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HARMONISED AIR TRAFFIC
MANAGEMENT RESEARCH
IN EUROCONTROL

PHARE

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PD/1 OPERATIONAL SCENARIOS

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EUROCONTROL
rue de la Loi 72
B-1040 BRUXELLES

Prepared by: R M Gingell
S A Fox

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PD/1 OPERATIONAL SCENARIOS

	NAME	SIGNATURE	DATE
AUTHOR 1	R M Gingell		
AUTHOR 2	S A Fox		
PD REVIEW TEAM LEADER	M. van Gool		
PHARE PROGRAMME MANAGER	H. Schröter		

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1. SCOPE

This document details the operational procedures to support PD/1. Details of the operation of the HMI to support these procedures will be developed during the facility test. This document forms the output of task PD1-7.1.

PD/1 is a collaborative venture between the PHARE partners which is being hosted by the CAA at DRA Malvern. The collaboration takes the form of consultancy to tasks led by CAA and deliverables to PD/1 from other PHARE projects. Details of the effort and deliverables to PD/1 are given in the "Demonstration Project Plan for PHARE DEMO 1 (PD/1)", reference 1.

There are major deliverables to PD/1 which have a direct impact on the development of the facility, the scenarios to be executed and the detail of the operational procedures, these are as follows:-

- the GHMI specification which is being delivered by the PHARE GHMI group
- the experimental validation concepts and measures which are being derived by the PHARE Validation and Tools group
- the computer assistance tools that are being provided by the PHARE Advanced Tools (PATs) group

The facility to support the PD/1 will be complete when these groups have delivered and the hosting site team has performed the integration and testing. A full description of the facility to support PD/1 can be found in the PD/1 Facility Specification, reference 2. The PD/1 Operational Specification, reference 3, provides a top-level description of the PD/1 operational concepts. The traffic samples will be provided as the output of task PD1-7.2.

Where reference is made to Related Documents the version and issue of such documents will be the most recent as specified in the Configuration Control document (see Related Documents).

2. INTRODUCTION

Today's ATC system in Europe (and elsewhere) is at times unable to handle the demands made upon it. Flow restrictions imposed to safeguard the system from overload often lead to delays during peak periods. In many of the less busy areas in Europe, the required capacity goals can be achieved by well-proven technology and procedures, representing "best current practice". In the busiest areas, however, the scope for increasing capacity through existing ATC methods and technology is limited. Although developments as regards airspace, routes and sectorisation undoubtedly must and indeed will be pursued, changes in the technology and the process of ATC must also be envisaged if capacity and productivity gains are to be secured. The limiting factor in the present ATC system is the capacity of the controller. A means has to be found by which the controller can be enabled to handle a larger number of aircraft in a given airspace without significant increase in workload. This will have to be achieved whilst maintaining or improving system safety.

One proposed method is by providing automated assistance to both the Planning and Tactical Controllers and, by the application of data links for air to ground communication. The provision of automated assistance to the controller will support him in the resolution of conflicts and in planning efficient use of the airspace. The introduction of datalink to communicate between the airborne systems and ground environment will remove some of the current communication load from the controller and in addition enable the use of onboard data to improve the precision of the ground system's aircraft model for track prediction and conflict prediction. In providing such support and removing from the controller and pilot certain executive tasks by means of direct computer to computer communication, it is necessary to ensure that the tasks removed from the pilot and controller are those which are best executed by computer and those which remain are those best executed using the flexibility and adaptability of human skills. The areas where computer support is expected to yield improvements are the accurate predictions of future aircraft profiles, the analysis of potential options for the resolution of conflicts and sequencing of aircraft for optimum use of airspace and runways. These, together with the monitoring of flight execution, could provide a support environment that would allow a safe reduction in aircraft separation. To achieve this, detailed aircraft performance data, meteo condition information and criteria concerning aircraft operational requirements would need to be made available to the ground environment using data link communications. These proposals raise a number of questions concerning the resulting division of responsibility and tasks between the aircraft and the ground. Proposed solutions for this responsibility sharing will need to take into account, *inter alia*, the relatively small bandwidth of the available data links and the differing strengths and weaknesses of the human and the computer. It is to answer some of these questions that the developments within the PHARE Programme have been proposed.

PHARE, has developed the necessary ground and airborne tools that will be initially evaluated as individual components. To evaluate the performance of the resulting air/ground integrated ATM system, a series of real time simulations entitled "PHARE Demonstrations" will be executed in which the proposed options will be compared and recommendations made on the contribution such automated support could make to the future European ATM system. The PHARE Demonstrations will be initiated by separate simulations of the en-route and TMA environments that will take place concurrently.

This simulation is run in the context of a demonstration of some of the PHARE tools.

3. OBJECTIVES OF THE SIMULATION

3.1. GENERAL

- Validation of the EATCHIP concepts;
- Partial definition of the description of the future Air Traffic System concepts.

3.2. SPECIFIC

PD/1 is intended to demonstrate the quantitative capacity and productivity change resulting from the introduction of computer assistance tools and data link facilities. The environment will be en-route airspace in the time scale circa 2000 simulating several en-route sectors and emulating entry and exit conditions at TMA sectors. It will be hosted by CAA at DRA Malvern. It is envisaged that the controller's basic roles of Planner and Tactical will not be subject to major changes but assistance will be provided in terms of "computer assistance tools" and datalink. The new elements will support the definition of a new control method, still based on current practices, but improved and adapted to provide "look ahead" facilities and conflict free planning. The fact that ATC will be performed in a similar manner to today's operation (i.e. maintaining the basic roles of Planner and Tactical together with the same sectorisation) will considerably reduce the number of options to be considered. The sectors to be used for the simulation will be the UK New En-Route (NERC) sectors 10 and 11.

These objectives can be summarised as follows:

1. To determine the effect on controller workload and traffic throughput of the introduction of computer assistance tools from the PATs programme.

2. To determine the effect on controller workload and traffic throughput of the increasing proportion of 4D FMS aircraft with full duplex datalink.

3. To gain a degree of controller approval for the introduced computer assistance.

4. ORGANISATIONS

PD/1 is a real-time simulation comprising three "organisations". The major concepts which characterise the different organisations are as follows:-

- the introduction of advanced computer assistance tools to assist the Planning Controller with his task of planning conflict free trajectories through his sector;
- the increasing use of datalink functionality and the resulting increased information content.

PD/1 will simulate a two-man sector operation applied to the NERC sectors 10 and 11. Each sector will have a Tactical Controller (TC) and a Planning Controller (PC). A full description of the simulated airspace is contained in the PD/1 Facility Specification, reference 2.

There will be no paper flight strips, the information that is normally held on the flight strips will be presented to the controllers electronically. The information will be presented to the controllers in a number of ways using various Human Machine Interface techniques.

PD/1 will comprise of a number of experiments that will test the effect of the introduction of computer assistance tools and of increasing proportions of 4D FMS equipped aircraft to the traffic sample on the controller workload. Initially a Reference System will be developed which will provide a baseline against which to measure the effect on performance of the introduction of computer assistance tools, 4D FMS aircraft and datalink facilities.

There will be three "Organisations":-

- ORG 0 Reference Baseline organisation
  - up to 10 minutes of planning anticipation (as in current systems);
  - mixed aircraft population (as foreseen for year 2000) with 3 flow rates (low, medium and high);
  - current controller roles of Planner and Tactical will be maintained;
  - derived from ODID III (Organisation 2) which operates without paper flight strips and with simple tools based on 10 minute look-ahead (e.g. Conflict Risk Display, Entry/Exit Aids);
  - airspace NERC sectors 10 and 11 with adjacent feed sectors.

- ORG 1
    - up to 20 minutes of planning anticipation;
    - mixed aircraft population (as foreseen for year 2000) with 3 flow rates (low, medium and high);
    - computer assistance derived from the PATs PD/1 Toolset:
        - Conflict Probe (CP)
        - Trajectory Predictor (TP)
        - Flight Path Monitor (FPM)
        - Problem Solver (PS);
    - controller methods reflect the extended look ahead and conflict free planning;
    - downlinked data is available from aircraft;
    - airspace as ORG 0.

- ORG 2
    - computer assistance as for ORG 1 with the inclusion of the PATs Negotiation Manager;
    - mixed aircraft population (as foreseen for year 2000) with 3 flow rates (low, medium and high). 30% and 70% ratio of 4D FMS equipped aircraft introduced in traffic samples; a live aircraft, the DRA (Bedford) BAC 1-11 will be included in this Organisation.
    - two-way datalink capability within pre-defined protocols, 4D trajectory and ATC clearance exchange;
    - airspace as ORG 0.

To support these organisations two software systems will be constructed to run on the same platform, one to support the reference organisation and the other, an advanced system incorporating the advanced computer assistance tools, to support the subsequent organisations. All the facilities required for ORG's 1 and 2 will be provided in the advanced system build. The essential differences in the advanced organisations (ORG's 1 and 2) relate to operational procedures and the inclusion of 4D FMS aircraft in the traffic sample therefore the underlying platform can remain the same. By not including 4D FMS aircraft in the traffic sample for ORG 1 those aspects of the facility relating to the handling of 4D FMS aircraft will not be invoked.

5. CONTROLLER WORKING PROCEDURES

5.1. ORGANISATION 0

The procedures used for ORG 0 will be based on those used in NERC. This is a task sharing environment with a Planning Controller (PC) and a Tactical Controller (TC) responsible for each sector. The PC has an advisory role with the TC always having the full Executive role. Facilities are provided for electronic co-ordination and system update together with full telephone/intercom communication facilities. It is intended that the two positions are immediately adjacent.

5.1.1. Planning Controller (PC)

The role of the PC will be one of co-ordination of traffic offered into his sector and co-ordination of traffic leaving his sector. He will continually compare information he has available on sector inbound traffic with the traffic situation within his sector to determine whether any potential conflicts exist. This includes sector entry, sector exit and sector transit conflicts. If a potential conflict is identified then he will attempt to negotiate new entry/exit conditions with the requisite sector.

The PC has available to him the following facilities with which he can interact to expedite his duties:-

- A Plan View Display (PVD) - The PVD provides a processed radar picture displaying aircraft positions, coastline, airspace points, airways and overlayed sectors, including restricted zones. Associated with each aircraft is an area of text describing the current status of the aircraft. This is termed the Radar Label or Track Data Block (TDB). Provided with the PVD is a comprehensive set of functions to manipulate the airspace features displayed, the positioning of TDB's, zoom and pan of the radar picture, and the provision of range and bearing functions. Figure 1 shows a typical PVD.

- Track Data Blocks - each data block contains a mixture of current and planned information relating to the individual aircraft. In addition the blocks are coloured to indicate the current ATC state in terms of aircraft control, co-ordination and transfer of control between sectors. From the block the PC can invoke functions to update the system including flight levels, speed and heading.

  The basic format of the full TDB is illustrated in the diagram below:

SSR Code		
Callsign	Next Sector	
Actual Flight Level (AFL)	Exit Port (XPT)	Ground Speed
Planned/Cleared Flight Level (PEL/CFL)	Exit Flight Level (XFL)	
Assigned Heading	Assigned Speed	

  Note: The above shows the full TDB format, however a concept of minimum information has been adopted. This results in fields being removed in certain

  circumstances (see section 5.1.1.1.1) and therefore the TDB will take on a different shape/size. The shape of the TDB will therefore provide an indication of the work remaining to be performed by the controller. An example TDB is shown in figure 1 for aircraft UKA875.

- Message display windows, as follows:-.

  - Sector Inbound List (SIL) see figure 1 - The Sector Inbound List is a window which displays the status of aircraft which are due to enter the controlled sector through a specific waypoint, with the waypoint name providing the SIL title. The display consists of a list of aircraft currently flying towards this waypoint. The SILs can be moved to any position on the PVD, but are generally moved to a position close to the geographic location of the waypoint. Each entry in the list contains the Expected entry time, the Callsign, the Planned Entry Level (PEL), the aircraft type, the Planned Exit Port (XPT), and a tick to indicate if co-ordination between this and the previous sector is in progress. **Once the TC has assumed control of the aircraft, the information is removed from the Sector Inbound List.**

- The Message In/Out windows see figure 1, display the co-ordination messages passed between adjacent sectors. The Message In window displays an incoming message in black text, and provides functions to accept a new value by clicking on the new value field (displayed in white text), or to counter propose a value by clicking on the original value field (displayed in yellow text). The Message Out window simply displays an outgoing message in white text. Messages displayed are for PEL, Exit Flight Level (XFL), speed and transfer/assume.

5.1.1.1 Sector-Sector and Intra Sector Co-ordination

Sector-Sector and intra sector co-ordination comprises three aspects, co-ordination with the previous sector for aircraft entering the sector, co-ordination with the following sector for aircraft leaving the sector and co-ordination within the sector with the TC.

5.1.1.1.1 Inbound aircraft

The PC will receive information on an aircraft inbound to his sector, termed *advanced information*, via the aircraft TDB and the message displayed in the corresponding SIL. The display of *advanced information* signals the beginning of the co-ordination procedure for the PC.

The sequence of co-ordination events will be as follows:-

1. The PC will be alerted to the incoming aircraft via the appearance of a message in the SIL and, if co-ordination is being requested, the Message In window. The TDB will change to the *Advanced Information* state.

    The TDB text colour changes from GREY (the not concerned state) to SALMON PINK. In addition to the SSR code and callsign information, the name of the next sector is added to line two, and additional information indicating actual flight level (AFL), the sector exit waypoint (XPT), the ground speed is added to a third line, and the PEL and XFL are added to a fourth line of the TDB. The PEL field becomes the Cleared Flight Level (CFL) when the aircraft enters the sector. If the PEL/CFL and XFL levels are the same, only one value is displayed. If the PEL/CFL, XFL and the AFL are the same just the AFL is displayed in line three. This reduction of data displayed in the TDB is known as *minimum information*.

2. The PC will assess the information provided in the TDB/SIL and any co-ordination request information displayed in the Message In Window to determine his course of action.

   If co-ordination is being requested on the incoming aircraft (e.g. flight level) then a 'tick' symbol will be added to the message in the SIL and the respective field in the TDB or in the message displayed in the Message In window will be highlighted. In figure 1 aircraft UKA875 is about to enter sector 10 and the previous sector is requesting a change of PEL from 310 to 330. This information as can be seen from the figure is indicated by a highlighted green field in the TDB and a message in the Message In window with the requested field highlighted in yellow. The ‘tick’ in the SIL indicates that co-ordination is taking place. The PC can interact with this field, wherever it is displayed, either to accept the value proposed or to counter-propose a value with the following consequences:-

- If the PC accepts the proposed value then the co-ordination will be complete and the 'tick' symbol will be removed from the SIL. The PC can now tell his TC that the aircraft is ready to be accepted into the sector.

- If the PC has made a counter-proposal then a message will appear in his Message Out window indicating the counter proposal value and a corresponding message will appear in the Message In window of the proposing sector. If the proposing sector accepts the counter proposal then the co-ordination will be complete and the 'tick' symbol will be removed from the SIL The PC can now indicate to his TC that the aircraft is ready to be accepted into the sector.

- If the PC has made a counter-proposal then a message will appear in his Message Out window indicating the counter proposal value and a corresponding message will appear in the Message In window of the proposing sector. If the proposing sector rejects the counter proposal then the co-ordination sequence will be terminated and a display message will indicate that a voice communication will be required to resolve the co-ordination. Following successful resolution of co-ordination by voice the PC can indicate to his TC that the aircraft is ready to be accepted into the sector. **NB This one proposal/counter-proposal cycle limit to electronic co-ordination may be reviewed following experience with the pilot phase experiments.**

If there is no co-ordination being requested by the previous sector then the PC can assess the information given and either indicates to his TC that the aircraft is ready to be accepted into the sector or he can propose a change. The propose/counter-propose/acceptance cycle then operates as above but in this case the PC is the instigator of the initial proposal for change rather than the previous sector.

5.1.1.1.2 Aircraft outbound from sector

When the aircraft has been accepted into the sector by the TC (see section 5.1.3.1) the PC will co-ordinate with the next sector when required. The PC will assess the information available to him, plan the aircraft's progress through the sector and decide if any co-ordination is required.

If the PC decides a co-ordination proposal is required e.g. a change of flight level then the following sequence of actions is required:-

- The PC will determine whether the aircraft is available for co-ordination with the next sector. This will be dependent on whether the next sector has received *advanced information* on the aircraft (see section 5.1.1.1.1). The criteria for *advanced information* to be made available to the next sector is an event related to the proximity of the aircraft to the sector boundary. If the PC wishes to instigate co-ordination prior to this event then he can force the provision of *advanced information* to the next sector. This is termed a "**FORCED ACT**". An indication of when the *advanced information* is available to the next sector is provided to the PC through the sector indicator field in the TDB.

- The PC can interact with the Exit Level field in the TDB to propose a new value. This will result in the field being highlighted in the TDB and a message being placed in the Message Out window. In the following sector the course of events as described in section 5.1.1.1.1 will occur.

- The co-ordination sequence of proposal/counter proposal described in section 5.1.1.1.1 applies.

When co-ordination is complete the PC informs his TC that updated clearances can be provided to the aircraft.

5.1.2. Summary of PC task

The PC will use flight information, in association with radar data to identify and assess potential conflicts with aircraft offered into the sector under inter-sector co-ordination procedures or Transfer of Control agreement from adjacent Area Control Centres (ACC's).

Notify subsequent sectors, and TC of XFL.

Notify TC of:

a. acceptance of co-ordinated traffic into the sector
b. any traffic accepted into the sector which requires radar monitoring or intervention
c. any special conditions applying to the transfer of aircraft to or from the sector

5.1.3. Tactical Controller (TC)

The TC will be responsible for ensuring conflict-free passage of aircraft through his airspace. He shall perform all direct communication with the aircraft in his sector and will be responsible for all transfers. Transfer of Control is coincident with the sector boundary (or other defined position) unless the aircraft is operating under a Standing Agreement. In this case, Transfer of Control is coincident with Transfer of Communication provided that the receiving controller does not descend an outbound or climb an inbound and keeps the aircraft on any assigned heading or speed, until within the confines of the receiving sector.

The offering TC shall be responsible for ensuring that co-ordination takes place before an aircraft reaches the adjacent sector's airspace.

With transfers the transferring TC must ensure before transferring communication that:

a. The aircraft is either at or will make the (XFL) displayed on the label before the sector boundary.
b. The aircraft is not in potential conflict with traffic within or entering the offering sector's airspace, whether in communication with that sector or not, unless notified to the receiving sector before transfer.
c. The planning separation of 15 nms exists for aircraft on same route, without vertical separation.
d. Any conditions agreed between the respective PCs have been met.

If any of the above conditions cannot be met a new co-ordination must be effected.

When an aircraft is to be transferred from one sector to another with a heading or speed restriction, the information is to be passed to the receiving sector of ACC by one of the following methods:

a. by telephone before communication is transferred or,

b. by instructing the pilot to report the restrictions on his first call to the receiving sector.

N.B. NERC sector to NERC sector. The receiving sector TC cannot release an aircraft from its radar heading until it is within the confines of his sector.

The HCI facilities provided for the TC to perform his task are similar to those provided for the PC. see section (5.1.1). The sequence of actions the TC has to perform can be considered as accepting traffic into his sector, controlling traffic within his sector and transferring traffic to the next sector.

5.1.3.1 Accepting traffic

The TC will be alerted to the fact that an aircraft is being transferred to him from a previous sector when he receives an R/T call from the aircraft and the system provides him with a visible indication via a change in the TDB state. The TDB will change from the *Advanced Information* state described in section 5.1.1 to the Assume permitted state:-

> This state indicates that the controller is free to assume control of the aircraft. This is indicated by highlighting the sector field of the Advanced Information state TDB described in section 5.1.1. The remaining fields in the label are drawn in SALMON PINK.

If the TC is satisfied with the flight levels of the aircraft and he has had an R/T call from the aircraft then he will update the system by accepting the aircraft using the *ASSUME* on the Callsign Menu. An indication that the TC has accepted the aircraft will be provided via a change in state of the TDB. The TDB will take-on the *ASSUMED* state:-

> This state indicates that the TC now has control of the aircraft. The label text colour changes from SALMON PINK to WHITE. The contents of the label are the same as described for the *Advanced Information* state.

If the TC is not satisfied with the flight levels he will negotiate with the TC of the offering sector. As described in section 5.1.1.1 the co-ordination will be performed by PC to PC action, however the TC will update the system by assuming or transferring aircraft.

5.1.3.2 Transferring traffic

After having accepted an aircraft into the sector the TC will provide tactical directives and clearances to the aircraft to enable it to progress conflict free through his sector. The tactical will provide clearances to the aircraft to enable it to exit the sector on the co-ordinated flight levels. To enable the TC to perform this task he will use the information provided to him by his PC. The PC provided information will be visible in the TDB and it will be the TCs task to convey, via R/T, the clearance to the respective aircraft. When the clearance has been given to the aircraft the TC will update the system by entering the cleared flight level by interacting with the TDB. When the TC is satisfied that the aircraft is in a position to exit the sector at the co-ordinated levels he is in a position to offer the aircraft to the next sector.

Prior to offering the aircraft to the next sector it is necessary that the next sector has *advanced information* on the aircraft concerned. The TC will have an indication that the next sector has advanced information when the next sector field is indicated in the TDB.

The TC offers the aircraft to the next sector by interacting with the TDB. the TDB adopts the transfer state as follows:-

> This state indicates that the controller has transferred control of the aircraft into the next sector. This state is entered after invoking either the **TRANSFER** or the **RELEASE** option on the Callsign Menu. The label text colour remains WHITE, with the next sector indicator highlighted in GREY see figure 1 for aircraft with callsign NOS052.

When the next sector TC has accepted the aircraft the TDB in the transferring sector will change to the concerned state as follows:-

> This state indicates that the controller is no longer in control of the aircraft, having transferred control to the next sector, even though the aircraft is still flying in the controller's sector. The label text is coloured MUSTARD. This state is entered after the controller in the next sector has assumed the aircraft.

5.1.3.3 Summary of TC Task

The TC's tasks can be summarised as follows:-

1. Check current situation
2. Select next aircraft for attention
3. Check related flight plan information
4. Check and co-ordinate PC generated information
5. Check for conflicts
6. Determine next control actions
7. Negotiate entry and exit conditions with adjacent sectors if necessary
8. Communicate with aircraft
9. Update system

5.2. ORGANISATION 1

The operational scenario described in the following sections represents an initial scenario for the advanced PD/1 Organisations characterised by the inclusion of PATs. It has been compiled following discussions with the GHMI group reference 4. It will be subject to refinement during the Facility Test and the Pilot Phase.

The scenario differs from ORG 0 by the quality of information provided to the TC from the PC. The inclusion of computer assistance tools will enable the PC to provide his TC with more accurate prediction data than in ORG 0. The PC generated information should provide directives (manoeuvres) to be communicated by the TC to the aircraft to solve potential conflicts within his airspace. The provision of this data should reduce the effort expended per aircraft and hence enable the TC to handle a greater number of aircraft.

5.2.1. Planning Controller

In ORG 1 the PC will be equipped with computer assistance tools (Trajectory Predictor, Conflict Probe, Flight Path Monitor and Problem Solver) to enable him to provide additional support information to his TC through the mechanism of advanced planning. The objective being to reduce the control effort required by the TC per aircraft and hence enable the TC to handle a larger number of aircraft through the sector.

The PC will monitor and perform his tasks with reference to a 'lookahead' traffic situation. Under normal conditions a prediction window will be selected so that it covers the width of the PC's sector including the exit conditions thereby enabling a complete sector transit plan to be produced. His major responsibilities will be:-

– acceptance of co-ordinated traffic into the sector;

– production of a conflict free sector transit plan;

– provision of information and directives to his TC where conflict resolution cannot be clearly planned in advance;

– planning and co-ordinating exit conditions with the following sectors.

The time threshold for the PC's planning activities will nominally be 20 to 25 minutes ahead however although a prediction will always be available a clearance may not always be available for this time ahead. The extent of the clearance will need to be considered by the PC during his planning to avoid unnecessary planning/replanning activities. The possible sequence of operations are shown in figure 5.2.1.

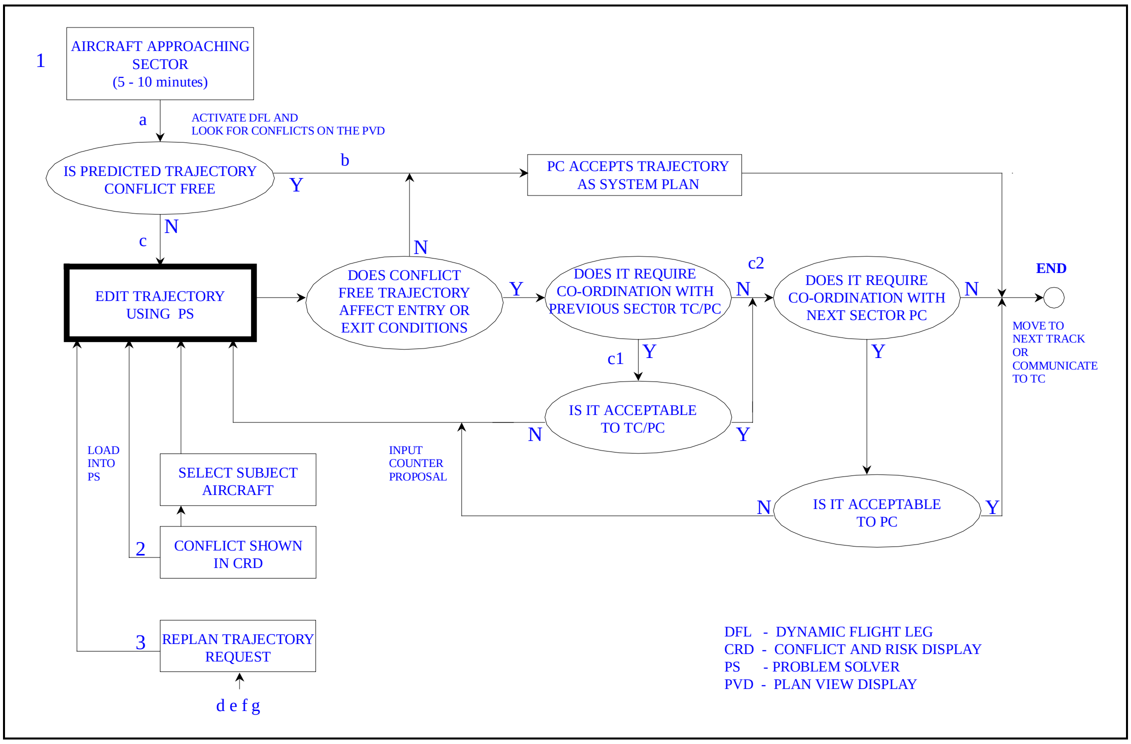

Figure 5.2.1 - ORG 1 PC Activities

5.2.1.1 Monitoring Advanced Information

The traffic sample for ORG 1 comprises 3D aircraft equipped with datalink for downlinking of aircraft parameters to assist the ground based Trajectory Prediction. It is expected that a usable prediction, given the likely errors with time, for this aircraft fit is likely to be between 20-25 minutes. Given this and the aim that the prediction window should ideally cover the PC's sector (including exit conditions to the next sector) leads to the PC commencing his task when the aircraft is 5 -10 minutes from his sector boundary. The sequence of operations is as follows (starting point 1 on fig 5.2.1):-

a. The PC will be provided with information relating to an aircraft, through the normal label and optionally through the extended label, when the aircraft is 5-10 minutes from his sector boundary. By invoking the Dynamic Flight Leg (DFL) a line showing the predicted trajectory for the selected aircraft will be displayed on his Plan View Display (PVD). Selecting the DFL for a specific aircraft will display the information relating to that aircraft in the Problem Solver (PS) windows.

b. If the predicted trajectory across the sector is conflict free the entry conditions are acceptable and the exit conditions conform with standing agreements or sector handover rules then the PC will accept the plan and update the system trajectory.

c. If the trajectory is not conflict free then the PC will use the PS to edit the trajectory and produce a proposal for a conflict free solution. Dependant on the proposed solution two courses of action will result as follows:-

    c1 if the proposed changes are solely within the PC's sector and do not impact on the entry or exit conditions then PC will propose control directives (manoeuvres) to his own TC for subsequent actioning.

    c2 if the proposed plan requires non-standard exit conditions or it could potentially result in a conflict in the next sector then the PC must co-ordinate/negotiate with the PC of the next sector. If the entry conditions require modification then the PC must negotiate with the previous sector TC/PC. Counter proposals from the next sector PC or TC will be resubmitted to the PS and the cycle of negotiation repeated if required.

5.2.1.2 Conflict Resolution

The PC task will address the resolution of system detected conflicts using a time ordered approach. This task will be executed through the selection of a conflict (from the Conflict and Risk Display CRD). The PC will select an aircraft from a conflict pair on the CRD (starting point 2 on fig 5.2.1) and the requisite aircraft trajectory will be loaded and displayed in the PS. The sequence of actions will then be as point c in section 5.2.1.1.

5.2.1.3 Request for Replanning

Requests for replanning could arise from 4 sources (starting point 3 on fig 5.2.1):-

a. The PC on the following sector who requests a modification to his sector entry conditions.

b. An aircraft which has deviated from its trajectory (as detected by the Flight Path Monitor FPM) and has been subjected to Tactical Intervention.

c. An aircraft requesting a new trajectory.

d. Tactical intervention e.g. STCA or an emergency

In case d) above the PC will enter the proposed modifications to the trajectory from the following sector PC into the PS and generate a conflict free trajectory. He will negotiate with the following sector PC if required.

In case e) the trajectory will be treated in the same manner as a new system trajectory and point c in section 5.2.1.1 will be invoked. If a Deviation Alert is active on an aircraft trajectory then the trajectory for this aircraft will not be subjected to planning by the PC until the deviation has been addressed by TC intervention.

In case f) for ORG 1 all requests from an aircraft will be via R/T to the TC who will then pass the request to the PC for replanning. Any modifications requested by the PC will have to be passed to the aircraft via the TC.

5.2.1.4 Communication requirements for the PC

In addition to the co-ordination mechanisms provided for ORG 0, the PC will have the capability of sending/receiving trajectory proposals to/from adjacent sectors for evaluation and acceptance. Communication between the sectors should be performed electronically via the mechanism of MESSAGE IN/MESSAGE OUT windows with the telephone providing a backup mechanism. All communications with an aircraft will be made via the TC.

5.2.2. Tactical Controller

In ORG 1 the TC will still maintain the same responsibility for ensuring conflict free passage and handover. The TC will still carry out all communication with the aircraft. The computer assistance tools will be available to the TC, however the use of these would be very limited in the time scale in which the TC operates.

Therefore the TC's major tasks are as for ORG 0 but with the additional task of monitoring the deviation alerts generated by the FPM and take the necessary corrective action.

5.3. ORGANISATION 2

5.3.1. Planning Controller

4D FMS equipped aircraft will be introduced into the traffic sample for ORG 2 which will exploit the full two-way datalink capability. This will impact on the PC by both providing him with more accurate trajectory predictions and the task of negotiating trajectories with the ability to communicate directives to the aircraft via the datalink. The PATs Negotiation Manager will be introduced to handle air/ground trajectory negotiation. Figure 5.3.1 illustrates his major activities.

In addition to the procedures described for the PC in ORG 1 in section 5.2.1. he will have the following tasks (starting point 4 on fig 5.3.1):-

- Negotiate trajectories with the aircraft via the negotiation manager, the aircraft will "send down" a preferred trajectory based on the route and favoured operating procedures. The PC will display the trajectory in the PS windows and either propose acceptance, if conflict free, or edit it to provide a proposal for a conflict free sector transit plan. The steps that follow will depend on the outcome of the planning task as follows:-

- if conflict free then the PC passes a clearance to aircraft via the datalink and updates the system trajectory with the aircraft's downlinked trajectory

- if the proposed changes are solely within the PC's sector and do not impact on the entry or exit conditions then PC will send the 'edits' to the aircraft via the datalink and will update the system trajectory with the subsequently downlinked aircraft trajectory.

- if the proposed plan requires non-standard exit conditions or it could potentially result in a conflict in the next sector then the PC must co-ordinate/negotiate with the PC of the next sector. If the entry conditions require modification then the PC must negotiate with the previous sector TC/PC. Counter proposals from the next sector PC or TC will be resubmitted to the PS and the cycle of negotiation repeated if required. The cycle of proposal/counter-proposal will be limited to one cycle. **NB This one proposal/counter-proposal cycle limit to electronic co-ordination may be reviewed following experience with the pilot phase experiments.**

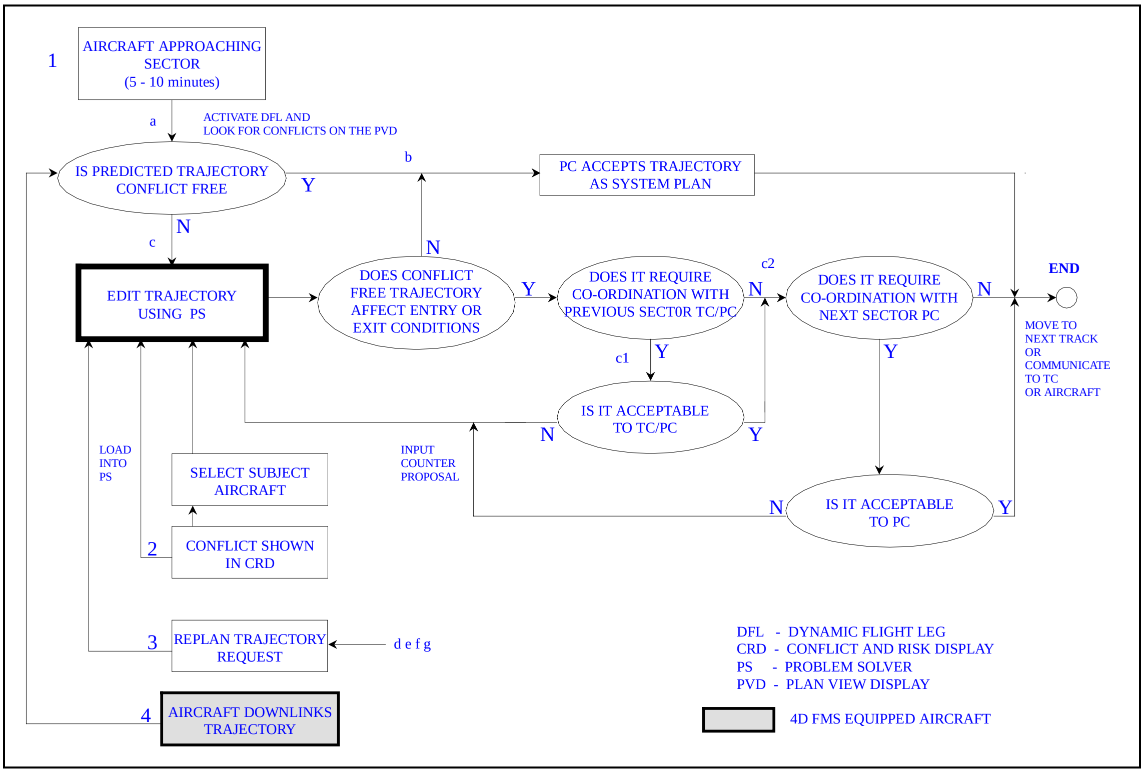

Figure 5.3.1 - ORG 2 PC Activities

5.3.1.1 Communications requirements for the PC

Communications for the PC in ORG 2 will be the same as for ORG 1 (section 5.2.1.4) with the addition of the capability for the PC to have direct communication with the aircraft via the two way datalink. The PC will be required to uplink trajectory proposals (as constraint edits) to an aircraft and receive the downlinked trajectories from an aircraft. As there will be a finite time associated with the trajectory negotiation the PC will be free to perform other tasks while the negotiation process is taking its course.

Details of the Air and Ground aspects of the datalink negotiation are provided in Section 6.

5.3.2. Tactical Controller

Organisation 2 will implement duplex datalink and contain proportion of 4D FMS aircraft in the traffic sample. The use of the datalink will provide the controllers with more accurate information about the aircraft and the 4D FMS will enable aircraft to fly trajectories more accurately.

As in ORG 0 and 1 the TC will maintain the responsibility for ensuring conflict free passage and handover. The Tactical Controller will be able communicate with the aircraft via the datalink or R/T.

6. COMMUNICATIONS

6.1. SEQUENCE OF EVENTS FOR THE AIR/GROUND NEGOTIATION

Figure 6.1 indicates (paths 1,2 and 3) the sequence of events that can occur in an air to ground dialogue. The operational procedures for use of this dialogue are not yet determined. A complete set of aircraft events is given in reference 5 with a full description of the proposed dialogue and message formats to support the dialogue is given in reference 6. Three cases are considered as initiators for the dialogue as follows:-

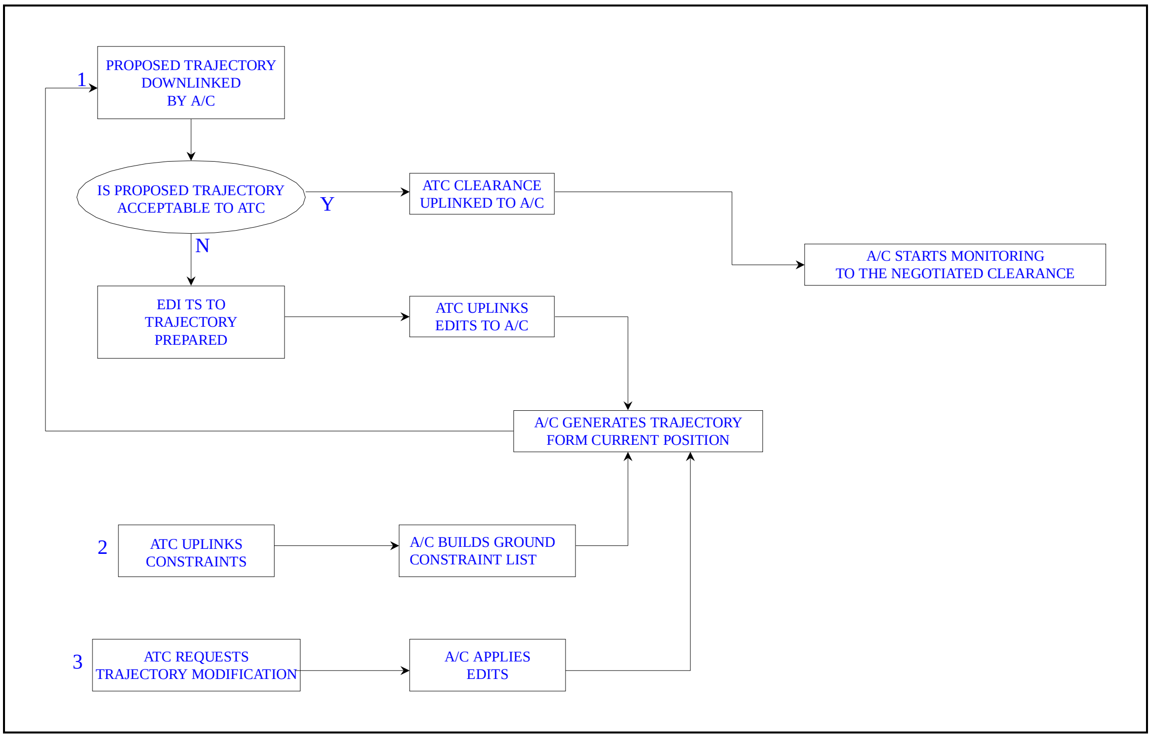

Figure 6.1 - Air/Ground Negotiation

1. A proposed trajectory is downlinked from the aircraft based on the route and favoured operating conditions. In this case the sequence of events is as follows:-

   a) the trajectory is assessed by ATC, see section 5.3.1 for mechanism and criteria, and if acceptable a clearance is uplinked to the aircraft.

   b) if the trajectory is assessed as unacceptable then ATC will prepare edits to the trajectory and uplink them to the aircraft. The aircraft will then generate a new trajectory and downlink it to ATC and the sequence will continue as in point a). **NB the dialogue will be restricted to one cycle i.e. if ATC rejects the aircraft's proposal and submits edits to the aircraft then, provided the aircraft can fly the trajectory corresponding to these edits, it is must adopt this trajectory. In case it physically cannot fly the trajectory, planning will be continued via R/T**

   c) the aircraft starts monitoring to the agreed clearance.

2. ATC uplinks a set of constraints to the aircraft with the following sequence of events being initiated:-

   a) the aircraft builds a ground constraint list

   b) the aircraft then generates a trajectory from its current position

   c) the trajectory is downlinked to the ground and providing it is acceptable a clearance is uplinked

   d) the aircraft starts monitoring to the agreed clearance.

3. ATC requests a trajectory modification by uplinking trajectory edits, the sequence of events is as follows:-

   a) the aircraft applies the edits

   b) the aircraft then generates a trajectory from its current position

   c) the trajectory is downlinked to the ground and providing it is acceptable a clearance is uplinked

   d) the aircraft starts monitoring to the agreed clearance.

The negotiation of trajectories with the aircraft must be able to continue in parallel to other tasks which have to be performed by the controllers and therefore the ground system must have the capability to provide the controller with an indication of the status of the air/ground negotiation.

6.2 COMMUNICATION FACILITIES

The following sections provide an overview of the communication facilities required to support the demonstrations. A full description is given in reference 2.

6.2.1 Air/Ground Communications

Simulated R/T channels will be provided for communication with pseudo pilot positions and a live R/T channel will be provided for communication with the BAC 1-11 trials aircraft.

Data link communications with the BAC 1-11 will utilise the DRA Mode S experimental system. Simulated data link facilities will be provided for the air server data link equipped aircraft.

6.2.2 Ground/Ground Communications

Telephone communication is required between all TC and PC positions. This will be provided by direct line selection with a dedicated selector for each addressee. Controllers will use a common headset for access to both telephone systems and, where applicable, R/T. Ground/ground data communications is provided by datalink.

6.2.3 Communication Logging

Provision will be made for logging the use of the live aircraft communication channel, the simulated R/T channels and the telephone circuits at all operator positions. Details of the parameters to be recorded is provided in reference 2.

7. AUTOMATION SUPPORT

All controller work positions will comprise the same interface components. The PC and TC will have access to the same toolsets, however the use of the facilities is expected to be different for the two roles. The PC is expected to make more use of the long-term planning facilities provided by the tools. The TC will work in a more immediate time frame and hence will make less use of the tools, relying on the PC to provide him with information gathered from the tools. The GHMI will be windows based. Most inputs will be effected using a three-button mouse.

An overview of the controllers GHMI is contained in the PD/1 Facility Specification, reference 2. The full description of the components of the GHMI and the interaction model utilised is contained in the PD/1 GHMI Requirements document, reference 4, 7 and 8.

8. TRAFFIC SAMPLES

The traffic samples to be used for the simulations will be developed to cover the varying requirements of the different phases of the demonstration. Three traffic flow rates will be used, these will represent the anticipated traffic in the year 2000 and will be 2000 low, 2000 medium and 2000 high. The traffic samples will be tested during the Facility Test and will be refined and fixed during the Pilot Phase. A full description of the traffic samples will be provided in reference 2.

9. ABBREVIATIONS

ACC	Area Control Centre
ACK	Acknowledgement
ACT	Activation
AFL	Actual Flight Level
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATM	Air Traffic Management
CRD	Conflict and Risk Display
CFL	Cleared Flight Level
CP	Conflict Probe
DFL	Dynamic Flight Leg
EATCHIP	European ATC Harmonisation and Integration Programme
FMS	Flight Management System
FPM	Flight Path Monitor
GHMI	Ground HMI
HMI	Human Machine Interface
NERC	New En-Route Centre
NFL	Entry Flight Level
NM	Negotiation Manager
OLDI	On-Line Data Interchange
PATs	PHARE Advanced Tools
PEL	Planned Entry Level
PD/1	PHARE Demonstration 1
PHARE	Programme for Harmonised Air Traffic Research in EUROCONTROL
PC	Planning Controller
PS	Problem Solver
PVD	Plan View Display
R/T	Radio telephony
SSR	Secondary Surveillance Radar
STCA	Short Term Conflict Alert
TC	Tactical Controller
TP	Trajectory Predictor
TMA	Terminal Manoeuvring Area
XFL	Exit Flight Level

REFERENCES

1 'PD/1 Demonstration Project Plan' R M Gingell and M van Gool, PHARE Ref DOC 94-70-04, PHARE/CAA/PD1-2.4/DPP;1, March 1994.

2 PD/1 Facility Specification, R M Gingell, B Bradford and S A Fox, PHARE Ref DOC 93-70-46, PHARE/CAA/PD1-2.2/FAC, December 1993

3 PD/1 Operational Specification, R M Gingell, B Bradford and S A Fox, PHARE Ref DOC 93-70-02, PHARE/CAA/PD1-2.3/OPS, January 1994

4 PD/1 GHMI Advanced Interface Discussion Paper on Planning for ORG's 1 and 2, 10/8/94 Alistair Jackson

5 EFMS Project Phase 1b Software Requirements Document Part 5:Event List: Requirements Trace: Glossary Doc 94-70-11 April 1994

6 EFMS Phase 1b Air/Ground ATC Data Link Communication for PD/1 and PD/2, PHARE Ref DOC 94-70-21 Sep 1994

7 Specification of the Reference System Ground Human Machine Interface for PHARE Demonstration 1, draft version 0.1, EEC Task AT68, April 1994

8 Modifications and Extension of Reference System Elements to Support the Advanced Organisations Draft V0.1 September 1994 A Jackson and Isabelle Pichancourt.

RELATED DOCUMENTS

1. PHARE Document Database

    This database contains a complete list of PHARE documents and their status and is maintained by the PHARE Cell from information provided by the projects. It will be updated whenever a document is updated or created

2. 'PD/1 Demonstration Project Plan' R M Gingell and M van Gool, PHARE Ref DOC 94-70-04, PHARE/CAA/PD1-2.4/DPP;1, March 1994.

    This document provides the detailed project planning for PD/1.

3. PD/1 Facility Specification, R M Gingell, B Bradford and S A Fox, PHARE Ref DOC 93-70-46, PHARE/CAA/PD1-2.2/FAC, December 1993

    The facility specification is a detailed description of the technical, operational and analysis requirements for the PD/1 facility.

4. PD/1 Operational Specification, R M Gingell, B Bradford and S A Fox, PHARE Ref DOC 93-70-02, PHARE/CAA/PD1-2.3/OPS, January 1994

    This document defines the broad operational objectives for PD/1.