PROGRAMME FOR HARMONISED AIR TRAFFIC MANAGEMENT RESEARCH IN EUROCONTROL

PHARE

EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION EUROCONTROL

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## Volume 2 of 2

# PD/2 FINAL REPORT

# Annex G

# The PD/2 Ground Human-Machine Interface

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# 1 Introduction

The new ATC support tools developed within PD/2 raised the need for a new design of the ground human-machine interface (GHMI). Unlike the traditional systems the representation of information is not the only task of the GHMI. Furthermore, the PD/2 GHMI was a highly interactive dialogue system that facilitated the exchange of information and interaction with the overall system.

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# 2 A Description of Today's GHMI

The PD/2 scenario was created based on the real APP situation at Frankfurt/Main airport. Compared to the traditional user interface in use at Frankfurt APP several new ideas were implemented within the PD/2 GHMI. In Frankfurt, the radar screen was employed primarily for a visualisation of the current state of the aircraft (aircraft) under control. Advisories of the controller were recorded on paper strips and in case of a handover of the aircraft, they were passed on to the subsequent working position. Apart from the definitions of some user preferences, inputs into the system were not possible.

Figure 2.1 gives a simplified overview about the flow of information in the present system for two controller working positions (CWPs).

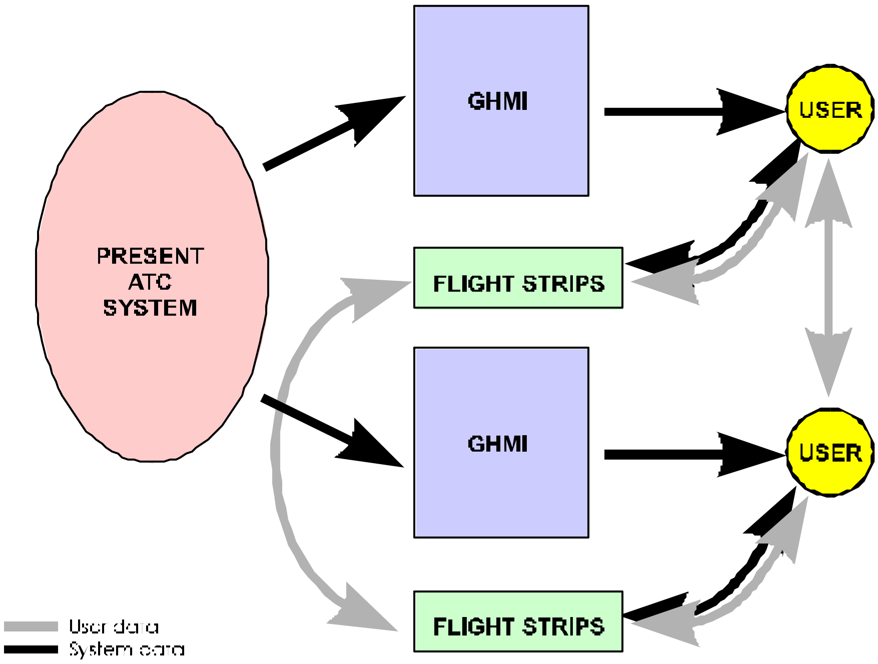


*Figure 2.1* *Flow of information in the present system*

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# 3 New Features Added to the PD/2 GHMI

The new ATC support tools called PHARE Advanced Tools (PATs) created a large amount of information that had to be presented to the controller in a suitable way. This information contained:

- planned times of overflight at the Metering Fix (MF) and at the gate
- trajectories
- system generated advisories
- planning conflicts
- status information for individual aircraft (aircraft class, data link)

Further information managed and displayed by the GHMI was:

- current state of control for all aircraft
- The last valid advisory for an aircraft

Because of the PATs generated advisories there was a need to substitute the traditional flight strips by an electronic representation. This meant that recording of controller advisories in the PD/2 environment was no longer performed using paper strips. Instead data was entered directly into the GHMI systemwhich then automatically passed and displayed the information to all other working positions. The following Figure 3.1 shows the corresponding diagram for the flow of information in the PD/2 system:

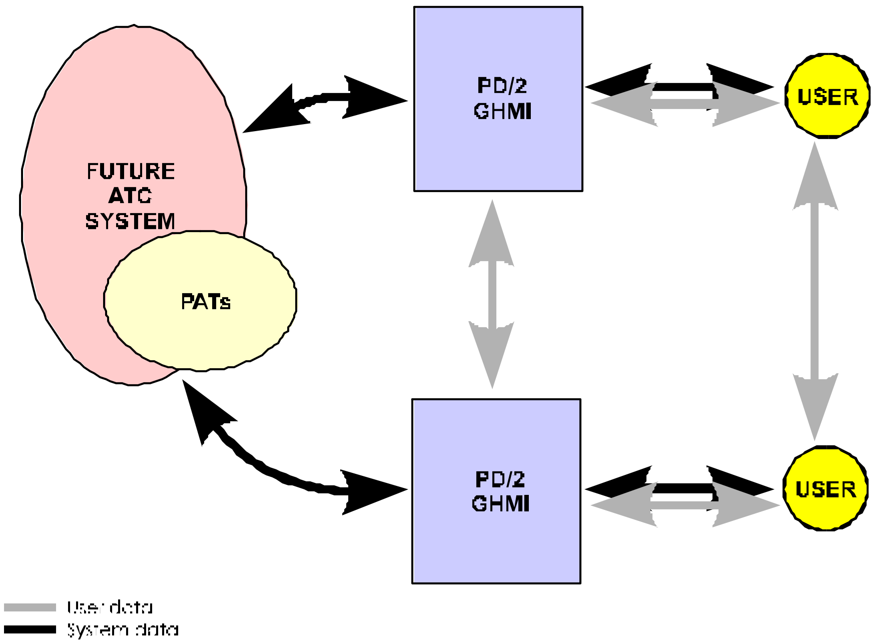


*Figure 3.1 Flow of information in the PD/2 GHMI*

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# 4 The PD/2 GHMI Set-up

In PD/2 three controller working positions were simulated: Two APP positions which were the main subject of PD/2 and one sample ACC position (ACC West). Each of these CWPs was equipped with a large display with a resolution of 2048x2048 pixels and a smaller display with 1280x1024 pixels. Figure 4.1 gives an overview of the arrangement of the three radar consoles in the PD/2 simulation environment.

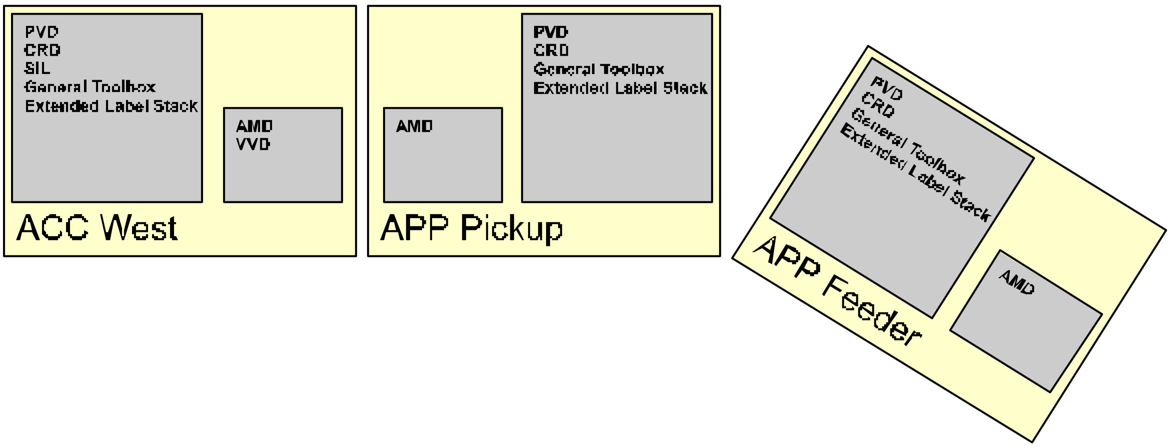


*Figure 4.1 The PD/2 GHMI set-up*

The radar display called Plan View Display (PVD) in PD/2 was the main GHMI component used for tactical control. The scheduled arrival sequence was presented on the Arrival Management Display (AMD) and was used for planning purposes. An additional Vertical View Window (VVD) was available for the western sector controller. This display showed the vertical distribution of air traffic. Another ACC specific component was the Sector Inbound List (SIL). This list contained the labels of all aircraft that were planned to enter the sector via a specific navigation point. The Conflict Risk Display (CRD) could be used by all controllers to warn of potential conflicts between aircraft. The controller could put certain aircraft on the Extended Label Stack as an aide-memoire. Finally the General Toolbox could be used to set-up the GHMI to personal preferences.

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# 5 The PD/2 GHMI Basic Components

## 5.1 The Aircraft Label

The fundamental GHMI component was the so-called "label". The label was employed in different versions by most of the GHMI components and contained the data of one aircraft. Depending on the context the label could be a single line with only the call-sign or a detailed flight strip containing almost all the relevant aircraft information. The layout of the label was consistent with any of the GHMI applications.

In addition to the actual label data, colour coding was used to mark special states of an aircraft. This alerted the controller to important information such as conflicts, aircraft under control and advisories. The following illustration shows as an example a radar label currently selected by the air traffic controller:

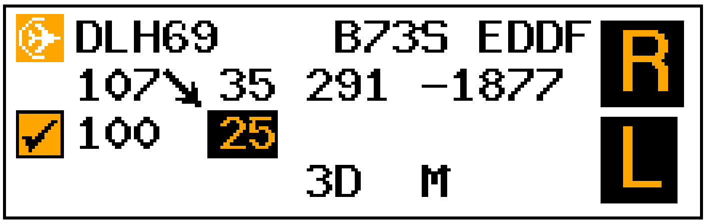


*Figure 5.1 Sample label layout (Extended radar label)*

The first line contains aircraft specific data. This is the call-sign, the weight category, the type of aircraft, the destination and the departure aerodrome. The second line shows the actual state of the aircraft. This includes the current flight level, the speed, the heading, and the rate of climb. The third line contains the corresponding values for the last advisories the controller has given. Alternatively, these fields may contain system-generated advisories that displayed in amber. The fourth line contains the STAR, the equipment category (3D or 4D), the SSR-code and the runway assignment. Not all fields were displayed in each context. Specific fields or entire lines may be omitted dependent on the situation.

## 5.2 Interaction With Labels

As well as their display function, most fields were sensitive to input actions. They could either be used to popup windows for data entry, or be employed to perform actions executable with a single mouse click. These actions could be for example: runway allocation, confirmation of system advisories or handover actions. All these fields were coloured amber. The following figure shows two examples of input operations on the radar screen:

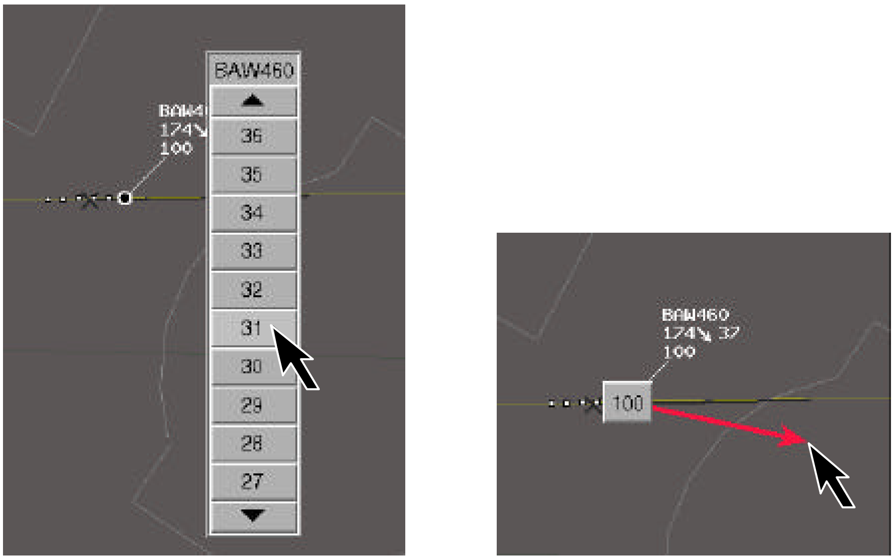


*Figure 5.2 Examples for input actions (speed and heading inputs)*

All inputs were automatically passed on to the other controller working positions. As a result a handover of paper flight strips became obsolete.

### 5.3 Display of Information on Request

In order to avoid higher controller workload despite the greater amount of information available, a particularly efficient GHMI design concept was required. The PD/2 GHMI design was strictly based on the concept "Display as little information as possible and as much information as required". Figure 5.3 gives an example how this concept was implemented. Normally only the bare minimum of label information was displayed on the screen. Additional information was made available on demand only.

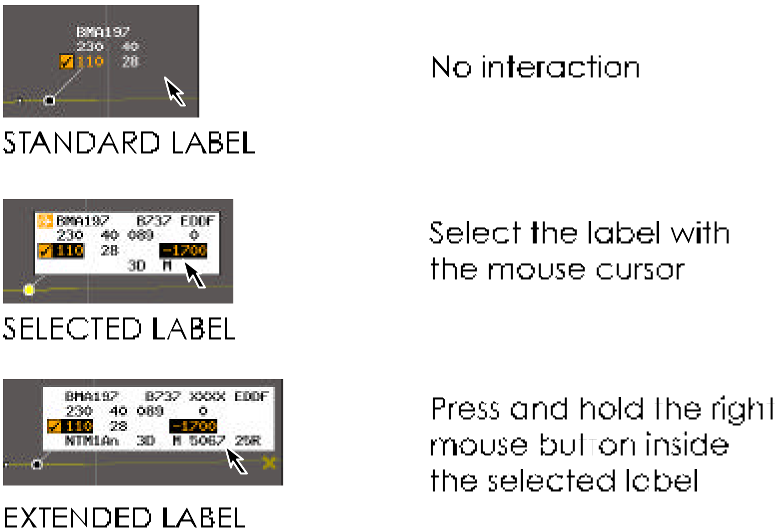


*Figure 5.3 Display of information on request*

### 5.4 Handover of Aircraft

The PD/2 scenario included three controller working positions: The ACC West controller as one sample ACC working position, the Pickup and the Feeder controller. The approach traffic first passed the ACC controller, then the Pickup and finally the Feeder working position. Traffic that entered the APP area from other directions than West went directly to the Pickup position in PD/2.

The colour of the label indicated the state of control of the corresponding aircraft. As long as an aircraft was under control of the previous sector it was drawn in grey. In this so-called "Unconcerned" state no interaction was possible. When the previous sector controller released the aircraft by selecting the handover icon, the label background changed to pink in all other working positions. This indicated that the aircraft could be taken under control of the next controller. This state was called the "Advanced" state.

After the pilot had made his initial R/T call, the controller of the concerned CWP simply assumed control of the aircraft by selecting the Assume-Icon inside the label. The background of the label then changed from pink to white, indicating the "Assumed" state of the aircraft. Passing the aircraft to the adjacent sector employed the same mechanism as described above.

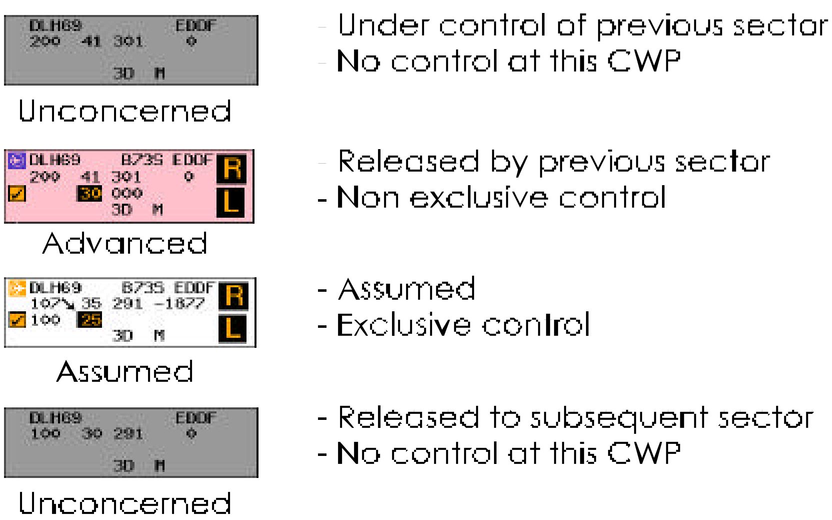


*Figure 5.4 Handover of aircraft passing one working position*

Figure 5.4 shows a label for the sequence of a complete handover procedure. This example was taken from the radar screen. However, the colour of a specifc aircraft label is always the same for one CWP, regardless which display is considered. This makes it easy to distinguish aircraft under control from other aircraft even in a busy situation.

### 5.5 Classes of Aircraft in the PD/2 Environment

Three levels of PATs support existed in the PD/2 scenario. The highest level of support was available for so-called "Class A" aircraft. These aircraft were fully equipped with a 4D-Flight Management System and had datalink capabilities for automatic negotiation of trajectories. These aircraft flew "automatically" on their planned trajectory with no further need for controller interaction except the handover procedure.

Aircraft having no datalink capabilities or aircraft having not enough time for a trajectory negotiation are called "Class B" aircraft. They were still supported by the ground system with trajectory based advisories. These advisories were not sent to the aircraft automatically but were displayed on the screen. The controller passed the advisories to the pilot by R/T and confirmed the transmission by a mouse click on the advisory indication on the aircraft label.

A "Class M" aircraft on the other hand was an aircraft for which no valid trajectory could be provided by the ground system. In this case, the aircraft had to be ‘manually’ controlled by the controller.

Different classes of aircraft were identified on the GHMI screens by different types of aircraft symbols. These symbols were shown, at the radar target position on the radar screen and within the planning label on the Arrival Management Display (AMD). The following table gives an overview about possible combinations of aircraft equipment and aircraft guidance classes and the corresponding aircraft symbols.

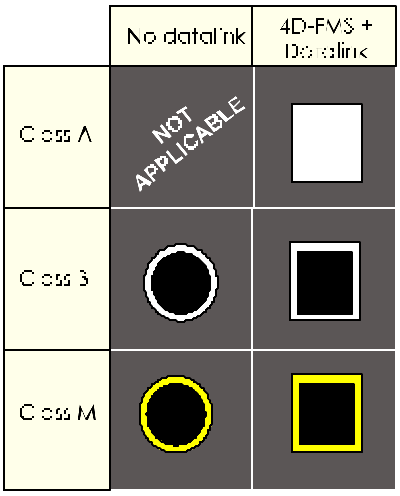


*Figure 5.5 Class dependent layout of the aircraft symbols*

Class A aircraft were marked by a filled white rectangle, Class B aircraft by a white outlined symbol of round or rectangular shape depending on the aircraft equipment, and Class M aircraft were the same as Class B aircraft but with a yellow border of the respective symbol.

# 6 The Plan View Display (PVD)

The main GHMI component in the PD/2 environment was the radar display, called Plan View Display (PVD), which is shown in Figure 6.1. It displayed the current position of all aircraft within the selected range. Each aircraft target symbol was provided with a label as described above. The configuration of the PVD could be adjusted to the personal preferences of the controller by means of the Radar Toolbox (shown in the upper left corner) or by the General Toolbox.

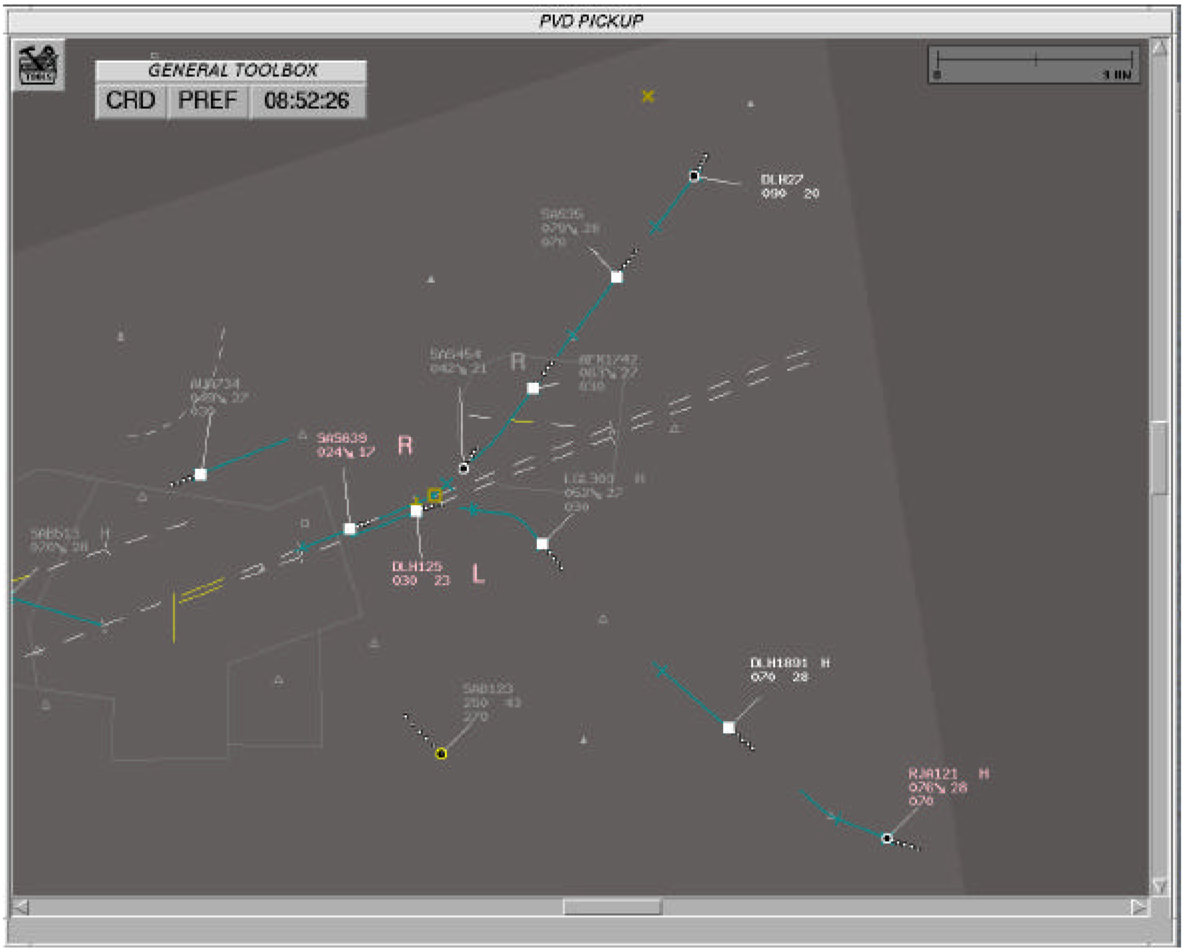


*Figure 6.1 The Plan View Display (PVD)*

Besides some standard features the PVD provided several new features such as the display of the trajectories for the next few minutes or the display of advisories. The prediction of the planned trajectory allowed the controller a better visualisation of the system's plan. In addition to this the display of advisories for Class B aircraft allowed a guidance of non-equipped aircraft according to the scheduled plan. Moreover areas of planning conflicts could be displayed on the PVD. Some of these features are described in more detail in the next paragraphs.

### 6.1 Representation of Trajectories

Entire trajectories for one ore more aircraft could be displayed on demand. The display shows the entire planned flight path with all positions marked where tactical intervention should take place such as begin of speed reduction or top of descend. All these positions were marked with a symbol and additional alphanumeric values. Figure 6.2 shows an example of the trajectory representation.

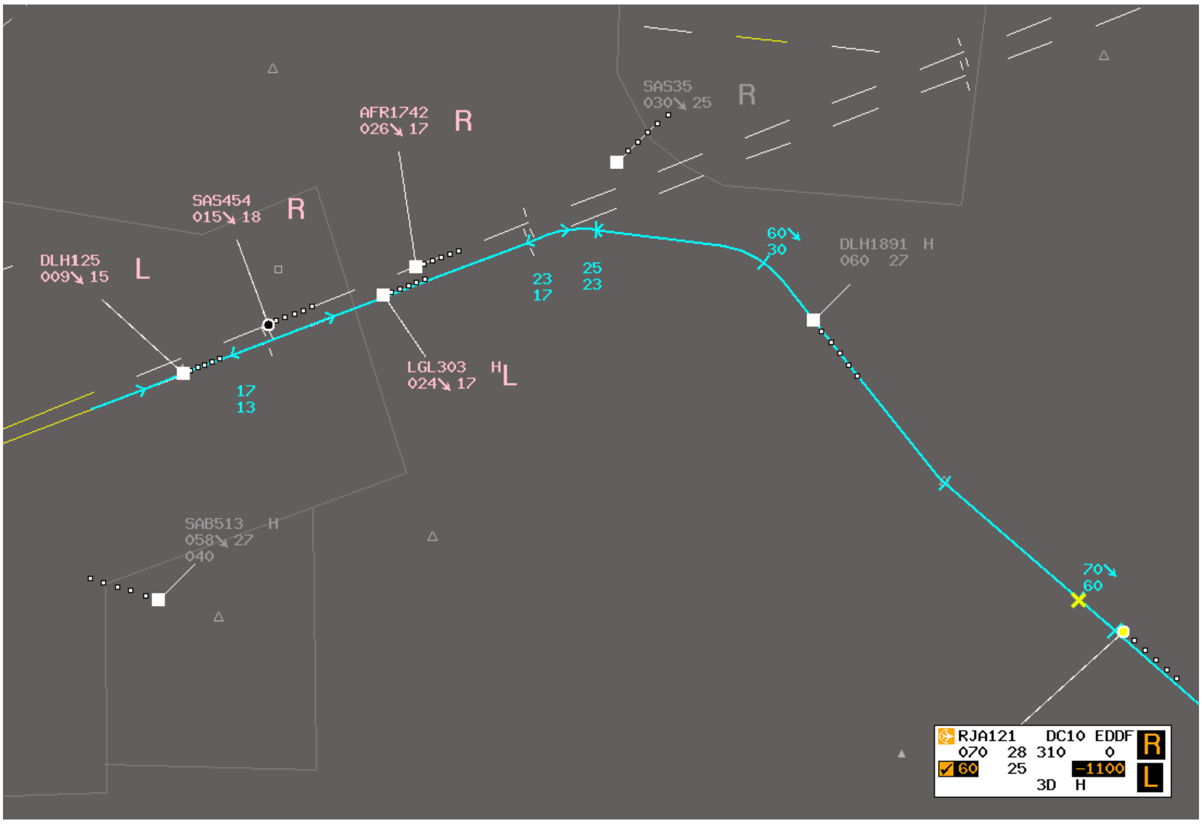

*Figure 6.2 Representation of trajectories*

# 7 The Arrival Management Display (AMD)

The Arrival Manager (AM) software tool generated an optimised arrival sequence that was displayed by the Arrival Management Display (AMD) on a separate screen. The AMD for the APP controllers showed the scheduled time of overflight for the Gate. The AMD for the ACC displayed the corresponding times for the so-called Metering Fix, which was the entry point to the TMA.

On the APP display the labels were arranged on the right and left side of the time line dependent on the runway allocation for the corresponding aircraft. The time scale displayed the scheduled times of overflight for each aircraft (See Figure 7.1). The time scale and the attached labels moved downwards in real time. The actual time was displayed in the field at the bottom of the AMD. The fields at the top and bottom of the time scale indicated the margin of the displayed time range that did not necessarily end at the actual time when scrolled.

The aircraft label in its normal state only contained the following basic information: call-sign, type of aircraft, and weight category. Nevertheless, full access to the aircraft data was provided by the standard GHMI interaction mechanisms. To allow a distinction between the different guidance classes (Class A, B, M) the label also contains the corresponding target symbol.

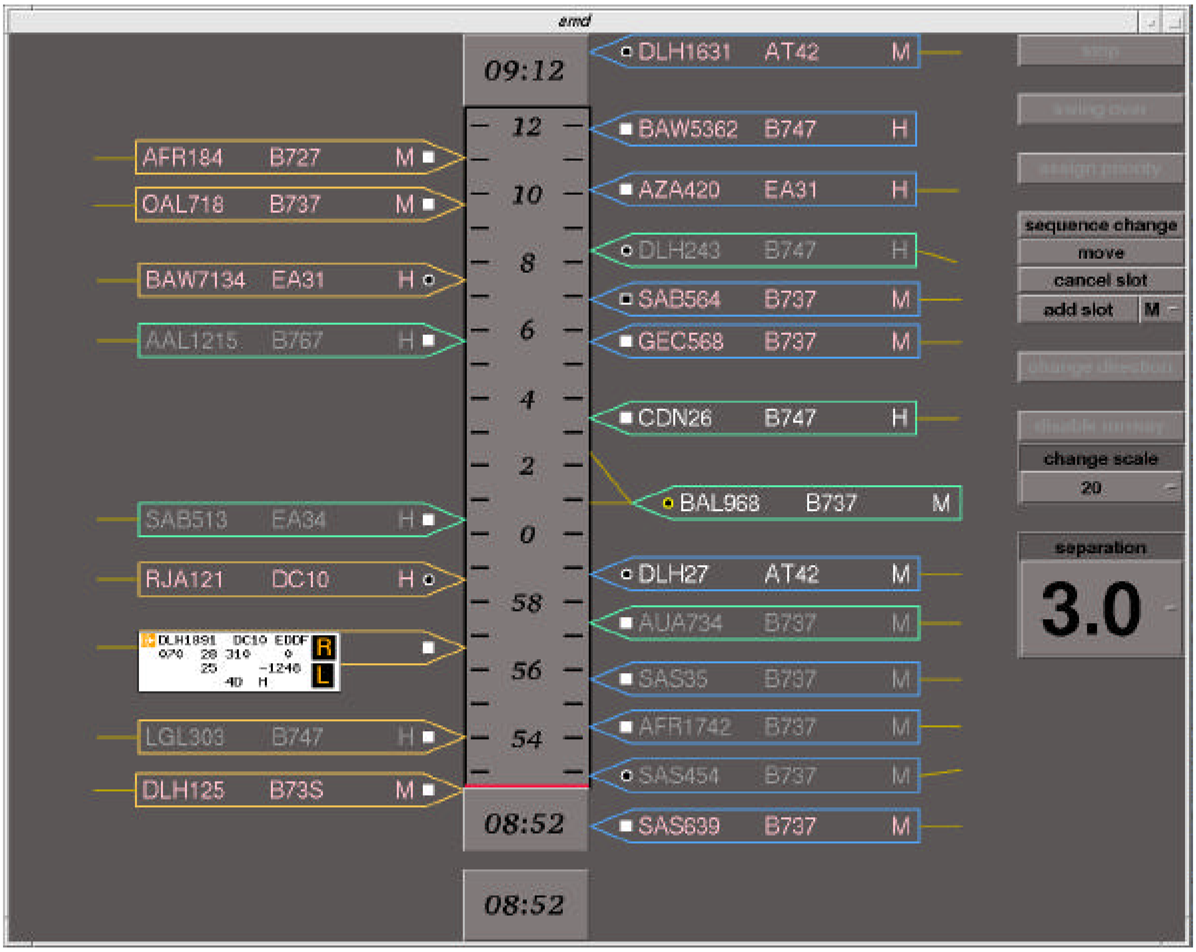


*Figure 7.1 The Arrival Management Display (AMD) with one aircraft label selected*

A further display component was added to the AMD label. A pointer-like line at the blunt end of each label indicated the deviation of the real aircraft position from its planned position. The data was provided by the Flight Pass Monitor (FPM). When this line pointed upwards the corresponding aircraft was behind its planned trajectory. If the line pointed downwards the aircraft was too early. The display covered a deviation time range of one minute. If the deviation of the aircraft position exceeded this limit the AMD labels were indented away from the time-scale and two lines are used to indicate the scheduled and the real time of arrival.

As well as some configuration options (e.g. allowing the user to set the displayed range of the time scale), some input functions for an interaction with the AM were provided. It was possible to change the sequence of two aircraft, to move one aircraft or to remove an aircraft from the planned sequence. Additional time slots could be added to the scheduled plan. To affect the spacing between aircraft the controller could specify a new minimum separation value as the basis for a re-planning of the AM.

# 8 The Conflict Risk Display (CRD)

The Conflict Probe (CP) software tool detected planning conflicts between two trajectories. These conflicts were displayed on the Conflict Risk Display (CRD) as shown in Figure 8.1. Pairs of aircraft with conflicting trajectories were displayed in a diagram with a vertical time axis and horizontal separation axis. The position of a conflict showed the time left to the closest approach and the minimum separation after that time. The conflict labels moved downwards in the diagram with time.

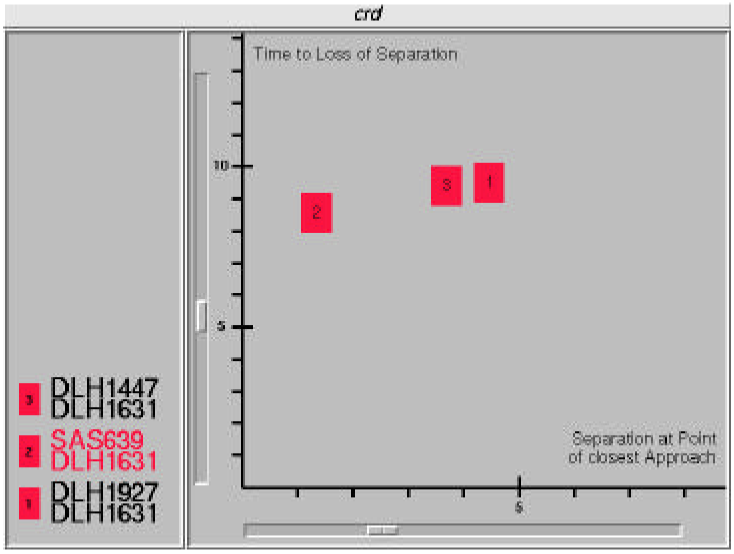


*Figure 8.1 The Conflict Risk Display (CRD)*

On the left side of the CRD a numbered list of all planning conflicts currently detected was displayed. The controller could select one of the displayed conflicts with a mouse click. In this case the call-sign within the label of the corresponding aircraft becomes highlighted on all displays of this CWP. In addition, the point of closest approach was marked on the PVD as shown in Figure 8.2.

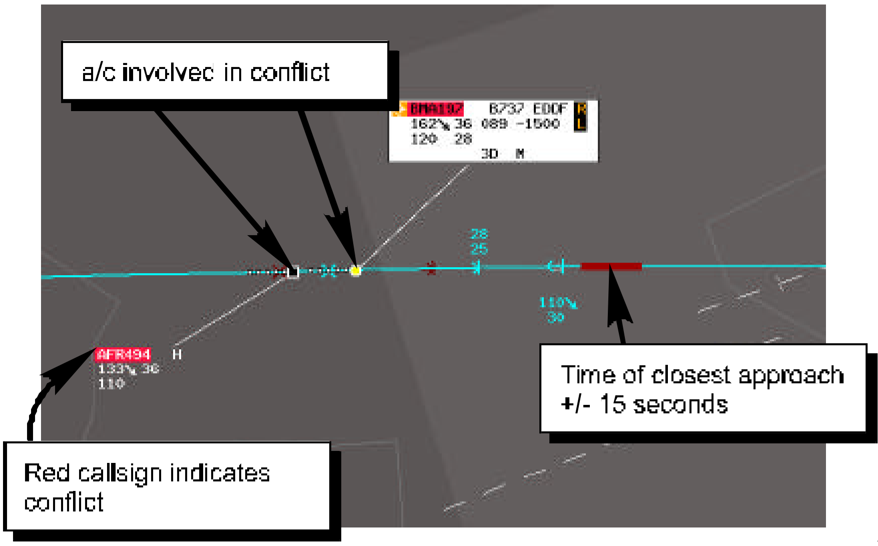


*Figure 8.2 Representation of planning conflicts in the PVD*

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# 9 The Vertical View Display (VVD)

It became apparent that there was a need for a vertical display of the airspace to provide a better picture of the vertical distribution of aircraft. The Vertical View Display (VVD) allowed the controller to display the air traffic of a selectable area in the vertical plane. The VVD was mainly intended to be used in ACC CWPs to display the air traffic within a holding stack. However, freely selectable parts of the airspace could also be displayed using the VVD. Figure 9.1 shows a snapshot of the RUD (MF Rüdesheim) inbound traffic displayed in the VVD.

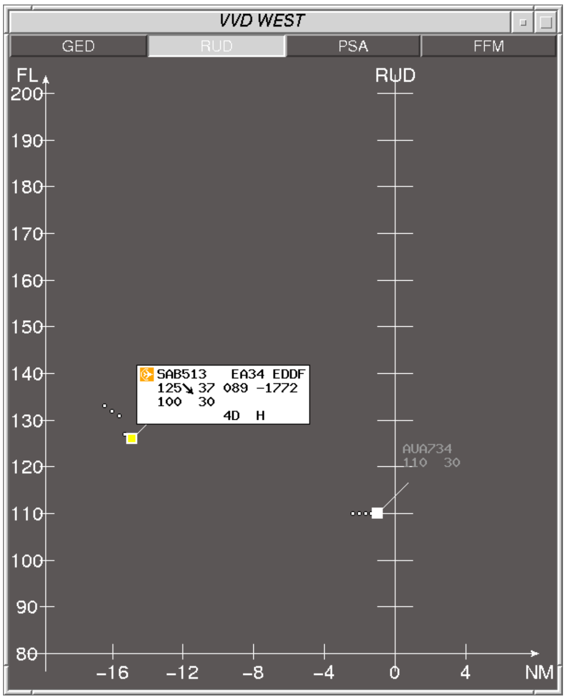


*Figure 9.1 The Vertical View Display*

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# 10 References

[1] PD/2 Design Team
ADVANCED GROUND HUMAN-MACHINE INTERFACE FOR PHARE DEMONSTRATION 2, Eurocontrol: PHARE/DLR/GHMI-3.5/FS;1, 1995

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