4

Coordination civile
Évaluer l’utilisation de la coordination automatisée (OLDI/SYSCO) avec les secteurs et les centres ATC adjacents (en particulier avec la Roumanie).

Comme dans la simulation Bulgarie 99, les contrôleurs se sont dits favorables à la coordination électronique et ont indiqué qu’elle diminuait sensiblement leur charge de travail. Les problèmes liés au choix du bon partenaire de coordination dans un environnement de secteurs superposés ont persisté ; l’utilisation du message de coordination “CHG LVL” (cf. Bulgarie-Roumanie 99, Objectif 1 - Interface contrôleur) a toutefois facilité la tâche des contrôleurs exécutifs.

Les contrôleurs ont indiqué qu’ils étaient favorables au système simulé, dans lequel aucune des révisions apportées avant l’envoi du message d’activation (ACT) n’est soumise pour approbation (pas de coordination) et toutes les révisions apportées après le sont (coordination). Ce système simplifié, bien compris par les contrôleurs, a été pris en compte dans la HMI de chaque État.

Les contrôleurs des deux États ont jugé que la coordination électronique totale entre la Bulgarie et la Roumanie constituait un grand succès. Il ressort des réponses au questionnaire que pour 84 % des contrôleurs bulgares, la coordination OLDI/SYSCO avec l’espace aérien adjacent roumain/bulgare simplifie "toujours ou régulièrement" les tâches de coordination. A cet égard, le commentaire des contrôleurs, selon lequel la coordination électronique totale entre la Bulgarie et la Roumanie rend la frontière internationale identique à “n’importe quelle autre limite de secteur”, est très révélateur.

3.11.1 Heure d’envoi du message d’activation

Selon les contrôleurs, l’utilisation d’une heure ACT différente de part et d’autre de la frontière commune ne pose pas de problème, les données étant fournies à un moment jugé ni excessivement tardif par la Roumanie, ni excessivement précoce par la Bulgarie. Comme la question de l’ACT se posera lorsque les deux centres seront convenablement équipés, la moindre importance de ce paramètre devrait faciliter l’harmonisation de l’interface commune.

3.11.2 Contournement de l’espace aérien réservé

Les contrôleurs ont indiqué qu’en cas d’activation de l’espace aérien réservé, ils n’avaient aucun moyen de modifier tactiquement la route d’un aéronef, si ce n’est par la commande "DIRECT", qui ne convient pas toujours ou ne permet pas d’éviter l’espace aérien réservé.

Ils souhaiteraient pouvoir modifier la trajectoire d’un aéronef de façon à lui faire contourner l’espace aérien réservé et à le ramener ensuite sur la trajectoire prévue dans le plan de vol. Une telle possibilité créerait une nouvelle route d’entrée dans le secteur roumain, qui pourrait être affichée pour acceptation dans le cadre du processus de coordination.

Les contrôleurs ont également demandé que des cartes vidéo de l’espace aérien roumain réservé puissent être affichées sur la HMI bulgare pendant la période d’activation dudit espace, afin que les contrôleurs bulgares puissent établir des déroutements plus appropriés, qui tiennent compte des restrictions roumaines.
3.11.3 Fonctionnalité "Request Direct"

Dans la simulation Bulgarie 99, les contrôleurs ont indiqué qu'ils souhaiteraient pouvoir demander une route directe pour un aéronef "attendu". Une coordination serait proposée en vue de guider "directement" l'aéronef de la position qu'il occupe dans le secteur précédent au point sélectionné dans le secteur du contrôleur. Dans la simulation Bulgarie-Roumanie 99, les contrôleurs ont indiqué que la fonction "Request Direct" devrait être disponible de part et d'autre de la frontière commune de manière à pouvoir coordonner de telles demandes avec les secteurs roumains.