Title:

PEGASUS

Software User Manual

Aircraft Dynamics Module

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Table of Contents

1. Introduction

This document is the User Manual of the Aircraft Dynamics module for the PEGASUS Software Version 3.0. It provides all information needed to install and use this module.

1.1. Intended Readership

Please refer to the Main Software User Manual for PEGASUS [3].

1.2. Applicability Statement

This Software User Manual is to be used as reference for the version 1.2 of the PEGASUS Aircraft Dynamics Module. Each reference to the current version of PEGASUS in this document is a reference to version 3.0.

As the PEGASUS software is based on integration of individual modules, the full documentation contains multiple PEGASUS module documentation items. To profit from the modular structure of the software, this version of the Software User Manual contains references to the relevant main Software User Manual only. It should be used in conjunction with the other User Manuals referenced in that main User Manual.

1.3. Purpose

1.3.1. Purpose of the Document

This document contains the necessary information related to the use of the PEGASUS Module Dynamics .
It describes the installation and de-installation procedures, the different functionalities of the module, as well as what the user has to do in order to perform the individual processing tasks.

1.3.2. Purpose of the Module

The Dynamics module main functionality is the calculation of path error (NSE, FTE, TSE) and associated statistics. It also supports meteorological data and aircraft dynamics (acceleration and ground speed) surveying.

1.4. Document Structure

This manual shall be used as reference for the use of the PEGASUS Module Aircraft Dynamics .

Section 1: Introduction contains a brief introduction to the PEGASUS software.

Section 2: Overview contains a general description of the module functionality.

Section 3: Installation describes the procedures needed to install the module on a new machine.

Section 4: Problem Reporting contains information on additional means to obtain support on the software and provides points of contact for the reporting of issues linked to the use of the software.

Section 5: General Use gives a step-by-step introduction to the module

Section 6: Services contains a more detailed presentation of the possible functionality of the module, describing the necessary input data, user actions and the obtained results. It is designed as a reference section.

Appendix A contains a list of error messages that might be encountered by using the module, together with the procedures to apply for correction.

Appendix B provides an example of an dynamics.ini file.

Appendix C is a glossary of all the terms in use within this Software User Manual.

1.5. Related Documents

[1] MARS-2 Technical Note, Doc.-No. PEG-TN-MARS2, current issue

[2] MARS-2 PEGASUS Interface Control Document Addendum, Doc.-No. PEG-ICD-01Add, current issue

[3] "Software User Manual", EEC PEGASUS User Manual PEGSUM-01 current issue

[4] “Visualisation Routines Software User Manual”, EEC **PEGASUS,** PEG-SUM-VIS current issue

1.6. Reference Documents:

[R1] “Guide to applying the ESA software engineering standards to small software projects”, ESA, BSSC(96)2 Issue 1

[R2] Eurocontrol Experimental Centre Software Engineering Unit (SEU)

This Software User Manual corresponds to the user part of the PEGASUS documentation set.

2. Overview

2.1. Objectives

2.1.1. Concepts

The Aircraft Dynamics module aims at analysing on board recorded approach flight trials.

2.1.2. Approach

Aircraft dynamics module main functionality is the calculation of error and associated statistics (NSE, FTE, TSE). It provides as well results concerning aircraft dynamics exceeding limitations and meteorological related results.

This module was realised in the context of the GBAS-MARS 2 program in order to analyse GBAS CAT 1 approaches but performance analysis enable to consider possible extension to CAT 2 and 3 (lever-arm and G-force corrections are performed).

The module interfaces with PEGASUS component, notably “Convertor”, “WinGPSAll”, “CarrierPhase” and “Procedure Visualisation” modules.

2.2. Components

The Aircraft Dynamics module consists of four parts

1. The GUI executable for integration (dynamics.exe)
2. The core processing module (dynamicsproc.exe)
3. The visualisation scripts, called from the M-File runner module
4. The GUI dll for PEGASUS integration (dynamics.dll)

This SUM just covers the GUI (dynamics.dll and dynamics.exe).

3. Installation

3.1. System Requirements

3.1.1. Hardware

This section describes only requirements differing from those in the main User Manual [3]

3.1.2. Software

This section describes only requirements differing from those in the main User Manual [3].

3.2. Installation Procedure

This section describes only the procedure for stand-alone use.

Currently no automatic installation procedure is provided to install the different components.

Therefore the different parts have to installed manually by copying the delivered components. Special directory structures have not to be taken into account.

In case that the Dynamics Module is foreseen to be run embedded in the PEGASUS framework, the following components should be installed into the same directory structure as PEGASUS ([PPlus] refers to the installation directory of PEGASUS):

- file [PPlus]\software\exe\dynamics.exe
- file [PPlus]\software\dynamics.dll
- directory [PPlus]\software\exe\dynamics
- file [PPlus]\software\exe\dynamics\dynamicsproc.exe
- file [PPlus]\software\exe\dynamics\dynamics.hlp (for online help information)
- file [PPlus]\software\exe\dynamics\dynamics.ini (for default configuration)

When running as standalone software, the files below can be copied to any desirable directory:

- file dynamics.exe
- directory dynamics
- file dynamics\dynamicsproc.exe
- file dynamics\dynamics.hlp (for online help information)
- file dynamics\dynamics.ini (for default configuration)

The “dynamics.ini” file will be provided with default values. If no ‘ini’ file is specified as command line argument, the dynamics.exe will search for the dynamics.ini in the installation directory. If not available, default parameter values will be used (specified inside the software).

After installation of the dynamics.exe core program, the user will see the following icon in the Windows explorer (large symbol view):

Figure 3.2-1: dynamics.exe program icon

Double-click on this icon will start the dynamics.exe.

The same icon can be seen from the ‘Standalone’ part of the PEGASUS framework program (which allows start of the dynamics.exe in standalone mode from inside the PEGASUS framework).

3.3. De-installation Procedure

This section describes only the procedure for stand-alone use.

In order to completely uninstall the software all installed files have to be deleted. As the module do not generate any entries into the ‘Windows system registry’, there are no other delete actions necessary.

4. Problem Reporting Instructions

PEGASUS is a software prototype under development for Eurocontrol in support of the SBAS and GBAS activities. The Eurocontrol Experimental Centre has been defined as a focal point for User Feedback Reporting.
Today a web-site for PEGASUS is already operational inside the Eurocontrol GNSS-Programme SBAS Project web-site and can be consulted for questions related to the software: http://www.eurocontrol.fr/projects/sbas/pegasus/

The different steps in problem investigation should be the following:

1) Use of information in the documents provided:
   - This User Manual for software operation issues ;
   - The Error Recovery Procedures in Annex A of this Manual for operating errors and warnings;
   - The ICD [2] for issues related to data formats and parameter limitations;
   - The Technical Note [1] for issues related to the algorithms employed for processing.

2) Review of the information provided on the website cited above, especially the “Frequently Asked Questions”.

3) Establishing contact with the development team via the following methods (explained in more detail in the main User Manual [3]):
   - E-mail: eec.pplus.support@eurocontrol.fr (preferred)
   - Fax: +33-1-6988-7307 (in exceptional cases)

5. General Use

The following chapters give an overview how to use the Aircraft Dynamics module.

As the usage of the Aircraft Dynamics module is foreseen just for one straightforward task, the general use is very simple:

- Start the dynamics.exe (embedded or standalone)
- Provide the necessary input data using a dynamics type ini file (see Annex B). The contents of this ini file can be either edited using the PEGASUS framework (using the dynamics.exe) or the Aircraft Dynamics module main window.
- 'Start' processing via control or automatic (in embedded mode)
- 'Stop' processing manually or wait until the complete input files are processed and output files are generated.

5.1. Graphical Interface

The following section provides an overview of the graphical user interface of the module.

5.1.1. Main Dialog Window

Initialisation and configuration of Aircraft Dynamics module is performed using the main GUI presented in Figure 5.1-1. The different sections in GUI are grouped and numbered. Description of the steps (Section 5.2) correspond to the numbers over impressed in the figure.

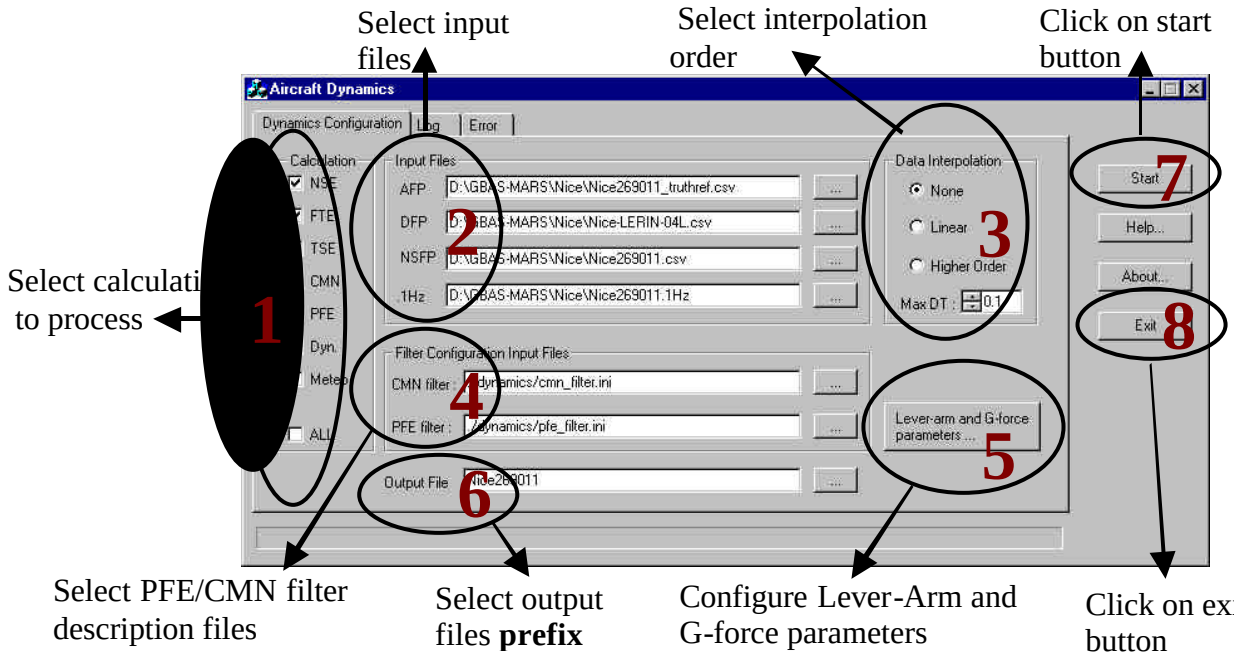

Figure 5.1-1: M4 main window in standalone mode

From the main window the 8 different parts can be seen:

1. Selection of calculation to process
2. Selection of input files
3. Selection of interpolation order
4. Selection of PFE/CMN filter characteristics
5. Configuration of Lever-arm and G-force parameters
6. Selection of output file name and path
7. Start Button
8. Exit Button

The log tab gives feedback on the processing being done by the module.

The error tab presents errors or warnings issued by the module during the processing.

5.2. Step-by-step Overview

In the following sections the main steps 'how-to-use' the dynamics.exe software in **standalone** mode are described.

5.2.1. Start and Initialise M4 Software

In general the dynamics.exe core module will be started manually by double-clicking the dynamics.exe (then the main dialog window of Figure 5.1-1 appears on the screen) or from inside the PEGASUS framework.

In any case, the framework/user can determine the behavior of the Aircraft Dynamics module through 2 'command line' parameters:

dynamics.exe [-b] [-ini xxx:ini]

The [-b] option determines, whether the module is running embedded (command [-b] is given in command line) or standalone (no option). Usually the [-b] option is used when called from the PEGASUS framework.

The second option [-ini xxx.ini] tells the dynamics.exe, that a 'xxx.ini' file shall be used. The xxx means that every name can be used here for the 'ini' file. The 'ini' determines all necessary data for processing.

When the dynamics module is running embedded ([-b] is given at command line), also the provision of a valid [-ini xxx.ini] command option is mandatory (the data from the 'ini' file are necessary to initialize all necessary processing input data). If the second option is not provided, the dynamics module will terminate.

If running standalone, the provision of a 'xxx.ini file is not mandatory. As the user has the option to set necessary processing data from the dialog window. However as a standard, the module will look for a 'dynamics.ini' in the installation directory. If it is found, this 'ini' file will be used.

If no 'ini' file is available, default values will be used as far as possible for the processing. But at least the input data files must be selected.

5.2.2. Selection of calculation to process

The user chooses which calculation he wants the module to perform as depicted in Figure 5.1-1. These check boxes determines the behaviour of the module. For example, if the user click on the NSE check box, the "AFP" and "NSFP" Input file names must be provided to module (see next section for configuration of input file names).

- NSE: Navigation System Error, needs AFP and NSFP input data files.
- TSE: Total System Error, needs AFP and DFP input data files.
- FTE: Total System Error, needs NSFP and DFP input data files.
- PFE: Path Following Error is calculated upon either TSE or FTE, it needs the PFE filter description file (a default file is provided).
- CMN: Control Motion Noise is calculated upon either TSE or FTE, it needs the CMN filter description file (a default file is provided).
- DYN: Needs the Aircraft input data file for extracting dynamics information (acceleration and ground speed).
- MTO: Meteorological data are processed by the module, it needs the Aircraft input data file.

The "ALL" check box have a special behaviour, it enables or disables all other check boxes.

5.2.3. Selection of Input and Output Files

Independent of embedded/standalone mode, the selection of the input processing files is the most important step.

Depending on the calculation chosen by the user in step 1, the module needs one or more input files :

- "AFP" is the actual flight path. This file is normally provided by the *"CarrierPhase"* module or any other external truth reference. This file is needed for the NSE and TSE check boxes.
- "NSFP" is the Navigation System Flight Path. This file is normally provided by the *"WinGPSall"* module but it can also accepted a 1Hz data file from the *"Convertor"* module. This file is needed for the NSE and FTE check boxes.
- "DFP" is the procedure description file. This file is normally provided by the *"Procedure Visualisation"* module but it can also be a user-written file. This file is needed for the TSE and FTE check boxes.
- ".1Hz" is the aircraft data file normally provided by the *"Convertor"* module. This file is needed for the DYN and MTO check boxes but also if Lever-arm corrections are to be applied on the AFP and NSFP data files.

In general the name of the input file will be selected by the user inside the 'File I/O' group box using the 'Input Files' edit fields. If the user does not want to type path and name of the input files, it is also possible to select the right file using the 'Button' right to the edit field (see next figure). This selection of input file name is mandatory.

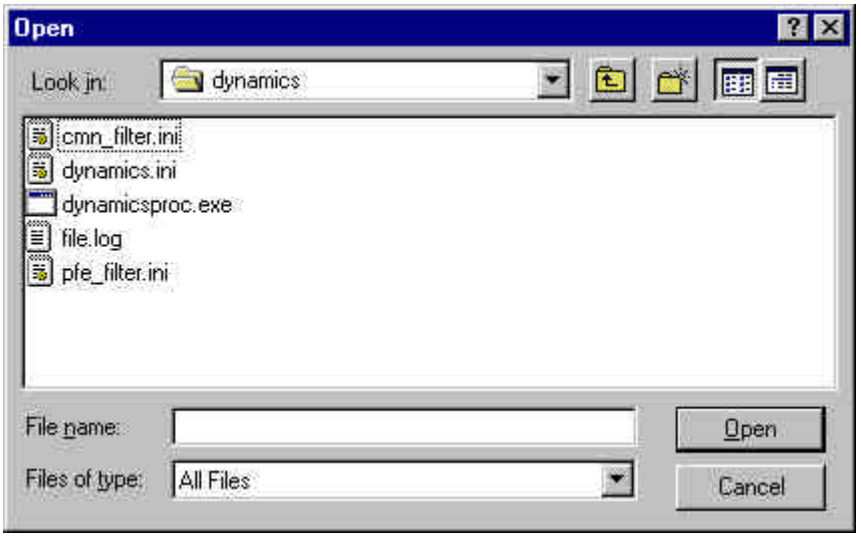

Figure 5.2-1: Select Input File Path and Name (here under Windows NT)

From the selected file, just the file name without extension is used. For dynamics, no input file is mandatory but GBAS messages and obstacles visualization necessitate to enter input files (.csv format) .

In case of embedded processing inside the PEGASUS framework, the framework will provide the user the input selection edit box and file browsing capability. The selected file name is than written (using the dynamics.ini) to a 'xxx.ini' file. Finally the framework will start the dynamics.exe with the 'xxx.ini' as argument on the command line.

For the output file, the user also can write a filename in the 'Output File' edit box (or using the browsing capability via the button right of the output edit field).

In case the user just gives a name without path, dynamics.exe will search the file in the installation directory.

When no output file name and path is specified, the output will be written also to the installation directory.

5.2.4. Interpolation configuration

The user has the choice between three type of interpolation:

- None: No interpolation performed.
- Linear: First order interpolation.
- Higher order: Higher order interpolation.

The user then should choose the maximum de-synchronisation between two data sets (Max DT). A value between 0 and 1s is allowed but a value greater than 0.3 is not recommended. The user can either write directly the “Max DT” edit box or use the Up and Down arrow to fix it to the desired value. A value of zero mean that no interpolation will be performed.

5.2.5. Filter description file specification

Two default files are provided in the “dynamics” directory:

- “dynamics\cmn_filter.ini” : file containing the description of the default band-pass filter needed to calculate the CMN.
- “dynamics\pfe_filter.ini” : file containing the description of the default low-pass filter needed to calculate the PFE.

If the user wants to provide alternate filter description files, those should respect the format defined in [2] and explained in [1].

5.2.6. Lever-arm and G-force configuration

By default, no lever-arm and G-force correction is performed unless this button is clicked. If the user click on it, a pop-up window as depicted in Figure 5.2-2 will be shown to the user where he can specify:

- the 3 co-ordinates of the static (on-ground) position of the centre of gravity,
- the 3 co-ordinates of the static (on-ground) lever-arm to apply to AFP, NSFP and INS,
- the five coefficients K0 to K4 needed to model the G-force correction.

All the edit boxes are empty by default. They must be filled up and the X value of the centre of gravity has to be set to a greater than zero value if lever-arm and G-force corrections are to be performed. If any of the edit boxes is empty or if the X value of the centre of gravity has a lower than or equal to zero value, then no correction and a warning will be produced at run-time.

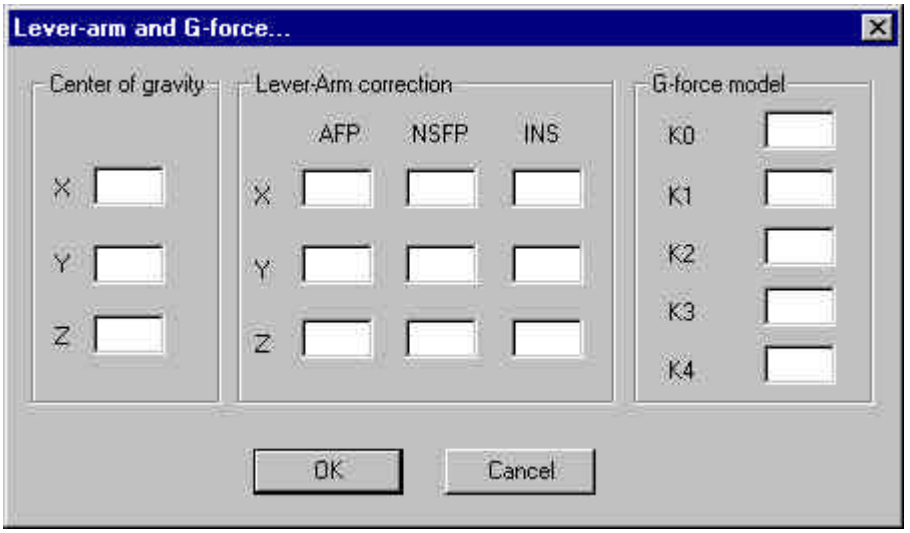

Figure 5.2-2 – Lever-arm and G-force configuration

Please see [1] section 6.4.3 and 6.4.4 for further understanding of this issue.

5.2.7. Selection of output files prefix

The user can choose a directory by clicking on the directory selector […] button and complete it by a name that will be used to prefix output file names. The *"Dynamics"* module will output one to four data files depending on user configuration options. These files will be prefixed by the name shown in this edit box.

5.2.8. Start and Check Processing

The processing is started when the user click on the "start" button which then transforms itself into a "stop" button and again into a "start" button when the processing is finished. If the user click on the "stop" button, the processing is prematurely stopped.

The user can exit the application by clicking on the Exit button.

By clicking on the "Log" tab, a new view is offered the user as shown in Figure 5.2-3. This windows gives feedback on the processing being done by the module. The user can switch between the Configuration GUI and the Log window during the processing.

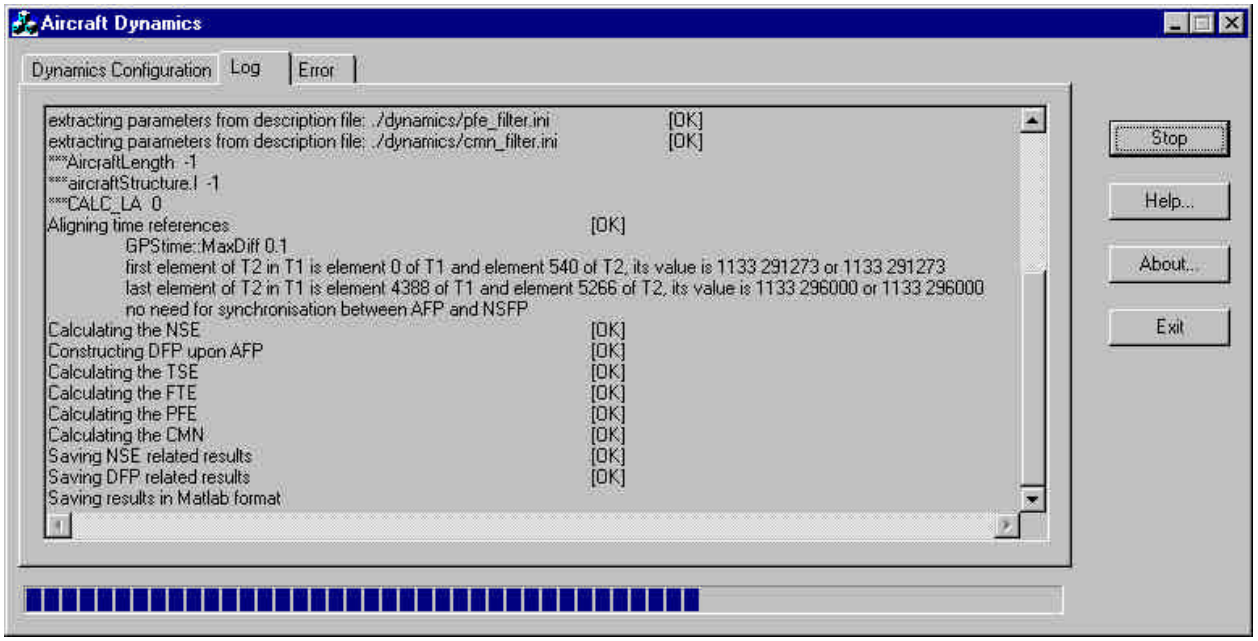

Figure 5.2-3 – Log Window

If any error or warning is issued by the module during the processing, the current view change to the Error window where the user can read a description of the error or the warning (see Figure 5.2-4).

An error stops the processing and a warning only informs the user of a possible problem but do not stop the processing. The user can switch between the Configuration GUI, the Log window and the Error window during the processing.

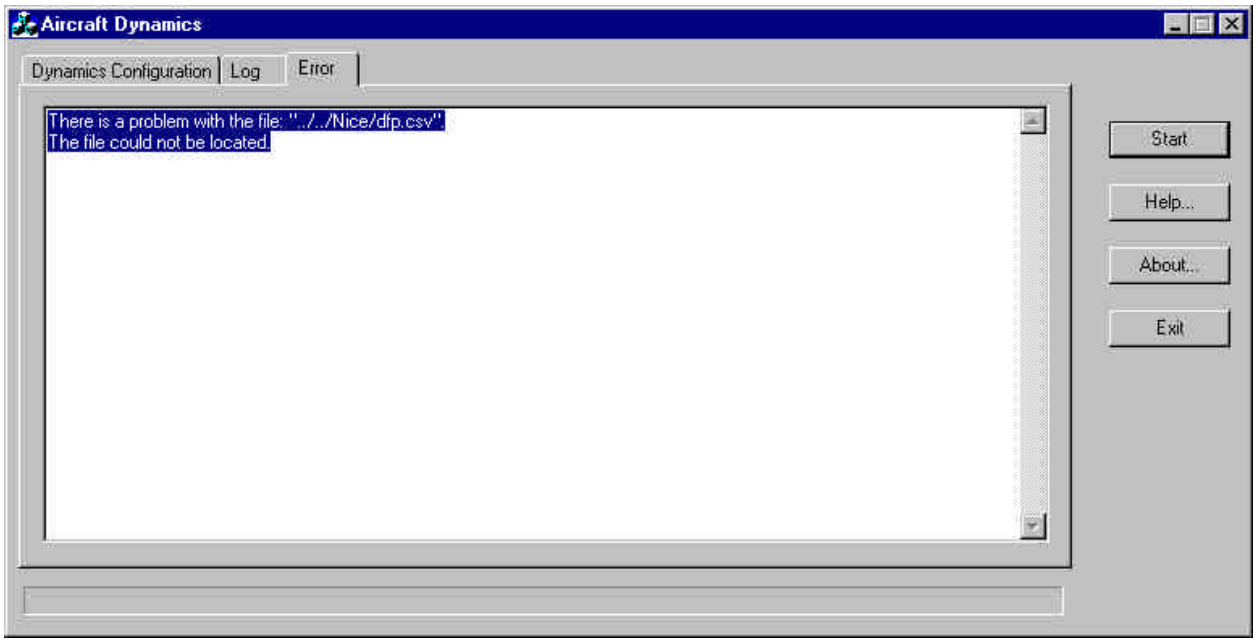

Figure 5.2-4 – Error Window

5.2.9. About Aircraft Dynamics

By pushing the 'About' button of the 'Control' group, a information dialog will be shown to the user, providing information concerning version, copyright and purpose of the software (see next figure):

Figure 5.2-5: About M4 module

5.3. Help

In addition to this Software User Manual, a Helpdesk covering all the aspects of the tool is available. The can be activated by clicking on the 'Help' button of the command control group of the main user interface.

5.4. Operating Modes

Each Module for PEGASUS must be able to be operated in three modes:

1. As stand-alone executable
2. Embedded in the PEGASUS frame
3. In command-line Mode

While the stand-alone mode is described as the baseline mode in this User Manual, the two following sections describe the specific elements of operation in the other two modes.

5.4.1. The Embedded Mode

When the module is running in the embedded mode, i.e. called by the PEGASUS framework, it allows parameter values to be set from inside the framework. That means that only the parameter GUI part of the module software is visible in the parameter selection window of the Frame GUI. The Frame will automatically create the INI-File which is passed then as a command line argument to the core module processing executable, containing the selections made inside the framework. Equally, the invocation of the module processing is automatic through the Scheduler provided in the Frame. Detailed descriptions of this

mechanism and a short description of the module GUI in Embedded Mode are contained in the main User Manual [3].

5.4.2. The Command-Line Mode

The core processing functions of the Module can be started in command line mode by typing:

<Module Name>.exe [-b] [-ini xxx:ini]

The [-b] option instructs the software not to display the GUI and to take all the inputs from an INI-file provided. The –ini option is mandatory if the –b option is used, if no valid INI-file is provided, the module execution will terminate.

Usually the [-b] option is used when called by the scheduler from the PEGASUS framework.

The option [-ini xxx.ini] tells the executable, that the ‘xxx.ini’ file shall be used. The xxx stands for an user-defined name for the ‘ini’ file. It must contain all necessary data for processing. This option may also be used without the –b option, to invoke the GUI with pre-defined settings that can be changed interactively.

6. Services

6.1. Service 1 : Computation

6.1.1. Input Data

Actual, Desired and Navigation Sensor Flight Paths : afp.csv, dfp.csv, nsfp.csv

Aircraft relative Data : aircraft.csv

Filter characteristics : pfe_filter & cmn_filter characteristics

6.1.2. Options

As described in Section 5.2.2, the user has to define the calculations to be performed.

6.1.3. Output Data

The “Dynamics” module will output one to four data files depending on user configuration options, these files are prefixed with the prefix configured in the output file prefix selector (see § 5.2.7):

[prefix]_nse.csv : CSV file containing NSE related results

[prefix]_dfp.csv : CSV file containing approach related results: TSE, FTE, CMN and PFE,…

[prefix]_dyn.csv : CSV file containing aircraft dynamics related results: Acceleration and Gound Speed,…

[prefix]_mto.csv : CSV file containing meteorological related results: Pressure and Temperature,…

Please see [2] section 5.3 for further details about these files.

6.2. Service 2 : Visualise Paths

6.2.1. Input Data

Synchronised paths : afp.csv, dfp.csv, nsfp.csv

6.2.2. Options

The graphical visualisation options are available after processing by the plotting routines [4].

6.2.3. Output

Create a 2D graphical display for all paths (AFP, DFP and NSFP) :

- Latitude vs. Longitude
- Altitude vs. Latitude

- Altitude vs. Longitude
- Altitude vs. Distance to threshold

6.3. Service 3 : Visualise Path Errors

6.3.1. Input Data

[prefix]_nse.csv : CSV file containing NSE related results

[prefix]_dfp.csv : CSV file containing approach related results: TSE, FTE, CMN and PFE,…

6.3.2. Options

The graphical visualisation options are available after processing by the plotting routines [4].

6.3.3. Output

- Create a graphical time plot display for all errors (NSE, FTE, TSE, CMN, PFE).
- Create a graphical display for statistics of all errors.
- Create a graphical display for CMN and PFE spectral analysis.

6.4. Service 4 : Visualise Aircraft Dynamics

6.4.1. Input Data

[prefix]_dyn.csv : CSV file containing aircraft dynamics related results : Acceleration and Gound Speed,…

6.4.2. Options

The graphical visualisation options are available after processing by the plotting routines [4].

6.4.3. Output

Create a graphical display for detection of aircraft dynamics exceeding pre-defined limits

6.5. Service 5 :Visualise Meteorological data

6.5.1. Input Data

[prefix]_mto.csv : CSV file containing meteorological related results: Pressure and Temperature,…

6.5.2. Options

The graphical visualisation options are available after processing by the plotting routines [4].

6.5.3. Output

Create a graphical display of the aircraft collected meteorological parameters.

Appendix A: Error messages and recovery procedures

Whenever the program exits abnormally it will exit with a certain value. Some of these exit codes are already defined in the Pegasus framework :

Exit code	definition
0	everything is fine
1	error in command line syntax
2	can't find ini file
3	error in ini file (bad data)
4	no input file specified
5	can't find specified input file
6	can't write output file
7	missing or inconsistent settings - can't start
8	missing or inconsistent data
9	out of memory
10	undefined error

Additionally, the following error messages will be written during the processing of input data and in the log file. The column “Exit Code” refers to the corresponding exit code of the program if relevant, if not the cell is left blank.

ID	Exit Code	Error message	Solution
1	6	The output file has not been created	See log file
2	5	The file could not be located	Input file could not be opened. Ensure that input file is available
3	6	The file is already open by another process	Close the other process
4		There is a problem with this file	An additional message will be written
5	5	All or part of the path is invalid	Ensure that the path is correct
6	5	There is an unknown problem with the file	Input file could not be opened. Ensure that input file is available
7	2	No ini file found	Provide correct ini file on command line in embedded mode

Additionally information messages will be provided. But they are not provided in the table above.

Annex B Initialisation file example

The following ini file is part of the Dynamics module provided files. It contains typical default values:

```
[AIRCRAFTDYNAMICSSystem]
Separator=;
AFP_FNAME=../../data/AFP2.csv
NSFP_FNAME=../../data/NSFP.csv
DFP_FNAME=../../Nice/dfp2.csv
AIRCRAFT_FNAME=../../Nice/Nice269011_convertor_2Hz.csv
[AIRCRAFT_FNAME=../../Nice/Nice269011_convertor_reduced.csv
PFE_FILTER_FNAME=./dynamics/pfe_filter.ini
CMN_FILTER_FNAME=./dynamics/pfe_filter.ini
OUTPUT_FNAME=
[AIRCRAFTDYNAMICSOption]
CALC_NSE=1
CALC_FTE=0
CALC_TSE=0
CALC_CMN=0
CALC_PFE=0
CALC_DYN=1
CALC_MTO=1
INTERP_TYPE=1
MAX_DT=0.1
CA_X=10
CA_Y=1
CA_Z=1
LA_AFP_X=4
LA_AFP_Y=7
LA_AFP_Z=10
LA_INS_X=6
LA_INS_Y=9
LA_INS_Z=12
LA_NSFP_X=5
LA_NSFP_Y=8
LA_NSFP_Z=11
G_FORCE_K0=13
G_FORCE_K1=14
G_FORCE_K2=15
G_FORCE_K3=16
G_FORCE_K4=17
```

Appendix C: Glossary

This appendix contains the list of all the specialised terms used within this Software User Manual, together with their definition.

ADD	Architectural Design Document
AFP	Actual Flight Path
ASCII	American Standards Committee for Information Interchange
CMN	Control Motion Noise
DFP	Desired Flight Path
DLL	Dynamic Link Library
DO	Document
EEC	EUROCONTROL Experimental Centre
EGNOS	European Geostationary Navigation Overlay Service
GBAS	Ground-Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
ICD	Interface Control Document
ID	Identifier
IFEN	IfEN GmbH
INS	Inertial Navigation System
M3S	M3 Systems
MARS	Modular Analysis and Research System
NED	North/East/Down
NSE	Navigation System Error
NSFP	Navigation System Flight Path
PEGASUS	Prototype EGNOS and GBAS Analysis System Using SAPPHIRE
PFE	Path Following Error
RLD	Rear Left Down
SAPPHIRE	Satellite and Aircraft Database Project for System Integrity Research
SBAS	Satellite-Based Augmentation System
TSE	Total System Error
WGS	World Geodesic System