Document Information Page

Distribution List

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<tbody>
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<td>Karim Zeghal (APO)</td>
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<td>Eric Hoffman (APO)</td>
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Revision History

<table>
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Approval

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1. Introduction

1.1. Scope of the Document

This document describes the set of user requirements for the software product denoted Cockpit Display of Traffic Information (CDTI) Evaluation System (CDTIES), or "system".

1.2. Scope of the Product

CDTI Evaluation System shall be a Java based system, allowing presentation and initial evaluation of experimental features added to cockpit displays.

1.3. Overview of the Document

This document is split into several sections describing the various requirements of the system.

− The Introduction describes the purpose of the document and defines the terminology and references.
− The General Description describes the context and high level functionality.
− Detailed Requirements are grouped into sub-chapters:
  - HMI Requirements define the HMI components of the system, and give references on the display formats that are described in Annex.
  - Functional Requirements define the items related to scenario description and aircraft flight.
  - System Requirements define the platforms on which the system shall run.
  - Performance Requirements define HMI and simulation performances.
  - Quality Requirements give recommendations on object modelling and architecture, with regard to possible future additional requirements.
  - Delivery Requirements describe the delivery schedule and the set of documents that shall be delivered to accompany the system.
− The annex provides use cases, list of information to display, and graphical representations.

1.4. Terminology

In order to ensure clarity and readability, the following notations are applied in this document:

− “shall” is used whenever a mandatory requirement is expressed.
− “should” is used to express a recommendation.
− “may” is used to express an option.
− “will” is used to express a future expectation.

All requirements are described by three attributes:

− Requirement $R.X.N$

  $X = H$ for HMI Requirement,
  $= F$ for Functional Requirement,
  $= S$ for System Requirement,
  $= P$ for Performance Requirement,
  $= Q$ for Quality Requirement,
  $= D$ for Delivery Requirement.

  $N =$ Requirement sequence.

− Constraint mandatory / recommended / optional

− Stableness stable / unstable
A requirement shall be considered “stable” when it is thought that the needs it addresses will not change before the first delivery of the system, and it shall be considered “unstable” otherwise. Unless specified, all requirements shall be considered as “stable”.

The following syntax will be used:

<table>
<thead>
<tr>
<th>RXN</th>
<th>Title of the requirement</th>
<th>Constraint, Stableness</th>
</tr>
</thead>
</table>

And the text following until, either the next requirement or the end of the section will constitute the body of the requirement.

### 1.5. Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADS-B</td>
<td>Automatic Dependant Surveillance - Broadcast</td>
</tr>
<tr>
<td>A/P</td>
<td>Autopilot</td>
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<tr>
<td>ASAS</td>
<td>Airborne Separation Assurance System</td>
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<tr>
<td>ATD</td>
<td>Along Track Distance</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<tr>
<td>CDTI</td>
<td>Cockpit Display of Traffic Information</td>
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<tr>
<td>CDTIES</td>
<td>CDTI Evaluation system</td>
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<tr>
<td>CDTI++</td>
<td>Enhanced Cockpit Display of Traffic Information</td>
</tr>
<tr>
<td>CDU</td>
<td>Control Display Unit</td>
</tr>
<tr>
<td>CR</td>
<td>Closure Rate</td>
</tr>
<tr>
<td>CPA</td>
<td>Closest Point of Approach</td>
</tr>
<tr>
<td>eDEP</td>
<td>early Development and Evaluation Platform</td>
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<tr>
<td>EEC</td>
<td>Eurocontrol Experimental Centre</td>
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<td>EFIS</td>
<td>Electronic Flight Instrument System</td>
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<tr>
<td>FMS</td>
<td>Flight Management System</td>
</tr>
<tr>
<td>FREER</td>
<td>Free Route Experimental Encounter Resolution</td>
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<tr>
<td>LSA</td>
<td>Lateral Separation Assurance</td>
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<tr>
<td>LP</td>
<td>Lateral Passing</td>
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<tr>
<td>LSK</td>
<td>Longitudinal Station Keeping</td>
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<td>ND</td>
<td>Navigation Display</td>
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<tr>
<td>MCP</td>
<td>Mode Control Panel</td>
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<tr>
<td>OD</td>
<td>Oblique Distance</td>
</tr>
<tr>
<td>PFD</td>
<td>Primary Flight Display</td>
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<tr>
<td>TIS-B</td>
<td>Traffic Information Service - Broadcast</td>
</tr>
<tr>
<td>VSA</td>
<td>Vertical Separation Assurance</td>
</tr>
</tbody>
</table>

### 1.6. References

[8] eDEP Air subsystem design document, EDEP_AIR_DDD, 5 December 2003
[10] eDEP GSDK design document, EDEP_GSDK_DDD, 18 June 2003
2. General Descriptions

2.1. Objective

The objective of the contract is to outsource the design and the implementation of a Java based system. This system shall enable the demonstration and the first evaluation of experimental features added to cockpit displays (or EFIS, Electronic Flight Instrument System) through a simplified simulation that (1) animates one or more cockpit environments, and (2) enables interactive control of the aircraft.

2.2. Context

This contract takes place in a project studying an evolutionary approach for Air Traffic Management, which relies on the principle of delegation of separation assurance between aircraft, from the controller to the pilot. In this context, the delegation is investigated for a problem involving two aircraft: one aircraft, denoted subject or manoeuvring aircraft, has to assure separation with respect to the other aircraft, denoted target or non manoeuvring aircraft.

Four types of problem may be delegated:

- Lateral separation assurance: a lateral separation has to be assured between subject aircraft and a target aircraft, and the manoeuvre allowed by the controller to the subject aircraft is lateral, typically a heading change.
- Vertical separation assurance: a vertical separation has to be assured between subject aircraft and a target aircraft, and the manoeuvre allowed by the controller to the subject aircraft is vertical, typically a vertical speed change.
- Lateral passing: subject aircraft has to overtake a target aircraft, by a lateral manoeuvre (a heading change). This problem differs from lateral separation assurance since the closure rate between aircraft is typically low, and aircraft routes (for the time-frame considered) are identical.
- Longitudinal station keeping: subject aircraft has to create or maintain a given distance behind a target aircraft by adjusting speed, typically when established in a sequence in approach phase.

Technology is available to get the air situation (i.e. positions and velocity vectors of surrounding aircraft) onboard the subject aircraft on a Cockpit Displays of Traffic Information (CDTI). However, depending on the type of problem delegated, additional information is required to help the pilot to manage the separation between his aircraft and target aircraft. Considering this additional information, it is envisaged to provide different levels and modes of representation through the availability of ADS-B messages from neighbouring aircraft, and TIS-B messages from a network of ground stations.

2.3. Product Perspective

In the project context, the system will be used to:

- Present the new features added to the CDTI and denoted Enhanced CDTI or CDTI++, along with the different options.
- Launch a first evaluation of the different options, typically through Internet.

The application will also be utilised to enable:

- Rapid prototyping of future enhancements.
- The re-use of some modules in a different software environment, typically the connection of the cockpit displays to a flight simulator.
2.4. Product Overview

The main expected functions are:

1. Initialisation
   − Selection of a scenario among a list of predefined scenarios, where a scenario is an encounter between two aircraft (or more).
   − Selection of one (or more) aircraft of the scenario, and activation of the corresponding cockpit environment(s).
   − Selection of the options concerning the cockpit displays.

2. Real-time execution
   − Simulation of the aircraft flights according to the flight plans defined in the selected scenario.
   − Animation of the corresponding cockpit environment(s).
   − User interaction on flight parameters and on display options through cockpit environment(s).

For illustration purposes, two typical examples of use are provided in Annex.

2.5. User Characteristics

Typical users will be airline pilots.

2.6. General Constraints

Emphasise, i.e. the acceptance criteria, is mainly put on cockpit displays (e.g. realism, display performance). Some aspects related to aircraft and flight (e.g. aircraft model) will be provided by EEC, and other aspects (e.g. definition of a flight plan, guidance and navigation along the flight plan) should be a simplified view of the reality. These aspects will be explicitly mentioned.

The second emphasis concerns evolution and extendibility. The system will be used in an experimental context, in which enhancements of existing features and developments of new ones, are part of the work process. For that purpose, appropriate modelling and straightforward modularity of the code, along with clear documentation are highly required.

The use of libraries for development is left free. EEC is aware that this could ease and speed up the development (typically for cockpit displays), and enable better performances. However, it may also induce limitations, constraints and dependencies (e.g. extra charges for future releases of the library, code updating for these releases, no source code for the components of the library). The tenderer shall state clearly all the implications of his choice.

2.7. Assumptions and Dependencies

Appearance and behaviour of cockpit environment components follow the principles of those of a real cockpit.
   − The specifications of Primary Flight Display (PFD) and Navigation Display (ND) are derived from the Boeing 777 with a high level of realism.
   − The specifications of Mode Control Panel (MCP) is also derived from the Boeing 777, with simplifications due to a simplified Autopilot (A/P) model. However, the principle of the MCP remains similar (e.g. use of “hold” and “sel” mode).
   − The specifications of EFIS Control Panel is an adaptation of a real one due to the introduction of new display options.
   − The Control Display Unit (CDU) is used for the new purpose of delegation operations.

For more information, the tenderer should refer to the Operation Manual of the B777 (or any glass-cockpit aircraft for the main principles). A version of the B777 Operation Manual is available at EEC.
3. Requirements

3.1. HMI Requirements

<table>
<thead>
<tr>
<th>RH.1</th>
<th>Main HMI components</th>
<th>Mandatory</th>
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<tbody>
<tr>
<td></td>
<td>The HMI of the system shall be constituted by:</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>A top-level application enabling higher level functions such as: selection of scenario and aircraft, and control of the execution [RH.1.1].</td>
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<tr>
<td>2.</td>
<td>One (or more) sub-application(s) representing the cockpit environment of particular aircraft, and enabling the control of flight parameters and the selection of display options [RH.1.2].</td>
<td></td>
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<tr>
<td>3.</td>
<td>A sub-application representing an overall view of the aircraft and denoted “air situation display” [RH.1.3]. This application is optional.</td>
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<table>
<thead>
<tr>
<th>RH.1.1</th>
<th>Top-level application</th>
<th>Mandatory</th>
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<tbody>
<tr>
<td></td>
<td>The top-level application shall provide the following functions, in a logical order of use:</td>
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<tr>
<td>1.</td>
<td>Selection of the scenario.</td>
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<td></td>
<td>This shall be performed through a file selection box set on the root directory of scenario files, and capable to navigate in sub-directories. (The scenario files will be organised by directories according to their types: Lateral Separation Assurance, Vertical Separation Assurance, Lateral Passing, Longitudinal Station Keeping.)</td>
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<tr>
<td>2.</td>
<td>Display of callsigns of aircraft present in the scenario.</td>
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<tr>
<td>3.</td>
<td>Selection of an aircraft from the list of callsigns, and activation of the corresponding cockpit environment.</td>
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<td>It shall be possible to activate one or more cockpit environments for each selected aircraft (typically to compare different options of displays for the same aircraft, or to see the situation from both subject and target aircraft point of view).</td>
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<td></td>
<td>It should be noted that multiple activations on the same aircraft could imply some consistency issues that shall be addressed.</td>
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<td>4.</td>
<td>Activation of the “air situation display” (if applicable).</td>
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<td>5.</td>
<td>Control of the execution through the following actions: start, pause, resume, time ratio control, replay and stop.</td>
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<td></td>
<td>The replay is optional.</td>
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<td>6.</td>
<td>Display of text messages at any time (before, during and after execution), in order to provide contextual assistance to the user.</td>
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<td>Five lines of messages should be displayed.</td>
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<td></td>
<td>The process of generation of these messages will be performed by EEC, and are not required. However, for testing purposes, a message shall be displayed.</td>
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<td>7.</td>
<td>Control of the application through the two actions: quit, help.</td>
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<tr>
<td></td>
<td>All functions shall be available at any time (before, during and after execution), except:</td>
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<tr>
<td></td>
<td>− The functions “selection of scenario” (item 1) and “quit” (item 6) that shall be available only if no execution is running.</td>
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<td></td>
<td>− The functions “start”, “pause”, “resume”, “replay” and “stop” (item 5) that shall be made available or inhibited depending on execution state (e.g. if an execution is running, “resume” shall be inhibited).</td>
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<td></td>
<td>The top-level application window should be of minimum size.</td>
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RH.1.2 Cockpit environment

The cockpit environment shall provide the following functions:

1. Selection of display options [RH.1.2.1].
2. Display of flight parameters and flight environment through EFIS components [RH.1.2.2].
3. Control of the EFIS through the EFIS Control Panel [RH.1.2.3].
4. Control of the flight through Autopilot (A/P) inputs on the Mode Control Panel (MCP) [RH.1.2.4].
5. Designation of a target aircraft through the Control Display Unit (CDU) [RH.1.2.5], and through a pointing device [RH.1.2.6].
6. Control of the application through the two actions: quit, help.

All these functions shall be available at any time: before, during and after execution.

The layout of a real cockpit environment is shown in Annex (see Glareshield Panel, and Left and Right Forward Panels). Only the left side (captain’s side) should be reproduced.

RH.1.2.1 Display options

The display options concerned:

- Display format depending on aircraft type. The display formats are: Boeing 777 and Airbus 340.
- CDTI++ options, which are twofold:
  - Type of representation. The types are denoted by: absolute, relative.
  - Level of assistance. The levels are denoted by: baseline, what-if, scale of effect, advisory.

Each of these selections shall be available through a menu listing all the options identified above. However, only the first option mentioned will be developed (respectively: Boeing 777, absolute, baseline).

RH.1.2.2 EFIS components

The EFIS components shall be:

1. Primary Flight Display (PFD) representing the artificial horizon and other basic flight parameters such as altitude, vertical speed, speed, and heading [RH.1.2.2.1].
2. Navigation Display (ND) representing aircraft 2D position relative to the environment (e.g. navigation aids) and to the flight (i.e. the list of waypoints) [RH.1.2.2.2].

For these EFIS components, three levels of functionality shall be available:

1. Baseline. This functionality is the basic functionality described in [RH.1.2.2.1] and [RH.1.2.2.2].
2. Cockpit Display of Traffic Information (CDTI) representing the surrounding aircraft positions relative to subject aircraft [RH.1.2.2.3].
3. Enhanced Cockpit Display of Traffic Information (CDTI++) representing the new features added to the CDTI [RH.1.2.2.4].

The PFD and ND components with Baseline functionality are actually available and used in real cockpits, whereas CDTI and CDTI++ are additional and experimental functions on the ND window. (See also [RQ.2] for possible use of PFD to implement CDTI++ functions.)

The EFIS environment shall be composed by a PFD and a ND, where the ND shall include Baseline, CDTI and CDTI++ functions.

RH.1.2.2.1 Primary Flight Display

The specification of the PFD is derived from the Boeing 777’s PFD. Information to display and graphical representation are specified in Annex.
**RH.1.2.2.2 Navigation Display**  
Mandatory

The specification of the ND is derived from the Boeing 777’s ND. Information to display and graphical representation are specified in Annex.

**RH.1.2.2.3 Cockpit Display of Traffic Information**  
Mandatory

The CDTI specification is derived from RTCA MOPS [5]. Information to display and graphical representation are specified in Annex.

The CDTI shall be capable of operating in a number of configurable modes, selectable either off-line or from a separate window in demonstration mode. These modes shall define the fields and layout of the labels associated with the displayed traffic, and a track data block for a specific selected aircraft. [RH.1.2.2.5]

**RH.1.2.2.4 Enhanced Cockpit Display of Traffic Information**  
Mandatory

The CDTI++ concepts mainly result from investigations carried out at EEC [3]. Information to display and graphical representation are specified in Annex.

The type of representation considered is “absolute” only.

The level of assistance considered is “baseline” only.

It should be noted that the computation of the information to be displayed on CDTI++ is not part of the contract. However, for testing purposes, this information shall be replaced by simulated data.

**RH.1.2.3 EFIS Control Panel**  
Mandatory

The EFIS Control Panel enables the control of the EFIS components.

Control functions shall be:

1. PFD
   - No control functions.
2. ND
   - Selection of the range (*i.e.* zooming and unzooming).
   - Selection of the mode. Two modes shall be available: expanded map, centered map.
   - Activation / deactivation of display of flight plan and nav aids.
3. CDTI
   - Activation / deactivation of the CDTI.
4. CDTI++
   - Selection of the mode. The modes are: none (*i.e.* CDTI++ not activated), Lateral Separation Assurance (LSA), Vertical Separation Assurance (VSA), Lateral Passing (LP), Longitudinal Station Keeping (LSK).
   - Selection of the trend value, *i.e.* predicted value in the future. The prediction times are: 30 seconds, 1 minute, 2 minutes, 5 minutes. Applicable for LP and LSK
   - Configurable CDTI Mode selector to allow specialist CDTI display modes.

Graphic components to be used are left free. For information, a real EFIS Control Panel is shown in Annex.

**RH.1.2.4 Mode Control Panel**  
Mandatory

The Mode Control Panel (MCP) is the device to select guidance / navigation modes, and to enter Autopilot (A/P) values. The graphical representation of the MCP is derived from the Boeing 777, which is provided in Annex. The MCP follows the principles of a real MCP.

Two guidance modes will be implemented [RF.1]: predefined guidance, and interactive control through A/P. The predefined guidance is a simplified FMS-like guidance, *i.e.* automatic guidance along the
trajectory. The predefined guidance is automatically set at initialisation, however, for simplification purposes, the predefined guidance cannot be recovered after being disengaged. In this context, the MCP is devoted to both indicate if the predefined guidance is engaged, and enter A/P values.

More precisely, the MCP shall enable:
- The indication if the predefined guidance is engaged. (Predefined guidance corresponds to LNAV and VNAV modes engaged.)
- The input and display of an A/P value, without guiding the aircraft. This corresponds to the HOLD mode. (This mode is used for cross-checking prior to engaging a manoeuvre.)
  The value is displayed on MCP and PFD.
- The selection of the value previously entered, which starts guiding the aircraft on the target value. This corresponds to the SEL mode. (This mode is used for engaging the manoeuvre.)

The value remains displayed on MCP and PFD.

The following A/P values shall be available: speed, heading, altitude, vertical speed.
For vertical speed, only the SEL mode shall be available.

The following behaviour shall be implemented (by “mode” it shall be understood “mode for a given A/P value”):
1. The two modes SEL and HOLD shall be exclusive.
2. It shall be possible to switch manually to one mode (SEL or HOLD), whatever the current mode.
3. In SEL mode for altitude, once the actual value reaches the target value, the mode shall be switched automatically from SEL to HOLD.
4. The modification of the current value shall be possible whatever the mode, i.e. even if the aircraft is manoeuvring to reach the target value (SEL mode).
5. Switching to HOLD when in SEL (i.e. aircraft manoeuvring), shall stabilise the aircraft along the value. For this purpose, when switching to HOLD, the target value should be set to the current value, or to the value predicted in $x$ seconds (typically in 10 seconds).

**RH.1.2.5  Control Display Unit  Mandatory**

In real cockpits, the Control Display Unit (CDU) is mainly used for interaction with the Flight Management System (FMS). In our context of delegation operations, the CDU will be used to manage the list of target aircraft.

The graphical representation of the CDU is defined in Annex. The keyboard attached to CDU is not represented, and does not need to be reproduced. (The actual keyboard of the computer will be used to emulate the CDU keyboard.)

The CDU shall provide the following functions:
1. Selection of a target aircraft by entering its callsign from the keyboard.
2. Display of the list of target aircraft callsigns.
3. Deselection of a target aircraft by designation of its callsign with the designation button. Multiple selections shall be possible (e.g. 12 aircraft maximum).

A Use case is provided in Annex, that follows the principle of use of a real CDU.

**RH.1.2.6  Aircraft designation pointing device  Mandatory**

The designation of a target aircraft shall be also possible through a pointing device (i.e. by the mouse).
The designation of an aircraft not selected shall switch it to “selected” (i.e. target), and conversely.

This designation function shall be compatible with the CDU designation [RH.1.2.5].

**RH.1.3  Air situation display  Optional**

The air situation display shall provide a graphical representation of the aircraft flights before and during the execution of the scenario. The following items shall be displayed for each aircraft (using a similar
representation to that of a controller display): aircraft position, callsign, flight level, past tracks, velocity vector with a leading line, and flight plan.

Note when connected to eDEP, the controller working position shall be available to view the integrated air situation.

3.2. Functional Requirements

**RF.1** Simulation of aircraft flights Mandatory

The simulation of aircraft flights shall be initialised from the scenario file previously selected that defines the encounter between two or more aircraft [RF.1.1].

The simulation shall follow the principle:

- Each aircraft begins under the “predefined guidance” mode [RF.1.2].
- If the user intervenes, i.e., if he enters then selects a value on the MCP, the predefined guidance for this aircraft is automatically disengaged and full guidance control comes to the user [RF.1.3]. (It should be noted that the predefined guidance cannot be re-engage.)

During the simulation, to reproduce ADS-B capabilities, surveillance data shall be transmitted among aircraft [RF.1.4].

The simulation shall be real-time, accelerated, or decelerated (variable time ratio, [RH.1.1]). Note that when connected to live tracking systems, the simulation shall run in real time, synchronised to UTC time [RF 1.5].

**RF.1.1** Initialisation functionality Mandatory

The eCockpit component shall be connected to services provided by the eDEP platform. This shall include the following sources of data:

- An airspace definition shall be provided from the Airspace service, to define the fixes, routes, approaches and airports of the eCockpit aircraft’s route. The data shall be loaded from the eDEP airspace server.
- A flight plan for the eCockpit subject aircraft shall be provided by subscription to the services defined by the eDEP Flight Plan service. The data shall be loaded from the IFPL server component. The flight plan shall be expanded to form a complete list of route points, defined by airspace fixes or by explicitly defined control points (identifying latitude and longitude points). The airspace points shall include departure and destination airport. The flight plan shall define an activation time, indicating a time delay prior to activation of the aircraft. The aircraft flight plan shall be sent to the eCockpit component when the activation time is reached.

For testing purposes, a full set of scenario files will be provided by EEC.

**RF.1.2** Predefined guidance Mandatory

The predefined guidance shall be a step-by-step progression along the trajectory. This should be done in a simple way by linear interpolation between consecutive points of the trajectory.

Initial position and altitude shall be the first position and altitude specified in the eDEP flight plan. The MCP mode shall be set to LNAV and VNAV.

**RF.1.3** User interactive control Mandatory, Unstable

The control of the aircraft is performed by Autopilot (A/P) control through the MCP.

The target values (values entered on the MCP and activated) are interactively entered by the user.

Under user interactive control, the aircraft shall:

- reach the target values in a smooth manner, reproducing the aircraft dynamic,
- stay on the other current flight parameters.
For simplification purposes, a simple aircraft model should be used, and will be provided by EEC.

**RF.1.4  ADS-B  Mandatory**

The component shall obtain ADS-B messages in ASTERIX Category 21 format from the eDEP ADS-B server component.
To simulate ADS-B capabilities [6], for each aircraft, the following information on the other aircraft of the simulation shall be available: callsign, 3D position, 3D velocity vector, selected MCP values, trajectory points.

**RF.1.5  TIS-B  Mandatory**

The component shall obtain TIS-B messages in ASTERIX Category 62 format from the eDEP TIS-B server component.
To simulate TIS-B capabilities [6], for each aircraft, the following information on the other aircraft of the simulation shall be available: callsign, 3D position, 3D velocity vector other track information.

### 3.3. System Requirements

**RS.1  Java / Web  Mandatory**

The system shall be written using HTML and Java (version 1.4 or later) and be compatible with Java Web Start (version 1.0.1 or later).
The system shall run under Microsoft Windows (NT, 2000, XP), Red Hat Linux, Sun Solaris and HP-UX.

**RS.2  Implications of a development library  Mandatory**

The system shall be implemented on top of the GSDK software library, which forms the basis of the eDEP platform.
The system shall use the ILog JViews library to provide the base for the graphics display. The ILog JViews library should be removed and replaced by the GSDK software library graphics framework.

### 3.4. Performance Requirements

**RP.1  Real-time look and feel  Mandatory**

All HMI components shall provide a real-time “look and feel”.
The graphical animation on the displays should be smooth and free of flicker.
User inputs should be detected and visual feedback given such as buttons changing colour or menus flipping down within 0.1 second (typical time for human to recognise change).

**RP.2  Real-time simulation  Mandatory**

The update rate of the flight control loop and aircraft model should be such that the exercises simulate scenarios in real time. The natural time periods of the dynamic behaviour of the real world objects such as aircraft and autopilot shall be used as references for the system specification.

### 3.5. Quality Requirements

**RQ.1  Object modelling  Recommended**
The software design should be object oriented for ease of understanding and reusability. Wherever appropriate, real world objects should be used as models for the design of the software objects. Typically, the architecture should include the following modules:

- Displays components and functions: PFD, ND, CDTI, CDTI++.
- Inputs components: EFIS Control Panel, CDU, MCP.
- Aircraft model (including A/P) encapsulating the essential state of an aircraft and the algorithms needed to update the state.
- Air situation display (if applicable).

The design should follow the existing design and architecture patterns established in the GSDK and eDEP ATC design documentation (see Ref. 7, Ref. 8, Ref. 9 and Ref. 10).

**RQ.2 Extendability**

The system should be able to evolve gracefully (i.e. no major changes to architecture and interfaces) if the following additional requirements were found necessary in the future:

1. Guidance and navigation
   - FMS-like module enabling to recover automatic navigation along the trajectory after user interactive control. This module would send target values to the A/P, depending on flight plan and current position.
   - Automatic guidance module based on CDTI++ information (“Airborne Separation Assurance System or ASAS”). This module would send target values to the A/P.
   - More accurate aircraft or A/P model.

2. Displays
   - New cockpit environment, typically a full cockpit with the co-pilot position, reusing the EFIS components developed: PFD, ND which may or may not include CDTI and CDTI++ functions.
   - New display format, typically Airbus 340 format.
   - New display modes for the ND or new displays, typically Head-up Display (HUD).
   - New display features, typically new graphical items for the CDTI++.
   - New functionality on EFIS components, typically CDTI++ functionality on the PFD.
   - New CDTI++ mode, e.g. vertical passing, or new level of assistance, e.g. what-if. This may imply new display features.

3. Input devices
   - New functionality of the CDU, e.g. display of the list of aircraft visible from ADS-B, detail information on right selection buttons.
   - New selection facilities for the CDU, e.g. completion of the callsign from first letters, from a pattern.

4. Environment
   - Modelling of communication capabilities (e.g. format of ADS-B messages, range of broadcast).
   - Wind or an atmosphere model (temperature / pressure / altitude).
   - Spherical or WGS84 Earth model.

5. Platform
   - Integration with services provided by an ATM platform (e.g. ESCAPE or eDEP)
   - Provision of services to an ATM platform (e.g. ADS-B reports)

**RQ.3 Internal data**

The data used and processed shall follow the standard units normally used in Air Traffic Control and Aeronautics.
Typically, the following data and units shall be used: position described by latitude and longitude in degrees, altitude in feet, horizontal distance in nautical miles (Nm), speed in knots (Nm/min), vertical speed in feet per minute.

The units shall, where appropriate, be in accordance with the units used within eDEP.

**RQ.4 Configuration**

The system shall be configurable. The colours used by displays shall be defined through a GSDK resource based colour palette, read from a configuration file. In addition, various behaviour and timing values shall be defined from resource values.

**RQ.5 Component appearance**

The graphic components that will be used should reproduce as best as possible the actual components used in real cockpits.

### 3.6. Delivery Requirements

**RD.1 Deliverables**

Following the proposed delivery schedule [RD.1.1], deliverables shall include:
- the source code, and any software required to run the system,
- the documentation as defined in [RD.1.2].

**RD.1.1 Delivery schedule**

The following packages shall be delivered, in priority order:
1. Baseline eCockpit already delivered to EEC
2. Basic integration with eDEP [TRS164 – WP2.1]
3. Live Air integration with eDEP and SMART/ARTAS [TRS164 – WP2.2]
4. Pseudo Live Air integration with eDEP and SMART/ARTAS [TRS164 – WP2.4]
5. Standalone eDEP simulation [TRS164 – WP2.3]
6. CDTI enhancements [TRS164 – WP2.5]

**RD.1.2 Documentation**

The following documents shall be delivered:
- Project Plan showing the deliverables and dates.
- Architecture Design Document (ADD), showing the overall platform architecture.
- Detailed Design Document (DDD), based off the existing SDD it shall include graphical representation of architecture, classes, and functions, and highlighting the items concerned by possible extension as mentioned in [RQ.2]. The class descriptions from the SDD shall be moved into Javadoc comments within the code.
- Software Component Test Document (CTD).
- Traceability Matrix showing how each User Requirement is taken into account in the respective document.
- User Guides, showing the use of the system.
4. **Annex**

4.1. **System Use Cases**

For illustration purposes only, two typical examples of use of the system are provided below. No limitation of any of the requirements specified in this document can be derived from these examples.

4.1.1. **Separation Assurance**

1. **Initialisation**
   - Selection of a Lateral Separation Assurance scenario.
     This scenario is an encounter between two aircraft AFR123 and DLH456. The user decides to experiment the scenario with AFR123 as manoeuvring aircraft (subject aircraft), and DLH456 as non manoeuvring aircraft (target aircraft). In other words, the user decides to be the pilot of AFR123.
   - Selection of AFR123 and activation of its cockpit environment.
     (The user may decide to activate an additional AFR123 cockpit environment, typically to compare a different option for the CDTI++.)
   - Selection of the options concerning the cockpit displays of AFR123.

2. **Real-time execution**
   - The user (as AFR123 pilot) can control AFR123 through its cockpit environment.
     He switches the CDTI++ in Lateral Separation Assurance mode, and selects DLH456 as target aircraft through the CDU.
   - Then, based on indications provided by the CDTI++ on the encounter with DLH456, the user modifies the heading of AFR123 through the MCP. (This disengages the predefined guidance of AFR123.)
     (In case a second cockpit for AFR123 has been activated, the user can control AFR123 indifferently from one or the other AFR123 cockpit environment.)

4.1.2. **Longitudinal Station Keeping**

1. **Initialisation**
   - Selection of a longitudinal station keeping scenario.
     This scenario involves two aircraft BAW321 and AZA654, where BAW321 has to maintain a given distance behind AZA654. (This brief description is displayed in a text box.) The user experiments the scenario as pilot of BAW321, i.e. BAW321 is the manoeuvring aircraft (subject aircraft), and AZA654 is the non manoeuvring aircraft (target aircraft).
   - Selection of BAW321 and activation of its cockpit environment.
     (The user may decide to activate an additional cockpit environment on BAW321.)
   - Selection of the options concerning the cockpit displays.

2. **Real-time execution**
   - The user (as BAW321 pilot) can control BAW321 through its cockpit environment.
     He switches the CDTI++ in ‘Longitudinal Station Keeping’ mode, and selects AZA654 as target aircraft through the CDU.
   - Then, based on indications provided by the CDTI++ on the distance with AZA654, the user adjusts the speed of BAW321 through the MCP. (This disengages the predefined guidance of BAW321.)
   - The user may also want to introduce some perturbations, typically by modifying the speed of the target aircraft AZA654. For that purpose:
   - Selection of AZA654 and activation of its cockpit environment.
     Then, the user (temporary as AZA654 pilot) modifies speed of AZA654. (This disengages the predefined guidance of AZA654. The cockpit of AZA654 may or may not be closed afterwards.)
Then, the user (back as BAW321 pilot) adjusts speed of BAW321 following the updated indications provided by CDTI++.

4.2. CDU Use Cases

For illustration purposes only, an example of section and deselection of a target aircraft is provided below. No limitation of any of the requirements specified in this document can be derived from these examples. These examples follow the principles of use of a real CDU, using scratchpad and line select buttons (see CDU representation). The principle can be outlined by:

- Items and actions are entered via the scratchpad (a “buffer” zone).
- Processing of the input is done while the user press a line select button (on the left side, or on the right, depending on the context).

4.2.1. Target Aircraft Selection

The selection of a target aircraft follows the sequence:

1. Input of the callsign in the scratchpad.
2. Press the appropriate left line select button, typically the first left button (on the top) for the first target aircraft. (Items are placed according to the line select button pressed. No automatic placement is done.)
3. If callsign is unknown, a message ‘unknown aircraft: <callsign>’ is displayed in the scratchpad. No other processing is performed.
4. Else,
   5. If corresponding line is free (i.e. no target aircraft has been previously entered at this line),
      - the callsign is displayed,
      - the aircraft is added to the target aircraft list.
6. Else, a message '<existing callsign>' is selected’ is displayed in the scratchpad, indicating that a target aircraft (existing callsign) has been previously selected that must be deselected explicitly (see below) prior to entering the new one. No other processing is performed.

4.2.2. Target Aircraft Deselection

The deselection of a target aircraft follows the sequence:

1. Input of the command ‘clr’ (clear) in the scratchpad.
2. Press the left line select button of the callsign to deselect. A confirmation message is displayed on the right side, with two options ‘confirmation’ and ‘cancel’ (these options are accessible via two right line select buttons). The confirmation:
   - clears the line,
   - removes the aircraft from the target aircraft list.

4.3. PFD Indications

To each item specified hereafter corresponds:

- A graphical representation provided in a following section.
- Possibly, a priority status (for the development). If no priority is specified, the priority is “High”. “LP” means “Low priority”.
- Possibly, a switch status specifying if the item can be switched on/off (indicated by “S”). If no switch status is specified, the item is permanently displayed.

For each item, the name of the variable shall be the concatenation of the actual name (e.g. Selected Speed becomes SelectedSpeed).

4.3.1. PFD Indications

1. Flight Mode Annunciations
2. Airspeed/Mach Indications
3. Attitude, Steering, and Miscellaneous Indications
4.3.2. PFD Flight Mode Annunciations

1. Autothrottle Mode (Engaged): THR, THR REF, HOLD, IDLE, SPD
2. AFDS (Autopilot, Flight Director System) Roll Modes (Engaged): HDG HOLD, HDG SEL, LNAV, LOC, ROLLOUT, TO/GA, TRK SEL, TRK HOLD, ATT
3. AFDS Roll Modes (Armed): LOC, ROLLOUT, LNAV
4. AFDS Pitch Modes (Engaged): TO/GA, ALT, V/S, VNAV PTH, VNAV SPD, VNAV ALT, G/S, FLARE, FLCH SPD, FPA
5. AFDS Pitch Modes (Armed): G/S, FLARE, VNAV
6. AFDS Status (Engaged): FLT DIR, A/P, LAND2, LAND3

Displayed in amber: NO AUTOLAND

The following convention is applied:
- Engaged in green
- Armed in white

4.3.3. PFD Airspeed Indications

1. Selected Speed [S]
2. Speed Trend Vector
   Indicates predicted airspeed in ten seconds based on current acceleration or deceleration.
3. Current Airspeed
   The box around the current airspeed indication turns amber when airspeed is below minimum manoeuvring speed
4. Current Mach
5. Maximum Speed
6. Maximum Manoeuvring Speed [S]
7. Speed Bug [S]
   The bug is five knots in height.
   When the selected speed is off scale, the bug is parked at the top or bottom of the tape, with only one half the bug visible.

4.3.4. PFD Reference Speeds

[LP for all items of the section]

1. Takeoff Reference Speeds [S]
2. Flap Manoeuvring Speeds [S]
3. Landing Reference Speed [S]
   VREF speed is displayed at the bottom of the airspeed indication when the value is off scale.
4. Minimum Manoeuvring Speed [S]
5. Minimum Speed
6. Selected Landing Flap and VREF Speed [S]

4.3.5. PFD Attitude Indications

1. Bank Pointer
   Fills and turns amber if bank angle is 35 degrees or more.
2. Slip/Skip Indication [LP]
   Displaces beneath the bank pointer to indicate slip or skid.
   Fills white at full scale deflection.
Turns amber if bank angle is 35 degrees or more;  
fills amber if the slip/skid indication is also at full deflection.

3 Pitch Limit Indication [LP, S]

4 Horizon Line and Pitch Scale
Pitch scale is in 2.5 degree increments.

5 Bank Scale
Scale marks are at 0, 10, 20, 30, 45, and 60 degrees.

6 Airplane Symbol

**4.3.6. PFD Steering Indications**

[S for all items of the section]

1 Flight Director Pitch and Roll Bars

2 Flight Path Vector (FPV)
Flight path angle is displayed relative to the horizon line.  
Drift angle is represented by the perpendicular distance from the centerline of the pitch scale to the FPV symbol.

3 Selected Flight Path Angle (FPA)

**4.3.7. PFD Radio Altitude Indications**

1 Radio altitude [LP, S]
Display radio altitude below 2500 feet AGL (Above Ground Level).
Turns amber when below radio altitude minimums.

**4.3.8. PFD Instrument Landing System Indications**

[LP, S for all items of the section]

1 Approach Reference
Displays the selected ILS identifier or frequency, approach front course, and ILS DME distance.

2 Localizer Pointer and Scale
The localizer pointer:
indicates localizer position relative to the airplane  
is in view when the localizer signal is received  
fills in solid when within 2 1/2 dots from the center.

The scale is in view after the frequency is tuned.
At low radio altitudes, with the autopilot or flight director engaged, the scale turns amber and the pointer flashes to indicate excessive localizer deviation.
At low altitudes, with LNAV engaged and LOC armed, the localizer scale turns amber and the pointer flashes if the localizer is not captured.

3 Marker Beacon Indication
The marker beacon indication appears flashing when over one of the marker beacon transmitters:
IM – an airway or inner marker beacon  
MM – a middle marker beacon  
OM – an outer marker beacon.

The indication flashes in cadence with the beacon identifier.

4 Glideslope Pointer and Scale
The glideslope pointer:
indicates glideslope position relative to the airplane, and:
is in view when the glideslope signal is received  
fills is solid when within 2 1/2 dots from the scale center.

The scale is in view after the frequency is tuned.
At low radio altitudes, with the autopilot or flight director engaged, the scale turns amber and the pointer flashes to indicate excessive glideslope deviation.

### 4.3.9. PFD Expanded Localizer Indications

[LP, S for all items of the section]

1. **Expanded localizer scale**
   
   Displays when the autopilot or flight director is in LOC mode and the airplane is close to the runway center line. Provides a more sensitive display.
   
   A rectangle equals 1/2 dots deviation.

### 4.3.10. PFD Rising Runway Indications

[LP, S for all items of the section]

1. **Rising runway**
   
   Displayed below 2500 feet radio altitude when the localizer pointer is in view for front and back courses.
   
   Moves toward the airplane symbol below 200 feet radio altitude.
   
   The stem of the rising runway symbol flashes when the localizer deviations cause the diamond to flash.

### 4.3.11. PFD Altitude Indications

1. **Selected Altitude Bug [S]**
   
   When the selected altitude is off scale, the bug is parked at the top or bottom of the tape, with only one half the bug visible.

2. **Selected Altitude – Meters [S]**
   
   Displays in 10 meters increments.

3. **Selected Altitude [S]**
   
   The selected altitude box is highlighted in white between 900 feet and 200 feet prior to reaching the selected altitude.

4. **Current altitude – Meters [S]**

5. **Current Altitude**

### 4.3.12. PFD Landing Altitude/Minimums Indications

[LP for all items of the section]

1. **BARO Minimum Pointer**
   
   When BARO minimum are displayed, the number is also represented as a pointer and line on the altitude scale.
   
   Turns steady amber when the airplane descends below baro minimums.

2. **Landing Altitude Indication**
   
   The crosshatched area indicates the landing altitude.

3. **Minimums Reference**
   
   Displays BARO or RADIO.
   
   Turns amber and flashes for 3 seconds when the airplane descends below selected minimum altitude.

4. **Minimums**
   
   Displays the approach minimum altitude.
   
   Turns amber and flashes for 3 seconds when the airplane descends below selected minimum altitude.

5. **Landing Altitude Reference Bar**
   
   Indicates the height above touchdown.
   
   White bar: 500 to 1000 feet above landing altitude.
   
   Amber bar: 0 to 500 feet above landing altitude.
4.3.13. PFD Barometric Indications
[LP, S for all items of the section]

1 Barometric Setting
   STD is displayed when STD is selected on the EFIS control panel barometric STD switch. The display is boxed and changes to amber if a barometric setting is set and altitude climbs above the transition altitude, or if STD is set and altitude descends below the transition flight level.

2 Barometric Reference
   Indicates the barometric setting units selected on the EFIS control panel barometric reference selector:
      IN is inches of mercury
      HPA is Hectopascals.

3 QFE Altitude Reference

4 Autopilot/Flight Director Barometric Source
   L or R indicates that the left or right EFIS control panel is the barometric setting reference for the autopilot or flight director.

5 Preselected Barometric Setting

6 QFE
   When STD is selected, a small QFE appears when QFE is selected.

4.3.14. PFD Vertical Speed Indications

1 Vertical Speed Pointer

2 Selected Vertical Speed Bug [S]

3 Vertical Speed
   Display vertical speed when greater than 400 feet per minute. The display is located above the vertical speed indication when climbing and below when descending.

4.3.15. PFD Heading/Track Indications

1 Current Heading Pointer

2 Selected Track Bug (MCP Selection) [S]
   The selected track bug is displayed on the inside of the compass rose.
   If selected track exceeds display range, the bug parks on the side of the compass rose in the direction of the shorter turn to the track.

3 Track line

4 Selected Heading/Track (MCP Selection) [S]

5 Selected Heading/Track Reference (MCP Selection)
   When HDG (heading) is selected, an H is displayed.
   When TRK (track) is selected, a T is displayed.

6 Selected Heading Bug (MCP Selection) [S]
   The selected heading bug is displayed on the outside of the compass rose.
   If selected heading exceeds display range, the bug parks on the side of the compass rose in the direction of the shorter turn to the heading.

7 Heading/Track Reference
   Displays the automatic or manually selected heading/track reference:
      MAG (magnetic north)
      TRU (true north).
4.4. **ND Indications**

4.4.1. **Expanded and Centered Map modes**

**Aircraft State**

1. Current Heading Pointer
2. Heading / Track Reference
3. Current Heading / Track
4. Selected Track Bug
   - Same representation and behaviour of Selected Track Bug displayed on PFD is applied.
5. Selected Heading Bug
   - Same representation and behaviour of Selected Heading Bug displayed on PFD is applied.
6. Selected Track Line [S]
7. Selected Heading Line [S]
8. Magnetic/True Reference
9. Groundspeed
10. True Airspeed [S]
11. Position Trend Vector [S]

**Wind**

12. Wind Direction / Speed
13. Wind Arrow

**Navigation and Route**

14. Navigation Point [S]
   - Indicates all navigation points as defined in the Navigation file. If a navigation point is also a waypoint of the route, only the waypoint symbol shall be used (instead of navigation point symbol).
15. Left VOR/ADF Selection
16. Left VOR/ADF Ident or frequency
17. Left VOR/DME
18. Right VOR/ADF Selection
19. Right VOR/ADF Ident or frequency
20. Right VOR/DME
21. Active Route [S]
   - Indicates the list of waypoints defined in the trajectory, and displays the route as computed by the FMS (e.g. possibly including turns).
   - The route should be sequence of segments linking consecutive waypoints.
22. Active Waypoint [S]
23. Active Waypoint ETA (Estimated Time of Arrival)
24. Active Waypoint Distance-To-Go

4.4.2. **Expanded Map mode**

**Navigation and Route**

25. VNAV Path Pointer [S]

4.4.3. **Centered Map mode**

**Navigation and Route**

26. Left VOR/ADF pointer [S]
27. Right VOR/ADF pointer [S]
4.5. **CDTI Indications**

In CDTI mode, information that shall be displayed for each surrounding aircraft:

- symbol with callsign, relative altitude and trend of vertical speed (climbing, descending or steady).
- velocity vector.

Symbols for aircraft shall be displayed based on the ADS-B and/or TIS-B messages received. Symbol of selected aircraft shall be highlighted as specified in the graphical representation.

The CDTI shall support a configurable altitude filter based around the controlled aircraft with a default range of ±9900 feet.

The callsign of the selected aircraft in first position in the list shall also be displayed in text.

CDTI information shall be brought to the front of ND.

The CDTI shall provide configurable data tags associated with each traffic aircraft on the display including the following fields:

- Altitude [mandatory]
- Identification (SSR, track, callsign)
- Rate of closure
- Ground speed
- Range

The CDTI shall provide a configurable track data block displayed at a fixed location on the CDTI window, showing more detailed information for a selected flight based on the ADS-B and/or TIS-B messages received.

The priority display of CDTI information shall follow the list order of selected aircraft, *e.g.* CDTI information of the aircraft in first position in the list shall be brought to the front.

The CDTI shall display range rings with markers at clock-face intervals centred on the controlled aircraft.

The CDTI should display a Range Ruler showing range intervals in the direction of flight for the controlled aircraft.

4.6. **CDTI++ Indications**

For CDTI++, information to display, depends on the selected mode of the CDTI++.

CDTI++ information shall be brought to the front of CDTI (and therefore ND).

The priority display of CDTI++ information shall follow the list order of selected aircraft, *e.g.* CDTI++ information of the aircraft in first position in the list shall be brought to the front.

The following convention for colour shall be applied (and appears in graphic representations):

- White for extrapolated trajectories
- Green for current conditions on selected aircraft (*e.g.* CR, current OD)
- Yellow for predicted conditions (*e.g.* CPA)
- Red for conflict conditions (*e.g.* TC).

The following units shall be used:

- Nm for lateral distances
- Flight level (100*feet) for altitude
- Minute for time values.

The CDTI shall display a fully configurable aircraft label tag for neighbouring traffic, and a more detailed, configurable label data block for a selected neighbouring aircraft.

4.6.1. **Lateral Separation Assurance**

1. Lateral positions at closest point of approach (CPA) of subject and target aircraft
2. Lateral CPA distance (LCPA)
3. Time before CPA (TCPA)
4. Time before conflict (TC) [S]
Extrapolated lateral trajectory of target aircraft
LCPA, TCPA and TC are displayed in the target aircraft information box.

### 4.6.2. Vertical Separation Assurance

1. Altitudes at CPA of subject and target aircraft
2. Relative altitude at CPA (VCPA)
3. Time before CPA (TCPA)
4. Time before conflict (TC) [S]

VCPA, TCPA and TC are displayed in the target aircraft information box.

### 4.6.3. Lateral Passing

1. Current and trend value of the (lateral) oblic distance (OD)
   - The trend value of the oblic distance represents the predicted oblic distance in \( x \) minutes (where \( x \) has been specified previously).
2. Closure rate (CR).
3. Oblic line [S]

### 4.6.4. Longitudinal Station Keeping

1. Current and trend value of the along track distance (ATD)
   - The trend value of the along track distance represents the predicted along track distance in \( x \) minutes.
2. Closure rate (CR)
3. Along track line [S]
   - The along track line should be defined as a list of segments (with a variable number of segments).

### 4.7. Mode Control Panel

#### 4.7.1. Autopilot (A/P) Flight Director (F/D) System Controls

1. A/P Engage Switches
2. A/P Engage Light
3. A/P DISENGAGE Bar
4. F/D Switches

#### 4.7.2. Autothrottle (A/T) System Controls

1. A/T ARM Switches
2. Climb/Continuous (CLB/CON) Thrust Switch
3. A/T Engage Switch
4. A/T Engage Light

#### 4.7.3. Autopilot Flight Director IAS/Mach Controls

1. IAS/Mach Window
2. IAS/Mach Reference Switch
3. IAS/Mach Selector

#### 4.7.4. Autopilot Flight Director Roll and Pitch Controls

1. Lateral Navigation (LNAV) Switch
2. LNAV Light
3. Vertical Navigation (VNAV) Switch
4. VNAV Light
5. Flight Level (FLCH) Switch
6. FLCH Light
4.7.5. **Autopilot Flight Director Heading, Track and Bank Angle Controls**

1. Heading/Track (HDG/TRK) Reference Switch
2. HDG/TRK Window
3. HDG/TRK Hold (HOLD) Switch
4. HDG/TRK Hold Light
5. Bank Limit Selector (outer)
6. HDG/TRK Selector (middle)
7. HDG/TRK Select (SEL) Switch (inner)

4.7.6. **Autopilot Flight Director Vertical Speed (V/S) and Flight Path Angle (FPA) Controls**

1. Vertical Speed/Flight Path Angle (V/S – FPA) Window
2. V/S – FPA Reference Switch
3. V/S – FPA Switch
4. V/S – FPA Light
5. V/S – FPA Selector

4.7.7. **Autopilot Flight Director Altitude Controls**

1. Altitude Window
2. Altitude Increment Selector (outer)
3. Altitude Selector (inner)
4. Altitude HOLD Switch
5. Altitude HOLD Light

4.7.8. **Autopilot Flight Director Approach Mode Controls**

1. Localizer (LOC) Switch
2. Localizer Light
3. Approach (APP) Switch
4. Approach Light

4.8. **EFIS Control Panel ND Controls**

1. ND Mode Selector (outer)
2. ND Center (CTR) Switch (inner)
3. VOR/ADF Switches
4. Map Switches
5. ND Range Selector (outer), supporting ranges up to 150nm
6. ND Traffic (TFC) Switch (inner)

4.9. **Instrument and Glareshield Panels Layout**

On the glareshield panel:
- Item 10 is the EFIS Control Panel.
- Item 4 is the Mode Control Panel.

On the Instrument Panel (Left and Right Forward Panels):
- Inner EFIS (e.g. right EFIS on the Left Forward Panel) is devoted to the ND.
- Outer EFIS is devoted to the PFD.

4.10. **Graphic Representations**
PFD Indications

(Option -Basic, Split Cue Flight Director Bars)
PFD Flight Mode Annunciations (FMAs)
PFD Airspeed Indications

![Diagram of PFD Airspeed Indications]

1. 250
2. 300
3. 280
4. 260
5. 240
6. 220
7. 200
8. 595
PFD Reference Speeds
PFD Reference Speeds
PFD Attitude Indications
PFD Steering Indications
PFD Radio Altitude Indications

![Diagram of radio altitude indications with values 10, 10, 20, and 2400.]
PFD Instrument Landing System Indications

1. IBFI/130°
2. DME 3.4
3. 10
4. 10
PFD Expanded Localizer Indications

PFD Rising Runway Indications
PFD Altitude Indications

1. 1550M
2. 5100
3. 5200
4. 5000
5. 4800
6. 4600
7. 4400

L 29.86 IN
PFD Landing Altitude/Minimums Indications

![Diagram of PFD Landing Altitude/Minimums Indications](image-url)
PFD Barometric Indications
PFD Vertical Speed Indications
PFD Heading/Track Indications
**ND Map Mode**

![ND Map Mode Diagram]

- Current Track Heading/Track Reference
- Magnetic/True Reference
- Active Route
- Track Line and Range Scale
- Selected Track Bug
- Position Trend Vector
- VNAV Deviation Scale
- VNAV Path Pointer
- Airplane Symbol
- FMC Position Update Status

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Centered Map Mode

Wind Direction/Speed
Groundspeed
True Airspeed
Wind Arrow
Left VOR/ADF Pointer Head
Selected Heading Bug and Line
Active Waypoint
Active Waypoint ETA
Active Waypoint Distance-To-Go
Right VOR/ADF Pointer Head
Left VOR/ADF Pointer Tail
VOR/ADF Selection
VOR/ADF Identi or Frequency
VOR/DME
Right VOR/ADF Pointer Tail
Centered Map Mode
ND Map Mode / CDTI

Target Aircraft

Environmental Aircraft

Target Aircraft Information Box

ND
ND Map Mode / Lateral Separation Assurance

Target Aircraft CPA Position

Target Aircraft Extrapolated Trajectory

Own Aircraft CPA Position

ND

Target Aircraft CPA Position

Target Aircraft Extrapolated Trajectory

Own Aircraft CPA Position

ND
ND Map Mode / Lateral Separation Assurance
ND Map Mode / Vertical Separation Assurance

![ND Map Mode Diagram](image_url)

- **Target Aircraft CPA Altitude**
- **Own Aircraft CPA Altitude**
- **Own Aircraft Current Altitude**
- **Target Aircraft Current Altitude**
ND Map Mode / Vertical Separation Assurance
ND Map Mode / Lateral Passing

Closure Rate

Oblic Line

ND

Closure Rate

Oblic Line

ND
**ND Map Mode / Longitudinal Station Keeping**

Along Track Line

ND

Along Track Line

ND
Mode Control Panel (MCP)

Autopilot Flight Director System Controls
Autothrottle System Controls

Autopilot Flight Director IAS/Mach Controls
Autopilot Flight Director Roll and Pitch Controls

Autopilot Flight Director Heading, Track, and Bank Angle Controls
Autopilot Flight Director Vertical Speed (V/S) and Flight Path Angle (FPA) Controls

Mode Control Panel (MCP)

Autopilot Flight Director Altitude Controls

Mode Control Panel (MCP)
Autopilot Flight Director Approach Mode Controls

EFIS Control Panel
Control Display Unit

Line 1
Line 2
Line 3
Line 4
Line 5
Line 6 Scratchline

Line 1
Line 2
Line 3
Line 4
Line 5
Line 6 Scratchline
Glareshield Panel
Left Forward Panel

Right Forward Panel
Schematic of CDTI Enhancements for AVT