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EEC PD/3 Simulation
Final Report

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EUROCONTROL

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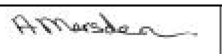
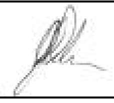
AUTHOR 1	Alan Marsden		Sep 99
AUTHOR 2	Douglas Hudson		Sep 99
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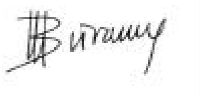
PD/3 Project Leader	Marc Bisiaux		Sep 99
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EXECUTIVE SUMMARY

This report presents the results of the PHARE Demonstration 3 (EEC PD/3) conducted at the EUROCONTROL Experimental Centre during May 1998. The report describes the controller training phase, the analysis methodology and the feedback from the controllers and conduct team arising from the four week study.

There were two specific objectives associated with the EEC PD/3 project namely:

- Provide evaluation of a future ATM concept for the time period 2005 – 2015, which supports the introduction of the following functional elements :
    - Multi-Sector Planning
    - Air/Ground integration
    - Traffic Organisation.
- Evaluate the transitional introduction of aircraft possessing both a data-link and 4D Flight Management System capability.

The range of operational concepts explored by EEC PD/3 combined a number of functional elements whilst keeping the controller firmly within the decision-making process.

The way in which anticipated advances in CNS technology and automation capabilities can be used and integrated in support of the EEC PD/3 operational concept were addressed:

- in the en-route environment;
- in the extended TMA environment;
- by the use of data-link applications.

For both the en-route and ETMA environments, EEC PD/3 was intended to demonstrate capacity and productivity benefits arising from:

- the introduction of advanced assistance tools
- the introduction of multi-sector planning, optimising the way traffic is organised on a larger scale than the traditional sector
- the introduction of 4D trajectory negotiation and planning.

The EEC PD/3 experiment conducted at the EEC failed to reach its objectives due to the reduced functionality of the simulation platform. Although this report contains a description of the way in which the experiment was planned, as well as a synthesis of operational feedback obtained from the participating controllers, the reader should bear in mind that the functionality of the simulation platform fell short of the EEC PD/3 concept.

In order to benefit as much as possible from this work, an internal ‘lessons learnt’ enquiry was undertaken after the EEC PD/3. The resulting document is attached as an appendix to this report, with the hope that it’s content will give a positive contribution for others undertaking exercises similar to EEC PD/3.

THE EEC PD/3 SIMULATION TEAM

The EEC simulation team for PHARE Demonstration 3 (EEC PD/3) comprised a number of people with different domains of specialisation who were responsible for the management and conduct of the EEC PD/3 series of exercises. The roles of each are described below and the summary reports of each member of the simulation team have provided the content for this report.

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J.P. Nicolaon	Operational Task Force and Operational expertise
R. McGregor	Operational expertise in MSP area
I. Pichancourt	EEC PD/3 GHMI Design and en-route observation
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P. Latron	Observation in en-route sectors
A. Gizdavu	Operational expertise in Departure sectors
M. Merkle	Research Analyst in Departure sectors (detachment from FAA)
A. Jackson	EATCHIP GHMI and Human Factors expertise
A. Marsden	Analysis and Conduct Lead
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1 INTRODUCTION

This report describes the results of the PHARE Demonstration 3 (EEC PD/3) experiment conducted at the EUROCONTROL Experimental Centre (EEC). The EEC PD/3 experiment was conceived as a comparative study of a baseline system and three derivatives of advanced systems employing various combinations of modified procedures, working practices, Ground Human Machine Interface (GHMI) and PHARE Advanced Tools (PATS) as well as aircraft navigational and communications equipment.

The global aims of the EEC PD/3 experiment were the following:

- To demonstrate the feasibility and merits of a future air/ground integrated air traffic management system in all phases of flight;
- To provide input to the definition of future European Air Traffic Management System concepts.

The series of EEC PD/3 experiments were therefore required to demonstrate the potential for capacity and productivity improvements within a full 'gate-to-gate' environment arising from:

- the introduction of multi-sector planning, to optimise the way traffic is organised on a scale larger than the traditional sector;
- the introduction of advanced PHARE tools and associated GHMI to assist the controller in the organisation and planning of traffic;
- the introduction of specific Arrival and Departure Management tools;
- the introduction of 4D trajectory negotiation and trajectory editing.

The experimental planning for the EEC PD/3 simulation was fully described in the 'EEC Conduct and Analysis Specification' (Reference 1). This document, which was produced as a result of co-operation between the EEC and the Air Traffic Management Development Centre (ATMDC) of NATS, described the simulation objectives, analysis hypotheses and simulation conduct. It also specified the analysis planned for simulation recorded data.

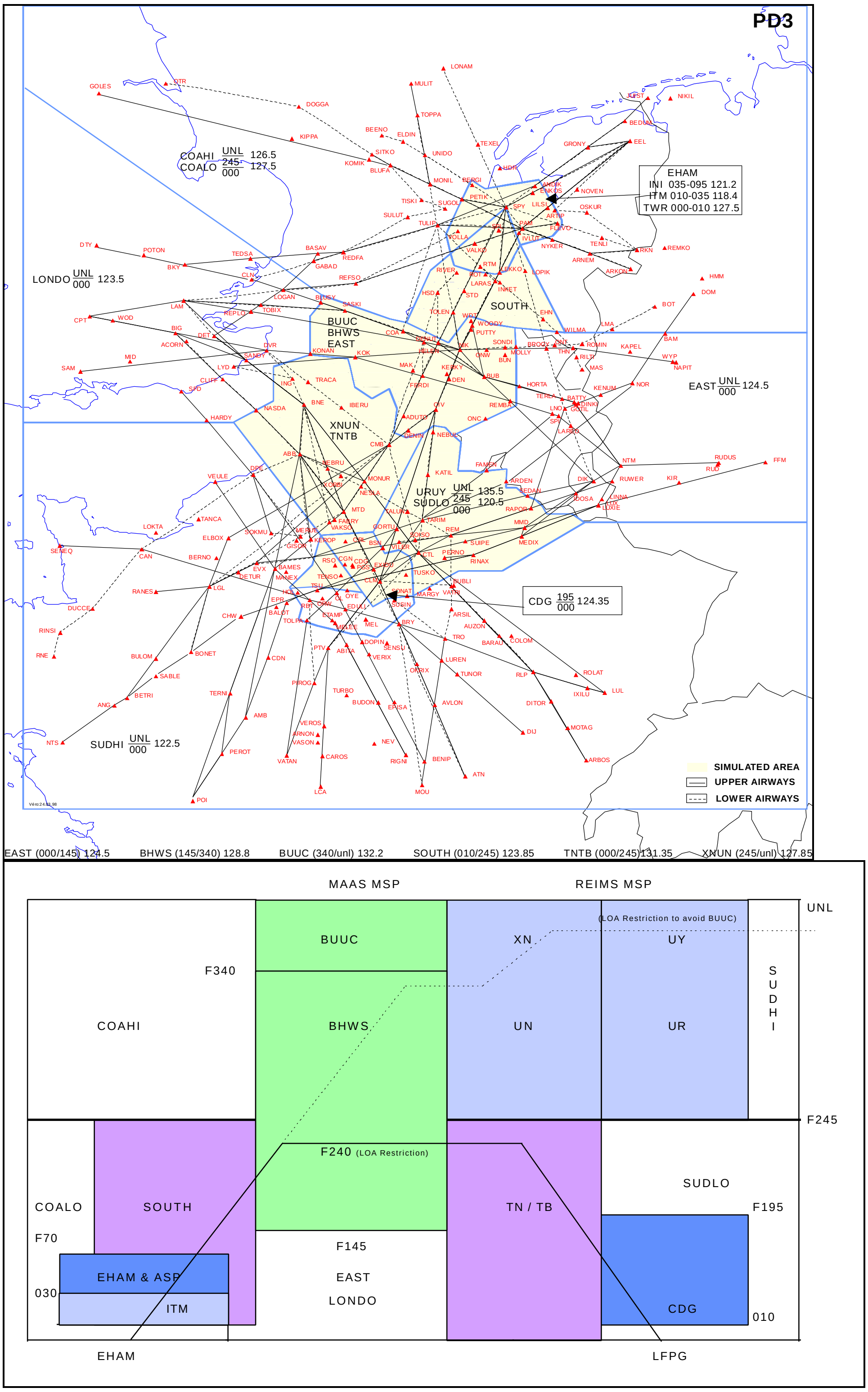
The series of PD/3 experiments conducted at the EEC between 4 May and 29 May 1998 did not achieve the objectives described in Reference 1. Severe limitations of the simulation platform limited the scope of the trial and effectively reduced it to a large scale system test. The reasons for the failure of the platform to attain the required level of functionality are not the subject of this report, these are addressed elsewhere in an internal EEC PD/3 audit.

Instead, this report presents feedback from the conduct of the EEC PD/3 simulation, the training phase and from the controllers' experiences with the PATS tools. **These comments, however, must not be taken outside the context in which they were gathered: they relate to a simulated system, the functionality of which fell considerably short of the envisaged PD/3 system.**

Section 2 of this report details the controller training, including the pilot phase and main demonstration. Section 3 describes the conduct of the simulation and Section 4 describes the comments made by the controllers relating to their experiences of the simulated system. Section 5 highlights a number of areas worthy of further consideration and possible study. Section 6 provides a discussion of the main aspects of the EEC PD/3 experiment and Section 7 provides the main conclusions and recommendations arising from this study.

The simulated airspace, comprising Paris departure sectors, Rheims and Maastricht (Multi-Sector) Planning sectors and Amsterdam arrival sectors is depicted in figure 1.

Figure 1: EEC PD/3 sector maps



2 CONTROLLER TRAINING

This section describes the controller training conducted during the pilot phase and main demonstration and presents the relevant feedback.

2.1 EEC PD/3 Pilot Phase

The EEC PD/3 Pilot Phase was conducted between 30 March and 3 April 1998. The objective of the pilot phase was to provide training for the participating controllers in the EEC PD/3 concept, the interface and the various tools associated with the advanced organisation. The training was intended to comprise classroom and Computer Based Training (CBT) sessions supplemented by ‘hands-on’ explanations using the EEC PD/3 simulation platform. For this specific aim, a three days training course had been conducted by INSTILUX for the EEC PD/3 simulation team covering the issues associated with coaching techniques.

The EEC PD/3 platform was not available and so the training was restricted to classroom and CBT sessions. The classroom sessions comprised a number of presentations on the concept, tools’ function and usage, individual controller roles and airspace rules. These presentations were supplemented by CBT sessions allowing the controllers to explore at their own pace the ideas evoked during the classroom sessions.

2.1.1 Presentations and classroom sessions

The presentations and classroom sessions were conducted by members of the EEC simulation team. Considerable time and effort was spent in preparing the presentation material which was generally considered to be of a good quality. However, a number of the subjects covered were very difficult for the controllers to assimilate. The inability to observe the ideas on the simulation platform meant that some of the fundamental concepts and roles were not clear to the controllers. Ideally these presentations would have been followed by practical sessions in the simulation room.

The classroom sessions concentrated almost exclusively on the advanced EEC PD/3 system. This was subsequently found to be an error as some controllers did not possess a sufficient understanding of the baseline system or the role of specific positions, most notably the feed sectors. It was noted that training in the baseline system is equally important since this is ultimately the system against which all other results will be compared.

2.1.2 Computer Based Training

The CBT package was prepared by NLR and employed a traditional approach of textual and graphical instruction supplemented by tests of controller comprehension. The material was presented in a logical manner ranging from simple concepts of mouse usage and radar label interaction through to the more challenging aspects of trajectory edition and negotiation.

The first few lessons were well structured and contained few errors. However, the later lessons describing the more advanced PD/3 concepts contained a number of errors and were incomplete. This missing information confused the controllers.

Due to limited hardware within the main training area, controllerswere required to be dispersed throughout the EEC during the CBT sessions. Although unavoidable, this situation was less than ideal because the level of support and assistance to each controller varied as a result.

The mixture of classroom sessions and CBT proved heavy going for a number of the controllers and there was little opportunity for either them or the EEC simulation team to assess their understanding of the concepts. Although the controllers were given feed-back sheets, not enough emphasis was placed on the importance for their completion. Had this been done, the simulation team would have gained more insight into the performance level of the controllers.

Following the EEC PD/3 Pilot Phase, a number of improvements to the CBT package were incorporated by NLR. The new version was sent to each of the participating controllers in the weeks prior to the main phase, as well as an instruction book describing each main tool and its method of interaction as well as the EEC PD/3 concept and associated controller roles (Reference2).

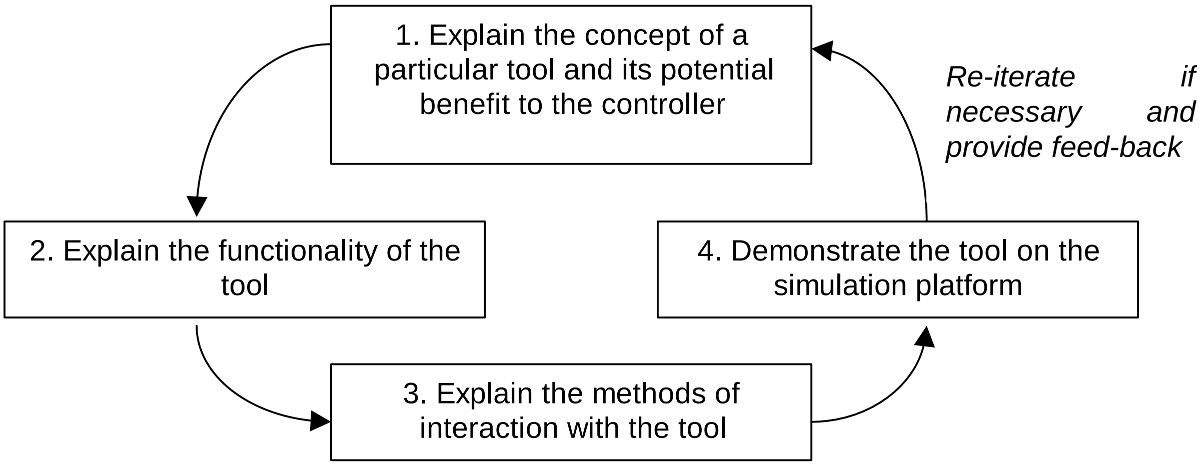
2.1.3 Simulation sessions during the pilot phase

During the pilot phase, the exposure of the controllers to the actual simulation environment was limited to two short sessions. In both cases the baseline system was employed. Due to problems associated with the communication system and poor system response times, these sessions served only to familiarise the controllers with the layout of the simulation room and some of the simulation hardware. During these two periods, it was not possible to supplement any of the material presented during the training sessions with genuine operational demonstration.

2.2 EEC PD/3 Main Demonstration

The training for the main demonstration sought to reinforce the classroom style briefing with operational demonstrations and hands-on learning with the actual system. This approach is seen as being fundamental to a system such as EEC PD/3, where the controller roles and system interaction represent a radical departure from current practices. As well as a number of improvements and additions to the actual training material, it was decided that presentations to the controllers would be made only by simulation team members with previous operational experience.

The approach to controller training in the advanced EEC PD/3 concept followed the following framework:



Following the controller training it was highlighted that insufficient emphasis was placed on the explanation of each tools' potential benefit to the controller, with too much emphasis being placed on functionality and modes of interaction.

The platform was initially unstable and the tools were often not as specified or lacked certain modes of interaction. Therefore it was very difficult to reinforce the level of detail presented in the classroom sessions with the equivalent level of 'hands-on' experience.

The lack of working platform availability prior to the EEC PD/3 simulation meant that the trainers were unable to attain the desired level of competency in tool usage and interaction. The trainers on occasions needed to query the operating procedures and design documents to differentiate between incorrect use of the tool or system failure.

Even with a fully functional and robust EEC PD/3 system, the challenge of training the controllers would have been an ambitious undertaking within the allocated time period. To allow a successful simulation including measured exercises, each controller would have needed at least a working familiarity and understanding of:

- airspace rules and procedures pertinent to their grouping (as described in Section 3.1)
- working method associated with the different controller roles pertinent to their grouping
- mouse and window interaction
- new concepts including the MSP function, 4D FMS, datalink, negotiation and co-ordination, trajectories and deviation, and conflict probing
- the new tools including the Arrival Manager Display (AMD), Trajectory Edition and Problem Solver (TEPS), Aircraft Advisories Display (AAD), Vertical View Display (VVD), Conflict Risk Display (CRD), Sector Load Windows (SLW), Tactical Load Smoother (TLS), Sector Inbound Lists (SILs), the radar toolbox, and the Message In/Out Windows (MIW/MOW).

Some of the participating controllers in EEC PD/3 were new to all these elements, even mouse and window interaction. In addition they had the obstacle of having to assimilate all of this new information being presented to them in a language other than their native tongue.

The training was considered more effective for those controllers already familiar with windows and mouse interaction and with some experience of similar experiments.

The strategy of short presentations, followed by exercises to reinforce the lesson, was found to be more stimulating for the controllers, and much more successful in terms of information retained. Within the approach sector grouping there were six different roles in which the controllers had to be trained. Rotation of the controllers through each position after each training exercise exacerbated the problem and the three members of the conduct team assigned to train and monitor the participants were at times stretched. Ideally the training and monitoring would have been on a one to one basis, with one member of the conduct team specialising in each role.

3 SIMULATION CONDUCT

This section describes the conduct of the EEC PD/3 simulation and presents the relevant feedback. Full details relating to the manner in which the EEC PD/3 conduct was designed to address the experimental objectives are given in Reference1.

3.1 The participating controllers

Twenty-five controllers participated in the EEC PD/3 experiment and were drawn from a number of national administrations of EUROCONTROL member states, namely, France, UK, Sweden, Hungary, Spain and Poland. Under the memorandum of Co-operation between EUROCONTROL and the FAA, a number of FAA staff participated as controllers and members of the conduct team.

Each participating controller was assigned to one of the following four airspace groups:

- Roissy (CDG) Departure positions
- Rheims MSP area
- Maastricht MSP area
- Amsterdam (EHAM) Approach positions

The objective of this assignment was to allow each controller to 'specialise' in one particular set of functional roles, to maintain a manageable group size for each ofthe debriefs, and to simplify the controller training. The assignment was based largely on the operational expertise of the controllers and their experience gained in previous simulations. These groups formed the basis of the controller rotation between exercises as well as the training sessions. The classroom training sessions covered both general topics for all controllers as well as role specific training for which the controllers split up into their assigned grouping.

In addition to the controller assignment, the members of the EEC simulation team were also assigned to individual airspace groupings. This assignment was again based on operational experience or experience with the PHARE concept. The aim was to provide operational, Human Factors and PHARE concept expertise within each of the four groups.

The role of the EEC simulation team members during the execution of EEC PD/3 was to provide training, assist the controllers with the operational concept, perform observation (described below) and lead the debriefs with each controller group following a simulation exercise.

3.2 Exercise sequence

A planned schedule of exercises was defined in Reference1. This aimed to minimise the effect of natural controller learning during the experiments on the objective results as much as possible by mixing the different experimental organisations[1] throughout the simulation period. Within each airspace group, a small number of

[1] An experimental organisation is a combination of operational concept and airspace procedures. EEC PD/3 comprised four experimental organisations combining the route structure (standard or free route) and the inclusion or otherwise of the PATs. The experimental plan was developed in such a way as to allow direct comparison between these experimental organisations.

feed sectors was also defined and each controller was assigned to either a measured or feed position within their grouping for each simulation exercise.

The planned controller rotation, defined in Reference 3, sought to satisfy two objectives:

- allow the controllers to experience the different roles associated with their particular grouping, and thereby enhance the validity of verbal and questionnaire feedback
- respect the need for 'balanced' exercises in order to permit statistical analysis of the different simulated organisations

As part of the EEC PD/3 data gathering strategy, the use of 'observers' had been defined in Reference 1. It was intended that these observers monitor the working method of the controllers, noting any difficulty in the use of the system, and subsequently discuss problems with the controller upon completion of the exercise. Due to the fact that all of the exercises were conducted as 'non-measured', a more informal interaction between controller and observer was possible and a large part of the feedback came from these observations.

Approximately 32 exercises were run in total over the four weeks, the first two weeks concentrating on the baseline and the second two weeks on the advanced system. The duration of each exercise varied from five minutes to one hour, however the effective part of each exercise was often less than the total run time, owing to various system problems.

3.2.1 Week one

The daily schedule in week one was based around the classroom lessons prepared for the baseline system. Each lesson covered some specific feature of the system, and was followed by an exercise using the system to reinforce that lesson. It immediately became apparent that many problems still remained in the system, and once the controllers had been taught the rudiments of using the system, the conduct team concentrated primarily on recording system errors.

3.2.2 Week two

By week two, a modified version of CWP software was introduced significantly improving the system response times. The aim was therefore to correct as many of the system errors as possible so that a series of baseline measured exercises could be completed by the end of the week. However, a number of problems persisted, most notably a divergence between the air and ground servers. This prevented any measured exercises being run for the baseline.

3.2.3 Week three

The advanced organisation was implemented at the start of week three, but with limited functionality. No trajectory edition was possible, no 4D trajectories existed and advisories for 3D aircraft were either missing or incorrect. As a result the controllers continued to work with the system as if it were the baseline. It also appeared as if the inclusion of the PHARE advanced tools had degraded the system response time. Any progress in this respect made over weeks one and two of the simulation had been lost. Although all the PHARE tools were present, none functioned as expected. The third week was spent recording system errors, i.e. no measured exercises, and training the participants on the advanced system was possible.

3.2.4 Week four

During the latter part of the simulation the conduct team was able to obtain some feedback on the advanced system. Acting as observers, the conduct team gathered controller comments as non-measured exercises progressed, and noted the controllers' difficulties with the system.

The controllers were debriefed several times in week four within their particular groupings. An objective was set for each debrief, for example window management, or use of the radar labels and the pop-up menus. These debriefs were successful, provoking some interesting discussion, and some useful data were gathered. Some of the controllers also remarked on the interest of these debriefs, particularly in the MSP groups, given that they were able to exchange views concerning the EEC PD/3 concept.

However, due to insufficient functionality, it was not possible for the controllers to provide feedback on the concept based on simulation exercises.

3.3 Questionnaires

As part of the analysis plan for EEC PD/3 a series of questionnaires was derived for each controller role. These questionnaires sought to provoke controller comment in each of the following areas:

- The working methods of the MSP, ASP, PC and TC
- The usefulness and ease of interaction with each of the PATS
- A comparison of the controller workload in the baseline and advanced organisations
- The impact of the EEC PD/3 concept on capacity, safety, quality of service and situational awareness.

The questionnaires were adapted in the latter part of the simulation to become relevant to the actual systems simulated and they were issued to the controllers during week four. Within the context of the PATs, the modified questionnaires aimed to address primarily the presentation and information content rather than the functionality and interaction with the tools as it was felt that the controllers would be unable to comment on these aspects.

3.4 Traffic samples and simulation realism

As a result of the system instability, only a very small subset of the traffic samples that had been prepared for the EEC PD/3 measured exercises were employed. Virtually all the samples used during the simulation contained less traffic (25%, 50% and 75%) than that intended for the baseline current day samples. Given that the PATs were designed primarily for use in high traffic volumes, the low traffic levels simulated were not conducive to evaluating the need for, or effectiveness of, these tools.

Whilst modifications to the system as well as the rotation of the controllers between positions prevented the exercises from becoming overly repetitive, most controllers stated in the questionnaire responses that a loss of simulation realism was incurred toward the end of the simulation as a result of their familiarity with the traffic samples.

An obvious loss of realism commented on by the controllers was the lack of system functionality and reliability, which meant that the system was not a realistic environment in which to evaluate the EEC PD/3 concepts and tools. It was also commented that some aspects of aircraft performance were not realistic.

The controllers experienced difficulty in evolving a working methodology due to the number of workarounds required related to reduced system functionality.

4 CONTROLLER FEEDBACK

The following sections describe the feedback obtained from the controllers on the simulated system. This feedback has been collated by the simulation team from observation and discussion with the controllers, from debrief sessions and finally from the simulation questionnaires. In order to supplement the controller comments, a number of images[2] of specific tools and windows are provided.

4.1 General

Some of the controller comments relate to aspects of the system which were specified but not implemented. These are included for completeness. Furthermore, the controller feedback provided in the following sections is based on a series of non-measured exercises where the absence of trajectory edition and 4D aircraft meant that many of the potential benefits of the EEC PD/3 advanced system could not be correctly evaluated.

4.1.1 The Mouse

System interaction via the mouse caused few significant problems, all controllers stating that the different mouse actions were easy to perform. The controllers cited the system response time as causing some difficulty and, in certain circumstances, provoking erroneous inputs e.g. double click causing data input. The controllers stated that an 'undo' function was possibly needed, perhaps a use for a third mouse button.

The other main problem with mouse interaction was the priority of the input 'hotspots', which caused some access difficulties, e.g. position symbol priority in relation to the display of the selected label.

Some small inconsistencies in the mouse button assignment for certain tasks were also highlighted. The Right Mouse Button (RMB) should always be used for information request whereas the Left Mouse Button (LMB) should always be used for action input. One particular example was the use of the RMB in order to access the TEPS in edit mode which was seen by the controllers as an action rather than information request.

The method of cancelling pop-up menus without input was discussed. Most controllers suggested that this could be performed by simply moving the mouse outside of the menu instead of clicking exterior to the menu.

4.1.2 Radar labels

The controllers considered that the use of colour for displaying aircraft status assisted them in their task, as did the dynamic nature of the label shape indicating outstanding level interventions required on a particular flight. Some controllers highlighted the need for a default position of the radar label based upon track in

[2] These images are as presented in the controller training material (Reference 2) and in some cases there may be minor differences (e.g. colour and font) between the image and the actual system as implemented for EEC PD/3.

order to simplify the need for manual label movement which can artificially augment the workload.

Specific comments related to the following:

- **Grey (non-concerned) labels**

The presence of a leader line for grey labels was considered to render them too large and therefore a source of clutter on the display.

- **Co-ordination**

Controllers were unanimous in their opinion that the presence of incoming co-ordination should be indicated in the standard label. This is, in fact, as defined in the specification, but the simulated system only displayed incoming co-ordination in the Message In Window (MIW) and selected label. It should naturally be possible to effect a response to an incoming co-ordination through the aircraft label.

- **Label content**

The controllers were generally happy with the content of the extended label although it was not frequently used. In the majority of cases the selected label proved sufficient.

Most controllers considered that the ground-speed should be displayed in the standard label. They had no requirement for the TAS and RFL

In the approach positions, runway indicator andground-speed are required in both the standard and selected label.

Within the selected label, controllers found the display of flight level information based on aircraft state (CFL for assumed and PEL for inbound) to be the source of some confusion. The controllers did find the notion of 'minimum information' in the standard label to be useful although, as stated above, there should be more consistency between the displayed levels.

4.1.3 Windows

The controllers considered that the available space on the SONY screen was not exploited in an optimal manner, with the different windows often cluttering the display. In general the different windows should be resizable and the controller should have the facility to minimise (set to icon) each of the windows.

It should be borne in mind, however, that the decision not to allow certain windows to be minimised is based upon the premise that they present information fundamental to the safe and efficient working practices of the controller. Within the simulation, a number of such windows (e.g. the CRD) did not function as specified and failed to provide useful information to the controller. The inability to minimise such windows, at the expense of reduced visibility of the RPVD, therefore proved a source of frustration for the controllers.

Some controllers considered that certain windows, most notably the Message windows should only be displayed when they contain pertinent information. If an incoming message is received, the MIW should automatically open and then shut once the co-ordination has been completed. The potential distraction for a controller associated with the automatic opening of a window would require further investigation.

A number of improvements should be made to reduce the size of certain windows whilst maintaining the integrity of the displayed information.

For pop-up menu windows, the addition of scroll bars was proposed as a means to improve the speed associated with paging to new values. This problem was accentuated by poor use of cursor defaulting associated with accepting coordination or counter proposing. Attention should also be paid to the display priority of certain windows.

4.2 Feedback relating to Departure Positions

4.2.1 Sector Inbound Lists (SILs)

The controllers would have preferred to have only one SIL at the TNTB (departure ACC) sector, rather than several based on runways and over-flights. Since aircraft arrived separated from CDG there was no advantage in knowing the departure runway.

The usefulness of SILs at the CDG sector was tempered by their failure to work correctly.

4.2.2 Trajectory Editor and Problem Solver (TEPS)

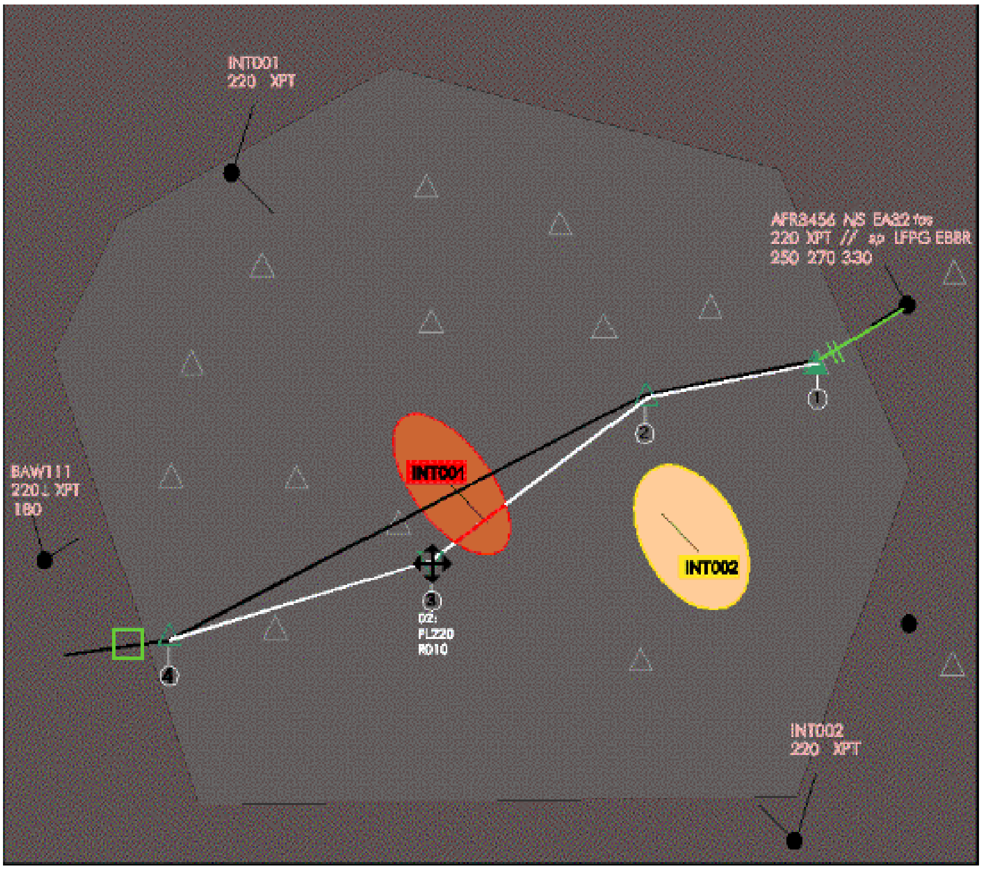


Figure 2: Lateral trajectory editor in the TEPS

In common with the other control positions, the zones displayed by the TEPS (conflict and risk) were often inaccurate. The TEPS was not considered to be useful in the departure sector due to the lack of planning time and the short transit time for aircraft in the sector.

At the departure ACC sector, the controllers were able to appreciate the potential usefulness of the TEPS. There was some concern about the overlap in functionality between the Dynamic Flight Leg (DFL) and the TEPS, with the controllers expressing a strong preference for the TEPS.

4.2.3 Conflict and Risk Display (CRD)

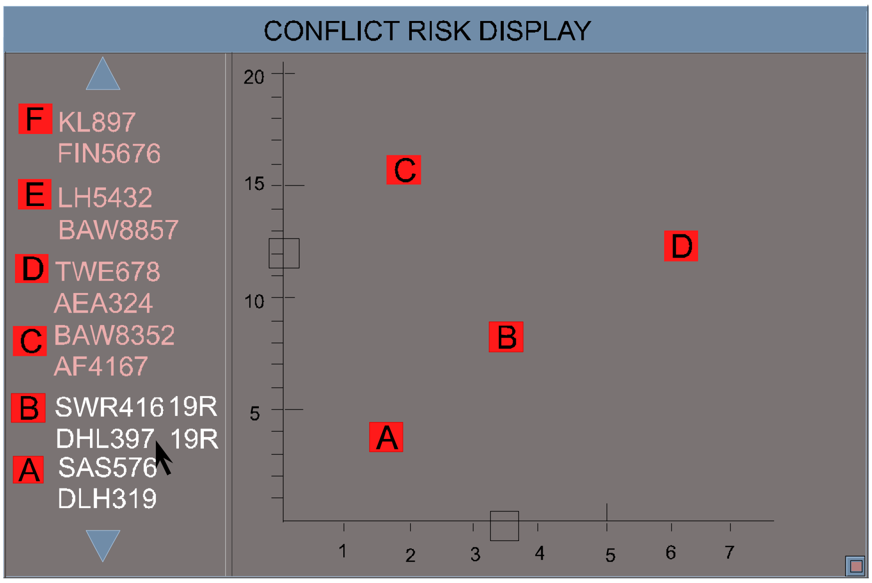


Figure 3: The Conflict and Risk Display

The controllers did not see the usefulness of the CRD given a correctly functioning TEPS. This assertion depends on the time available to check every flight. This is a topic for more discussion during training and re-enforcing the working method in order to show how the usefulness of the two tools differs.

No departure controllers employed the CRD as part of their working method. Instead they hid as much of it as possible from the screen display area (no 'minimise' function being available).

4.2.4 Departure sectors working methodology

The evolution of a working methodology within the departure sectors was hindered by the reduced tool-set available at these positions. There was no Departure Manager or advisories at CDG and TNTB. Without a departure window, the CDGPC could not plan in the advanced organisation. The controllers essentially replicated today's controller roles, one sector controller interacting with the aircraft and the second team member assisting as necessary.

4.3 Feedback relating to the MSP and en-route (PC/TC) Positions

The following sections contain feedback obtained from the controllers relating to the MSP and PC/TC tools and working methodology.

4.3.1 Activity Predictor Display (APD)

The information presented in the APD during EEC PD/3 was not sufficiently reliable for the controllers to assess its usefulness. However the controllers did explore the interaction with the APD and attempted to interpret the usefulness of such a tool in the event that the information provided is representative of the air situation.

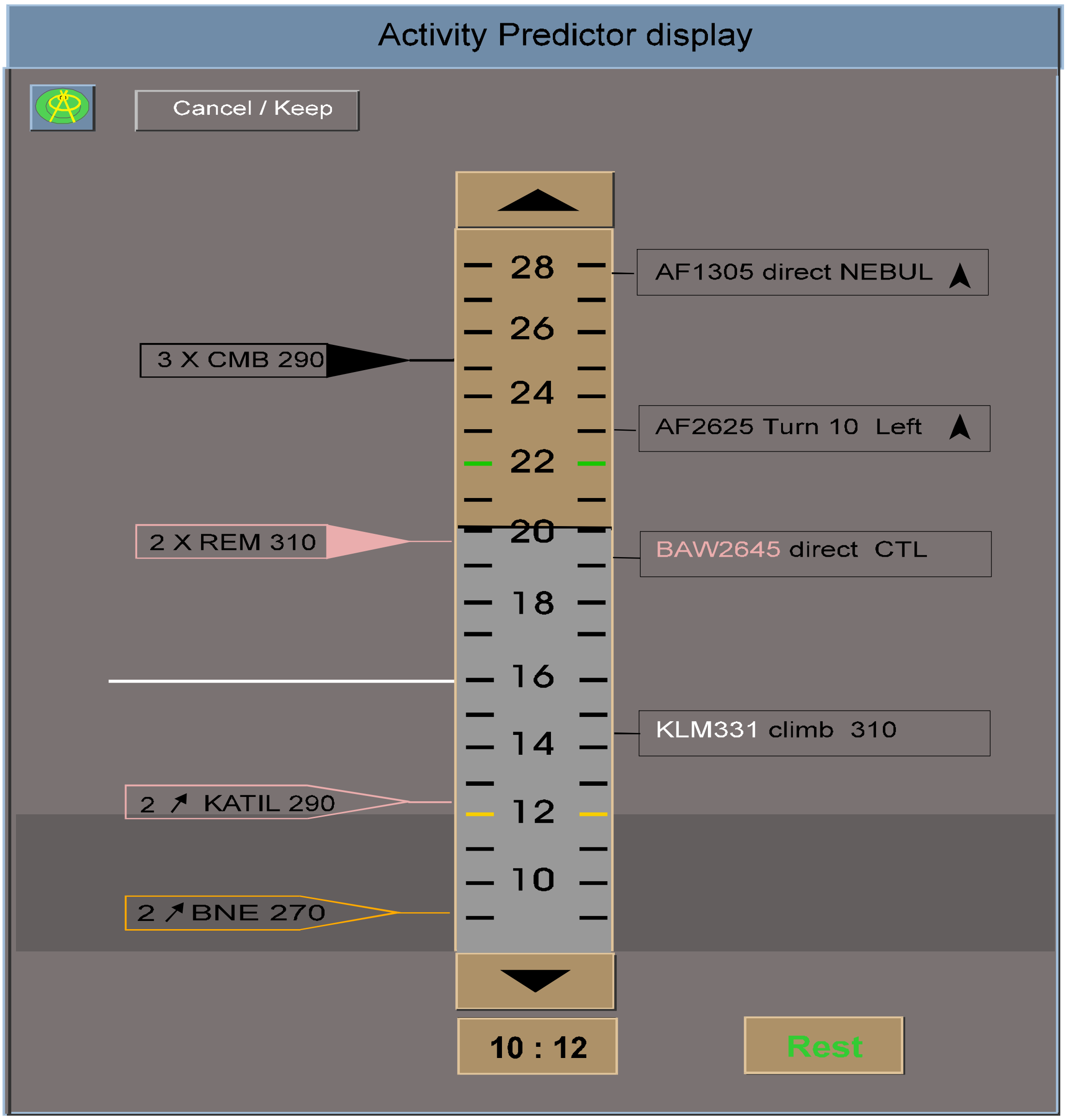


Figure 4: The Activity Predictor Display for the Planner Controller position

The APD was considered by the controllers to be too large and occupied too much of the overall available screen space. It was felt that controllers should see the PROblem SITuations (PROSITs) displayed at the time the system calculates that the problem will occur, not at the best resolution time. The time scale should therefore be a count down to zero minutes before conflict in order to know the time remaining for action, which corresponds more closely to their current working methods.

The format of the window and its applicability to the Planning and Tactical roles was questioned by some controllers. It was considered that under normal conditions, the PC would not need to see the aircraft advisories.

Controllers had difficulty in understanding the meaning of a PROSIT. A PROSIT represents an indication of a necessary intervention in order to avoid a separation loss and this is intrinsically associated with a system indicated time at which the intervention should occur. The use of time management and the display of PROSITs caused some confusion notably when the time for optimal resolution had passed (PROSIT displayed in the 'past')

For the PC, the functions of time navigation (LAD) and extrapolation (prosit selection and displacement) were both integrated into the APD. Future training should stress separately the advantages of time navigation and the meaning of prosits, underlining their behaviour and meaning in relation to variations in situational time.

4.3.2 Area Flows Window (AFW)

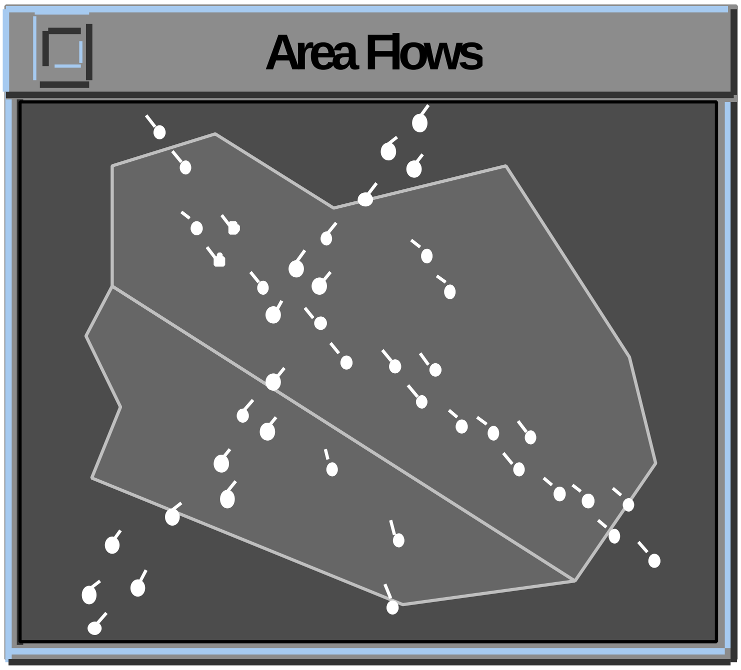


Figure 5 : The Area Flow Window

The aim of the AFW was to provide the MSP controller with an intuitive visualisation of the evolution of aircraft movements on a global scale as a means of determining future strategy.

The AFW as it was simulated was not considered to be a useful tool. Controllers had difficulty forming an understanding of the flows and found that the method of displaying the evolution of the flows in time was not intuitive. It was also difficult to understand the AFW with respect to the situational time being employed by the MSP. The AFW should enable identification of the zones of critical density (and their eventual evolution) upon which the MSP should concentrate, rather than represent simply flows – the nature of which are dependent on the sector route structure and in any case are well understood by the controller.

The content of such a window would require to be optimised according to the MSP function and information requirements, for example in relation to the display of arriving aircraft in an MSP area encompassing an ETMA.

Although ‘free routes’ (direct from SID exit to STAR gate) were not simulated, the AFW may be of interest within such a scenario. Further investigation is required into how such a tool may assist the controller in this environment.

4.3.3 Trajectory Editor and Problem Solver (TEPS)

The controllers were only able to explore the TEPS display in a very limited manner and no interaction in terms of trajectory and constraint edition was possible.

The conflict zones were considered to be frequently inaccurate and in particular, too many yellow zones were displayed far away from the subject aircraft.

Given this limited exposure, the controllers did consider the TEPS to be a potentially useful tool although the logic for displaying the yellow zones should be reviewed, taking more account of the distance and angle from the predicted track of the subject aircraft.

The implementation of TEPS in EEC PD/3 provided conflict and risk (albeit not always reliable) information exterior to the controllers area of responsibility. This resulted in a visualisation of the effect of trajectory modification in the downstream sectors. This provoked a lot of discussion about the responsibility of controllers for solving conflicts in adjacent airspace as well as being mindful of the effect of their actions in the downstream sectors. This is an interesting topic for further study.

Some controllers stated that the TEPS was not currently adapted to the tactical controller role. It would need to be more reactive and integrated with the elastic vector functionality to permit optimal heading instructions.

The implementation of the TEPS led to some confusion in differentiating the indication of those aircraft implicated in the generation of a no-go zone and the actual position on the RPVD of the corresponding aircraft.

4.3.4 Radar Plan View Display (RPVD) and complexity zones

The complexity zones (bubbles) displayed on the MSP RPVD were a combination of complexity and probability of occurrence. This notion proved difficult for many of the controllers to assimilate and was probably inadequately explained during the training.

When selecting a complexity zone, the controllers often had difficulty in determining those aircraft involved and subsequently the best strategy for minimising the associated complexity.

The controllers considered that although the complexity bubbles provided useful information, it was not immediately obvious which aircraft should be modified in order to reduce the complexity. A more rapid means of associating a complexity zone with the ‘key aircraft’ should be investigated. Furthermore, the impact of an edit on the complexity should be instantaneous. During the edition process the curve of the sector complexity should be updated (as specified but not implemented).

When editing a bubble, the usefulness of displaying the involved aircraft at a certain time parameter prior to separation infringement should be investigated.

The criteria taken into account for displaying complexity zones should be reviewed so that the MSP can work more easily on a macroscopic scale rather than with individual aircraft. It was considered that too many complexity zones are displayed involving too few aircraft.

A number of improvements to the use of colour for the complexity zones could be considered in order to better distinguish the different complexity levels. Similarly, the controllers evoked the need for improvement in the use of the mustard colour for distinguishing concerned and non-departed aircraft at the MSP position.

4.3.5 Look Ahead Display (LAD)

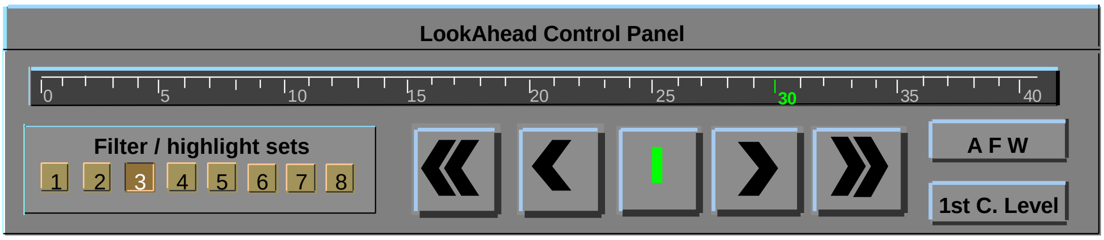


Figure 6: The Look Ahead Display control panel

The controllers considered that the LAD facilitates the task of time navigation for the MSP. A number of ergonomic improvements were suggested, notably more rapid time navigation using continual depression of the mouse button on the ‘forward’ and ‘backward’ buttons, and better integration with the Sector Load Window.

A number of controllers cited the need for a better link between the LAD and the presence of conflicts over the planning horizon of the MSP. The EEC IOCP experiments had shown conflicts to the controllers in the LAD although this representation was rejected by the controllers as it rapidly became overloaded in high traffic situations. Some of the controllers participating in EEC PD/3 did, however, cite the need for a representation of conflict situations in future time to the MSP along with an indication of the number of aircraft involved. Such a conflict display should be closely integrated with the RPVD/TEPS to allow rapid identification and modification of the ‘offending’ aircraft. The controllers preferred to determine time navigation strategy from the information presented in the Sector Load Windows (SLW). The time functions of the LAD could ultimately be integrated into the SLW with the remaining set up buttons related to RPVD content being integrated into a specifictool box.

4.3.6 Sector Load Window (SLW)

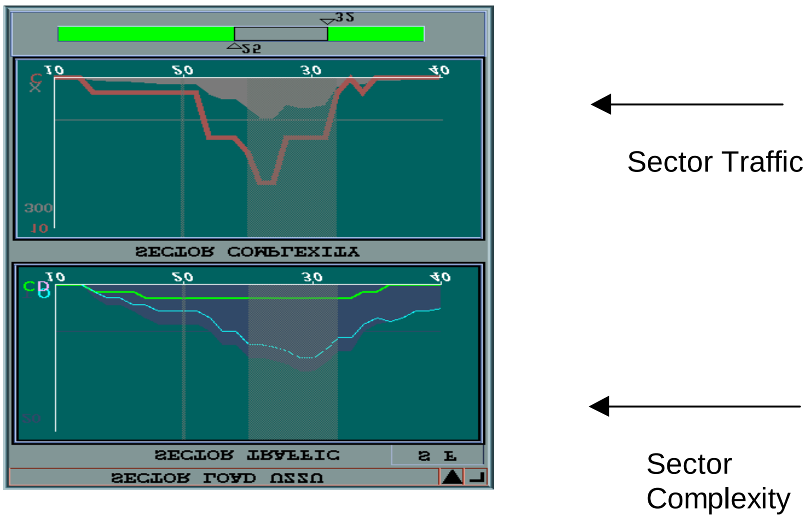


Figure 7: The Sector Load Window

The Traffic window was not considered useful, and the controller should at least be able to minimise this window and to display it only on request. During the debrief sessions there was considerable discussion concerning the MSP working method and the intrinsic link with the reduction of complexity. The controllers considered that sector traffic (volume alone) was not their primary concern as it is generally considered to be merely one factor in the description of overall complexity. The controllers were more interested by the information contained in the overall complexity curves. However, the usefulness of a sector traffic window requires further investigation, in a scenario where the MSP controllers can realistically assess the feasibility of sector balancing for different sector configurations within the MSP area.

The controllers considered that the Sector Load Windows (Complexity and Traffic) associated with the sectors in the MSP area could be grouped into a single window, using colour to distinguish the sectors.

4.3.7 MSP Working methodology

Within the EEC PD/3 experiment, the tools were not sufficiently evolved to allow the controllers to assess different working methodologies for the MSP role. The controllers were, however, of the opinion that future research, and definition of the MSP tools and HMI, should be focused on the task of interaction at a global level rather than individual aircraft.

The most popular working method suggested by the controllers in the questionnaire responses consisted of identifying critical periods in the SLW, moving to the particular time period of interest and then using animation (small time increments in the LAD) to examine the cause of the complexity.

The simulation highlighted that special attention should be paid to the tools and the visualisation of superposed sectors within the multi-sector area.

4.3.8 PC/TC Working methodology

The working method of the PC (+10 minutes) was not fully evaluated during the simulation

There was considerable discussion about the roles performed by the PC and TC within the EEC PD/3 concept. A number of the controllers considered that there will be a distinct difference between the roles of the PC and the TC, and therefore different needs regarding the provision of decision support tools. The existing implementation of tools in EEC PD/3 (based on harmonised information for the PC and TC) was considered by these controllers to introduce an element of redundancy into each position. On the other hand, the duplication of information was considered to promote the idea of teamwork. It is clear that the layered planning concept and the degrees to which these roles interact should form the basis of further experimentation.

4.4 Feedback relating to the Approach Positions

4.4.1 Radar display and toolbox

The controllers were generally happy with the radar display. The most frequent comments were requesting features that were already in the system, but not functioning, for example the preference set.

The lack of functionality of the automatic label anti-overlap resulted in difficulty in reading the labels and the necessity for extra manipulation.

The only additional criticism of the radar display related to the scroll bars which were considered to be overly sensitive, and the scroll arrows which were considered too slow.

The radar toolbox was easily understood by all six approach controllers, but four of them found it slow to use. The main factor attributing to this opinion was that the submenus opened behind the toolbox window, causing extra work moving other windows aside to gain access.

4.4.2 SILs and Message Windows

At the approach positions, ASP, INI and ITM, the SILs were not required for Amsterdam departures, which were procedurally separated from all arrivals. At the ITM position, since all arrivals are sequenced via the INI, the controllers stated that no SILs were required at all.

The controllers also agreed that no Message windows were required by the ITM, since by then it was too late for co-ordination. The readability of messages was also criticised by the controllers.

4.4.3 Radar labels

The controllers found the radar label information content to be suitable in the South ACC sector, but they all agreed that it had not been optimised for the approach positions, ASP, INI and ITM.

A number of the parameters displayed in the standard label at the approach positions lost their meaning due to the nature of the sectors. For example:

- XFL = 0 for all aircraft landing
- XPT = EHAM for all Amsterdam arrivals

Instead the controllers would prefer to be presented with the callsign, AFL and CFL as well as runway assignment. In addition, the controllers considered that within TMA airspace it was important to have the ground speed displayed in the standard label.

The speed menu contained Mach values in both approach and departure airspace which were redundant.

Approach controllers evoked the need to facilitate multiple inputs. A menu comprising the ability to modify CFL, heading, and speed within a simple interaction would prove useful.

4.4.4 Arrival Manager Display (AMD)

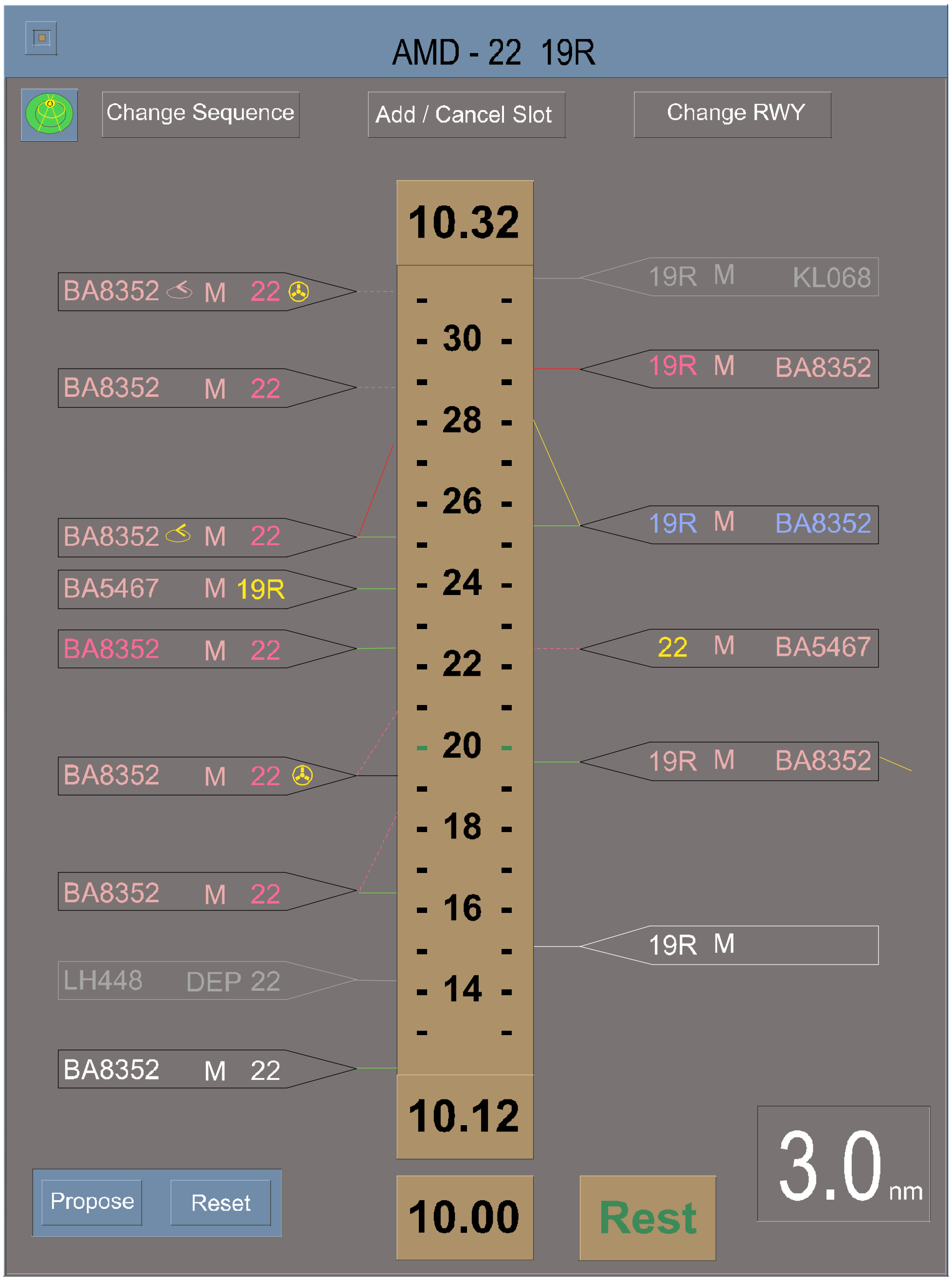


Figure 8: The Arrival Manager Display

The degree of interaction with the AMD was severely limited, compared to the system specification, and merely consisted of the ability to move one label and then reset the AMD to its original state. No AMD re-sequencing of aircraft was ever possible throughout the simulation. The advanced Arrival Manager software was never integrated with the AMD, and as a result the sequence predictions and planned arrival times were often, if not always, inaccurate.

Despite these shortcomings controllers provided feedback on the presentation and information content of the AMD.

All approach controllers agreed that the AMD was very difficult to learn. The aircraft presentation was criticised as being non-intuitive, confusing and presenting a plethora of unnecessary information.

One particular criticism of the AMD was that it only reflected reality via the deviation lines. It did not allow the ITM to determine the actual sequence, and the presentation gave priority to planned time rather than actual time.

There was some discussion concerning the different information each role needed from the AMD in the extended TMA. As ITM, one controller specifically made the comment that he did not need to see the AMD, merely to know the sequence and runway assignment. The INI and South TC had different requirements, however both needed access to the AMD in case holding was required. An additional comment made by another controller stated that the AMD should be echoed between South TC and INI - on a separate screen rather than a window.

All the controllers agreed that it was necessary to move the AMD onto a separate screen as the font size and information clutter rendered the display difficult to read when incorporated as a window on the RPVD. Controllers were further frustrated to find that the AMD toolbox opened at the opposite corner of the display rather than adjacent to the AMD.

Interaction with the AMD received some positive feedback, although the controllers had little experience with it. In general the interaction was considered to be easy, and the ability to move in time was liked by the controllers. The ability to move labels to the opposite side of the display in the event of a runway change was seen as a positive step although the ‘ghost’ label left behind when performing a runway change was disliked due to the fact that it often remained for a long period of time.

The controllers agreed that such a tool would probably be useful in an environment with a mix of 3D and 4D aircraft, but that the information has to be displayed more clearly and intuitively.

Towards the end of week four, the controllers began to question why the labels were represented on a timeline. As they currently space aircraft crossing the outer marker in terms of distance rather than time, it seemed illogical to represent this distance between aircraft in terms of time.

When moving an aircraft label to a new position, the need to convert mentally the required spacing from a distance to a time seemed unnecessary, and could easily be performed by the computer. One suggestion was that the label should ‘snap’ to the correct spacing, taking account of wake vortex category, and computing the required time automatically.

Taking this a step further, it was suggested that time representation is maybe not needed on the AMD: only a representation of the arrival order on each runway, with the Arrival Manager logic taking care of the time calculations ‘behind the scenes’ including any requirements for holding. Any change to the sequence would highlight the other aircraft that would be ‘perturbed’ by such a change.

4.4.5 Trajectory Edition and Problem Solver (TEPS)

In common with the rest of the simulated airspace, the TEPS in approach presented the aircraft's trajectory and its associated no-go zones, although no interaction in terms of trajectory edition was possible. The majority of the approach controllers considered the no-go zones to be at best rarely correct, and they all agreed that these no-go zones offered them only poor visualisation of potential conflict situations in ETMA airspace.

When asked via the questionnaires whether they thought that TEPS has the potential to allow them to resolve conflicts in the TMA quickly and easily, the controllers responded with either "Never", or at most "Rarely". One controller stated that in approach airspace it would be very difficult to find a method of conflict resolution that performs well and another doubted the validity of no-go zones in approach airspace since the prediction process would lead to the generation of an unacceptably large number of zones. Most of the controllers could not comment any further on TEPS, other than to state that the philosophy of trajectory edition in this manner was worthy of further research.

4.4.6 Aircraft Advisories Display (AAD)

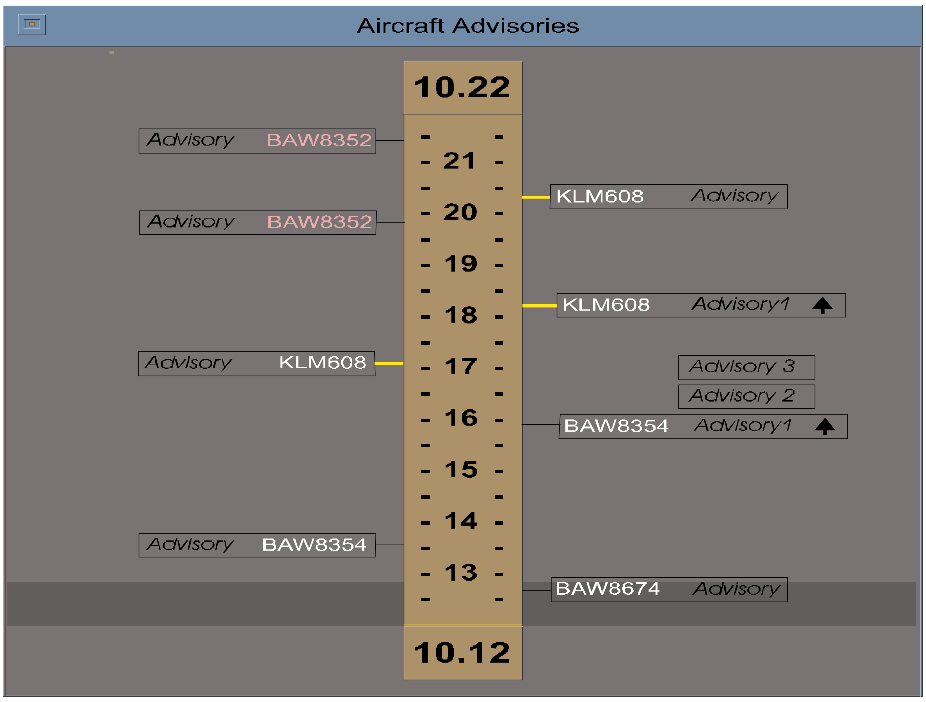


Figure 9: The Aircraft Advisories Display

Aircraft advisories never functioned properly during EEC PD/3, so the controllers gave the AAD very little attention. However, they were able to comment on its presentation. As for the AMD, they agreed that it was too big, and would be better suited to another screen.

It was questioned whether the ASP needed to see the advisories. Perhaps the only circumstances when such visualisation may be necessary is when assisting the TC.

4.4.7 Vertical View Display (VVD)

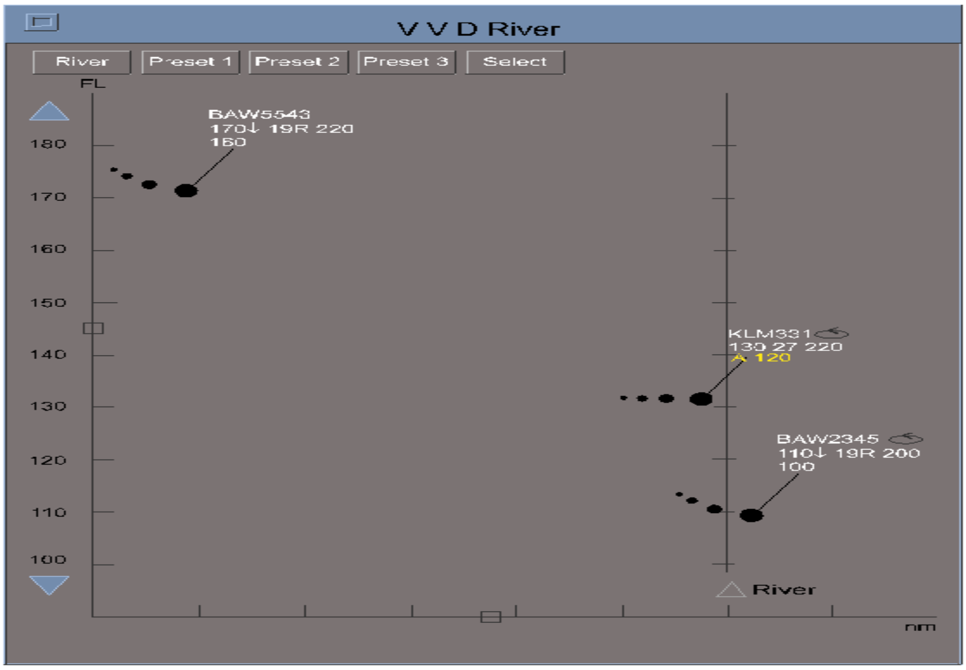


Figure 10: The Vertical View Display

Holding was never simulated. As a result, most of the controllers found it difficult to judge the usefulness of the VVD with respect to stack visualisation and management. However, in response to a question about how the VVD presents the location of holding aircraft, one controller was able to comment that although potentially a good tool it would be necessary to have a warning in the label in order to know when the aircraft have to leave the holding pattern. As for the AMD and AAD, the controllers found that the VVD covered too much of their radar displays.

4.4.8 Conflict Risk Display (CRD)

The CRD performed badly in EEC PD/3 and the approach controllers considered that there was little or no relationship between conflicts on the CRD and real ones. The CRD received unanimously negative feedback. All controllers agreed that there were always problems with the accuracy of its conflict detection, and that it was at most only rarely useful as a warning of potential conflicts.

5 FURTHER STUDY

During the EEC PD/3 simulation, a number of areas of concern regarding the concept in each of the different phases of flight were expressed by the controllers. Although these concerns were not based on sufficient experience with fully functioning tools, the comments do however merit repetition as they may provoke further studies related to the PHARE EEC PD/3 concept.

5.1 En-Route positions

A general view was expressed that several separate concepts seemed poorly combined. Whilst the potential benefits of each of the individual tools associated with the EEC PD/3 en-route concept are reasonably well understood and documented, further study is required in order to determine how the tools could work together and to identify areas requiring reinforcement or areas of redundancy.

A simpler system of 4D only in upper airspace with the use of direct routing and multi-sector planning was suggested. The base level of such airspace could be lowered as the number of equipped aircraft increased. Below this base level 3D and 4D aircraft would be treated the same using normal R/T control, but with the addition of advanced tools for conflict detection (MTCA and STCA).

Time layered planning (LAD / SLW) and Co-operative Tools (CT) were considered as not necessarily compatible, each using a different approach to problem resolution. The combination of both tools on a single CWP increases the HMI complexity and makes training and evaluation more difficult. Further studies could consider a separate presentation of these tools in order to determine their individual benefits.

The EEC PD/3 scenario provided a combined control system for 3D and 4D aircraft and a layered planning environment for Multi-sector then PC and TC control. The system is primarily targeted at 4D control and is most efficient in this area. An attempt has been made to incorporate 3D aircraft, while trying to maintain most benefit for equipped 4D flights. This has involved a redistribution of control tasks between PC and TC, where the PC becomes more tactically involved and the TC is left to implement ‘planned tactical interventions’ and react to unplanned situations. The TC becomes very system driven, and the degree of situational awareness both required and maintainable by the TC requires further investigation.

The entire notion of teamwork and the feasibility of the layered planning concept require further study as both were insufficiently demonstrated during EEC PD/3. The roles of the MSP, PC and TC and their ability to operate effectively within different timeframes should be demonstrated with emphasis on their individual needs regarding decision support tools. The ability of the MSP to perform an effective role in higher traffic situations requires further study.

For the PC, the notions of operating in a future (situational) time reference and the display of traffic at the proposed time of resolution (prosit time) were considered as not necessarily compatible, due to the need to manage different time references. Further study is required to determine the acceptability of displaying simultaneously information from three different time frames whilst retaining compatibility between them.

5.2 Approach (ETMA) positions

The approach controllers found it difficult to comment on the EEC PD/3 concept, as it had not been adequately realised for them to evaluate it. Nevertheless, some views were presented.

5.2.1 Arrival Management with 4D aircraft

The ASP had no interaction with 4D aircraft, in the 100% 3D scenarios played during EEC PD/3. The controllers stated that the ASP role would only become useful when 4D aircraft are introduced and the ASP is required to sequence a mixture of 3D and 4D aircraft.

Another controller astutely pointed out a potentially fundamental flaw in the EEC PD/3 concept of arrival management with 4D aircraft: "*In a situation with the sequence being 4D-3D-4D, with the 4D aircraft spaced at 6nm, I would either require direct control over the speed of the 4D aircraft, or I would need to see their speed in order to time the speed reduction for the 3D accurately enough. Otherwise the spacing would be lost.*" The underlying problem is that on final approach, in current operations, aircraft normally fly at equal speeds to enable accurate and efficient spacing between them. However, 4D aircraft may not necessarily follow the same speed profile, and thus their speed is unpredictable on final approach, making it difficult to manually space 3D aircraft between them.

Conflict resolution between 4D aircraft using TEPS was seen as part of the role for the ASP. Resolving conflicts in advance requires that the trajectories remain stable, and 4D aircraft navigate accurately enough to ensure this stability. This stability is less easy to achieve for 3D aircraft, particularly in approach airspace where many manoeuvres are necessary.

One controller was emphatic that in approach airspace, for safety reasons, all aircraft, including 4D, should call in as they come on frequency.

5.2.2 Advisories in approach

Arrival management using the Arrival Manager and AMD, and advanced conflict resolution using the TEPS, are both sensitive to aircraft deviations. If an aircraft deviates from its trajectory, then all benefit is lost and extra work is generated to either re-establish those aircraft on their trajectories, or re-plan them.

The EEC PD/3 concept requires that 3D aircraft are kept on their trajectories, by use of advisories. This should allow confident and accurate planning, such as sequencing arrivals and resolving conflicts, a long time in advance. In approach airspace, however, aircraft are required to perform many manoeuvres, some of them requiring very accurate timing to ensure efficient spacing between them as they cross the outer marker. For 3D aircraft, each manoeuvre would require an advisory to ensure they do not deviate from their trajectories. Although it was never tested during EEC PD/3, it may be the case that 3D aircraft would need so many advisories requiring high precision timing that it would be impossible for the controllers to prevent them all from deviating.

6 DISCUSSION

The EEC PD/3 experiment did not achieve its objectives within the context of PHARE due to the simulator functionality, which fell significantly short of the EEC PD/3 Design Specification. The aim of this document has been to describe the conduct of the EEC PD/3 simulation, and to highlight the controller comments which have a bearing on the PHARE concept, whilst placing these comments within the context in which they were gathered.

The training schedule for EEC PD/3 was considered to be ambitious given the number of different controller roles and tools involved in the scenario. Furthermore, the majority of controllers involved in the simulation were not familiar with the selected airspace which further augmented the training requirement.

It is important that controllers be able to perform the role of experimenters i.e. able to examine the concept and provide useful feedback. Although those controllers involved in this experiment gave useful feedback in so far as the platform would allow them, the complicated nature of the PHARE concept may provoke too steep a learning curve for those controllers without previous simulation experience using an advanced (ODID type) GHMI, and ultimately affect the integrity of the objective data gathered and hence the accuracy of the conclusions.

Classroom sessions were most successful when limited to a short time duration and concentrating on key areas (especially the intended virtues of each tool) and then were reinforced by operational experience on the simulation platform. The controllers stated that too much emphasis was placed on the methods of tool interaction rather than the anticipated benefits of a given tool. The CBT was of limited use due to its static nature and the fact that there were a number of errors and omissions in the package. The effectiveness of the CBT was certainly not aided by the inability to reinforce the ideas on the simulation platform.

Simplification of the platform and HMI appears necessary with consideration given to the number of new concepts and their interaction. This should be established and developed through a series of prototyping exercises (ideally involving a specialist controller team). A large scale demonstration and evaluation should only be reserved when the software has been fully integrated and tested, allowing controller evaluation of the concept rather than technical stability.

The EEC PD/3 sector configuration caused a number of problems and could either be simplified or a virtual airspace created more suitable for the application of direct routes and RVSM introduction (as in any case, the current airspace will be modified for these applications). Larger sectors with straight boundaries (compared to the current boundary between XNUN and BHWS which provoked up to 5 sector re-entries for a single flight when direct routes were applied) could also be studied.

Several controllers stated that the PC would not need to see the advisories in the right hand column of the APD as the timely issuing of these advisories is the role of the TC. Further study is required to determine the required format of the APD for both the PC and TC in order to cater for the unique aspects of their roles as well as to ensure that the tool allows the appropriate level of teamwork to be exercised.

The training phase highlighted the need to concentrate on the potential benefits to the controller of the various decision support tools. Prior to acceptance of a given tool it is natural that controllers investigate the integrity of the presented data as well as the various modes of interaction. It is only when controllers believe that a given tool provides both correct information in a manner closely aligned with their own cognitive processes, and facilitates a response that overall acceptance may be achieved. A particular example cited was the display of PROSITs at the system-determined ideal time for intervention. Controllers may consider the system more able to determine the time of loss of separation whereas the time of intervention lies more within their domain of training and expertise.

7 CONCLUSIONS AND RECOMMENDATIONS

The main conclusions to be drawn from the EEC PD/3 experiment are as follows:

- **The EEC PD/3 experiment did not achieve its objectives**

  However, controllers in each of the airspace groupings were able to give useful feedback relating to the presentation and data content of the individual PHARE advanced tools.

- **The training programme**

  The complexity of the various PHARE advanced tools and the required airspace knowledge meant that the training programme was ambitious. This was exacerbated by the inability to reinforce the ideas presented via CBT and classroom sessions on the actual simulation platform. The CBT proved to be of only limited usefulness due in part to its static nature and also to the presence of a number of errors in critical lessons.

  A great deal of time and effort was spent in preparing the material for the classroom lessons but the experience of EEC PD/3 showed that, despite the quality of the material, there will only be limited comprehension on the part of the controllers if the material cannot be reinforced dynamically on the simulation platform.

- **Correct mix of skills in the conduct team**

  The aim of providing a mix of expertise from operational, Human Factors and analysis domains within each of the controller groupings was considered to be a success. This combination of skills ensured that the maximum information was gleaned from the controllers in relation to the simulated platform.

The main recommendations arising from the EEC PD/3 experiment are as follows:

- **Simplify platform tools and HMI**

  Consideration should be given to the number of new concepts and their interaction. These aspects should be investigated through a series of small scale simulation exercises (ideally involving a specialist controller team).

- **Evaluate only when fully integrated and tested**

  A more focused demonstration and evaluation should only be reserved when the software has been fully integrated and tested, allowing controller evaluation of the concept rather than technical stability.

- **Training should concentrate on hands-on experience with more emphasis on what the tools are actually used for**

  Any future experiment should provide for significant hands-on experience during the training phase. As well as investigating the functionality and interaction with a given tool, the training should also highlight the intended benefit to the controller of the provision of such a tool. Despite the majority of lessons being given by operational experts during the EEC PD/3 main phase it was felt that this aspect of the training was neglected.

- **Simplified airspace options should be studied**

  The compatibility of the new concept and system assistance with airspace design should be considered, potentially via fast-time modelling techniques in the first instance.

- **Use similar conduct teams**

  Future experiments should use conduct teams with the necessary mix of skills required for the execution of a real-time simulation study and evaluation.

- **Further study**

  Further experimentation is required in order to fully test the EEC PD/3 concept in the different phases of flight. The topics discussed in Section 5 of this report should be considered under realistic experimental conditions. Specific aspects of the EEC PD/3 environment which have been highlighted as meriting further study are:

  - The suitability of automatically opening windows when information becomes pertinent (e.g. SILs, Message windows) as a means of reducing clutter on the RPVD
  - The need for a CRD and TEPS for different controller roles
  - The roles of controllers in relation to the resolution of conflicts outside their own airspace in conjunction with the TEPS
  - The usefulness of the sector traffic window in a scenario where the MSP can realistically assess the feasibility of sector balancing
  - A focus on the interaction on flows rather than individual aircraft for the MSP
  - The layered planning concept and the degree of interaction between the PC and TC
  - Optimised label content, better use of default values and more dynamic input methods in approach airspace
  - Development of a refined, simplified, AMD according to the controller role
  - Use of TEPS
  - The feasibility of advisories
  - Navigation functionality
  - Investigation of the situational awareness that is both required and maintainable by the TC.

8 ABBREVIATIONS

AFW	Area Flows Window
AMD	Arrival Manager Display (PATs)
APD	Activity Predictor Display
ASP	Arrival Sequence Planner
ATC	Air traffic Control
ATM	Air Traffic Management
ATMDC	Air Traffic Management Development Centre, Hurn (UK)
CBT	Computer Based Training
CDG	Roissy Charles-de-Gaulle Airport
CENA	Centre d'Etude de la Navigation Arienne (France)
CFL	Cleared Flight Level
CFMU	Central Flow Management Unit
CNS	Communication, Navigation and Surveillance
CP	Conflict Probe (PATs)
CRD	Conflict and Risk Display
CT	Co-operative Tools
CWP	Controller Working Position
EATCHIP	European ATC Harmonisation and Integration Programme
EEC PD/3	EUROCONTROL Experimental Centre PHARE Demonstration 3
ETMA	Extended Terminal Manoeuvring Area
FMS	Flight Management System
FPM	Flight Path Monitor (PATs)
GHMI	Ground Human Machine Interface project
HIPS	High Interactive Problem Solver
HMI	Human Machine Interface
INI	INItial approach controller
INSTILUX	EUROCONTROL Institute (LU)
ITM	InTerMediate approach controller
LAD	Look Ahead Display
MSA	Multi-Sector Area
MSP	Multi-Sector Planner
NATS	National Air Traffic Services (UK)
NLR	Nationaal Lucht- en Ruimtevaartlaboratorium (NL)
NM	Negotiation Manager (PATs)

OSD	Operational Scenarios Document
OTF	Operational Task Force (EEC PD/3)
PATs	PHARE Advanced Tools
PEL	Planned Entry Level
PHARE	Program for Harmonised ATM Research in EUROCONTROL
PROSIT	Problem Situation
PS	Problem Solver (PATs)
RFL	Requested Flight Level
RPVD	Radar Plan View Display
RVSM	Reduced Vertical Separation Minima
R/T	Radio / Telephony
SID	Standard Instrument Departure route
SILs	Sector Inbound Lists
SLW	Sector Load Window
STAR	Standard Arrival Route
TEPS	Trajectory Editor and Problem Solver
TMA	Terminal Manoeuvring Area/ Terminal
TP	Trajectory Predictor (PATs)
VAL	PHARE Validation Project
XFL	Exit Flight Level
3D	Three Dimensional
4D	Four Dimensional

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10 APPENDIX A – EEC PD/3 LESSONS LEARNT

In order to benefit as much as possible from this work, an internal 'lessons learnt' enquiry was undertaken after EEC PD/3. The resulting document was an honest assessment of the events and organisation surrounding the project. It is included here with the hope that it's content will form a positive contribution for others undertaking exercises similar to EEC PD/3.

A.1 INTRODUCTION

A.1.1 Purpose of this document

At the beginning of June 1998 an enquiry was commissioned into the conduct of the EEC PD/3 project at the Eurocontrol Experimental Centre (EEC). The project had recently terminated and had failed to meet any of its objectives. A 'post-mortem' enquiry was initiated, and was conducted by Eric Watkins. This appendix is adapted from his original report.

A.1.2 Overview of this document

The document is divided into five sections. Section zero is this introduction. Section 1 briefly covers the conduct of the enquiry: the method, scope, constraints, and objectives. Section 2 lists the people who provided information. Section 3 contains a compilation of views, problems, and analyses, classified by subject. Section 4 identifies the main process weaknesses which led to the failure of EEC PD/3, and section 5 makes some recommendations for process improvement at the EEC.

A.1.3 Terminology

This report addresses mainly the EEC PD/3 project at the EEC but also addresses some aspects of the global EEC PD/3 project. To distinguish between the two, the acronym **EEC PD/3** on its own refers to the project at the EEC and the phrase **global EEC PD/3** refers to the entire PHARE EEC PD/3 project which encompassed all of the individual projects of all of the partners and at all of the sites.

A.2 CONDUCT OF THE ENQUIRY

A.2.1 Constraints

The author had complete freedom regarding the conduct and content of the enquiry. Nevertheless the author's effort was limited and the time to deliver was short. It was thought that in the time available the benefits obtained by setting up a small team would not compensate for the overheads of team setup and coordination, so the author decided to work alone and to conduct an informal and short enquiry which consequently had to remain at a high level. The timeframe for the enquiry itself was set as: start enquiry 15 June 1998, deliver report 30 June 1998.

A.2.2 Method

Information was gathered mainly by interview but some documentation was sampled. Interviewees were chosen by the author, the intention being to interview all key players. In addition, an open invitation was issued to everybody at the EEC to contact the author if the person thought that he/she could usefully contribute to the enquiry. A few people responded to this invitation and they were interviewed or they supplied written information. Finally, less people were interviewed than the author had originally intended but the author feels that additional interviews would not have changed the recommendations significantly since most people expressed similar views and highlighted similar problems.

A.2.3 Scope of the enquiry

The scope of the enquiry was set as follows: from the beginning of the EEC PD/3 project to the present but concentrating on more recent events. The enquiry mainly addressed the EEC PD/3 project at the EEC but some consideration was given to EEC interfaces with the global EEC PD/3 project and to the global EEC PD/3 project organisation since clearly this impacted the EEC.

A.2.4 Objectives of the enquiry

- identify main process weaknesses
- make recommendations focusing on those areas that will provide the biggest improvement opportunity

A.3 PEOPLE WHO SUPPLIED INFORMATION

The order of the names is not significant.

Name	Mechanism	Role in EEC PD/3
Colin MECKIFF	Interview	1) EEC representative on the PATS project co-ordination group 2) provider of project engineers and some PATS
Jean-Marc GAROT	Interview	Chairman of PHARE Management Board (PMB)
Marco GIBELLINI	E-Mail	Configuration management expertise and service
Bob GRAHAM	Interview	EEC PD/3 Project Leader
Dave YOUNG	Interview	Provider of people, procedures, facilities, expertise
Marc BISIAUX	Interview	Global EEC PD/3 Project Leader
Chris CHICKEN	Interview	ESCAPE[3] project leader
Rob AYNSWORTH	Report	Build Manager
Peter MARTIN	memo	Early involvement in the project
Michel GEISSEL	Report	HMI data preparation, build and test
Richard BECK	Interview	Provider of expertise

[3] ESCAPE is the simulation platform of the Experimental Centre

A.4 VIEWS, PROBLEMS, AND ANALYSES

A.4.1 Global EEC PD/3 organisation and management issues

Abandonment of continuity between EEC PD/3 and PD1/2

The global EEC PD/3 project was originally planned as a combination of PD1 and PD2, in that their deliverables were to be the main inputs into the global EEC PD/3. In reality this did not happen and the global EEC PD/3 developed from scratch some of its components which did exist in PD1/2. This significantly increased the risk to the global EEC PD/3 project.

Small scale concept proving and integration as a prerequisite to large scale simulation

EEC PD/3 was organised as a large-scale real time simulation which, because of its size, required the use of the main real time simulation facilities. Consequently EEC PD/3 was synchronised with the real time simulation programme and was scheduled into an immutable slot. Such an organisation is inappropriate for experiments because of the large degree of uncertainty. EEC PD/3 had planned a series of small-scale concept proving exercises call IOCPs (Internal Operational Clarification Programme) which were designed to reduce the risk to the final simulation. These IOCPs made slow progress and were finally abandoned by the PMB largely due to the rapidly approaching fixed slot. This was certainly unwise since an essential step in the process was skipped and unproven components were injected directly into a large-scale simulation. In any case, the EEC PD/3 IOCP was conducted on a separate platform, none compatible with the final simulation platform.

Lack of trust and lack of a spirit of collaboration amongst the partners.

Distrust and competition between partners seem to have been the two main attributes of the partner relationship in the global EEC PD/3 project. This led to:

- duplication of some activities where a partner, because of lack of confidence, developed a component which was to be delivered by another partner
- lack of commitment in that plans and specifications were not adhered to
- lack of information exchange resulting in uncoordinated evolution and changes

A.4.2 Global EEC PD/3 technical issues

Lack of an overall system architecture at the application (PATS) level

An overall system architecture is a prerequisite for the successful development and integration of a complex set of co-operating tools. In the global EEC PD/3 project, concepts were translated directly into a set of tools to be developed by different partners but how these tools would co-operate at an architectural level seems to have been omitted. It seems that an overall architecture was subsequently developed but it was never made available to the ESCAPE engineers in a comprehensive, usable, and up to date form, despite repeated requests. This severely handicapped the integration activities. This problem may have been alleviated by the knowledge gained using the CMS PARADISE integration platform that was installed at the EEC, but this facility never worked satisfactorily.

A.4.3 Internal EEC organisation and management issues

Experiments and real time simulation slots

As explained above, a large scale real time simulation was planned as the final phase of the EEC PD/3 project. Such a phase is clearly an essential step towards eventual operational implementation of the concepts and tools, but the fundamental error is to schedule such a phase into a fixed slot years in advance. Experiments imply a large degree of uncertainty and progress is usually iterative and unpredictable. The experiment must be proven on a small scale before large-scale exercises can be scheduled and when this point of ability to schedule occurs cannot be accurately predicted in advance. In the case of EEC PD/3, the fixed slot coupled with a multitude of other problems meant that prior essential phases were shortened or cancelled and staff worked enormously excessive hours for long periods to try to meet the fixed time scale. Such behaviour is praiseworthy but is unacceptable as an organisational philosophy and it can have negative consequences in the longer term. It is clear that experiments must be decoupled from real time simulation slots.

<u>Management continually ignored expert advice and report red flagging</u>

Early on in the project many project staff were of the opinion that EEC PD/3 was over ambitious and that it would not work. As long ago as 1995 expert advice indicated that EEC PD/3 scale and complexity added to platform uncertainty and evolution would mean that it would be very difficult to meet the objectives in the planned timescale. The EEC PD/3 Project Management Plan (PMP) which was issued in Q3 1996 documented several high risk factors which had a relatively high probability of occurring. The project should not have been allowed to proceed without extensive and realistic risk reduction. Several go-nogo events were programmed but the non attainment of go criteria were apparently repeatedly ignored. In mitigation it can be said that attempts were made to reduce expectations and reduce scope, for example by the removal of the ATN component, and by the splitting of one distributed simulation into three separate simulations. Such measures were clearly not enough, and at the EEC they may have been neutralised by the increase in scope from en-route to gate-to-gate.

<u>Non-Technical Project Leader and lack of key resources</u>

The project leader had an operational background with a good track record as operational lead and project leader in real time organisational and study simulations, but had no technical experience and had not managed complex large-scale software and system developments. Two key positions of operational and technical lead were not resourced and consequently the project leader attempted to cover all three jobs, with resulting significant impact on his effectiveness.

<u>Lack of cohesion between different staff groupings at the EEC</u>

Several different staff groupings exist at the EEC. Concerning EEC PD/3 type projects the three principle groupings can be designated as follows:

- operational, people with an ATC background
- systems, people engaged in software and systems work
- research, people engaged in ATM functional research

At the EEC, large gulfs seemed to exist between the mindset and motivations of these different groupings which lead to lack of mutual understanding, and unwillingness of one grouping to be fully committed to projects ‘controlled’ by one of the other groupings.

A.4.4 Internal EEC Technical Issues

A.4.4.1 Inadequate test platform facilities and lack of rigour in integration and integration testing

The equipment in the experimental room is not hardwired in order to give maximum flexibility. Subsets of the equipment are configured according to project needs. One subset is configured on a more or less permanent basis as a testbed for applications being prepared for real time simulations or for any other exercise. It seems that the oldest equipment is configured on to the Testbed with the result that 2 of the 4 screens are unusable. The Testbed should clearly have first class equipment. It is a mistake to think that integration test equipment can be second best. This jeopardises one of the critical phases of the project. The testbed is shared among many users and groups of users. Because of the deliberate flexibility of the facilities, systems have to be carefully configured before the start of the test. This is not an easy process for a user without detailed knowledge of ESCAPE and EONS[4], and EEC PD/3 users lost a lot of time setting up the correct configuration and finding expert help. Later on in the project an ESCAPE expert was assigned to help EEC PD/3 users to configure the testbed and this did raise the efficiency of the test process. In its current form ESCAPE is slow to start. Clearly configuration difficulties coupled with slow system startup meant that useful testing time during a slot was often severely reduced. On the platform user side, there was an apparent lack of test plans and test scripts which meant that the testing was sometimes ad hoc and users had difficulty explaining to ESCAPE support engineers what precise test results should be expected thus making joint debugging very difficult. Moreover users did not always strictly conform to change management and problem reporting procedures resulting in uncoordinated evolution of ESCAPE components. One consequence of this is that the ESCAPE base version now contains some EEC PD/3 specific functionality which impacts the development of the next real time simulation.

A.4.4.2 General Computing Facility (GCF)

Standard computing tools and the equipment and networks which support them form the essential basic infrastructure for projects and for almost all other activities in a modern organisation. Such tools are in addition to project software development facilities. Such standard computing tools are essential for activities such as e-mail, information exchange, reporting, project document production, planning, and co-ordination. During the EEC PD/3 project, the service delivered by GCF was frequently poor and several long outages occurred. Such problems were compounded by incompatibilities between the facilities of different users because of an ad hoc approach to tool and system upgrades. All of these problems severely impacted EEC PD/3 productivity and morale.

A.4.4.3 IPAS[5] and data preparation

IPAS lacks batch type functionality which can be very useful for simulation data preparation. In this particular respect it is inferior to the mainframe facility which it replaced In addition, responsibilities between the Centres of Expertise involved regarding preparation staff allocation to projects is not clear. Preparation staff were

[4] EONS is the CWP display system at the Experimental Centre

[5] IPAS is the Experimental Centre's facility for data preparation and analysis.

taken off the EEC PD/3 project because of work which was allegedly of higher priority.

A.4.4.4 EONS in its current form requires highly skilled users

One of the long term (perhaps implicit) objectives for all ODS (Operational Data System) preparation facilities at the EEC has been ease of use, the ultimate aim being a facility which can be used easily by an operational expert to specify ODS displays and behaviour, and which can easily and seemlessly integrate at a technical level with simulators and other data preparation facilities. EONS in its current state does not seem to meet many of these criteria. The principal attribute seems to be flexibility which is certainly a highly valued attribute, but it seems to have been privileged over the other cited attributes. The EEC PD/3 user perception was inadequate change and version control, poor performance, and difficulty of use. It is not yet clear if the current ODS Prep Team will be able to acquire the necessary skills to use EONS effectively. Currently it seems that only an EONS skilled software engineer can effectively use EONS. The suitability of EONS to fulfill the complete range of EEC needs has still to be proven. It should be added that performance problems are to be expected when new technology is used to deliver enhanced facilities. These new facilities are not free and they have to be paid for with hardware investments to increase memory and processor capacity. The fact that this was not planned is a failing of project management.

A.4.4.5 Platform immaturity

Early on in the project, the EEC simulation technical group committed EEC PD/3 to a target platform which was being developed in parallel to the EEC PD/3 project and which was based on a different philosophy from the philosophy (CMS) used at other PHARE sites. This constituted a large risk which was correctly identified in the EEC PD/3 PMP. The late delivery, lack of performance, lack of stability, and lack of flexibility of the platform have all been cited by users. The degree of these deficiencies is debatable, but finally is not the important factor. What is important is that they existed to a certain degree and certainly all combined to contribute to the eventual failure of the EEC PD/3 project despite the fact that most PATS were eventually integrated into ESCAPE from a ‘software point of view’ by the end of the project. Clearly the choice of a non-CMS target platform had far reaching consequences. PATS were CMS compliant when delivered by other sites and they had to be stripped and rewrapped before integration onto the ESCAPE platform.

A.4.4.6 Network overload

It is frequently stated that network overload was one of the main technical problems encountered by EEC PD/3, that it was due to the middleware, and that this will be solved when the existing architecture (ARH-SPV) is replaced by a new system know as OASIS. It is true that large demands were placed on the network by EEC PD/3, but to say that this was due to the middleware is an over simplification. The application itself must bare a large part of the blame because of the poor overall application system design or even the absence of an overall application system design which generated a large amount of indiscriminate and unordered data exchange. For the future it is vital to understand that the transition form ARH-SPV to OASIS will not on its own solve this problem. What OASIS will provide is an additional set of functions which will enable application data exchanges to be filtered and reduced but it is still the application which must be modified to use the new facilities intelligently and thereby reduce network load.

A.5 MAIN PROCESS WEAKNESSES

A large number of problems and issues have been mentioned in section 3. This section lists the author's view of the main process weaknesses.

At the level of the global EEC PD/3 project:

- lack of trust in the partnership
- lack of overall system design

At the level of the EEC:

- no technical project manager
- wrong choice of target platform (but no other option existed)
- lack of adequate resourcing
- inadequate testing facilities and testing strategy
- inadequate small scale concept proving and integration testing
- poor general computing facility service
- strong coupling between experiments and the real time simulations programme and platform evolution

A.6 RECOMMENDATIONS FOR FUTURE EEC PROJECTS

A.6.1 Set trust and a spirit of collaboration at the heart of all future partnerships

It is essential that trust and a spirit of collaboration be at the heart of any cooperative venture. This was certainly lacking in the global EEC PD/3 project. Such elements are a prerequisite to the best use of total R&D investment in Europe and to the attainment of the objectives of the R&D Programme Review Group. How to achieve these essential elements in a competitive environment is certainly a challenge and is an issue which must be openly and fully debated during the initiation of any new collaborative venture. The guiding light must be the delivery of cost-effective ATM solutions within an overall win-win framework.

A.6.2 Strengthen projects and project management.

Some of the aspects which must be improved are:

- Give project leaders real authority so that they have total control over the allocated project resources and how they are deployed.
- Allocate adequate resources to a project and ensure that these resources are protected. Agreed changes to a project's resources either increases or decreases must be accompanied by a revised project schedule. In the case of EEC PD/3, designers and integrators and dedicated platform support were all missing.
- Locate all project staff in a single project space.
- Improve risk management skills and ensure that risk identification, management and monitoring are effective
- Develop fact based and realistic decision making and monitoring at all levels. It should be impossible for management, at all levels, to ignore well informed expert advice.
- Make it mandatory that experiments execute successfully on a small scale before scaling up is scheduled

A.6.3 Improve the EEC General Computing Facility as a matter of utmost urgency

The General Computing Facility (GCF) is the single most important EEC service. It has been consistently delivering a poor service which has a catastrophic effect on the productivity and morale of the whole EEC and which had a non-negligible impact on the EEC PD/3 project. The main GCF deficiency is lack of service and customer orientation. Other deficiencies certainly contribute and combine to produce this main end user deficiency. Whether GCF is also lacking resources has to be verified. All reasonable means must be deployed to improve the GCF service as a matter of urgency.

A.6.4 Decouple experiments from the real time simulation programme

As explained above in section 3.3, it is a fundamental error to plan years in advance large scale exercises based on results of experiments and involving large numbers of controllers. The experiment must be a success before a large-scale exercise can be planned. It is clear that a totally sequential process may be unsatisfactory, but it is clear also that to schedule the large scale exercise too early, before there is a strong likelihood that the experiment will be a success, can be an extremely costly and wasteful undertaking.

A.6.5 Decouple experiments from the evolution of the real time simulation platform

It has been pointed out in section 3 that platform immaturity contributed to the failure of the EEC PD/3 project. The main EEC real time simulation platform has to evolve to respond to many different requirements. This evolution is inevitable, even vital, to the continued credibility of the EEC and as an enabler for EEC strategy deployment. The key issue here is that experiments do not need the latest version of the full scale real time simulation platform.

Main requirements for the experimental platform are:

- stability
- availability
- independence
- existence of good technical support service which has high availability
- small scale
- and it is highly desirable that it be compatible with the main real time simulation platform in order to facilitate scaling up and porting of proven experiments

In order to fulfil the last requirement the ideal situation is that the experimental platform be a scaled down version of the real time simulation platform thus ensuring 100% compatibility. However, to satisfy other criteria, total synchronisation with platform evolution must be avoided. Rather, a new delivery of the real time simulation platform to the experimental facility should be made only when the real time simulation platform is stable and proven and the delivery of the upgrade should be requested and controlled by the users of the experimental platform.

A.6.6 Divorce operational expertise from specific service delivery

The lack of cohesion between different staff groupings at the EEC has been cited above in section 3. This lack of cohesion is addressed to some degree by the recommendation which deals with the strengthening of projects and project management. Two other related issues need to be addressed:

- the difficulty of resourcing experiments with operational expertise
- the organisation of people having operational expertise which is currently too rigid.

Both of these issues can be addressed by removing the fixed link between operational staff and the service which is delivered such as the fast time simulation service and the real time simulation service. This measure will also address a related issue, that of the desirability to benefit real time simulations from fast time and airport simulation knowledge and skills and vice versa. This will benefit the EEC from the point of view of cross fertilisation and increased people allocation flexibility, and will benefit the people themselves by widening their knowledge and skillset. It is therefore recommended that an organisation be found whereby all operational skills are pooled and are made available to projects in a flexible and equitable manner.