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PD/3 AHMI Design Document

CDU and Navigation Display

for use with EFMS Phase II

Final Version 2.0



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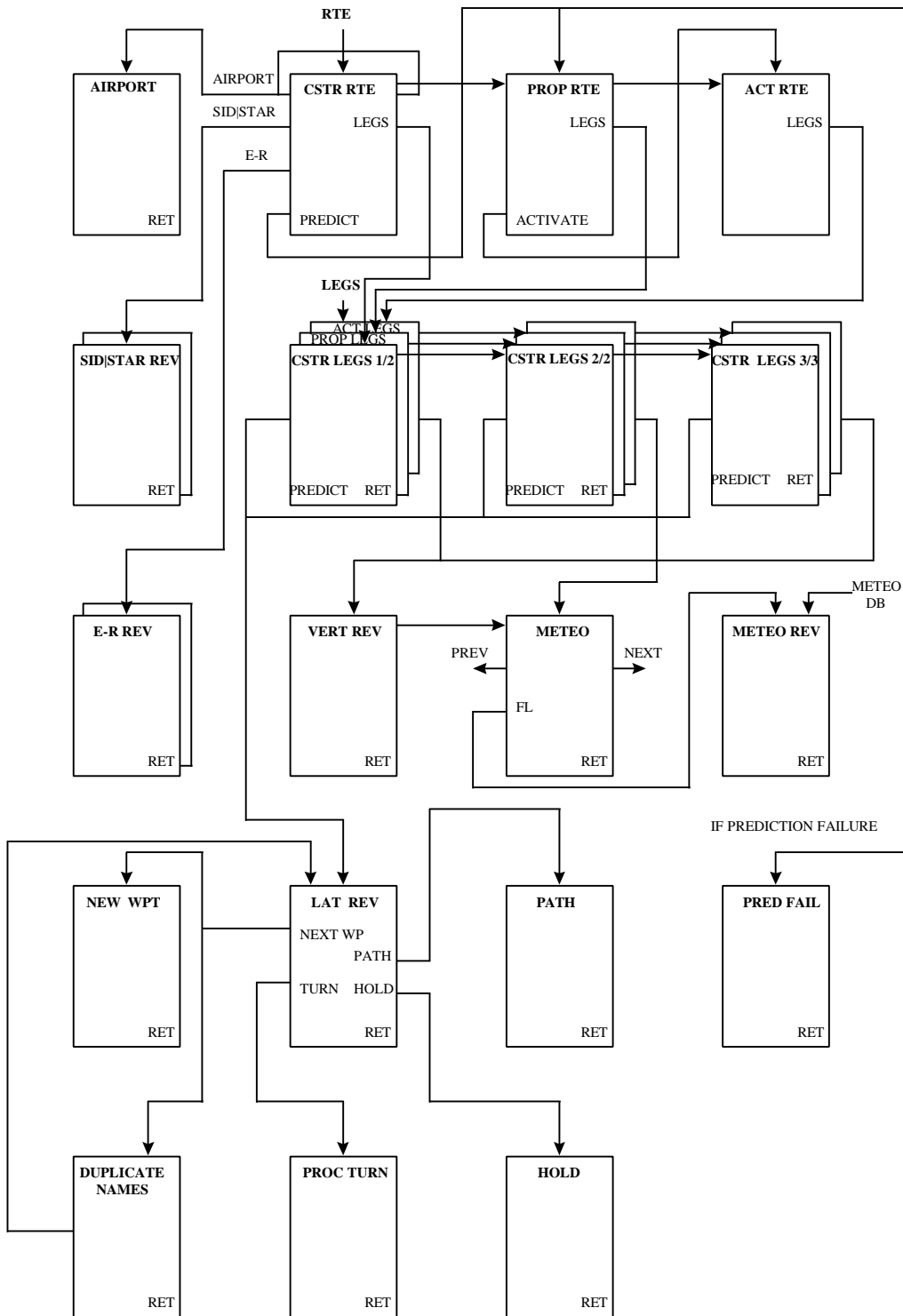
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1 INTRODUCTION

1.1 General

The PHARE programme is investigating a highly integrated airborne-ground ATM environment in which aircraft and ATC closely cooperate with each other using Data Link. In order to operate safely and economically within this 4D ATM system, the pilot needs an optimised Human Machine Interface for carrying out the necessary pilot tasks which include:

- 4D flight planning
- 4D flight negotiation
- 4D flight progress monitoring and alerting
- EFMS system control

The AHMI components will include a CDU (LCD flat-panel with touchscreen overlay) for EFMS control, and an EFIS Navigation Display (ND) using a cursor control device (rollerball or touchpad) to carry out route editing, display control and negotiation of 4D clearances. The CDU is designed for use with a conventional CDU hardware case, to enable implementation at all participating PHARE sites.

This document describes the designs of the Experimental EFIS and the EFMS CDU to be used in the Eurocontrol PD/3 Demonstration programme. The designs are in accordance with the AHMI User Requirements Document [1] and have been developed from the results of the prototyping stage of the AHMI project. Included in the document are the designs for linking the EFIS and EFMS CDU to provide the pilot with an integrated AHMI system when carrying out route editing. Close coordination has been maintained with the EFMS project and with the Eurocontrol EFMS Integration Team. The AHMI project is part of the Eurocontrol PHARE (Programme for Harmonised ATM Research in Eurocontrol) programme, and is being carried out by the following PHARE partners:

DLR Braunschweig, Germany
DRA Bedford, UK
EEC Bretigny, France
NLR Amsterdam, Netherlands

1.2 Scope of the Designs

The EFIS and CDU Designs will be used to implement an advanced pilot interface with EFMS Phase 2 on the two aircraft participating in the PD/3 demonstrations (BAC 1-11 operated by DERA, and Cessna Citation operated by NLR). They will also be used in the cockpit simulator at EEC, Bretigny, where the initial AHMI evaluation will be carried out prior to in-flight evaluation and demonstration.

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2 EFIS DISPLAYS DESIGN

2.1 Lateral Display Modes

2.1.1 Introduction

There will be two basic lateral display modes provided by the EFIS system as described below. EFMS routes, trajectories and tubes will be shown on both modes.

2.1.2 Basic Lateral Monitoring Mode

This mode will take the form of a moving map display, with a stationary aircraft symbol representing the present position. This symbol will be centred laterally on the display and two thirds of the way down the screen vertically.

Two circles representing range will be drawn around the aircraft symbol. The outer circle will represent twice the range of the inner circle, which will be labelled with the range value attributed to it. (The range scale will be selectable by the pilot - either 10, 20, 40, 80, 160, or 320 nautical miles). The outer range circle will also include a heading arc (representing magnetic heading). A track angle indicator will be drawn on the heading arc. All displayed objects will be truncated just inside the heading arc.

Additional information will be presented to the pilot in the corners of the display, namely groundspeed and true airspeed (Top left corner), wind speed/direction (Bottom left corner), time (Bottom right corner), and next waypoint information (name, distance to go, time to go - Top right corner). A status flag will be drawn in the top left corner of the display when the EFMS datalink is not operating.

2.1.3 Basic Lateral Planning Mode

This mode will present a “North Up” display to the pilot. The map display will be stationary (when the cursor is within the limits of the screen - see below) with the present position/heading represented by a moving aircraft symbol on the screen (if aircraft position is within displayed area). The display origin will be in the centre of the screen, and will be centred on the aircraft symbol when the mode is first entered.

The pilot will be able to inspect the route (or whatever else is being displayed) by moving the display origin using the cursor input device (Rollerball). When the cursor reaches the limits of the screen, the map display will move rather than the cursor, enabling the pilot to drive the map to any desired position.

A second method for inspecting the Pilot route using Forward/Back/Home controls will also be provided. The Forward and Back controls will be used for stepping along the route from constraint to constraint. If EFMS guidance is active, the Home control will return to the constraint just behind the aircraft position. Otherwise, the Home control will return to the first constraint in the list. After a step, the origin of the display will be centred on the position of

the indexed constraint. The cursor will then be automatically repositioned at the origin (over the indexed constraint).

Two circles representing range will be drawn around the display origin as for the lateral monitoring mode. The heading arc will not be drawn in this mode. Additional information will be presented to the pilot in the corners of the display, similar to the Lateral Monitoring mode. All displayed objects will be truncated just outside the outer range circle.

2.1.4 Information Presented on Lateral Displays

2.1.4.1 Display of Routes (Constraint Lists)

Symbols representing the individual waypoints (constraint points) in a route will be drawn on the screen. The Waypoint symbols will be joined by route lines. Colour coding and line type (solid, dashed etc.) will be used to differentiate between routes on the display.

Five types of route are to be displayed:-

- 1) Pilot Route
 - The route entered by the pilot.
 - Cyan waypoint symbols, dotted cyan route lines.
 - Can be edited via the EFIS in Lateral Planning Mode(See section 2.1.6)
- 2) Ground Route
 - The latest route uplinked by ATC.
 - Brown waypoint symbols, dotted brown route lines.
- 3) Proposed Route
 - The route associated with the proposed trajectory.
 - Cyan waypoint symbols, with no route lines (trajectory displayed instead)
- 4) Secondary Route
 - A route “stored” by the pilot for future use.
 - Yellow/Green waypoint symbols, with no route lines (trajectory displayed instead)
- 5) Active Route
 - The route associated with the activated trajectory.
 - White waypoint symbols, no route lines (trajectory displayed instead)

When the aircraft is airborne, an extra route line will be drawn from the aircraft symbol to the first waypoint in the constraint list. This is to provide a visual clue that a subsequent trajectory generation will be an airborne one, where the constraints already overflown will be deleted prior to generation from aircraft present position. (This is of course only true for the Pilot and Ground routes, which include the route lines)

2.1.4.2 Display of Trajectories

Trajectories will be drawn as solid lines on the screen. Colour coding will be used to differentiate between trajectories on the display.

Three types of trajectory are to be displayed:-

- 1) Proposed Trajectory
 - The latest generated trajectory.
 - Solid cyan line.
 - Displayed with the Proposed Route
- 2) Secondary Trajectory
 - A route “stored” by the pilot for future use.
 - Solid Yellow/Green line
 - Displayed with the Secondary Route
- 3) Active Trajectory
 - The latest activated trajectory.
 - Solid white line.
 - Displayed with the Active Route

2.1.4.3 Display of Tubes (ATC Clearances)

Tubes will be drawn on the screen, using colour coding and line type (solid, dashed etc.) to differentiate between them. The early and late time boundaries of the ATC Clearance will be shown by lines drawn across the tube.

Two types of tube are to be displayed:-

- 1) Proposed Tube
 - The latest tube up-linked by ATC.
 - Dotted amber lines.
- 2) Active Tube
 - The latest activated tube.
 - Solid amber lines.

2.1.4.4 Display of Features

The software will also allow features such as Nav aids, Airports and Waypoints to be displayed in the lateral monitoring mode or the Lateral Planning mode. These will be read from a database and drawn on the screen (when in display range), using colour and symbology to differentiate between the various types. The display of these features will be Pilot selectable. They will be displayed as follows:-

- 1) Nav aids
 - Displayed as symbol & Ident; Colour Pale Magenta
- 2) Airports
 - Displayed as symbol & Ident; Colour Sienna
- 3) Waypoints
 - Displayed as symbol & Ident; Colour Light Blue

2.1.4.5 Display of Messages

Status messages will be generated by the EFIS and displayed as text strings centred in the lower half of the screen. These messages will be placed in a buffer, with the oldest one being displayed. The pilot will be able to cancel the displayed message by pressing the cancel button on the Rollerball. The messages will also be automatically cancelled where appropriate, as described below:-

1) Ground List Received

Displayed on receipt of a new Ground Constraint List (up-linked by the ATC System). Cancelled when the Ground List is copied to the Pilot List as part of a "Generate To Ground" operation (See Section 2.1.7.2) or when the Ground Constraint List is copied to the Pilot Constraint List by the pilot (via the CDU).

2) Lateral Route Error

Displayed when the system fails to generate a lateral route for the Pilot Constraint List (on completion of an edit sequence carried out via the EFIS or the CDU). Cancelled when a new EFIS edit sequence is initiated (i.e. the system assumes the Pilot is taking action to rectify the problem) or when the problem is rectified via the CDU.

Also displayed when the system fails to generate an opening from aircraft position to the first constraint during a "Generate to Pilot" operation (see Section 2.1.7.1), or a "Generate to Ground" operation. Cancelled if a generation is subsequently initiated successfully via the EFIS or the CDU.

3) Services Locked

Displayed when an EFIS edit sequence is initiated and the Pilot Constraint List and/or Planning Values are locked by another system (i.e. the CDU). Cancelled when the services become free and the EFIS system locks them.

Also displayed when the "Store Route", "Recall Route", "Clear Route" or "Generate To Ground" operations are initiated and the Pilot Constraint List and/or Planning Values are locked by another system (i.e. the CDU). Cancelled when the required operation is initiated successfully.

4) Weights Invalid

Displayed when a trajectory generation is initiated via the EFIS (to the Pilot or Ground Lists) and the aircraft weights are invalid. Cancelled when valid weights have been entered via the CDU.

5) List Invalid

Displayed when the Pilot Constraint List becomes invalid (usually as a result of inserting/deleting height constraints via the CDU - validity is maintained when height constraints are inserted/deleted via the EFIS). Cancelled when a new EFIS edit sequence is initiated (i.e. the system assumes the Pilot is taking action to rectify the problem) or when the problem is rectified via the CDU.

6) Prediction Failed

Displayed when a trajectory generation has failed. Cancelled when a new edit sequence is initiated (i.e. the system assumes the Pilot is taking action to rectify the problem), when a new generation is initiated by the EFIS system, or when a new Proposed Trajectory has been successfully generated (initiated via the CDU).

7) Prediction Deviation

Displayed when a trajectory generation has succeeded, but contains deviations. Cancelled when a new edit sequence is initiated (assumes the pilot is taking action to rectify the problem), when a new Proposed Trajectory has been generated (initiated via the CDU), or when the trajectory is activated.

8) Datalink Failure

Displayed when the “Negotiate Proposed Trajectory” or “Negotiate Active Trajectory” operations are initiated by the EFIS system and the EFMS Datalink is not operating. Cancelled when the operation is initiated successfully.

9) Generation in Progress

Displayed when the pilot initiates an edit sequence on the EFIS, and a trajectory generation is currently in progress. Cancelled when the trajectory generation completes.

2.1.5 Control of Information displayed

The display logic in the EFIS will be as automated as possible to minimise pilot workload. However, it is envisaged that certain control functions for the display of information cannot easily be automated. These will be selected by the Pilot either through hardware switches, a keyboard device or a separate graphical softkey control panel. If the softkey control panel is used, then the functionality for moving the display origins in the Lateral and Vertical Planning modes will not be available. A summary of the control functions is given below:-

2.1.5.1 Display of Pilot Route (Constraint List)

The Pilot Route will be displayed when a Company Route is loaded, or when the pilot starts to build the route (either via EFIS or CDU). It will be occulted when a new Proposed Trajectory is successfully generated (either initiated via the EFIS or the CDU).

The Pilot Route is re-displayed when an Active trajectory is de-activated (or end of route reached) if no Proposed Trajectory is being displayed or if the Proposed Trajectory is “Cleared” and there is no Active Trajectory. Initiation of an edit sequence will also cause the Pilot Route to be re-displayed. It will remain displayed on completion of the edit sequence, but will be occulted if the edit sequence is cancelled.

2.1.5.2 Display of Ground Route (Constraint List)

The Ground Route will be displayed when a new Ground Constraint List is received from the ground ATC system. It will be occulted when it is copied to the Pilot Constraint List by the pilot (via the CDU), or when the EFIS system copies the list to the Pilot List as part of the “Generate To Ground” operation (See 2.1.7.2).

2.1.5.3 Display of Proposed Route/Trajectory

The Proposed Route/Trajectory will be displayed as soon as it has been successfully generated (either initiated via the EFIS or the CDU). It will be occulted when the Proposed Trajectory is activated (through EFIS or CDU).

If the Proposed Route/Trajectory is “Stored” as a Secondary Trajectory and there is no Active Trajectory, or it is “Cleared”, then it will be occulted. It will be re-displayed if “Recalled” from the Secondary Trajectory.

Initiation of an edit sequence will also cause the Proposed Route/Trajectory to be occulted. It will remain occulted if the edit sequence is completed, but will be re-displayed if the editing is cancelled.

2.1.5.4 Display of Secondary Route/Trajectory

The display of the Secondary Route/Trajectory is enabled when a Proposed trajectory is stored as the Secondary Route. The actual display of the Secondary Route is controlled by the “Display Secondary Route” input (Pilot Control).

2.1.5.5 Display of Active Route/Trajectory

The display of the Active Route/Trajectory is enabled when a Proposed Trajectory is activated (either via the EFIS or the CDU). It will be occulted when the Active Trajectory is de-activated or when reaching the end of the route. The display of the Active trajectory can be over-ridden by the “Hide Active” input (Pilot Control) to temporarily de-clutter the screen.

2.1.5.6 Display of Proposed Tube

The Proposed Tube will be displayed when it is received from the ground ATC system. It will be occulted when it has been activated (either via the EFIS or the CDU).

2.1.5.7 Display of Active Tube

The Active Tube will be displayed when as soon as the Proposed Tube is activated (either via the EFIS or the CDU). It will be occulted when the Tube is de-activated (via the CDU) or when reaching the end of the route.

2.1.5.8 Other Display Controls

The following Display Controls can be manually selected by the pilot at any time:-

- 1) Display Select (Lat/Vert)
- 2) Plan Mode Select (Monitoring/Planning)
- 3) Range Scale (10, 20, 40, 80, 160 or 320 nautical miles)
- 4) Navaid Features (On/Off)
- 5) Waypoint Features (On/Off)
- 6) Airport Features (On/Off)
- 7) Display Position (Fwd/Back/Home)
(Or selected via the CDU - see section 2.1.8)
- 8) Hide Active Trajectory (On/Off)
- 9) Display Secondary Trajectory (On/Off)
- 10) Halt EFIS System (only available on hardware switch)

2.1.6 Route Editing Functionality

When in the Lateral Planning mode, the EFIS will include the functionality to edit the Pilot Constraint List. These route editing functions need to be as straightforward and obvious as possible, minimising the use of “menus” and other multiple choices. To enable this, a Rollerball will be used to move a cursor around the screen. The Rollerball buttons will be used for selecting objects.

The “Go-direct from aircraft position” operations will also be available in the Lateral Monitoring mode to allow rapid pilot response to tactical instructions in the current ATC environment.

After extensive prototyping, the following functionality has been defined:-

2.1.6.1 Selection of Objects

An edit sequence will be initiated by selecting an object. As the cursor is moved around the screen, selectable objects will be highlighted (by a colour change) when the cursor passes over them (to provide a visual clue as to what would be selected). The required object will then be selected by a button-press. When this happens, the object will undergo another change of colour to provide a visual clue that it has been selected. Selectable objects will be the aircraft

symbol and the constraints and route lines of the Pilot Route. (Selection of the route lines gives an alternative “Drag and Drop” function for inserting waypoints in the route).

Whenever the Pilot route is occulted (after a generation), selection of an object on the Proposed route (or Active route if the Proposed is occulted) can be used to initiate the edit process. This is because the Proposed route is the same as the Pilot route if the latter is occulted (if the Pilot route has changed since the generation, then it would be displayed). Similarly, if the Pilot route and the Proposed route are both occulted then the Active route must be the same as the Pilot Route. Once an edit process has been initiated, the pilot route will be re-displayed. It will remain re-displayed if the edit process is completed. If the edit process is cancelled then it will be occulted again.

An edit sequence will be completed by making a second selection (or third in the case of a waypoint deletion). This will be a similar operation to the above, in that selectable objects will be highlighted when the cursor passes over them. The required object will then be selected by a button press. Objects selectable to complete an edit sequence will be the Background Features (Nav aids, Airports and Waypoints) and the waypoints in the Pilot Route.

It should be noted that, during an edit sequence (when inserting/adding waypoints), if no object is highlighted when the button press is received, then a “new” waypoint will be created at the cursor position.

One of the buttons on the Rollerball will act as a cancel button. This is to allow the user to cancel edit sequences which have inadvertently been initiated.

The deletion of an Open-Before or Open-After height constraint from the Pilot Route could result in an invalid list which cannot be used for trajectory generation. To overcome this, the remaining height constraints will be modified automatically at the completion of the edit sequence to maintain the validity of the list.

2.1.6.2 Go Direct from Aircraft Position to Route Waypoint (Delete Waypoints)

- 1) Cursor is used to highlight the aircraft symbol.
- 2) Button is pressed to select the aircraft symbol.
- 3) Cursor is moved to highlight a waypoint in the route.
(Line is drawn from the A/C symbol to the cursor as a visual clue)
- 4) Button is pressed to go direct from a/c position to the selected waypoint .

2.1.6.3 Go Direct from Aircraft Position to Waypoint not in Route (Insert Waypoint after Aircraft Position)

- 1) Cursor is used to highlight the aircraft symbol.
- 2) Button is pressed to select the aircraft symbol.
- 3) Cursor is moved to highlight a background feature.
(Line is drawn from the A/C symbol to the cursor as a visual clue - a second line is drawn from the cursor to the waypoint the aircraft is flying towards).

- 4) Button is pressed to delete all waypoints the aircraft has already passed and insert the selected feature at the start of the route.

2.1.6.4 Insert Waypoint in Route

- 1) Cursor is used to highlight a waypoint in the route.
- 2) Button is pressed to select the waypoint.
- 3) Cursor is moved to highlight feature to be inserted as a waypoint.
(Line is drawn from the selected waypoint to the cursor and from the cursor to the next waypoint as a visual clue)
- 4) Button is pressed to insert the feature after the selected waypoint.

2.1.6.5 Delete Waypoint from Route

- 1) Cursor is used to highlight a waypoint in the route.
- 2) Button is pressed to select the waypoint.
- 3) Cursor remains over selected waypoint.
- 4) Button is pressed to select waypoint for deletion.
(Line is drawn from the previous waypoint to the next waypoint as a visual clue)
- 5) Button is pressed for a third time to delete the waypoint from the route.

2.1.6.6 Go Direct from Route Waypoint to Route Waypoint (Delete Intermediate Waypoints)

- 1) Cursor is used to highlight a waypoint in the route.
- 2) Button is pressed to select the waypoint.
- 3) Cursor is moved to highlight a waypoint further along the route.
(Line is drawn from the selected waypoint to the cursor as a visual clue)
- 4) Button is pressed to delete the intermediate waypoints from the route.

2.1.6.7 Add Waypoint to End of Route

- 1) Cursor highlights the last waypoint in the route.
- 2) Button is pressed to select the waypoint.
- 3) Cursor is moved to highlight a feature to be added as the next waypoint.
(Line is drawn from the selected waypoint to the cursor as a visual clue)
- 4) Button is pressed to add the feature as a waypoint at the end of the route.

2.1.7 Display and Operation of Softkeys

When in the Lateral Planning mode, softkeys for generation, negotiation and activation will be drawn. These will be activated via the Rollerball. (The Softkeys described in 2.1.7.1 and 2.1.7.3 will also be drawn in the lateral monitoring mode to enable Go-Directs from Aircraft Position to be initiated without having to enter the Planning mode).

2.1.7.1 Generate To Pilot

This softkey will be displayed whenever the Pilot Route is displayed, and will be occulted whenever the Pilot Route is occulted. It will also be temporarily occulted when a trajectory generation is in progress (either initiated via the EFIS or the CDU)

When the softkey is operated, the EFIS will initiate a trajectory generation to the Pilot Route. If the aircraft is on the ground then the generation will be a Ground Generation. If the aircraft is airborne and on the route defined by the Pilot Route, then all waypoints up to and including the third one behind the aircraft will be deleted prior to initiating an Abeam Point Generation. If airborne and not on the defined route, all waypoints up to and including the one behind the aircraft will be deleted prior to initiating a Generation from Aircraft Position.

2.1.7.2 Generate to Ground

This softkey will be drawn whenever the Ground Route is being displayed and will be occulted whenever the Ground Route is occulted. It will also be temporarily occulted when a trajectory generation is taking place (either initiated from the EFIS or the CDU). When the softkey is operated, the EFIS will copy the Ground Route to the Pilot Route and initiate a trajectory generation to the Pilot Route.

2.1.7.3 Activate Trajectory

This softkey will be drawn whenever the Proposed Trajectory is displayed and occulted whenever the Proposed Trajectory is occulted. When the softkey is operated, the EFIS will initiate activation of the Proposed Trajectory.

2.1.7.4 Negotiate Active Trajectory

This softkey will be drawn whenever an Active Trajectory is displayed, provided that the Active trajectory has not already been negotiated as the Proposed trajectory. It will be occulted whenever the Active Trajectory is occulted, and also when the data link is inoperative. When the softkey is operated, the EFIS will initiate the downlink of the Active Trajectory and occult the softkey. The softkey will also be occulted when a negotiation is initiated via the CDU.

2.1.7.5 Negotiate Proposed Trajectory

This softkey will be drawn whenever a Proposed Trajectory is displayed and occulted whenever the Proposed Trajectory is occulted. It will also be occulted when the data link is inoperative. When the softkey is operated, the EFIS will initiate the downlink of the Proposed Trajectory and occult the softkey. The softkey will also be occulted when a negotiation is initiated via the CDU.

2.1.7.6 Activate Tube

This softkey will be drawn whenever a Proposed Tube is displayed and occulted whenever the Proposed Tube is occulted. When the softkey is operated, the EFIS will initiate the activation of the Proposed Tube and occult the softkey.

2.1.7.7 Store as Secondary Route

This softkey will be drawn whenever a Proposed Trajectory is displayed and occulted whenever the Proposed Trajectory is occulted. When the softkey is operated, the Proposed Trajectory will be stored as the Secondary Route, enabling the display of the Secondary Route and occulting the softkey. If there is an Active Trajectory, then the Proposed Trajectory and associated softkeys will be occulted. The Active Route will then be copied to the Pilot Route (to allow the Pilot Route to be re-displayed if the pilot starts an editing sequence by selecting an Active Trajectory item).

2.1.7.8 Recall Secondary Route

This softkey will be drawn whenever a Secondary Route is displayed and will be occulted whenever the Secondary Route is occulted. When the softkey is operated, the Secondary Route will be copied to the Proposed Trajectory, enabling the display of the Proposed Trajectory and associated softkeys. The associated Secondary constraint list will be copied to the Pilot Route (to enable the Pilot Route to be re-displayed if the pilot starts an edit sequence by selecting a Proposed Trajectory item).

2.1.7.9 Clear Proposed Trajectory

This softkey will be displayed whenever the Proposed Trajectory is displayed and occulted whenever the Proposed Trajectory is occulted. When the softkey is operated, the EFIS will occult the Proposed Trajectory and associated softkeys. If there is an Active Trajectory, the Active Route will then be copied to the Pilot Route (to allow the Pilot Route to be re-displayed if the pilot starts an edit sequence by selecting an Active Trajectory item). If there is no Active Trajectory, the existing Pilot Route will be re-displayed.

2.1.8 EFIS/CDU Interaction

The AHMI interface to the EFMS will allow sharing of data objects (constraint lists, trajectories and tubes etc.) between the EFIS and the CDU. It will also support the sharing of a Pilot Constraint List Index (a pointer to a particular constraint in the Pilot Constraint List). This is to be used by the EFIS as follows:-

The EFIS will act on an incoming Pilot Index in a similar way to a Forward/Back or Home operation (see sections 2.1.3 and 2.2.3). The display will centre on the Indexed constraint and the cursor will be re-positioned over that constraint.

The EFIS will circulate a Pilot Index to the AHMI interface on initial selection of a constraint in the Pilot List (Index to selected Constraint circulated) or after Insertion of a new constraint into the Pilot List (Index to inserted Constraint circulated). An index will also be circulated by a Forward/Back or Home operation.

(The above features ensure that the EFIS Lateral Planning display will be centred on the appropriate waypoint whenever the pilot carries out route edits through the CDU, and that the appropriate waypoint will be displayed on the CDU whenever the pilot carries out route edits through the EFIS).

2.2 Vertical Display Modes

2.2.1 Introduction

There will be two basic vertical display modes provided by the EFIS system as described below. EFMS routes, trajectories and tubes will be displayed on both of them. Each display mode will show height on the vertical scale and along-track distance on the horizontal scale. The distance scale will be selectable by the pilot -either 10, 20, 40, 80, 160, or 320 nautical miles (as for the Lateral Display Modes). Maximum and minimum values will be automatically chosen for the required height scale (depending on the mode and the information selected for display) and the display scaled appropriately.

2.2.2 Basic Vertical Monitoring Mode

This mode will take the form of a moving map display showing progress along the trajectory(s) (Active, Proposed, Secondary) with an aircraft symbol representing the present position. (If the aircraft is not on any of the trajectories then no display will be drawn). This aircraft symbol will be fixed horizontally on the display (just to the right of the height axis) and will move vertically as required to represent the aircraft height.

The scaling of the height display will be automatically selected so that all parts of the trajectory(s) (Active, Proposed, Secondary) within the selected distance range and the aircraft symbol are displayed within the screen limits. The minimum and maximum limits of the height display will be set to -500 feet and 40,000 feet. The minimum height scaling will represent a range of 2000 feet. The distance scale will be labelled to represent along-track distance from aircraft position.

The effect will be to position the aircraft symbol near the bottom of the screen during a climb, near the top during a descent, and in the centre during level flight, with smooth transitions from one position to another. This ensures that the full vertical screen dimension is always utilised, thus providing the pilot with an optimum view of the profile ahead of the aircraft.

In addition, wind speed/direction information will be presented to the pilot in the top left corner of the display. A status flag will also be drawn in the top left corner of the display when the EFMS datalink is inoperative.

2.2.3 Basic Vertical Planning Mode

This mode will provide a stationary (when the cursor is within the limits of the screen - see below) display to allow the inspection of the trajectories, constraint lists and tubes by the pilot. The present position (in terms of distance along the route) will be represented by a moving aircraft symbol on the screen (if the aircraft position is within the displayed area and the aircraft is on one of the trajectories). The EFMS datalink status flag will also be drawn in this display mode.

The origin will initially be centred on the aircraft symbol when the mode is entered, if the aircraft symbol is displayed. Otherwise the origin will be centred on the first constraint in the master route.

The scaling of the height display will be automatically selected so that all parts of the trajectories and constraint lists within the selected distance range are displayed within the screen limits, along with zero height (as constraint points without height limits are displayed at zero height on the display). The minimum and maximum limits of the height display will be set to -500 feet and 40,000 feet with the minimum height scaling representing a range of 2000 feet, as for the vertical monitoring mode. The distance scale will be labelled to represent along-track distance from aircraft position if the aircraft is currently on the route (if not, then it will represent along-track distance from the start of the master route).

The pilot will be able to inspect the trajectories, constraint lists and tubes by moving the display origin using the cursor input device (Rollerball). When the cursor reaches the horizontal limits of the screen, the map display will move rather than the cursor, enabling the pilot to drive the map along the route(s) to any desired position. This feature will not be available when the softkey control panel is being used for pilot selections.

A second method for inspecting the Pilot route using Forward/Back/Home controls will also be provided. The Forward and Back controls will be used for stepping along the route from constraint to constraint. If the aircraft is airborne, the Home control will return to the constraint just behind the aircraft position. Otherwise, the Home control will return to the first constraint in the list. After a step, the horizontal origin of the display will be centred on the position of the indexed constraint. The cursor will then be automatically repositioned over the indexed constraint. This is disabled if the softkey control panel is being used.

The scaling of the height display in planning mode will also be automatically adjusted during edit processes (using the Rollerball) to allow constraints to be set to values outside of the current range. During an edit, when the cursor reaches the maximum horizontal limit of the screen, the maximum of the height range will be increased accordingly (with the minimum remaining constant at zero). This allows a constraint to be set to any height value. When the edit process is completed or cancelled, the height scaling then reverts to normal.

2.2.4 Information Presented on Vertical Displays

2.2.4.1 Display of Routes (Constraint Lists)

Symbols representing the individual waypoints (constraint points) in a route will be drawn on the screen at positions representing their heights and distances along the route. Different symbology will be used to differentiate between open and closed height constraints. Colour coding will be used to differentiate between routes.

With the basic constraint lists (Pilot, Ground), the waypoint symbol will be displayed at a height midway between the upper and lower limits (or to a height of zero if there are no limits). With the lists associated with trajectories (Proposed, Active, Secondary), the waypoint symbol will be displayed at the predicted height of that point on the associated trajectory.

In Vertical Planning Mode any associated upper and lower height limits will also be displayed, above and below the waypoint symbol respectively.

Five types of route are to be displayed:-

- | | |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1) Pilot Route | <ul style="list-style-type: none">- The route entered by the pilot.- Only displayed in Vertical Planning mode- Cyan waypoint symbols.- Can be edited via the EFIS in Vertical Planning Mode (see section 2.2.6) |
| 2) Ground Route | <ul style="list-style-type: none">- The latest route uplinked by ATC.- Only displayed in Vertical Planning mode- Brown waypoint symbols. |
| 3) Proposed Route | <ul style="list-style-type: none">- The route associated with the proposed trajectory.- Cyan waypoint symbols- (trajectory displayed) |
| 4) Secondary Route | <ul style="list-style-type: none">- The route “stored” by the pilot for future use.- Yellow/Green waypoint symbols- (trajectory displayed) |
| 5) Active Route | <ul style="list-style-type: none">- The route associated with the activated trajectory.- White waypoint symbols- (trajectory displayed) |

2.2.4.2 Display of Trajectories

Trajectories will be drawn as solid lines on the screen. Colour coding will be used to differentiate between trajectories on the display. The formats are identical to those for the lateral displays (see 2.1.4.2).

2.2.4.3 Display of Tubes (ATC Clearances)

Tubes will be drawn on the screen, using colour coding and line type (solid, dashed, etc.) to differentiate between them. The formats are identical to those for the lateral displays (see 2.1.4.3).

2.2.4.4 Display of Cruise Flight Level

The Cruise Flight Level for the Pilot Constraint List will be displayed as an indicator on the height axis at the corresponding height. The Flight Level will also be numerically displayed on the indicator. If it is out of the current range of the display, then it will still be displayed, but it will be drawn at the current maximum height scale with an arrow head to represent that it is out of range. This allows the cruise flight level to be selected for edit at all times.

2.2.4.5 Display of Messages

Status messages generated by the EFIS will be displayed as text strings centred in the top half of the screen. The operation will be identical to that for the lateral displays (see 2.1.4.5).

2.2.5 Control of Information displayed

The main display logic for the vertical modes of the EFIS display is identical to that for the lateral modes (See 2.1.5) with the exception that Waypoints, Nav aids and Airports cannot be displayed. The EFIS software will also implement the following additional logic to control the display of the routes:-

2.2.5.1 Vertical Planning Mode Display Logic

- 1) A master route will be selected for display from the following:
Ground, Pilot, Proposed, Active, Secondary, Proposed Tube, Active Tube (Listed in descending order of desirability based on what the Pilot will most likely want to look at)
- 2) The remaining routes will be compared with the master route. If they share common lateral waypoints, then they will be selected for display and drawn in the correct positions relative to the master route.
- 3) If aircraft along-track position can be determined on the selected trajectories and/or tubes, then this will be shown by a moving aircraft symbol.

2.2.5.2 Vertical Monitoring Mode Display Logic

- 1) A master route will be selected from the following:
Active Trajectory, Active Tube, Proposed Trajectory, Proposed Tube, Secondary Trajectory (listed in descending order of desirability based on what the pilot will most likely want to monitor).
- 2) The remaining routes will then be compared with the master route. If they share common lateral waypoints, then they will be selected for display.
- 3) If aircraft along-track position can be determined on the selected trajectories and/or tubes, then they will be drawn in relation to the aircraft symbol on the display. If along-track position cannot be found, then the start of the master route will be drawn at zero along-track distance.

2.2.6 Route Editing Functionality

When in the Vertical Planning mode, the EFIS will include the functionality to edit the Pilot Route. These editing functions will be implemented using the Rollerball as for the lateral display modes (see 2.1.6). After extensive prototyping, the following functionality has been defined:-

2.2.6.1 Selection of Objects

The Selection of objects will be carried out in the same way as for the lateral display modes. Selectable objects will be highlighted (by a colour change) when the cursor passes over them (to provide a visual clue as to what would be selected). The required object will then be selected by a button press. When this happens, the object will undergo another change of colour to provide a visual clue that it has been selected. Selectable objects will be Constraint Symbols, Height Limit Symbols and the Cruise Flight Level Bug.

As for the Lateral Modes, an edit process can be initiated by the selection of an object on the Proposed or Active routes if the Pilot route is occulted (See 2.1.6.1). Once an edit process has been initiated, the Pilot Route will be re-displayed. It will remain re-displayed if the edit process is completed. If the edit process is cancelled then it will be occulted again.

To de-clutter the screen, the Proposed Route, Trajectory and associated softkeys will be occulted and will remain occulted if the edit sequence is completed. They will be re-displayed if the edit sequence is cancelled. The scaling of the height display will be automatically adjusted if required, and the cursor re-positioned appropriately.

One of the buttons on the Rollerball will act as a cancel button. This is to allow the user to cancel edit sequences, which have inadvertently been initiated.

2.2.6.2 Insertion Of Height Limits

- 1) Cursor is used to highlight the waypoint symbol.
- 2) Button is pressed to select the waypoint symbol.
(Wpt symbol with limit symbols displayed at zero height as a visual clue)
(The limits are displayed at default values of 300 feet above and below)
(Cursor is automatically re-positioned over the waypoint symbol)
- 3) Cursor is moved to the required height.
(Waypoint and limit symbols track the cursor as a visual clue)
(Height in feet is displayed next to waypoint symbol as a visual clue)
- 4) Button is pressed to add the height limits at the displayed height.
(At the default values of 300 feet above and below)
(Height limits can then be individually modified if required - see 2.2.6.4)

2.2.6.3 Deletion Of Height Limits

- 1) Cursor is used to highlight the waypoint symbol.
- 2) Button is pressed to select the waypoint symbol.
- 3) Cursor remains over selected waypoint symbol.
- 4) Button is pressed to select deletion of height limits.
(Wpt symbol without limits displayed at zero height as a visual clue)
- 5) Button is pressed for a third time to delete the height limits.

2.2.6.4 Modification of Height Limits

- 1) Cursor is used to highlight the upper or lower limit symbol.
(Height in feet is displayed next to symbol as a visual clue)
- 2) Button is pressed to select the upper or lower height limit symbol.
- 3) Cursor is moved to the required height.
(Limit symbol tracks the cursor as a visual clue)
(Height in feet is displayed next to symbol as a visual clue)
- 4) Button is pressed to set the limit to the displayed height.

2.2.6.5 Modification of Cruise Flight Level (CFL)

- 1) Cursor is used to highlight the CFL Bug.
- 2) Button is pressed to select the CFL Bug.
(If the CFL bug is currently outside the displayed height limits then the screen is re-scaled to position the bug at the correct height)
(Cursor is automatically re-positioned over the CFL Bug)
- 3) Cursor is moved to the required height.
(CFL Bug tracks the cursor as a visual clue)
- 4) Button is pressed to set the CFL to the displayed height.
(At completion of the Edit, the Scaling reverts to normal)

2.2.6.6 Maintaining Pilot Route Validity

The deletion of Open-Before or Open-After height limits could result in an invalid Pilot Route which cannot be used to generate a trajectory. To overcome this, the remaining height constraints will be modified at completion of the edit sequence to maintain validity. (The same logic will be used in lateral editing).

An Open-After height constraint prevents the aircraft from climbing to cruise flight level until the point is passed. If this is deleted then it is assumed that the aircraft is free to climb to cruise flight level after passing the previous height constraint, if one exists. To maintain validity, the height regime after the previous point will be changed to Open.

Similarly, the aircraft will descend from cruise flight level to meet an Open-Before constraint. If this is deleted then it is assumed that the aircraft will need to descend to meet the following constraint, if one exists. To maintain validity, the height regime before this following point will be changed to Open.

List validity problems can also occur when height constraints are inserted. If the height regime in which they are inserted is Closed, then the height constraint will be set to Closed. If the height regime is Open, then the along-track distances to the adjacent height constraints need to be taken into account to decide whether the aircraft should be permitted to climb to cruise flight level (and descend again) between the constrained points.

If the distance between the inserted constraint and the previous constraint is not great enough for the aircraft to reach cruise flight level, then the height regime between the points will be set to Closed. If cruise flight level can be attained, then the height regime will be set to Open. Similarly, the height regime between the inserted point and the following height constraint will also be set in accordance with the distance between them. The distance values to be used will be determined experimentally.

2.2.7 EFIS/CDU Interaction

The interaction between the vertical displays and the CDU is identical to that between the lateral displays and the CDU (see 2.1.8).

3 CONTROL AND DISPLAY UNIT HMI DESIGN

3.1 Introduction

This chapter describes the PD/3 AHMI CDU design. The CDU HMI is designed for use with a conventional CDU hardware case, having 12 line select keys and a display area width of 24 characters and a display area height of 14 lines. A touch screen overlay can be used to emulate the hardware CDU device. It is intended that this CDU design will be used by all participating PHARE participants during PD/3. In order to be able to mount the CDU as described within this chapter in all participating research aircraft and simulators, a landscape shaped CDU design and a portrait shaped CDU design is described. In the following section an overview will be given of the main CDU HMI components, succeeded by a more detailed description of each component.

3.2 CDU Hardware Layout

In figure 1 and figure 2 both the landscape design and portrait design of the CDU are shown. The layout includes a Display, various Key Pads and State Annunciators. The portrait layout is similar to a conventional CDU layout as can be found in many currently used aircraft. The landscape layout is specially designed for use in the BAC1-11 of DRA.

- The various Key Pads enable the pilot to navigate through pages, initiate commands or enter alphanumeric data. The Key Pads include a Numeric Key Pad, a Mode Key Pad, an Alpha Key Pad, and a Navigation Key Pad.
- The Display comprises 14 lines. Each line can contain up to 24 characters. The characters are displayed in colour. Eight different colours and two fonts are available for display of the characters.
- Annunciators (indicated by an 'A' in the figure below) are used to inform the pilot about persistent states. Four Annunciators are available.

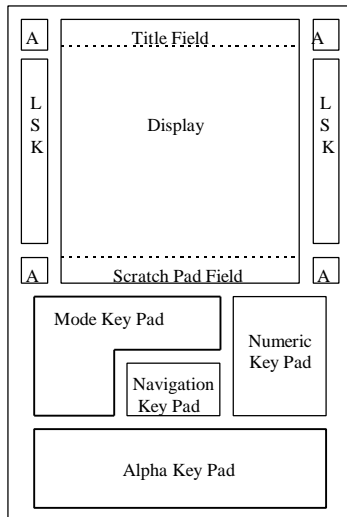


Figure 1 CDU Layout (portrait)

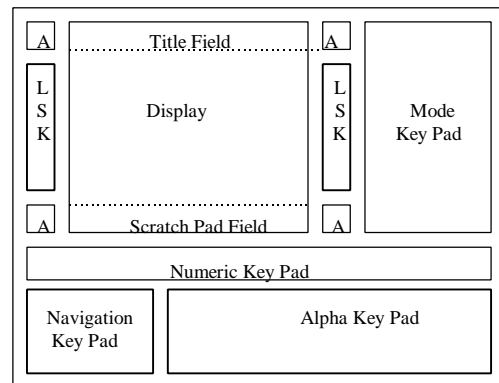


Figure 2 CDU Layout (landscape)

3.3 CDU Functional Description

3.3.1 Display

The Display is partitioned into three areas:

- Page Title Field
- Page Display Area
- Scratch Pad

The Page Title field identifies which page is currently viewed. It consists of one line of 18 characters. The last 6 characters are reserved to indicate whether additional pages of a set are available. The Page Display Area comprises six pairs of lines. A line pair comprises a label line and a data line. The pilot has access to the data line of each pair through a Line Select Key (LSK). The Scratch Pad (SP) is used for Data Entry and CDU Message Annunciation. The Scratch Pad consists of one line of 22 characters. The remaining last two characters of this line are reserved for vertical slew indicators.

3.3.2 Line Select Keys

There are six Line Select Keys (LSK) on each side of the Page Display Area. For reference in this document, the left set of keys is identified as 1L through 6L and the right set of keys is identified as 1R through 6R from top to bottom.

3.3.3 Numeric Key Pad

The Numeric Key Pad is available for numeric data entry into the Scratch Pad. The Numeric Key Pad comprises the following set of keys: ‘0’ up to ‘9’, ‘-’ and ‘.’ button. The key layout is shown in Figure 3 and Figure 4.

1	2	3
4	5	6
7	8	9
-	0	.

Figure 3 Numeric Key Pad (portrait)

-	1	2	3	4	5	6	7	8	9	0	.
---	---	---	---	---	---	---	---	---	---	---	---

Figure 4 Numeric Key Pad (landscape)

3.3.4 Alpha Key Pad

The Alpha Key Pad provides alphabetic data entry capability into the Scratch Pad. The Alpha Key Pad consists of the keys ‘A’ up to ‘Z’ and a ‘CLR’ key. The Key Layout of the Alpha Key Pad is shown in figure 5.

Q	W	E	R	T	Y	U	I	O	P
	A	S	D	F	G	H	J	K	L
	Z	X	C	V	B	N	M	CLR	

Figure 5 Alpha Key Pad for portrait and landscape CDU layout

The CLR key is used to clear messages and data from the Scratch Pad (SP) or an individual field. If alphanumeric characters have been entered into the SP, a single short press of the CLR key will erase the last character entered. A longer press of the CLR key will erase the entire contents of the SP. If the SP is empty, operation of the CLR key will enter the legend CLR into the SP. This action, followed by selecting an updatable data field, will clear the data from that data field as well as the SP itself. If the cleared data field has a default or EFMS calculated value, the data field will revert to this value. The CLR legend can be removed from the SP by pressing the CLR key a second time or by entry of an alphanumeric character.

3.3.5 Mode Key Pad

The Mode Key Pad is the default Key Pad providing page select, and command functions. The function allocation of the Mode Key Pad is fixed. Keys which are used more frequently are located in the corners of the Pad. The Key Layout of the Mode Key Pad is shown in Figure 6

PROG	INIT	DIR TO	ATC
RTE	PERF		
LEGS	REF		

Figure 6 Mode Key Pad of portrait CDU layout

and Figure 7.

LEGS	DIR TO
RTE	INIT
REF	PERF
PROG	ATC

Figure 7 Mode Key Pad for landscape CDU layout

The Mode Key Pad includes the following buttons:

- INIT button gives access to the initialization page of the EFMS. This entry allows selection of the company route, initializing fuel, weight and t/o time.
- RTE button gives access to the top level view of the flight plan. This entry allows for SID/STAR and E-R segment oriented modifications. The RTE page also allows for prediction and activation of a 4D trajectory.
- LEGS button gives access to the legs of a flight plan. This entry allows for waypoint-oriented modifications. The LEGS page also allows for prediction and activation of the 4D trajectory.
- DIR TO button enables a direct to a specific waypoint. A 'direct to' action modifies the pilot constraint list and predicts a 4D trajectory. The trajectory is not automatically activated.
- ATC button enables the pilot to perform all datalink related functions, such as trajectory negotiation and review of ATC responses.
- PROG button gives access to flight progress information.
- REF button gives access to the database related information.

3.3.6 Navigation Key Pad

Page navigation is performed using the following keys:

- Page Key '→' and '←'
- Scroll Keys '↑' and '↓'

The Page Key provides access to additional pages of a set when another page is required to complete the display of data. A horizontal arrow on the right side of the Page Title line indicates the availability of an additional page. The Page Key is closed loop, wrapping around from the last page to the first page.

→ PAGE	-
@ PAGE	-

Figure 8 Navigation Key Pad

The Scroll Keys enable the pilot to scroll through a list of data. Up and down arrow symbols ↑↓ are used on the right side of the SP line to indicate that there is more data to display. They may appear only on pages where the length of the list is variable. The list may be 'scrolled' up (and down again) to display the rest of the list. A single up or down arrow indicates scroll capability in the appropriate direction only. When the list is short enough to display completely on one page, the scroll indicators will not appear. The scroll mechanism extends to the ability to scroll through entries in a list even when the user has selected to view a nested page. The scroll mechanism in this case takes the pilot on from the nested page of a list entry to the nested page of the next item.

3.3.7 State Annunciation

Annunciators are used to indicate persistent states to the pilot. There are four annunciators. Two are located on the left side, two on the right side.

One tri-state annunciator is used to indicate the guidance status of the aircraft:

- The guidance annunciator is off when the guidance system is off
- The guidance annunciator is on in state 1 when the active guidance detects that the aircraft is within the bubble. In addition the guidance annunciator is on in state 1 when the aircraft flies without a contract, but with activated guidance.
- The guidance annunciator is on in state 2 when the active guidance detects that the aircraft is outside the bubble.

One bi-state annunciator is used to indicate the availability of ATC datalink:

- The ATC annunciator is off when the datalink is up.

- The ATC annunciator is on when the datalink is down.

One bi-state annunciator is used to indicate the presence of undisplayed SP messages:

- The message annunciator is off when all SP messages have been displayed.
- The message annunciator is on when one or more SP messages are not displayed.

3.3.8 Message Annunciation

Any instantaneous messages from the system are stored in a 'First In First Out' buffer. The first message in this buffer is displayed in the SP when the SP is empty. The pilot acknowledges this message by pressing the CLR key, upon which the message is removed from the SP and the next message is displayed (if present).

When a message is pending and the pilot starts a data entry, the message is temporarily suppressed until the the SP is empty again. As long as there are messages in the buffer that are not displayed yet (e.g. during pilot data entry or more than one message pending), the message annunciator light is turned on.

3.4 CDU Page Format Description

3.4.1 Introduction

In this section a generic page description is given in which the different types of data fields are described and how data can be entered in these data fields. In the succeeding sections the entry path table and field definition table are described.

3.4.2 Data Field Types

Pertinent EFMS formats and data labels are displayed on the various CDU pages. An example of a general CDU page is given below:

	1	2	3	4	5	6	7	8	9	0	1	2	3	4						
1	R	E	A	D	O	N	L	Y				U	P	D	A	T	A	B	L	E
2	-	-	-	-	-	-	-	-	-	-		.	.	.	.	.	.
3												[]	*					
4	<	T	R	A	N	S	F	E	R			>	T	O	G	G	L	E	<	
5	<	L	A	T		R	E	V				V	E	R	T		R	E	V	>
6	*	O	P	E	R	A	T	I	O	N		R	T	E		I	N	I	T	>
												S	C	R	A	T	C	H		
												P	A	D						-
																				-

Figure 9 An example CDU page

Colour, font and symbology are used to indicate the type of data field. In the following table all types are summarized together with their associated appearances.

Field	Description	Appearance		
		Format	Colour	Font
PAGE TITLE	Identifies selected page	text	white	normal
1/3 →	Indicates page 1 out of 3 pages. The Page Key can be used to access page 2 and page 3.	x/y →	white	normal
label	Identifies the data displayed directly under the label line.	text	white	small
READONLY	Data calculated by the EFMS, which cannot be modified. There will be a space in between the data field and the LSK.	text	cyan	normal
-----	Data entry is not allowed or data is being calculated by the EFMS.	-----	cyan	normal
UPDATABLE	Updatable alphanumeric data field. There will be no space in between the data field and the LSK	text	green	normal
•••••	Data entry is required for minimum EFMS operation.	•••••	green	normal
[]*	Data entry is optional for EFMS operation.	[]*	green	normal
>TOGGLE<	Data field which can be toggled between two or more values.	>text<	green	normal
<TRANSFER	Transfer to another CDU page.	<text	yellow	normal
*OPERATION	Initiation of an operation, which affects the current situation.	*text	yellow	normal
SCRATCH PAD	Scratch Pad. Data entry is enabled by the alpha and numeric key pads.	text	green	normal
↑↓	Scroll indicators.	↑↓	white	normal

Table 1 Description of Field Types

An updatable data field may be modified by the pilot using the Scratch Pad (SP). The format in which the data should be entered in the SP equals its display format. Units are never included. Decimal points and the minus sign symbol must be entered when required. The time is displayed as hhmm:ss. Any time which is entered should follow this format, but the colon is never entered. If seconds are omitted, they are assumed to be zero. At least four digits should be entered, leading zeros included. A shortcut editing possibility is to copy the current value of a potentially editable field into the empty SP by selecting that field. The field value can then be edited using the CLR key and/or alphanumeric keys before being copied back into the same or another field. For entry of a company route, SID/STAR procedure or E-R segment a data selection page will be displayed if the associated LSK is pressed and SP data is not valid or if the SP is empty.

3.4.3 Entry Path Table

Each page has a table which describes the routes in which the page may be reached. Typically the sequence will begin with the use of a Mode key, possible followed by some page transfer operation. In general pages may have more than one access path. Example entry path table:

Possible Entry Path
power-on/reset
REF, FMS INIT

3.4.4 Field Definition Table

The fields on each page are described in a table which defines when and how they are displayed, whether they are updateable, and the results of selecting fields. Example field definition table:

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	U	co route?	company route	••••••••	text:10	def co route
2R	RO	co route?	origin airport	----	text:5	
3L	RO	pos?	latitude	----.-	hddmm.m	
4R	U	t/o time?	t/o time	---:--	hhmm:ss	def t/o time
5L	U	cfl?	cruise flight level	•••	nnn	def cfl level
5R	T	TRUE	SENSOR>			>SENSOR
6R	U	ufob?	useable fuel on board	•••••	nnnnn	def ufob

Table 2 Example of Field Definition table

The LSK column indicates the data line. The possible type of fields are described in the following table:

Type	Description
RO	A field which is read-only
U	A field which is updatable either via the SP or by toggle.
T	A field which results in a page transfer when selected
O	A field which results in some operation without page transfer
OT	A combination of an operation followed by a page transfer

Table 3 Field type description

The display condition describes the condition under which the field may appear or not. Display TRUE or FALSE define what is to be displayed when the condition is met or not. The format outlines the format used for the display (and in general for input of updatable fields):

Format	Description
text:n	An alphanumeric field of n chars
nnn	A numeric value. The position of a decimal point is usually specified if needed.
hhmm:ss	A time field indicating hours, minutes and seconds
hddmm.m	A position field indicating hemisphere, degrees and minutes, decimal minutes

Table 4 Field format description

All values are left aligned if displayed on the left side on the CDU page, and right aligned if displayed on the right side of the CDU page. The action which results from selection of a field is defined in the last column of the field definition tables.

3.5 CDU Page Set

3.5.1 FMS init

This page is the initial entry to the system, being displayed following power on or reset. It allows the crew to review the aircraft type, engine type, navigation data base, and software version of the EFMS. Any CDU messages may be cleared from the SP by using the CLR key. When all the data has been checked and verified as correct, press 6R to access the RTE INIT page, or press the INIT mode key. Alternate access to the FMS INIT page can be made through the REF key and 2L FMS INIT.

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      F M S   I N I T
model                engine
1  C 5 5 0                P W J T 1 5 D - 4      1
  o p   p r o g r a m
2  E F M S   2   V 2 . 1      2
  d a t a   b a s e   v a l i d i t y
3  0 1 / 0 1 / 1 9 9 7      3
  3 1 / 1 2 / 1 9 9 8
4
4  d a t a   b a s e   v e r s i o n
5  1 0 9 4 - 0 0 2      5
6
6                R T E   I N I T >      6

```

Possible Entry Path
power-on/reset
REF, FMS INIT

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	RO	aircraft model?	aircraft model	-----	text:11	
1R	RO	engine type?	engine type	-----	text:11	
2L	RO	EFMS s/w version?	EFMS s/w version	-----	text:12	
3L-4L	RO	nav db validity	nav db validity	--/--/--	text:10	
5L	RO	nav db version?	nav db version	-----	text:8	
6R	T	TRUE	RTE INIT>			call RTE INIT

3.5.2 Route Initialization

The INIT function allows the pilot to enter EFMS initialization parameters. Pressing the INIT function key anytime displays the RTE INIT page. It allows the pilot to initialize the company route, takeoff time, cruise flight level, initial fuel and weight data. A company route predefines a pilot constraint list, an origin airport and a destination airport. If the origin airport is cleared or an existing airport is entered into the SP, then the current SID is removed from the pilot constraint list, and if the destination airport is cleared or an existing airport is entered into the SP, then the current STAR is removed from the pilot constraint list. If an airport field is pressed with empty SP, the AIRPORT details will be shown. If an airport field is pressed with non valid airport name in SP, an appropriate message will be shown in the SP.

If the EFMS is in contact with a radio clock then the current time read from this source is shown. This allows the pilot to set the UTC time to be consistent with the radio clock. In addition the current UTC time, latitude and longitude read from the navigation system are displayed. These values may be updated by the pilot, but will be immediately reset once contact with the navigation system is established.

ÿ

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      R T E   I N I T
c o   r o u t e                c f l
1 • • • • • < M O D I F I E D >          2 5 0      1
  f r o m                          t o
2 * [   ]                          [   ] *        2
  l a t                              l o n g
3 N 4 1 5 8 . 8                    W 0 8 7 5 0 . 3  3
  r a d   t i m e
4 1 2 0 7 : 6 6          U S E   R A D   T I M E *  4
  U T C                          t a k e o f f
5 1 2 0 6 : 2 2          1 2 3 0 : 2 0          5
  z f w                          u f o b
6 • • • • •                      • • • • •        6

```

Possible Entry Path
INIT
REF, FMS INIT, RTE INIT
power-on/reset, RTE INIT

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	U	co route?	Company route	•••••	text:5	if CLR then delete co else if co exists then use co else call SEL CO ROUTE
	RO	co modified?	<MODIFIED>			
1R	U	crz defined?	cruise flight level	default value	nnn	def crz
2L	U	origin airport defined?	ICAO ident	*[]	text:5	def origin airport or call AIRPORT
2R	U	destination airport defined?	ICAO ident	*[]	text:5	def destination airport or call AIRPORT
3L	RO	lat pos?	latitude	----.-	hddmm.m	
3R	RO	long pos?	longitude	----.-	hdddmm.m	
4L	RO	radio time?	radio time	----:--	hhmm:ss	
4R	O	TRUE	USE RAD TIME *			UTC := radio time
5L	U	UTC time?	UTC time	----:--	hhmm:ss	def UTC time
5R	U	takeoff time?	takeoff time	----:--	hhmm:ss	def takeoff time
6L	U	zfw?	zero fuel weight	•••••	nnnnn	def zfw
6R	U	ufob?	useable fuel on board	•••••	nnnnn	def ufob

A company route should be entered into the flight plan through 1L. Pressing 1L with valid CO in SP copies it into the CO field, pressing 1L with CLR in SP deletes the currently defined CO, in all other cases (empty or invalid SP) the CO ROUTE SEL page is shown. Note that a pilot can only select a company route from the data base. The pilot cannot define a company route. If the company route is modified, <MODIFIED> will be shown after the company route name.

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  SEL CO ROUTE
  co routes
1 CO 1
2 CO 2
3 CO 3
4 CO 4
5 CO 5
6
  return to
  RTE INIT >
  
```

Possible Entry Path
REF, CO ROUTES
INIT, co route

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	RO	co route?	co route name	NONE	text:5	select co, call CO ROUTE
6R	T	calling page RTE INIT?	return to RTE INIT			call RTE INIT
6R	T	calling page REF INDEX?	return to REF INDEX			call REF INDEX

Selecting for example 3L automatically results in:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      C O R O U T E
co route
1 C O 3          < S E L >
2 remaining
3 co routes
4 C O 1
5 C O 2
6 C O 4
      return to
6 * I N S E R T      R T E I N I T >
      -
    
```

Possible Entry Path
SEL CO ROUTE, co route

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	RO	TRUE	selected co route <SEL>		text:10	
3L-5L	RO	remaining co routes?	co route name		text:10	select co
6L	OT	new co route selected?	*INSERT			def co route, call RTE INIT
6R	T	calling page RTE INIT?	return to RTE INIT			>RTE INIT
6R	T	calling page REF INDEX?	return to REF INDEX			>REF INDEX

Entering the CO ROUTE automatically fills the FROM/TO field on the second line. If any part of a CO ROUTE is modified later in the flight, the CO ROUTE field is blanked, since it is no longer exactly as originally stored. A co route is considered to be modified if:

- a point or segment of the pilot constraint list is modified, deleted or inserted
- a constraint window is modified, deleted or defined
- origin airport or destination airport is changed

After entering a CO ROUTE on the RTE INIT page, Zero Fuel Weight (ZFW) and Useable Fuel On Board (UFOB) must be entered. Optionally the CFL and/or TO time can be modified. Default the TO time equals the current UTC time.

Pressing on 1L or 1R with empty SP, the details of the airport and the details of the selected runway are displayed:

```

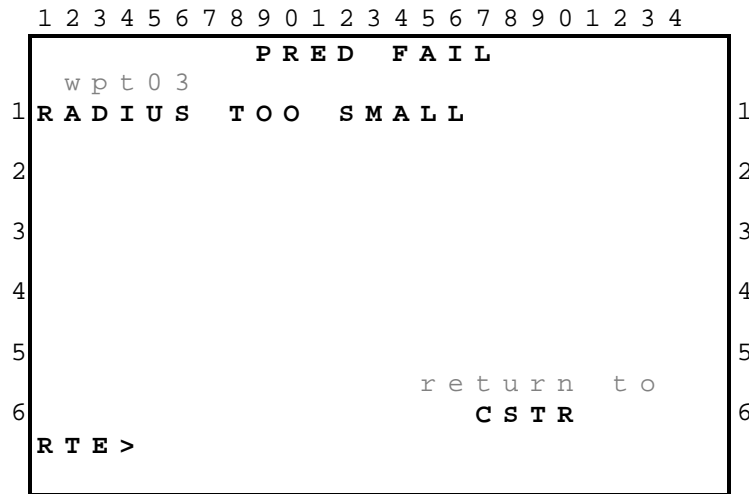
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  AIRPORT  ARPT 1
  trans alt          trans fl
1 6 0 0 0          6 0
  speed limit      below
2 2 5 0          1 0 0
  QNH              OTA
3 * [    ]          [    ] *
  RUNWAY  RW 0 9 L
  angle / elev / alt      elev
4 3 / 1 0 8 / 2 0 0 0      7 5
  ils id              return to
5 G H U              C S T R
6 R T E >
  
```

Possible Entry Path
RTE, to
RTE, from

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	RO	trans alt?	transition altitude	----	nnnnn	
1R	RO	trans fl?	transition flight level	---	nnn	
2L	RO	speed limit?	speed limit	---	nnn	
2R	RO	speed limit below altitude?	speed limit below altitude	----	nnnn	
3L	U	QNH?	QNH	*[]	nnnn	
3R	U	OTA?	OTA	*[]	nnn	
5L	RO	SID/STAR defined?	angle/elev/alt	----	nnn/nnnnn/nnnnn	
5R	RO	SID/STAR defined?	Elevation	----	nnnn	
6L	RO	SID/STAR defined?	ils id	----	text:5	
6R	T	calling page CSTR RTE?	return to CSTR RTE			call CSTR RTE
6R	T	calling page PROP RTE?	return to PROP RTE			call PROP RTE
6R	T	calling page ACT RTE?	return to ACT RTE			call ACT RTE
6R	T	calling page RTE INT?	return to RTE INIT			call RTE INIT

The selected runway is determined by the selected SID or STAR. Every selected SID or STAR as an associated runway.

If a prediction failure has occurred, the PRED FAIL> button gives some information about the type of failure.



Possible Entry Path
RTE, PRED FAIL

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	RO	TRUE	type of prediction error		text	
6R	T	TRUE	return to CSTR RTE			call CSTR RTE

The 6L key is used for prediction and activation of a 4D trajectory. The various states are shown in the next table:

state	6L	6R	CSTR	PROP	ACT	event	transit to
state#0	*PREDICT	PROP xxx> ¹	*				
						*PREDICT	state#1
state#1	PREDICTING	PROP xxx> ¹	*				
						result FAIL	PRED FAIL page
						result OK	state#3
state#2	<PRED FAIL	PROP xxx> ¹	*				
						<PRED FAIL	PRED FAIL page
						modify pilot_cl	state#0
state#3	*ACT TRJ	ACT xxx> ²		*			
						*ACT TRJ	state#5
						accept neg tube	state#4
						modify pilot_cl	state#0
state#4	*ACT TUBE	ACT xxx> ²		*			
						*ACT TUBE	state#5
						modify pilot_cl	state#0
state#5		CSTR xxx>			*		
						modify pilot_cl	state#0

The asterisk '*' indicates the presented type of information. Activate tube requests monitoring the most recently ATC approved tube. The event 'modify pilot_cl' covers any modification of

¹ Only if proposed rte available

² Only if active rte available

Selecting SID3 by pressing 3L automatically results in the next display:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  S I D   f r o m   A R P T 1
1  s i d           r w y           1
  S I D 3           R W 0 3   < S E L >
2  r e m a i n i n g           2
  s i d s           r w y s
3  S I D 1           R W 0 1           3
4  S I D 2           R W 0 2           4
5  S I D 4           R W 0 4           5
  r e t u r n   t o
6 * I N S E R T           C S T R   R T E >           6
  -

```

Possible Entry Path

SEL SID|STAR from ARPT

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	RO	TRUE	selected SID|STAR, rwy <SEL>		text:10	
3L-5L	RO	remaining SIDs|STARs?	SID|STAR name, rwy name		text:5, text:5	select SID|STAR
6L	OT	new SID|STAR selected?	*INSERT			def SID|STAR, return to calling page
6R	T	calling page 2D RTE?	return to 2D RTE			call 2D RTE
6R	T	calling page 4D TRJ?	return 4D TRJ			call 4D TRJ
6R	T	calling page ACT TRJ?	return to ACT TRJ			call ACT TRJ

Similarly, a STAR procedure review or revision is performed as a lateral revision of a STAR segment. A SID segment or STAR segment can be deleted using the CLR key.

3.5.3.1.2 Enroute Segment Entry

This function enables RTE construction or revision via use of inserting E-R segments and their associated waypoints into the RTE. A segment is inserted at SEG3 by pressing the left LSK adjacent to SEG3:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      S E L   E - R   S E G M E N T
1 S E G 1
2 S E G 3
3 S E G 4
4 S E G 5
5 S E G 6
6
      r e t u r n   t o
      C S T R
R T E >
  
```

Possible Entry Path
RTE, E-R segment

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	RO	E-R?	E-R name	NONE	text:5, text:5	select E-R
6R	T	calling page CSTR RTE?	return to CSTR RTE			call CSTR RTE
6R	T	calling page PROP RTE?	return to PROP RTE			call PROP RTE
6R	T	calling page ACT RTE?	return to ACT RTE			call ACT RTE

Note that after selection of a segment the *INSERT prompt appears for insertion of the segment into the RTE:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      E - R   S E G M E N T
1 S E G 3           < S E L >
2 r e m a i n i n g
  s e g m e n t s
3 S E G 1
4 S E G 4
5 S E G 5
6
      r e t u r n   t o
      C S T R
* I N S E R T
R T E >
  
```

Possible Entry Path
SEL E-R SEGMENT

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	RO	TRUE	selected E-R <SEL>		text:10	
3L-5L	RO	remaining E-Rs?	E-R name		text:5, text:5	select E-R
6L	OT	new E-R selected?	*INSERT			def E-R, return to calling page
6R	T	calling page 2D RTE?	return to 2D RTE			call 2D RTE
6R	T	calling page 4D TRJ?	return 4D TRJ			call 4D TRJ
6R	T	calling page ACT TRJ?	return to ACT TRJ			call ACT TRJ

In the current CDU implementation all available segments in the data base will be listed. An E-R segment can be deleted using the CLR key.

3.5.3.2 LEGS page 1

By pressing the LEGS top level button key, the last modified RTE will be shown. An example of a typical LEGS page after initialization and before prediction is:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  C S T R   L E G S           1 / 3 ®
  t i m e                   a l t
1 W P 1   1 2 0 0 - 1 2 0 1   2 9 0 - 2 9 2   1
  s i d 1   t r a c k 1   d i s t 1
2 W P 2
  s e g 2   t r a c k 2   d i s t 2
3 W P 3   1 4 0 0 - 1 4 0 4   3
  s e g 2   t r a c k 3   d i s t 3
4 W P 4
  s e g 2   t r a c k 4   d i s t 4   2 8 0 - 2 8 2   4
5 W P 5   5
6 * P R E D I C T           r e t u r n   t o
  C S T R   R T E >           6
  -

```

Possible Entry Path

LEGS
RTE, LEGS

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	T	route waypoint?	waypoint name, time constraint window, alt constraint window		text:5, min-max time wind, min-max alt wind	call LAT REV
1R-5R	T	route waypoint?				call VERT REV
6L	O	modified lateral route?	*PREDICT			predict PROP RTE
6L	T	prediction failure?	PRED FAIL>			call PRED FAIL
6R	T	TRUE	return to CSTR RTE>			call CSTR RTE

The size of time or altitude constraint windows are shown on this CSTR LEGS page. Seconds of the time constraint window are not shown, because there is no display space available. Constraint windows can be modified by pressing the associated right LSK. Constraint points can be inserted or removed by pressing the associated left LSK. A constraint point can be removed by using the CLR key as well. The corresponding distance and track information is displayed in between the waypoint lines.

By pressing *PREDICT a 4D trajectory is predicted by the EFMS:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  from      P R O P   L E G S       1 / 3 ®
1 W P 1     1 3 0 0 : 2 3   1 6 0   2 0 0 0 0   1
  sid 1     t r a c k 1   d i s t 1
2 W P 2     1 3 0 0 : 4 4   1 7 0   F L 1 9 9   2
  seg 2     t r a c k 2   d i s t 2
3 W P 3     1 3 0 5 : 3 0   1 8 0   F L 2 5 9   3
  seg 2     t r a c k 3   d i s t 3
4 ( T / C ) 1 3 0 7 : 4 4   2 1 0   F L 2 7 0   4
           t r a c k 3   d i s t 4
5 W P 4     1 4 5 0 : 4 0   2 3 0   F L 2 9 0   5
           r e t u r n   t o
6 * A C T I V A T E           P R O P   R T E >   6
                                     -

```

Possible Entry Path
LEGS
RTE, LEGS

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	T	route waypoint?	waypoint name, etc, spd, alt		text:5, nnn:nn, nnn, nnnnn	call LAT REV
1R-5R	T	route waypoint?				call VERT REV
6L	O	TRUE	*ACTIVATE			activate PROP RTE
6R	T	calling page PROP RTE?	return to PROP RTE>			call PROP RTE
6R	T	calling page ATC?	return to ATC>			call ATC

In non ATC controlled area the flight plan is activated by pressing *ACTIVATE:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  from      A C T   L E G S       1 / 3 ®
1 W P 1     1 3 0 0 : 2 3   1 6 0   2 0 0 0 0   1
  sid 1     t r a c k 1   d i s t 1
2 W P 2     1 3 0 0 : 4 4   1 7 0   F L 1 9 9   2
  seg 2     t r a c k 2   d i s t 2
3 W P 3     1 3 0 5 : 3 0   1 8 0   F L 2 5 9   3
  seg 2     t r a c k 3   d i s t 3
4 ( T / C ) 1 3 0 7 : 4 4   2 1 0   F L 2 7 0   4
  seg 2     t r a c k 3   d i s t 3
5 W P 3     1 4 5 0 : 4 0   2 3 0   F L 2 9 0   5
           r e t u r n   t o
6           A C T   R T E >   6
                                     -

```

Possible Entry Path
LEGS
RTE, LEGS

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	T	route waypoint?	waypoint name, ete, spd, alt	NONE	text:6, hhmm, nn, nnn	call LAT REV
1R-5R	T	route waypoint?				call VERT REV
6R	T	TRUE	return to ACT RTE>			call ACT RTE

The pseudo waypoints are computer predicted and are enclosed in brackets (). They are placed in the flight plan for pilot reference and indicate a change in the phase table. The next Table lists example pseudo waypoint types:

CDU display	Pseudo waypoint	Description
T/D	Top of Descent	EFMS predicts where the A?C should start its descent.
T/C	Top of Climb	EFMS predicts where the A/C will reach the cruise altitude.
T/P	Turn Point	
C TO	Climb TakeOff	
C NA	Climb Noise Abatement	
CL1	Climb 1	
CL2	Climb 2	
CL3	Climb 3	
CLA	Climb A	Climb Acceleration
CLM	Climb Mach	
CR	Cruise Altitude	
CR D	Cruise Deceleration	Cruise Deceleration
CRDD	Cruise Descent	
D1	Descent 1	
D DE	Descent	
D1A	Descent	
D LE	Descent to Level	
D L2	Descent	
D2	Descent	
D D2	Descent	
D AP	Descent to Approach CAS	

The possible pseudo waypoint types are defined in the PHASETAB.DAT preparation file. Pseudo waypoints cannot be modified by the pilot. Vertical scrolling ↓ is used for slewing the flight plan. The FROM label disappears when the point in 1L is not the 'FROM' waypoint.

3.5.3.2.1 Lateral Route Revision

By pressing a left LSK on a LEGS page a lateral route revision can be accomplished. For example, pressing 2L results in:

1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	
L A T R E V f r o m W P 2																								
n e x t w p t																								
1	*	[		]																			D E L E T E *	1
2	<	P R O C		T U R N																			S T R E T C H >	2
3	<	H O L D																						3
4																								4
5	*	D I R E C T		T O																				5
6																								6
r e t u r n t o																								
A C T L E G S >																								
-																								

Possible Entry Path
LEGS, left LSK

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	OT?	TRUE	*[]			duplicate name? call DUPLICATE NAMES new wpt?call NEW WPT else ins after selected wpt, return to 2D LEGS
1R	OT	TRUE	*DELETE			remove waypoint, return to 2D LEGS
2L	T	TRUE	<PROC TURN			call PROC TURN
2R	T	path stretch defined?	STRETCH>			call STRETCH
3L	T	hold permitted?	<HOLD			call HOLD
5L	OT	TRUE	*DIRECT TO			direct to wpt, return to ACT LEGS
6R	T	calling page 2D LEGS?	return to 2D LEGS			call 2D LEGS
6R	T	calling page 4D LEGS?	return to 4D LEGS			call 4D LEGS
6R	T	calling page ACT LEGS?	return to ACT LEGS			call ACT LEGS

Waypoints may be entered into the flight plan by using the trackball on the Navigation Display (ND) or by entering the NEXT WPT field at the LAT REV page. Duplicate waypoints and new waypoints are covered in the following sections. If the next waypoint is on the current RTE, then all waypoints in between are automatically removed. *The *DIRECT TO function automatically generates and activates (even in ATC controlled area) a 4D trajectory from the current aircraft position towards the current selected waypoint³.*

3.5.3.2.1.1 New Waypoint

The NEW WAYPOINT page allows the pilot to add a new waypoint by defining the latitude and longitude values:

³ Not implemented

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
NEW WAYPOINT
ident
1 WPT 1 1
lat long 2
2 ..... 2
3
4
5
6 *INSERT return to LAT REV > 6
    
```

Possible Entry Path
LEGS, LAT REV, next waypoint entry

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	RO	wpt ident not empty?	Waypoint ident	<unknown>	text:5	
2L	U	lat new wpt?	lat new wpt	.....	hddmm.m	def lat
2R	U	long new wpt?	long new wpt	.....	hdddmm.m	def lon
6L	OT	lat/lon defined?	*INSERT			add waypoint, return to calling page
6R	T	calling page LAT REV?	return to LAT REV			call LAT REV
6R	T	calling METEO REV?	return to METEO REV			call METEO REV

3.5.3.2.1.2 Duplicate Waypoints

If a non-unique waypoint is entered, the duplicate names page will be automatically displayed for pilot review and waypoint selection. The LAT/LONG of the waypoint is displayed in whole degrees. Pilot selection of the desired waypoint is made through the associated LSK where upon the display reverts to the previously display page.

Duplicate waypoints will be displayed top to bottom in order of closest distance to the revise waypoint and/or aircraft position. For example, suppose WP3 is a duplicate waypoint and entered in the SP:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
DUPLICATE NAMES
lat/long
1 *WP3 N4940.1/W05630.3 1
2 *WP3 N4430.4/W08827.5 2
3 *WP3 N5822.2/E01224.4 3
4 *WP3 N4538.1/E00527.4 4
5 *WP3 N4457.3/E00916.3 5
6 return to LAT REV > 6
    
```

Possible Entry Path
LEGS, LAT REV, next waypoint entry
NEW WPT

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	OT	duplicate wpt?	*waypoint name, lat/long		text:5,hddmmss/h dddmmss	sel wpt,return to calling page
6R	T	calling page LAT REV?	return to LAT REV			call LAT REV
6R	T	calling page NEW WPT?	return to NEW WPT			call NEW WPT

Choose the correct WP3 waypoint by comparing the LAT/LONGs. To insert the correct waypoint, simply press the associated LSK.

3.5.3.2.1.3 Procedure Turn

The PROC TURN page enables the pilot to specify a turn with a fixed radius. The type toggles between a 'normal turn' or 'start of turn' waypoint. The direction toggles between 'left' or 'right'.

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  P R O C   T U R N   a t   W P 1
1
  r a d i u s                               t y p e
2 * [      ]                               > S O T <
3                                           d i r
3                                           > L E F T <
4
5
6
  r e t u r n   t o
  L A T   R E V >
  
```

Possible Entry Path
LEGS, LAT REV, PROC TURN

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
2L	U	radius?	Radius	*[]	nnn.n	def turn radius
2R	U	TRUE	SOT|NORMAL			def turn type
3R	U	SOT?	LEFT|RIGHT|NONE			def turn direction
6R	T	TRUE	return to LAT REV			call LAT REV

3.5.3.2.1.4 Hold

The HOLD page enables the pilot to insert a hold procedure into the 4D trajectory, or modify an existing hold procedure.

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      H O L D   a t   W P 2
i n b   c r s           t u r n
1 * [   ]               > L E F T < 1
s p d
2 * [   ]               2
d i s t
3 * [   ]               3
4
5
6 * I N S E R T           r e t u r n   t o
                           L A T   R E V > 6
    
```

Possible Entry Path
LEGS, LAT REV, HOLD

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	U	hold defined?	hold bearing	*[]	nnnn	def hold bearing
1R	U	TRUE	LEFT|RIGHT			def hold turn direction
2L	U	hold defined?	hold speed	*[]	nnn	def hold speed
3L	U	hold defined?	hold distance	*[]	nnn.n	def hold length
6L	OT	hold defined?	*DELETE			delete hold definition
6L	OT	no hold defined?	*INSERT			insert hold definition
6R	T	TRUE	return to LAT REV			call LAT REV

3.5.3.2.1.5 Path Stretch Data

The STRETCH page gives the pilot extra information about the path stretch parameters. None of the fields can be modified by the pilot.

```

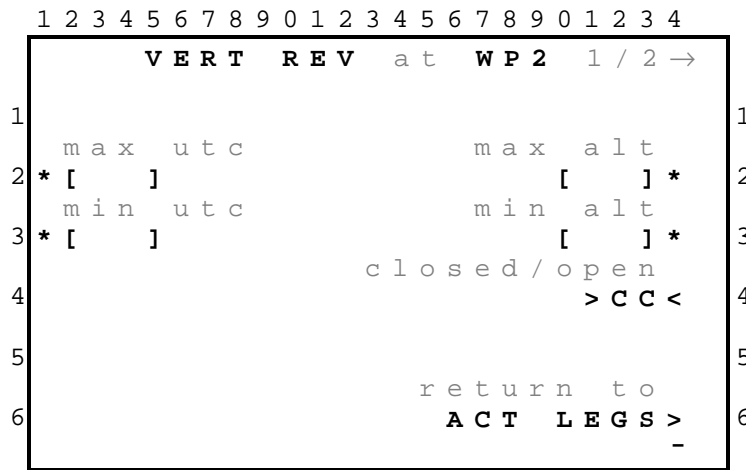
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
      S T R E T C H   a t   W P 1
t y p e
1 T R O M B O N E 1
i n t e r c e p t   a t
2 W P 2 2
i n n e r   r a n g e
3 - - . - 3
o u t e r   r a n g e
4 - - . - 4
5
6 r e t u r n   t o
                           L A T   R E V > 6
    
```

Possible Entry Path
LEGS, LAT REV, STRETCH

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	RO	TRUE	TROMBONE|FAN			
2L	RO	TRUE	interception wpt name		text:5	
3L	RO	TRUE	inner range	--.	nn.n	
4L	RO	TRUE	outer range	--.	nn.n	
6R	T	TRUE	return to LAT REV			call LAT REV

3.5.3.2.2 Vertical Route Revision

The VERT REV page enables the pilot to define or modify an altitude or time constraint at a specific waypoint. In addition the pilot can specify the scope of the constraint: closed or open.



Possible Entry Path
LEGS, right LSK

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
2L	UT	time cstr?	max utc	*[]	hhmm:ss	def time cstr, call 2D LEGS
3L	UT	time cstr?	min utc	*[]	hhmm:ss	def time cstr, call 2D LEGS
2R	UT	alt cstr?	max alt	*[]	nnnnn	def alt cstr, call 2D LEGS
3R	UT	alt cstr?	min alt	*[]	nnnnn	def alt cstr, call 2D LEGS
4R	U	alt cstr?	CC|OC|OO|CO			def alt cstr scope
6R	T	calling page 2D LEGS?	return to 2D LEGS			call 2D LEGS
6R	T	calling page 4D LEGS?	return to 4D LEGS			call 4D LEGS
6R	T	calling page ACT LEGS?	return to ACT LEGS			call ACT LEGS

3.5.3.4 LEGS Page 2

LEGS page 2 provides great circle distance to the next waypoint, route outbound course for the next leg, temperature, and wind information for the identical waypoints displayed on page 1. Pressing the → key with LEGS page 1 displayed accesses LEGS page 2. The labels provide an explanation of the LEGS page 2 data.


```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  METEO to WP 3
at dist qnh from
1 3 0 . 1      1 0 0 0 . 2      WP 2
2 < P R E V          N E X T >
  alt      wind      ° C
3 < 3 3 0      2 8 0 ° / 1 0 0      - 2 7
4 < 3 0 0      2 7 0 ° / 9 0      - 4 5
5 < 2 9 0      2 8 0 ° / 8 5      - 4 5
6 < N E W P O I N T          r e t u r n t o
  A C T L E G S >
  
```

Possible Entry Path
LEGS, right LSK

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	U	dist non zero?	distance from wpt	*[]		def distance
	RO	TRUE	qnh		nnnn.n	
1R	RO	dist non zero?	From wpt name			
2L	T	not first point?	<PREV			call previous meteo point
2R	T	not last point?	NEXT>			call next meteo point
3L-5L	T	meteo defined at lvl?	flight level, wind, temp			call MET REV
6L	T	TRUE	<NEW POINT			call MET REV
6R	T	calling page CSTR LEGS?	return to CSTR LEGS			call CSTR LEGS
6R	T	calling page PROP LEGS?	return to PROP LEGS			call PROP LEGS
6R	T	calling page ACT LEGS?	return to ACT LEGS			call ACT LEGS

Pressing on one of the altitude fields or the <NEW POINT button results in:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  METEO REV to WP 3
  at dist      from
1  3 0 . 1      WP 2
  qnh
2 1 0 0 0 . 5
  alt      temp
3 * [      ]      - -
  wind dir      wind spd
4 - - -      - - - -
5 * R E S E T          D E L E T E *
  return to
6 * I N S E R T          M E T E O >
  
```

Possible Entry Path
METEO from, <NEW POINT
METEO from, <altitude

The PERF page enables the pilot to review and adjust EFMS predictor parameters. It is a scrollable list. All parameters which are flagged as 'Pilot_Editable' in the PLANVALS.DAT file which is read during the power-on/reset process or after pressing DEFAULT VALUES*. The list is presented in the same order as the parameter definitions, enabling the HMI design engineer to organise the list in such a way that the human factors criteria are met. Example PERF page:

1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	
1	1	7	9																					1
2	2	2	0																					2
3	3	2	4	0																				3
4	4	0	.	7	5																			4
5	5	2	8	0																				5
6																								6

Possible Entry Path
PERF

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	U	parameter?	parameter name, min, max		text:7, text:7-text:7	
6R	O	TRUE	DEFAULT VALUES*			read prep file again

3.5.5 Flight Negotiation

After approval of the predicted 4D trajectory by the pilot, the trajectory needs to be negotiated with ATC. This can be accomplished by pressing the ATC button in order to access the ATC page:

1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	
1	*	N	E	G	O	T	I	A	T	E		P	R	O	P									1
2	*	D	O	W	N	L	I	N	K		A	C	T											2
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
4	<	A	T	C		C	S	T	R															4
5	*	A	C	C	E	P	T		T	U	B	E												5
6																								6

Possible Entry Path
ATC

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	O	prop_trj defined?	*NEGOTIATE			downlink prop trajectory
1R	T	prop_trj defined?	REVIEW>			call PROP LEGS page
2L	O	act_trj defined?	*DOWNLINK ACT			downlink act trajectory
2R	T	act_trj defined?	REVIEW>			call ACT LEGS page
4L	T	ATC constraint list received?	<ATC CSTR			show ATC proposed trajectory
5L	O	ATC negotiated tube received?	*ACCEPT TUBE			accept negotiated tube

The *NEGOTIATE button is available if a proposed trajectory is defined. The REVIEW> button enables the pilot to review the proposal before negotiating it. If ATC uplinks a negotiated tube, the pilot can accept this tube by pressing 5L. If ATC uplinks an ATC constraint list a SP message will be shown. The ATC uplinked constraint list can be reviewed by the pilot using the <ATC CSTR button:

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  f r o m           A T C   L E G S           1 / 3 →
  e t e           s p d           a l t
1 W P 1           1 3 0 0 : 2 3   1 6 0   2 0 0 0 0   1
  s i d 1         t r a c k 1     d i s t 1
2 W P 2           1 3 0 0 : 4 4   1 7 0   F L 1 9 9   2
  s e g 2         t r a c k 2     d i s t 2
3 W P 3           1 3 0 5 : 3 0   1 8 0   F L 2 5 9   3
  s e g 2         t r a c k 3     d i s t 3
4 ( T / C )       1 3 0 7 : 4 4   2 1 0   F L 2 7 0   4
  s e g 2         t r a c k 3     d i s t 3
5 W P 3           1 4 5 0 : 4 0   2 3 0   F L 2 9 0   5
  r e t u r n   t o
6 * L O A D   C S T R           A T C >           6
  -

```

Possible Entry Path

ATC, <ATC CSTR

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L-5L	T	route waypoint?	waypoint name, etc, spd, alt	NONE	text:5	call LAT REV
1R-5R	T	route waypoint?				call VERT REV
6L	OT	TRUE	*LOAD CSTR			copy ATC ground_cl into pilot_cl, and predict, call PROP RTE
6R	T	TRUE	return to ATC>			call ATC

The *LOAD RTE key copies the ATC constraint list into the pilot constraint list and automatically predicts a 4D trajectory and returns to the PROP RTE page. If the trajectory predictor cannot predict a 4D trajectory through the ATC constraint list, the CSTR LEGS page is shown with just the constraint window information.

Pressing LSK1 results in a GO DIRECT towards waypoint WP4.

3.5.8 Reference Data Base Entry

The REF INDEX page provides the pilot capabilities to review and/or modify meteo database and nav data base related information. Furthermore, it gives in addition access to the available CO ROUTES. The CDU 1B entry give access to the complete CDU 1B page hierarchy.

1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	
REF INDEX																								
1	< CO ROUTES																		CDU 1B >				1	
2	< FMS INIT																		2					
3	< FMS RESET																		3					
4																								4
5	< METEO																		5					
6																								6

Possible Entry Path
REF

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	T	co routes available?	<CO ROUTES			call SEL CO ROUTES
1R	T	TRUE	CDU 1B>			call CDU 1B page
2L	T	TRUE	<FMS INIT			call FMS INIT
3L	T	TRUE	<FMS RESET			call FMS RESET
5L	T	meteo db available?	<METEO			call METEO DB

1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	
FMS RESET																								
1																								1
2	* CONFIRM RESET																		2					
3																								3
4																								4
5																								5
6	return to																		REF INDEX >				6	

Possible Entry Path
REF, <FMS RESET

The <METEO entry provides access to the meteo point data base of the EFMS. Every waypoint, and intermediate point on a leg, for which meteo data has been defined at some time is recorded. The pilot may inspect the meteo data held, modify it or reset it to a standard value. In the example page below, the meteo point is located at a distance from 30.1 NM relative to WP2 on a leg from WP1. A dashed FROM waypoint indicates a point on the opening leg of an in flight situation.

```

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
  METEO DB
  from
1  WP 1
  at dist qnh to
2 30.1 1000.2 WP 2
  alt wind °C
3 < 330 280°/100 -27
4 < 300 270°/90 -45
5 < 290 280°/85 -45
6 < NEW POINT return to
  REF INDEX >

```

Possible Entry Path

REF, <METEO

LSK	Type	Display condition	Display TRUE	Display FALSE	Format	Action
1L	U	dist non zero?	from wpt name	-----		def from wpt name
1L	U	dist non zero?	distance from wpt	*[]		def distance
	RO	TRUE	qnh		nnnn.n	
1R	U	dist non zero?	to wpt name			
3L-5L	T	meteo defined at lvl?	flight level, wind, temp			call MET REV
6L	T	TRUE	<NEW POINT			call MET REV
6R	T	TRUE	return to REF INDEX			call REF

3.6 Differences with EFMS Phase 1b CDU Design

The EFMS Phase 1b CDU design is described in document 94-70-25 [1]. The main differences between the EFMS Phase 1b CDU Design and the CDU design as defined within this document are:

- Complete redesign of mode key button panel. For example, instead of a separate top level entry for viewing (VIEW key) and editing (EDIT CL key) a trajectory, there is one top level entry for segment oriented operations (RTE key) and one top level entry for waypoint oriented operations (LEGS key).
- Constraint list information, trajectory information and phase table information are all integrated into one list, for review and editing purposes.

-
- Actuation of prediction and activation of a trajectory can be performed directly on the ROUTE and LEGS pages: the pilot does not need to transfer to another page to perform these operations.
 - Selection of which list is being viewed (proposed, negotiated, active,) is made context dependent. Default the active trajectory is shown. At the moment, for example, the pilot attempts to modify the active trajectory, the CDU automatically shows the pilot constraint list (which is called the PROP ROUTE).
 - Furthermore, instead of using Left LSK for access to details of a waypoint (attributes) and Right LSK for point oriented operations (such as insert and delete), Lateral Revisions using the Left LSK and Vertical Revisions using the right LSK are proposed.
 - Changes in the used phraseology, for better pilot understanding. For example, EDIT became REVISE (or MODIFY), GROUND became ATC, and CONSTRAINT LIST became CSTR ROUTE.
 - The REF mode key gives in the proposed design access to data base related information, as well as the engineering CDU of Phase 1B.

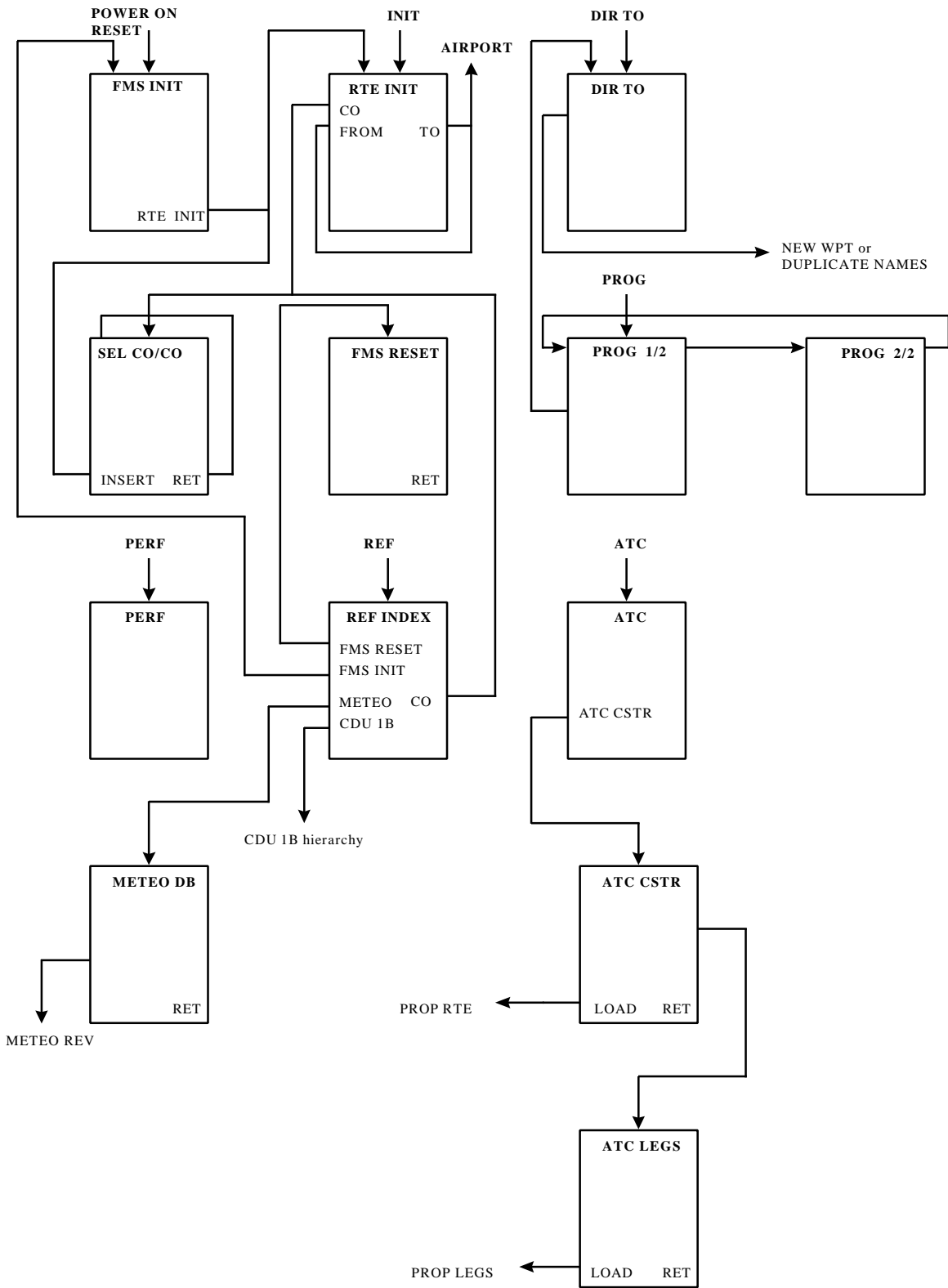


Figure 10 CDU Page hierarchy

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4 INTERACTION BETWEEN CDU AND NAV DISPLAY

The following table gives an overview of pilot initiated events on the NAV display resulting in events on the CDU display:

event on NAV display	resulting event on CDU display
panning through pilot constraint list	scroll through associated LEGS page

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ABBREVIATIONS

A/C	Aircraft
A/P	Airport
ACT	Active
ADC	Air Data Computer
ALT	Altitude
AP	Auto Pilot
APPR	Approach
ATC	Air Traffic Control
ATD	Along Track Distance
ATT	Attitude
BRG	Bearing
CAS	Calibrated Airspeed
CDU	Control and Display Unit
CLB	Climb
CLR	Clear
CO	Company
CRS	Course
CRZ	Cruise
CSTR	Constraint
DECEL	Deceleration
DES	Descent
DEST	Destination
DEV	Deviation
DIR	Direct
DIST	Distance
DME	Distance Measuring Equipment
DTG	Distance To Go
E	East
ECON	Economy
EFOB	Estimated Fuel On Board
ELEV	Elevation
ESI	Energy Sharing Index
ETA	Estimated Time of Arrival
ETE	Estimated Time Enroute
ETO	Estimated Time Over
F-PLN	Flight Plan
FCC	Flight Control Computer
FF	Fuel Flow
FL	Flight Level
FMS	Flight Management System
FOB	Fuel On Board
FQ	Fuel Quantity
FREQ	Frequency
G/A	Go Around

GS	Ground Speed
GW	Gross Weight
HGD	Heading
I/O	Input Output
I/P	Intercept Point
IAS	Indicated Air Speed
IDENT	Identification
ILS	Instrument Landing System
INB	Inbound
INIT	Initialisation
INTC	Intercept
IRS	Inertial Reference System
IRU	Inertial Reference Unit
KCAS	Knots Calibrated Air Speed
kts	Knots
LAT	Latitude
LAT REV	Lateral Revision
LONG	Longitude
LSK	Line Select Key
LW	Landing Weight
M	Mach
MAX	Maximum
MIN	Minimum
MSG	Message
MTI	Modified Thrust Index
N	North
NAV	Navigation
ND	Navigation Display
NM	Nautical Mile
OAT	Outside Air Temperature
OUTB	OutBound
PERF	Performance
PF	Pilot Flying
PFD	Primary Flight Display
PNF	Pilot Not Flying
POS	Position
PRED	Prediction
PREV	Previous
PROF	Vertical Profile
QTY	Quantity
RAD	Radio
REF	Reference
REQ	Request
RTE	Route
RW	Runway
RWY	Runway
S	South

SEL	Select
SID	Standard Instrument Departure
SP	Scratch Pad
SPD	Speed
SPD LIM	Speed Limit
STAR	Standard Arrival Route
T/C	Top of Climb
T/D	Top of Descent
T-P	Turn Point
TBD	To Be Defined
TEMP	Temperature
TO	Takeoff
TOGW	Takeoff Gross Weight
TRK	Track
TTG	Time To Go
UFOB	Usable Fuel On Board
UTC	Universal Time Coordinated
V/S	Vertical Speed
VERT REV	Vertical Revision
W	West
WPT	Waypoint
WPTS	Waypoints
Z	Zulu (time)
ZFW	Zero Fuel Weight

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5 REFERENCES

- [1] PHARE: PD/3 AHMI User Requirements Document.
Eurocontrol DOC 97-70-07 March, 1997
- [2] PHARE: EFMS PHASE 1b User Requirements Document. Part 2: Description of
Initial CDU Page Layouts. Eurocontrol DOC 94-70-25 June, 1994
- [3] PHARE: AHMI Display Format Prototypes and Initial Evaluation Results
Eurocontrol DOC 95-70-08 May, 1995
- [4] PHARE: EFMS PHASE 1b Technical Reference Document
Eurocontrol DOC 96-70-15, 1996
- [5] PHARE: EFMS PHASE 2 User Requirements Document, EFMS and EFMS/AHMI
Interface Eurocontrol DOC 96-70-19, 1996