

August 2023

Advanced
Aircraft
Analysis
User's Manual
Version 5.1

The software described in this document is furnished under a license agreement. The software may be used or copied only under the terms of the license agreement.

Advanced Aircraft Analysis User's Manual
2023

No part of this manual may be photocopied or reproduced in any form without prior written consent from Design, Analysis and Research Corporation.

Microsoft Windows, Windows 95, Windows 98, Windows NT, Windows 2000, Windows XP, Windows 7, Windows 8, Windows 8.1, Windows 10 and Windows 11 are trademarks of Microsoft Corporation

While the information in this publication is believed to be accurate, Design, Analysis and Research Corporation (DARcorporation) makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Design, Analysis and Research Corporation shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance or use of this material. Information in this publication is subject to change without notice.

Copyright 1989-2023 DARcorporation

Table of Contents

PART I	1
1. Introduction.....	1
2. Structure of Software	2
2.1 Windows and Command Bars	2
2.1.1 Application Windows	4
2.1.2 Input/Output Windows.....	7
2.1.3 Input/Output Window Command Bar	11
2.1.4 Plot Windows.....	12
2.1.5 Plot Window Command Bar.....	14
2.2 Toolbars.....	15
2.2.1 Main Toolbar.....	16
2.2.1.1 Flight Condition Definition Dialog Box	17
2.2.1.2 Recalculate Dialog Box.....	22
2.2.1.3 Project Notes Dialog Box.....	24
2.2.1.4 Print Dialog Box.....	25
2.2.1.5 Atmosphere Dialog Box.....	26
2.2.2 Configuration Toolbar.....	27
2.2.2.1 Aircraft Configuration Dialog Box	28
2.2.2.2 Controls Configuration Dialog Box	28
2.2.2.3 Flap/Slat Dialog Box.....	30
2.2.2.4 Structure Dialog Box.....	31
2.2.2.5 Landing Gear Dialog Box.....	32
2.2.2.6 Feedback Dialog Box.....	32
2.2.2.7 Miscellaneous Dialog Box.....	33
2.2.3 Propulsion Toolbar	34
2.2.3.1 Engine Dialog Box.....	35
2.2.3.2 Propeller/Fan Dialog Box.....	36

2.2.3.3	Nacelle Dialog Box.....	37
2.2.3.4	Inlet/Duct Selection Dialog Box.....	38
2.2.4	Useful Load Toolbar.....	39
2.2.4.1	Store Dialog Box.....	40
2.2.4.2	Fuel Tank Dialog Box.....	41
2.2.4.3	Payload/Crew Dialog Box.....	42
2.2.4.4	Weapon Dialog Box.....	43
2.2.5	Certification Toolbar.....	44
2.2.5.1	Certification and Type Dialog Box.....	44
2.2.5.2	Classification Dialog Box.....	46
2.2.6	System Setup Toolbar.....	46
2.2.6.1	Units Dialog Box.....	47
2.2.6.2	Date and Time Format Dialog Box.....	48
2.2.6.3	Project Name Dialog Box.....	48
2.2.6.4	Company Name Dialog Box.....	48
2.2.6.5	Printer Set Up Dialog Box.....	49
2.2.6.6	Calculator Setup Dialog Box.....	50
2.2.6.7	Program Options Dialog Box.....	50
2.3	Menu Bar.....	53
2.3.1	File Import.....	55
2.3.2	File Export.....	56
3.	Input Devices for the Software.....	57
3.1	Operation of the Mouse and Cursor.....	57
3.2	Operation of the Calculator.....	57
3.3	Operation of the Keyboard.....	59
3.4	System Messages.....	59
3.5	Flexible Input.....	59
4.	Generating Hardcopy Output.....	60

5.	Software Databases and Projects.....	62
5.1	The System Database.....	62
5.2	File Compatibility with Previous Versions.....	62
5.3	Projects and Their Databases.....	63
6.	Help System	64
6.1	User's Manual Topics.....	64
6.2	Variable Info Topics.....	65
6.3	Theory Topics	65
	Part II.....	66
1.	Weight Module.....	66
1.1	General Description.....	66
1.2	Weight Main Window.....	66
1.3	Weight Sizing.....	67
1.3.1	Mission Profile.....	68
1.3.2	W_{TO} , W_E , W_F	69
1.3.3	W_{TO} , W_F , given W_E	70
1.3.4	L/D from Weights.....	70
1.3.5	Regression.....	70
1.3.6	Sensitivity	71
1.3.7	Payload Range.....	71
1.3.8	Remarks.....	71
1.4	Class I Weight.....	71
1.4.1	Weight Fractions	72
1.4.2	Center of Gravity.....	73
1.4.3	Inertia Estimate.....	74
1.5	Class II Weight.....	75
1.5.1	Weight	76
1.5.1.1	Structure Component Weight Estimation	76

1.5.1.2	Powerplant Components Weight Estimation	77
1.5.1.3	Fixed Equipment Components Weight Estimation.....	78
1.5.1.4	Miscellaneous Weight.....	79
1.5.1.5	Useful Load Weight.....	79
1.5.1.6	Empty/Take-Off Weight.....	79
1.5.1.6.1	Weight Calculation Process	80
1.5.1.7	Weight Fractions.....	81
1.5.2	Center of Gravity.....	81
1.5.3	Moment of Inertia.....	82
1.6	Radii of Gyration.....	83
2.	Aerodynamics Module.....	84
2.1	General Description	84
2.2	Aerodynamics Main Window.....	84
2.3	Airfoil Characteristics.....	85
2.3.1	Mach Correction.....	85
2.3.2	Wing, Horizontal Tail, Vertical Tail, Canard and V-Tail Airfoil Characteristics..	85
2.3.3	Airfoil Definition.....	85
2.4	Lift.....	86
2.4.1	Wing, Horizontal Tail, Vertical Tail, Canard and V-Tail Lift.....	86
2.4.1.1	Maximum Lift Coefficient.....	87
2.4.1.2	Lift/Sideforce Distribution.....	87
2.4.2	Pylon.....	87
2.4.3	Fuselage.....	88
2.4.4	Nacelle.....	88
2.4.5	High Lift Devices	88
2.4.6	Aircraft No Empennage	88
2.4.7	Propeller.....	89
2.4.8	Aircraft.....	89

2.5	Drag.....	89
2.5.1	Class I Drag.....	90
2.5.2	Class II Drag.....	93
2.5.2.1	Wing Drag.....	94
2.5.2.2	Horizontal Tail Drag.....	94
2.5.2.3	Vertical Tail Drag.....	94
2.5.2.4	Canard Drag.....	95
2.5.2.5	V-Tail Drag.....	95
2.5.2.6	Ventral Fin Drag.....	95
2.5.2.7	Dorsal Fin Drag.....	95
2.5.2.8	Pylon Drag.....	95
2.5.2.9	Fuselage Drag.....	95
2.5.2.10	Nacelle Drag.....	96
2.5.2.11	Inlet/Duct Drag.....	96
2.5.2.12	Tailboom Drag.....	96
2.5.2.13	Store Drag.....	97
2.5.2.14	Float Drag.....	97
2.5.2.15	External Fuel Tank Drag.....	97
2.5.2.16	External Weapon Drag.....	97
2.5.2.17	High Lift Device Drag.....	97
2.5.2.18	Spoiler Drag.....	98
2.5.2.19	Speed Brake Drag.....	98
2.5.2.20	Landing Gear Drag.....	98
2.5.2.21	Canopy Drag.....	98
2.5.2.22	Windshield Drag.....	99
2.5.2.23	Windmilling Drag.....	99
2.5.2.24	Nozzle Drag.....	99
2.5.2.25	Trim Drag.....	99

2.5.2.26	Miscellaneous Drag.....	99
2.5.2.27	Aircraft Drag.....	100
2.5.2.28	Recalculate All.....	100
2.5.2.29	Trendline.....	100
2.5.2.30	Plot.....	100
2.5.3	Drag Distribution.....	101
2.5.4	Critical Mach Number.....	102
2.5.5	Wind Tunnel Drag.....	102
2.6	Pitching Moment.....	103
2.6.1	Wing, Horizontal Tail, Vertical Tail, Canard, V-Tail, Pylon Pitching Moment..	104
2.6.1.1	Lifting Surface Zero-Lift Pitching Moment Coefficient.....	104
2.6.1.2	Moment Distribution.....	104
2.6.2	Fuselage, Nacelle, Tailboom, Store, Float, External Fuel Tank and External Weapon Pitching Moment.....	105
2.6.2.1	Body Zero-Lift Pitching Moment Coefficient.....	105
2.6.2.2	Body Pitching-Moment-Coefficient-due-to-Angle-of-Attack Derivative	105
2.6.3	Aircraft No Empennage Pitching Moment.....	105
2.6.4	Aircraft Pitching Moment.....	105
2.6.4.1	Pitching-Moment-Coefficient due to Angle-of-Attack Derivative.....	106
2.6.4.2	Zero-Angle-of-Attack and Zero Lift Pitching Moment Coefficients.....	106
2.6.4.3	Miscellaneous Pitching Moment Coefficient.....	106
2.6.4.4	Aircraft Pitching Moment Coefficient based on Components.....	107
2.6.4.5	Aircraft Pitching Moment Coefficient for Given Angle of Attack.....	107
2.7	Aerodynamic Center.....	107
2.7.1	Wing, Horizontal Tail, Vertical Tail, Canard, V-Tail, Ventral Fin, and Pylon Aerodynamic Center.....	107
2.7.2	Fuselage Aerodynamic Center Shift.....	108
2.7.3	Aircraft No Empennage Aerodynamic Center.....	108

2.7.4	Aircraft Aerodynamic Center.....	108
2.8	Dynamic Pressure Ratio.....	108
2.8.1	Wing, Horizontal Tail, Vertical Tail, Canard and V-Tail Dynamic Pressure Ratio 109	
2.9	Power Effects.....	109
2.9.1	Immersed Area.....	109
2.10	Ground Effects.....	110
2.11	Deep Stall Angles.....	110
2.12	Pitch Break.....	110
3.	Performance Module.....	111
3.1	General Description.....	111
3.2	Performance Main Window.....	111
3.3	Performance Sizing.....	112
3.3.1	Stall Speed Sizing.....	112
3.3.2	Take-Off Distance Sizing.....	112
3.3.3	Climb Sizing.....	113
3.3.4	Maximum Cruise Speed Sizing.....	113
3.3.5	Maneuvering Sizing.....	113
3.3.6	Landing Distance Sizing.....	113
3.3.7	Matching Plot.....	113
3.3.8	Maximum Lift Verification.....	114
3.3.9	High Lift Device Sizing.....	115
3.4	Performance Analysis.....	115
3.4.1	Thrust-Speed or Power-Speed Performance Curve.....	115
3.4.2	Take-Off Distance.....	116
3.4.3	Cruise.....	116
3.4.3.1	Maximum Cruise Speed.....	116
3.4.3.2	Range.....	117

3.4.3.3	Endurance.....	117
3.4.3.4	Payload-Range Diagram.....	117
3.4.4	Maneuver.....	118
3.4.5	Landing Distance.....	118
3.4.6	Stall Speeds.....	119
3.4.7	Climb.....	119
3.4.8	Dive & Descent.....	120
3.4.9	Glide.....	120
3.5	Export to APP.....	121
4.	Geometry Module.....	122
4.1	General Description.....	122
4.2	Aircraft Geometry Categories.....	122
4.3	Wing Geometry.....	123
4.3.1	Straight Tapered.....	123
4.3.2	Cranked Wing.....	124
4.3.3	Aileron/Elevon/Tab.....	124
4.3.4	High Lift Device.....	124
4.3.5	Spoiler.....	124
4.3.6	Fuel Volume.....	124
4.3.7	Chord, Thickness, Twist, Sweep.....	125
4.3.8	Airfoil.....	125
4.3.9	Exposed.....	126
4.4	Horizontal Tail Geometry.....	126
4.4.1	Straight Tapered.....	126
4.4.2	Cranked Horizontal Tail.....	126
4.4.3	Volume Coefficient.....	126
4.4.4	Elevator/Tab.....	127
4.4.5	Chord, Thickness, Twist, Sweep.....	127

4.4.6	Airfoil	127
4.4.7	Exposed	127
4.5	Vertical Tail Geometry	127
4.5.1	Straight Tapered	128
4.5.2	Cranked Vertical Tail.....	128
4.5.3	Volume Coefficient	128
4.5.4	Rudder/Tab	128
4.5.5	Chord, Thickness, Twist, Sweep.....	128
4.5.6	Airfoil	128
4.5.7	Exposed	129
4.6	Canard Geometry.....	129
4.6.1	Straight Tapered	129
4.6.2	Cranked Canard.....	129
4.6.3	Volume Coefficient	129
4.6.4	Canardvator/Tab.....	130
4.6.5	Chord, Thickness, Twist, Sweep.....	130
4.6.6	Airfoil	130
4.6.7	Exposed	130
4.7	V-Tail Geometry	130
4.7.1	Straight Tapered	131
4.7.2	Cranked V-Tail.....	131
4.7.3	Volume Coefficient	131
4.7.4	Ruddervator/Tab.....	131
4.7.5	Chord, Thickness, Twist, Tab.....	131
4.7.6	Airfoil	131
4.7.7	Exposed	131
4.8	Ventral Fin Geometry	132
4.9	Dorsal Fin Geometry.....	132

4.10	Pylon Geometry	132
4.11	Fuselage, Nacelle, Inlet/Duct, Tailboom, Store, Float, Fuel Tank, Weapon Geometry 132	
4.11.1	Simplified Body	132
4.11.2	Detailed Body.....	133
4.12	Landing Gear Geometry	133
4.13	Canopy Geometry.....	133
4.14	Propeller Geometry	133
4.15	Engine.....	133
4.16	Aircraft Wetted Area	133
4.17	Aircraft 3-View	134
4.18	Angles.....	135
4.19	Scale/Move.....	135
4.20	Export.....	135
4.20.1	Exporting to SharkCAD Pro-AeroPack.....	136
4.20.2	Exporting to FlightStream.....	136
4.21	Electrical Wire Routing.....	137
4.22	Flight Control Routing.....	137
4.23	Hydraulic Routing.....	137
5.	Propulsion Module.....	138
5.1	General Description	138
5.2	Type of Propulsion	138
5.3	Propulsion Main Window	139
5.4	Power Extraction	139
5.5	Inlet Design.....	140
5.6	Nozzle Design	140
5.7	Engine.....	141
5.8	Propeller.....	141

5.9	Thrust from Drag.....	141
5.10	Thrust Forces and Moments.....	141
6.	Stability and Control Module.....	142
6.1	General Description.....	142
6.2	Stability & Control Main Window.....	142
6.3	Steady State.....	143
6.3.1	Thrust.....	143
6.4	Derivatives.....	144
6.4.1	Longitudinal Stability Derivatives.....	145
6.4.2	Lateral-Directional Stability Derivatives.....	146
6.4.3	Longitudinal Control Derivatives.....	146
6.4.4	Lateral Control Derivatives.....	148
6.4.5	Directional Control Derivatives.....	149
6.4.6	Hingemoment Derivatives.....	150
6.4.7	Recalculate All.....	151
6.5	Longitudinal Stability.....	151
6.5.1	Surface Area Sizing.....	151
6.5.2	Stick Fixed and Stick Free Static Margin.....	152
6.5.3	Wing Location.....	152
6.6	Longitudinal Trim.....	152
6.6.1	C_L, α given W, U_1	153
6.6.2	C_L given W, U_1	153
6.6.3	Trim Diagram.....	153
6.6.4	Matrix Method for Longitudinal Trim.....	154
6.6.5	Take-off Rotation.....	154
6.6.6	Trimmed Lift (T from D).....	154
6.6.7	Trimmed Lift (T=Const).....	154
6.7	Directional Stability.....	154

6.8	Lateral-Directional Trim.....	155
6.8.1	Matrix Method for Lateral-Directional Trim.....	155
6.8.2	Straight Line Flight Trim	156
6.9	Control Forces/Hingemoments.....	156
6.9.1	Stick Force.....	156
6.9.2	Pedal Force.....	157
6.9.3	Aileron/Elevon Force.....	157
6.9.4	Longitudinal Hingemoments.....	157
6.9.5	Directional Hingemoments.....	157
6.9.6	Aileron Hingemoments.....	157
6.10	Wind Tunnel.....	158
6.11	Angular Rates.....	158
6.12	6 DOF Coefficients.....	158
7.	Dynamics Module.....	159
7.1	General Description.....	159
7.2	Dynamics Main Window	159
7.3	Dynamics.....	159
7.3.1	Longitudinal Dynamics.....	160
7.3.1.1	Transfer Function – Longitudinal.....	160
7.3.1.2	Flying Qualities – Longitudinal	161
7.3.1.3	Sensitivity – Longitudinal	162
7.3.2	Lateral-Directional Dynamics	162
7.3.2.1	Transfer Function – Lateral-Directional.....	163
7.3.2.2	Flying Qualities – Lateral Directional.....	164
7.3.2.3	Sensitivity – Lateral-Directional.....	165
7.3.3	Roll Coupling.....	165
7.4	Control.....	166
7.4.1	Root Locus (s) S-Plane Analysis	166

7.4.1.1	Single and Double Loop S-Plane Analysis.....	166
7.4.1.2	Gyro Tilt S-Plane Analysis.....	167
7.4.2	Bode Method.....	168
7.4.3	Human Pilot.....	168
7.4.4	Time Delay.....	168
7.4.5	Erase T.F.....	168
8.	Loads Module.....	170
8.1	General Description.....	170
8.2	Loads Main Window.....	170
8.3	V-n Diagram.....	170
8.4	Structural Loads.....	171
8.4.1	Wing, Horizontal Tail, Vertical Tail, Canard, V-Tail, Fuselage.....	171
8.4.1.1	Concentrated Weights.....	172
8.4.1.2	Distributed Weights.....	173
8.4.1.3	Aerodynamic.....	174
8.4.1.4	User Loads.....	175
8.4.1.5	Load Stations.....	175
8.4.1.6	Gear/Engine/Misc.....	176
8.4.1.7	Total Internal.....	176
8.4.2	Load Factors.....	176
8.5	Lateral Gust Loads.....	176
9.	Structures Module.....	177
9.1	General Description.....	177
9.2	Structures Main Window.....	177
9.3	User Materials.....	177
9.4	Class I.....	178
10.	Cost Module.....	179
10.1	General Description.....	179

10.2	Cost Main Window.....	179
10.3	AMPR Weight.....	180
10.4	R.D.T.E. Cost.....	180
10.5	Acquisition Cost.....	180
10.6	Operating Cost.....	181
10.6.1	Block Data.....	181
10.6.2	Direct.....	181
10.6.3	Indirect.....	182
10.6.4	Program.....	182
10.7	Life Cycle Cost.....	182
10.8	Prototype Cost.....	183
10.9	Price Data.....	183
11.	References.....	184

Software System Organization

This part describes the general functions of the program options used in the software and gives an overview of the different types of files used.

1. Introduction

The software provides a powerful framework to support the iterative and non-unique process of aircraft preliminary design. It allows students and preliminary design engineers to rapidly evolve a preliminary aircraft configuration from early weight sizing through open-loop and closed-loop dynamic stability and sensitivity analysis, while working within regulatory and cost constraints.

The software is written for the Microsoft Windows graphical interfaces. This allows the user to take full advantage of the interface. It is recommended that it be run as a full screen program with a display resolution of at least 1024×768 or higher. It will run with any display resolution but scrolling may become necessary for display resolutions less than 1024×768.

The software consists of ten application modules, a detailed help system, environment setup and project handling tools. Section 2 describes the structure of the program. Sections 3 and 4 describe and explain the various tools used in the program. Section 5 discusses the project handling methods and capabilities of the software. Section 6 describes the online help system in the software.

All information contained in this manual is also contained in the software help system. The help system can be accessed at any time from within the program by selecting the **Help** button at the bottom of the main window, by selecting an option in the Help menu at the top of the main window, by selecting the **Theory** button in the input/output window, or by pressing **F1** on the keyboard. The help system can also be accessed by selecting the User's Manual icon in the software program group in Windows.

2. Structure of Software

The software uses windows, toolbars and dialog boxes to communicate with the user. This section describes the structural elements of the software, their purpose and their functionality. The following elements of the software are described in this section:

2.1 Windows and Command Bars

2.2 Toolbars

2.3 Menu Bar

2.1 Windows and Command Bars

The Advanced Aircraft Analysis software (“AAA51.exe”) is started by opening the executable file. When the program is started, the main window (Figure 2.1) is displayed. This window is open as long as the program is running. The main window contains a Windows menu bar at the top, the main menu of application modules, the software toolbars and the status bar. The status bar is located at the bottom of the main window and contains the company name and project name as specified by the user and the current date and time. When an element of the status bar is double clicked with the mouse button, a dialog box appears to change the content or format of that element (see Part I Section 2.1.2).

The main window minimize button, maximize button, the restore button and the close button all function per standard Windows functionality. The application window minimize button, maximize button, the restore button and the close button all perform their expected functions within the application window of the software.

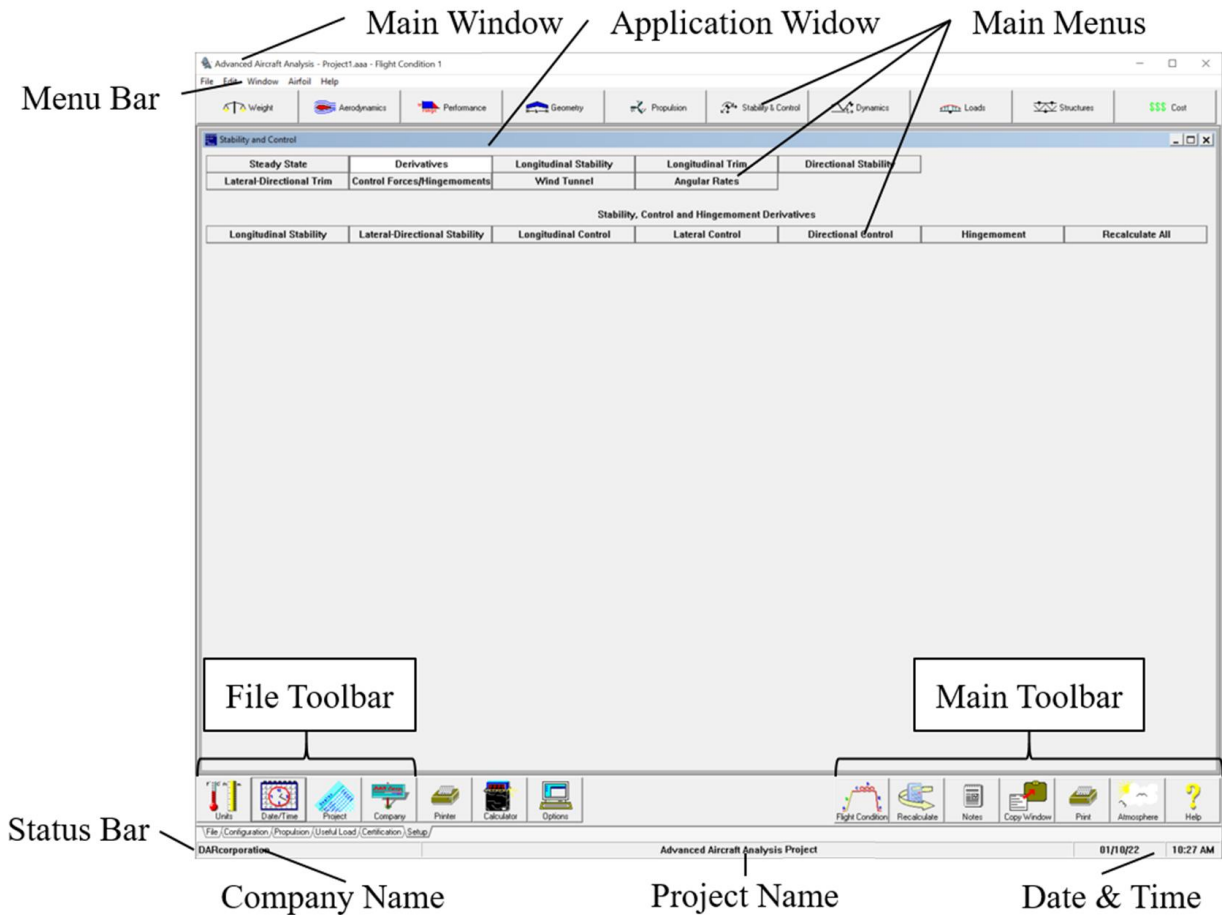


Figure 2.1 The Main Window

Three types of windows can be contained within the main window. There are application windows, input/output windows and plot windows. Application windows, input/output windows and plot windows are child windows and are always displayed within the main window.

Descriptions of each of these window types and their components are presented in the following Sections:

- 2.1.1 Application windows
- 2.1.2 Input/Output windows
- 2.1.3 Input/Output windows command bar
- 2.1.4 Plot windows
- 2.1.5 Plot window command bar

2.1.1 Application Windows

When one of the application buttons at the top of the main window is selected, the corresponding application window is displayed (see Figure 2.1). The application window contains menu button selections that allow the user to select a calculation to be performed. The software uses a flow chart method for the user interface as shown in Figure 2.1. This allows the user to see the path selected in reaching a certain location.

The software consists of various calculation modules that can be accessed through the application windows. Table 2.1 presents the application buttons in the main window and the calculation modules accessed by that application module.

Table 2.1 Application Modules

Application Button	Calculation Modules
Weight	<ul style="list-style-type: none"> • Weight sizing of take-off weight, empty weight, and total mission fuel weight for a given mission • Class I take-off weight and fuel calculation • Class I and Class II weight & balance analysis, center of gravity calculation and moment of inertia calculation for current loading • Radii of Gyration calculation based on Class II moment of inertia
Aerodynamics	<ul style="list-style-type: none"> • Airfoil aerodynamic characteristic definition • Class II lifting surface and aircraft lift calculation • Class I and Class II drag polar calculation • Class II lifting surface and aircraft moment calculation • Aircraft aerodynamic center calculation • Dynamic Pressure Ratio calculation • Power effects on aircraft lift and pitching moment • Ground effects of aircraft lift and pitching moment • Aircraft deep stall angles • Aircraft pitch break
Performance	<ul style="list-style-type: none"> • Class I performance sizing • Class II performance analysis • Export to Aircraft Performance Program (APP)
Geometry	<ul style="list-style-type: none"> • Class I wing, fuselage and empennage layout • Powerplant positioning and orientation • Electrical wire, flight control, and hydraulic routing • Aircraft wetted area • Lateral tip-over analysis • Aircraft 3-View • Aircraft component angles • Scale and move the aircraft • Aero-Pack Interface

Table 2.1 Continued

Application Button	Calculation Modules
Propulsion	<ul style="list-style-type: none"> • Class I installed thrust/power calculation • Inlet/Nozzle sizing • Jet engine and propeller performance • Thrust from Drag • Thrust Forces & Moments
Stability & Control	<ul style="list-style-type: none"> • Steady state and derivative coefficients for longitudinal and lateral directional stability and control, including speed and thrust/power • Longitudinal and lateral-directional trim • Longitudinal and directional stability, including Class I stability & control empennage sizing and Class II stick force and pedal force calculations • Control surface and trim tab hingemoment derivatives • Steady state and derivative coefficients for longitudinal and lateral-directional stability and control from wind tunnel data • Steady state pitch, yaw, and bank angles
Dynamics	<ul style="list-style-type: none"> • Open loop longitudinal and lateral-directional stability dynamic analysis • Automatic dynamic control system analysis
Loads	<ul style="list-style-type: none"> • Velocity-Load Factor (V-n) diagram generation • Structural component internal load estimation • Lateral gust loads estimation
Structures	<ul style="list-style-type: none"> • Material property tables • Class I component structural sizing
Cost	<ul style="list-style-type: none"> • Aircraft program cost estimation

Clicking on the appropriate buttons in the application window activates each module. When the menu buttons leading to a calculation module have been selected, the input/output window for that calculation module is opened.

2.1.2 Input/Output Windows

The input/output window opens after selecting the type of calculation to be performed. The input/output window contains numeric data necessary to perform a calculation. For some calculations, information about the aircraft configuration and aircraft certification type are required so that the correct calculation method can be used. If they have not been previously defined, before the input/output window is displayed, the program will display a dialog box allowing the user to specify configuration choices. For example, the program will ask the user to define empennage surfaces before the input/output window for longitudinal stability calculations is displayed.

Input/output windows contain a command bar at the top of the window, an input group and an output group (See Figure 2.2). The input/output window command bar is described in Part I Section 2.1.3.

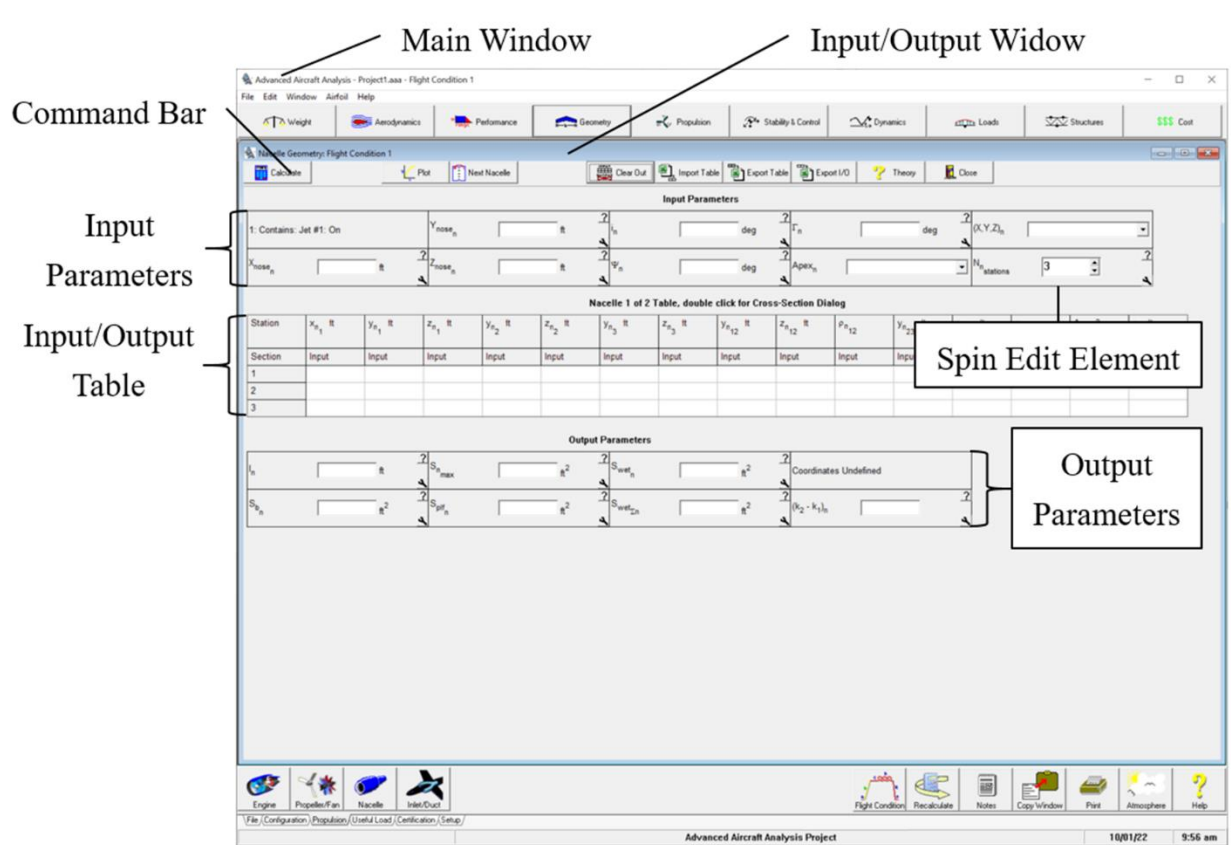





Figure 2.2 Input/Output Window

Input/output windows contain one or more input/output elements. Figure 2.3 shows an input/output element. The input/output element contains the following:

- Variable Symbol
- Edit Box for keyboard input
- Unit (SI or British)
- Info  button
- Go To  button
- Work Pad  button

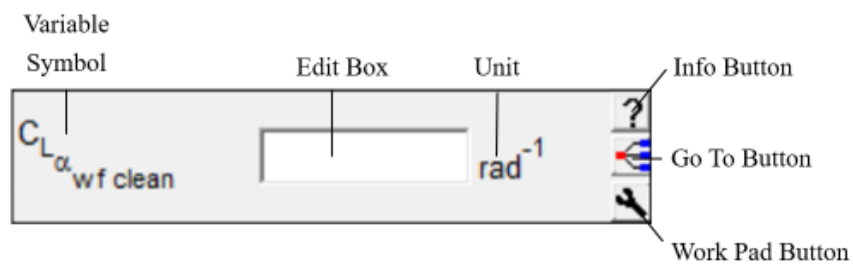


Figure 2.3 Input/Output Element

When the cursor is positioned over an input/output element, a brief description of the parameter is displayed. When the cursor is located over the edit box of the input/output element, it appears as a vertical bar. When the edit box is selected with the left mouse button, a vertical insertion bar appears in the edit box, and the keyboard can be used to type a numeric input. When the cursor is positioned outside the edit box, it appears as a small calculator. When the left mouse button is clicked while the cursor appears as a calculator, the program calculator is opened (see Part I Section 3.2).

When the **Info** button is clicked, an information window is displayed for that variable. The information window contains a definition of the variable with graphics and suggested values when available (see Part I Section 6.2).

Figure 2.4 shows the Work Pad window. When the **Work Pad** button is clicked, this window is displayed and allows the user to type notes about that variable.

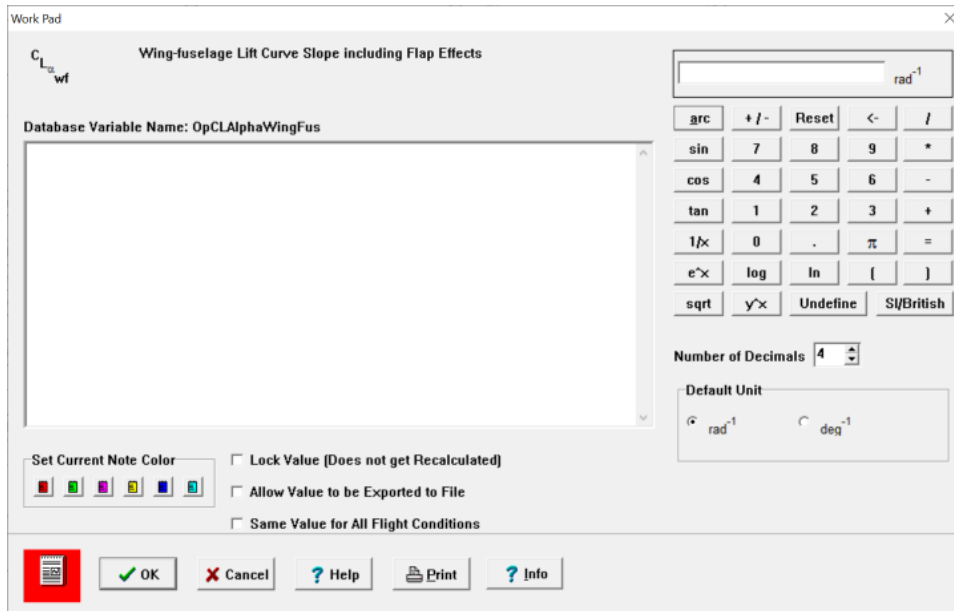


Figure 2.4 Work Pad Window

These notes are specific to that variable and will be saved with the project. Notes may also be designated one of six colors to identify certain stages of the design process. This is done by simply clicking on the desired color in the “Set Current Note Color” box of the Work Pad window. If a color is not selected from this portion of the Work Pad window, the default color will be used with that particular note. If notes have been entered for a variable, the **Work Pad** button will change colors to the default notes color. The default notes color can be set or changed in the Program Options dialog box (see Section 2.2.6.7). The Work Pad window also has options to allow the user to lock the value of the variable so that it does not get recalculated, export the value to an ASCII text file, or select whether or not the variable is flight condition dependent. The “Default Unit” box in the Work Pad window allows the user to change the units for the variable associated with the window without changing the default units for the entire project. The number of decimals can be increased or decreased to a maximum of 8 decimals using the “Number of Decimals” box.

The **Go To** button appears next to parameters which have been calculated by AAA in another module. Selecting the **Go To** button will display the module in which the corresponding parameter was calculated. This allows the user to see what variables were used in producing the parameter, and confirm its validity. Clicking on the **Go To** button a second time will return the user to the previous module.

An input/output window can also contain a table for numeric input and output data. Figure 2.2 shows an input/output window with a table for nacelle section input. The table can be resized (rows added or subtracted) using the spin edit element, which appears as the last element in the input menu.

The input menu of the input/output window may also contain a combo box element (see Figure 2.5).

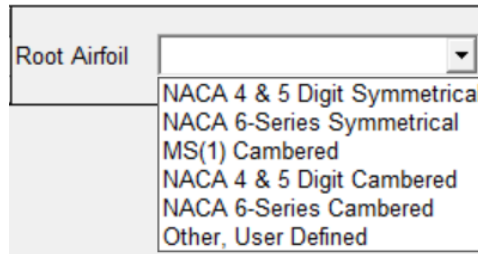


Figure 2.5 Combo Box Element

The combo box element is similar in appearance to an input/output element, but does not contain an edit box. The combo box element contains a list of choices that affect the calculation results. The list of choices is displayed by clicking on the arrow at the right side of the element or by clicking anywhere in the edit box. A choice can then be made by clicking on the desired option.

Most input/output windows contain an output group of elements showing the results of the calculation performed in the window. The output group can contain output elements or a table of values. The output results of some input/output windows can be displayed as a graph or plot. The plot of the output is presented in a plot window when the **Plot** button on the input/output window command bar is selected. The plot window is described in Part I Section 2.1.4.

2.1.3 Input/Output Window Command Bar










The input/output window command bar is displayed at the top of the input/output window. The buttons that can appear on the input/output window command bar are shown in Figure 2.6.



Figure 2.6 Input/Output Window Command Bar Buttons

Each button in the command bar represents an action that can be performed in the input/output window. A command bar button is not displayed if its action is not available for the particular input/output window. The **Close** button in the command bar, that closes the input/output window, is always displayed. The remaining buttons that can be displayed on the input/output command bar are shown and described in Table 2.2.

Table 2.2 Input/Output Window Command Bar Functions

 Calculate	Calculate: Using the specified input parameters and table inputs, the calculations for the output parameters and table outputs are performed.
 Clear Out	Clear Out: Allows the user to erase all output parameters and table outputs in the input/output window.
 Theory	Theory: Opens a Help window containing the calculation methods corresponding to the input/output window (see Part I Section 6.3).
 Close	Close: Closes the input/output window.
 Plot	Plot: Opens the corresponding Plot window when applicable.
 Import Table	Import Table: Imports an Excel file in the same format as the table in the active window.
 Export Table	Export Table: Exports an Excel file in the same format as the table in the active window.
 Export I/O	Export I/O: Export input/output data to an Excel Spreadsheet or to a text file (ASCII).
 Next Nacelle	Next Item: If there are multiple tables of inputs (e.g., multiple nacelles, inlets/ducts, tailbooms, stores, floats, fuel tanks and weapons) needed for the calculation, the next table of parameters will be displayed. If the last table is currently displayed, the first table will be displayed after selecting the button.

2.1.4 Plot Windows

The plot window contains a graphical representation of a calculation in an input/output window. Figure 2.7 shows a plot window of a Class I drag polar of a prop-powered aircraft. The plot window contains a command bar at the top. The functionality of the plot window command bar is described in Part I Section 2.1.5.

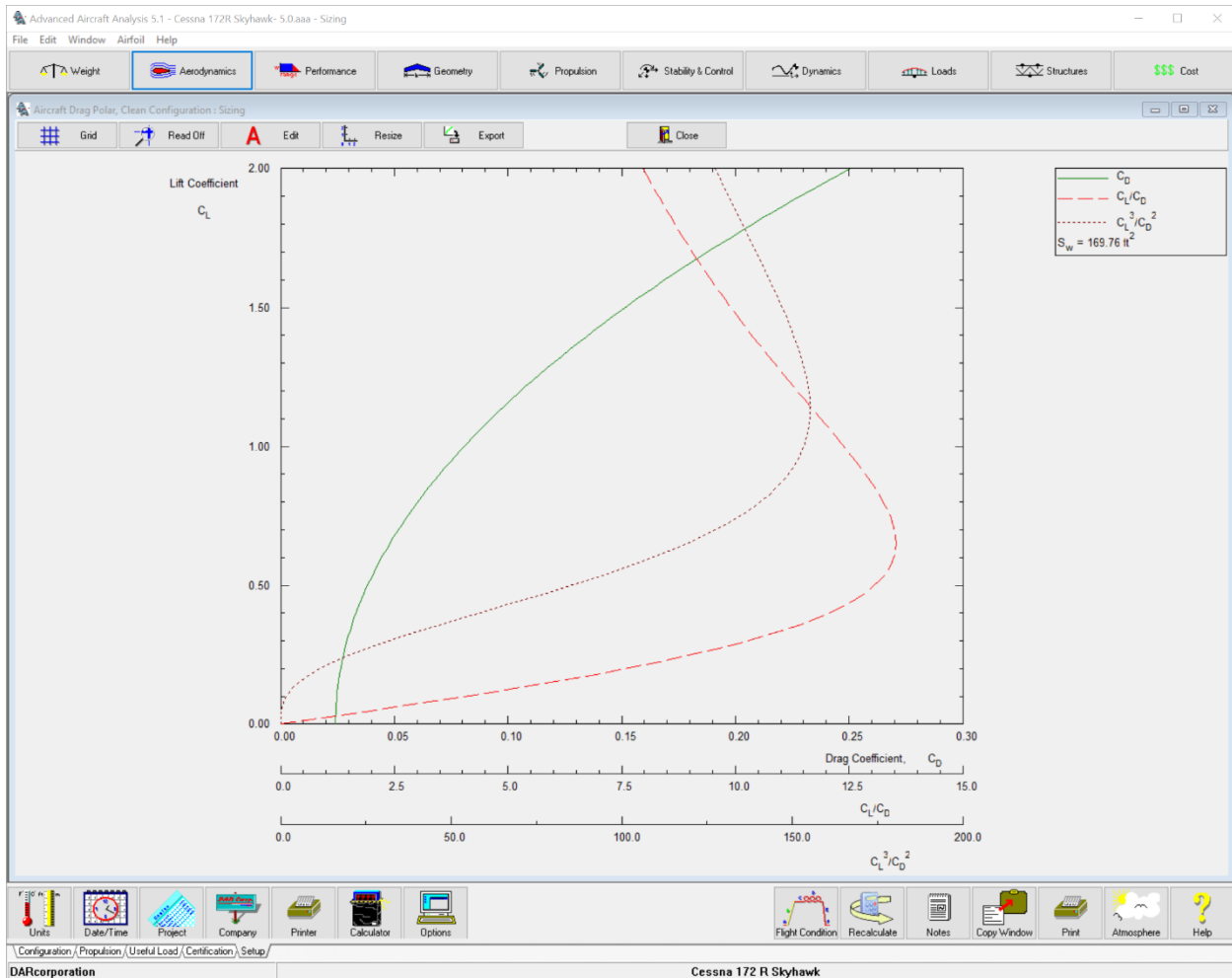


Figure 2.7 Plot Window

Most plot windows contain a legend at the top right corner of the window. Plot windows also contain one or more vertical and one or more horizontal axes. When the cursor is moved over an axis, it appears as horizontal and vertical axes. When the cursor changes, the left mouse button can be double clicked and a dialog will be displayed allowing the user to change the axes (see Figure 2.8). The minimum and maximum values, the major and minor divisions and the number of displayed decimal places can be changed. If the axes are expanded beyond the original range of the calculation, the plotted parameters will not be recalculated for the expanded range. To recalculate the parameters, the user should close the plot window and increase the range of calculation in the input/output window. The first time the program creates a specific plot, the software calculates the plot area to encompass the entire graph. The values defining the first plot area will be saved and used the next time the plot is generated. If the axes are changed to redefine the plot area, those parameters will be saved and used the next time the graph is generated. The

parameters are saved in the user database. The user can always have the program recalculate the plot area to show the entire graph by selecting the **Resize** button in the plot window command bar.

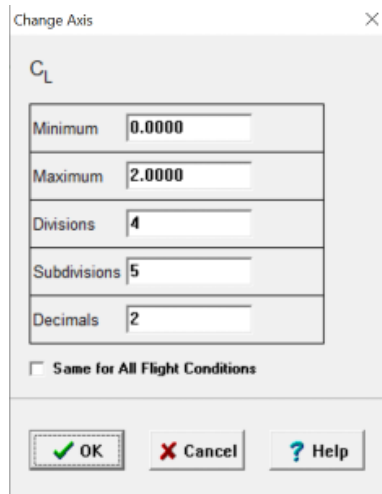


Figure 2.8 Change Axis Dialog

The functionality of the plot window command bar buttons is described in the next Section.

2.1.5 Plot Window Command Bar







The plot window command bar is displayed at the top of the plot window. The buttons that can appear on the plot window command bar are shown in Figure 2.9.



Figure 2.9 Plot Window Command Bar Buttons

Each button in the command bar represents an action that can be performed in the plot window. A command bar button is not displayed if its action is not available for the particular plot window. The **Close** button in the command bar, that closes the plot window, is always displayed. The buttons that can be displayed on the plot command bar are shown and described in Table 2.3.

Table 2.3 Plot Window Command Bar Buttons

 Grid	Grid: Allows the user to turn the axis grid on or off on the plot.
 Read Off	Read Off: Allows the user to read a value from the plot. When selected, the corresponding X and Y coordinates are displayed when the user positions the crosshairs on the plot by holding down the left mouse button. The crosshairs will be set at the instant that the mouse button is released.
 Edit	Edit: Allows the user to modify the font, font style, size and color of all text displayed on the plot window.
 Resize	Resize: Changes the axes so that the whole graph will show up on the plot window.
 Export	Export: Export the data used to create the plot to an Excel Spreadsheet or to a text file (ASCII).
 Close	Close: Closes the plot window.

2.2 Toolbars

The program main window contains five toolbars located above the status bar (Figure 2.1). The main toolbar is located on the right and is always visible. The four remaining toolbars can be displayed by clicking on the corresponding tab underneath the currently displayed toolbar on the left side of the main window. The five toolbars are described in the following Sections:

2.2.1 The Main toolbar

2.2.2 The Configuration toolbar, displayed by clicking on the Configuration tab

2.2.3 The Propulsion toolbar, displayed by clicking on the Propulsion tab

2.2.4 The Useful Load toolbar, displayed by clicking on the Useful Load tab

2.2.5 The Certification toolbar, displayed by clicking on the Certification tab

2.2.6 The Setup toolbar, displayed by clicking on the Setup tab

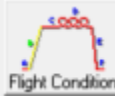

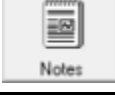
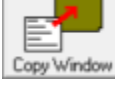



2.2.1 Main Toolbar

The Main toolbar (Figure 2.10) consists of seven buttons at the bottom right of the main window. The Main toolbar supplies general functions needed throughout the program. The functionality of the buttons in the main toolbar is described in Table 2.4.



Figure 2.10 Main Toolbar

Table 2.4 Toolbar Buttons

	<p>Flight Condition: Set and define each flight condition to be included in the analysis. An aircraft project can have up to 95 flight conditions defined.</p>
	<p>Recalculate: Calculates the output parameters of different modules for selected flight conditions.</p>
	<p>Notes: Record general notes about the current project. Notes are saved with the project.</p>
	<p>Copy Window: Copy a representation of the active window into the clipboard in Windows Metafile Format (WMF). The contents of the clipboard can then be pasted into a word processing or drawing program that supports Windows Metafiles. The contents can also be saved to files if the Save Copy Window to File option in the Program Options dialog box (see Section 2.2.6.7) in the Setup toolbar is checked.</p>
	<p>Print: Make a hard copy of the data currently displayed on the screen to be printed on a selected printer.</p>
	<p>Atmosphere: Display an input/output window for calculation of properties of the standard atmosphere at a given altitude and temperature offset. The module also calculates Mach number and Reynolds number per unit length.</p>
	<p>Help: Display the help system associated with the software. Part I Section 6 describes the help system.</p>

2.2.1.1 Flight Condition Definition Dialog Box

The **Flight Condition** button displays the Flight Condition Definition dialog box, which is shown in Figure 2.11.

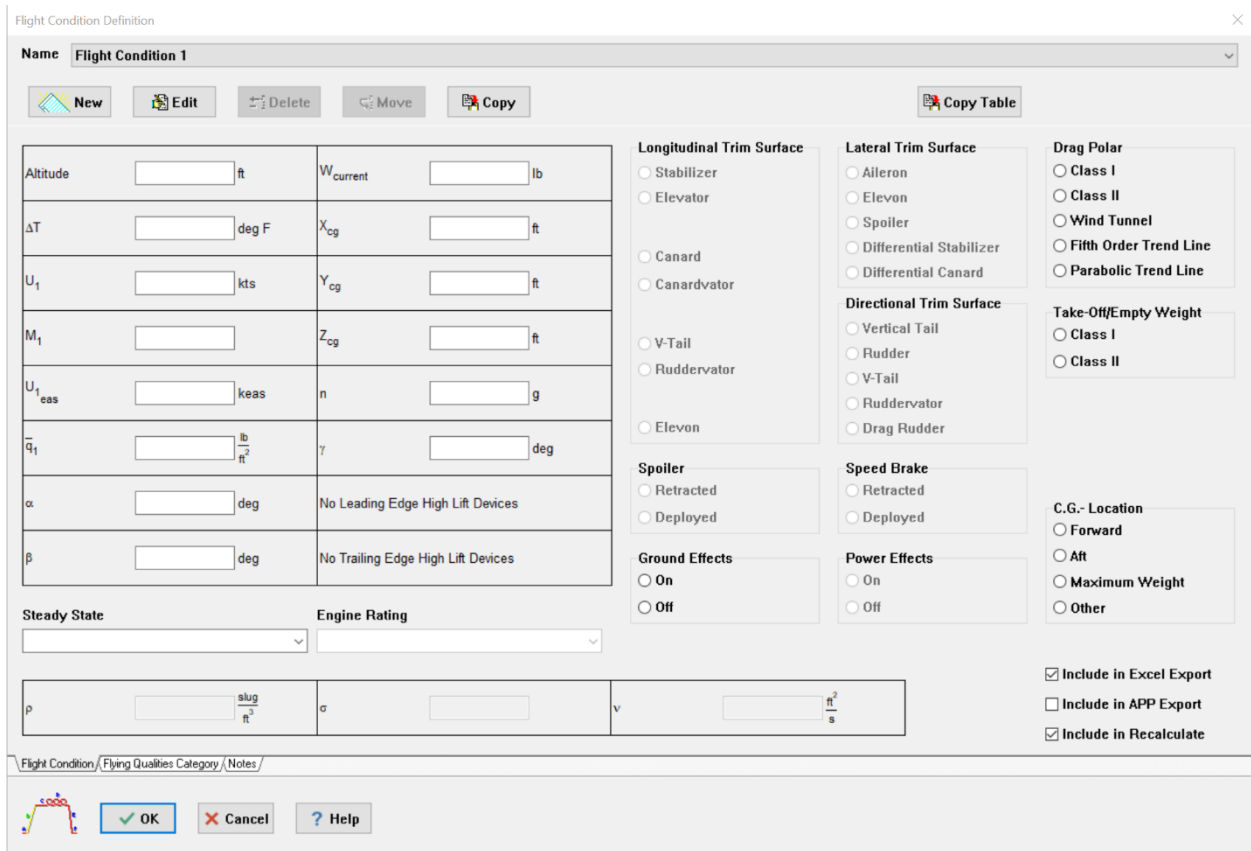


Figure 2.11a Flight Condition Definition Dialog Box, Flight Condition Tab

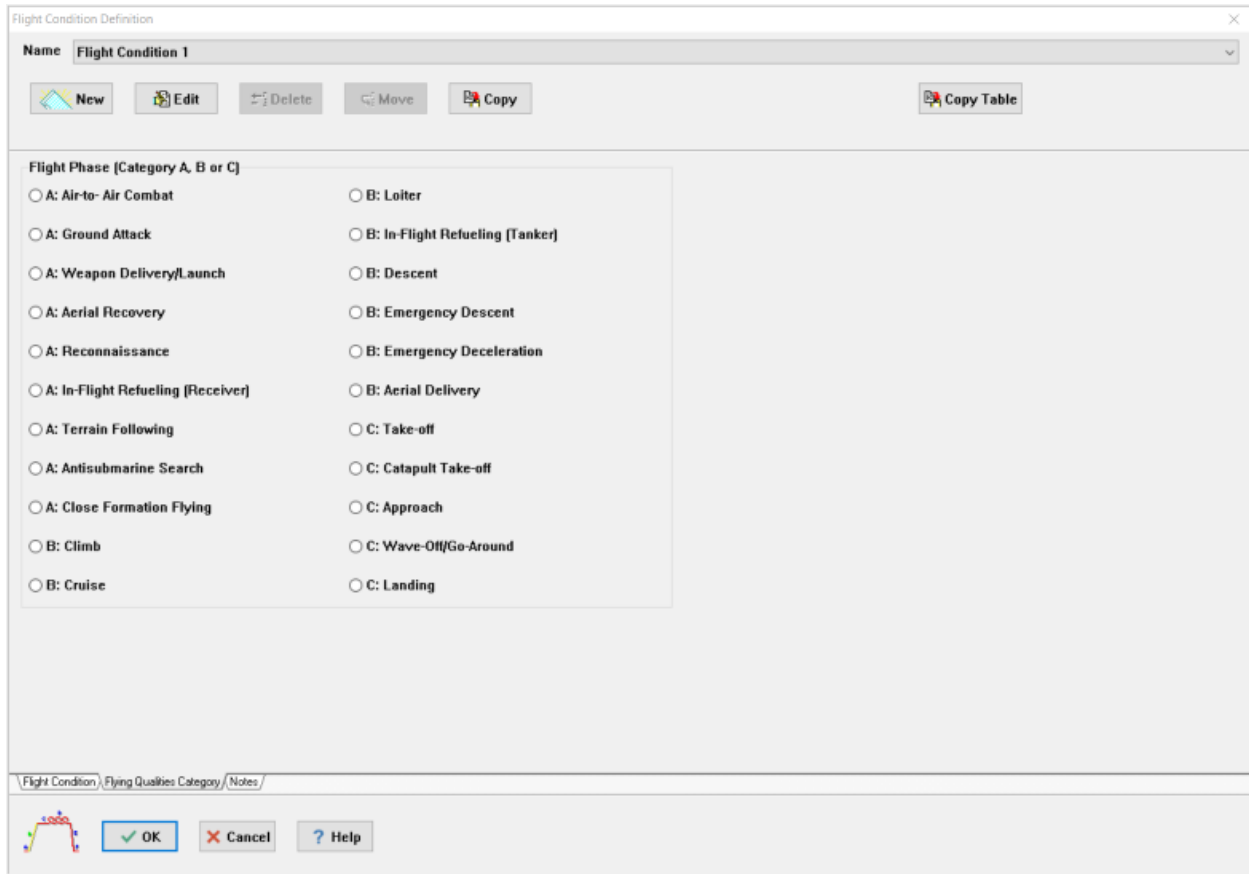


Figure 2.11b Flight Condition Definition Dialog Box, Flying Qualities Category Tab

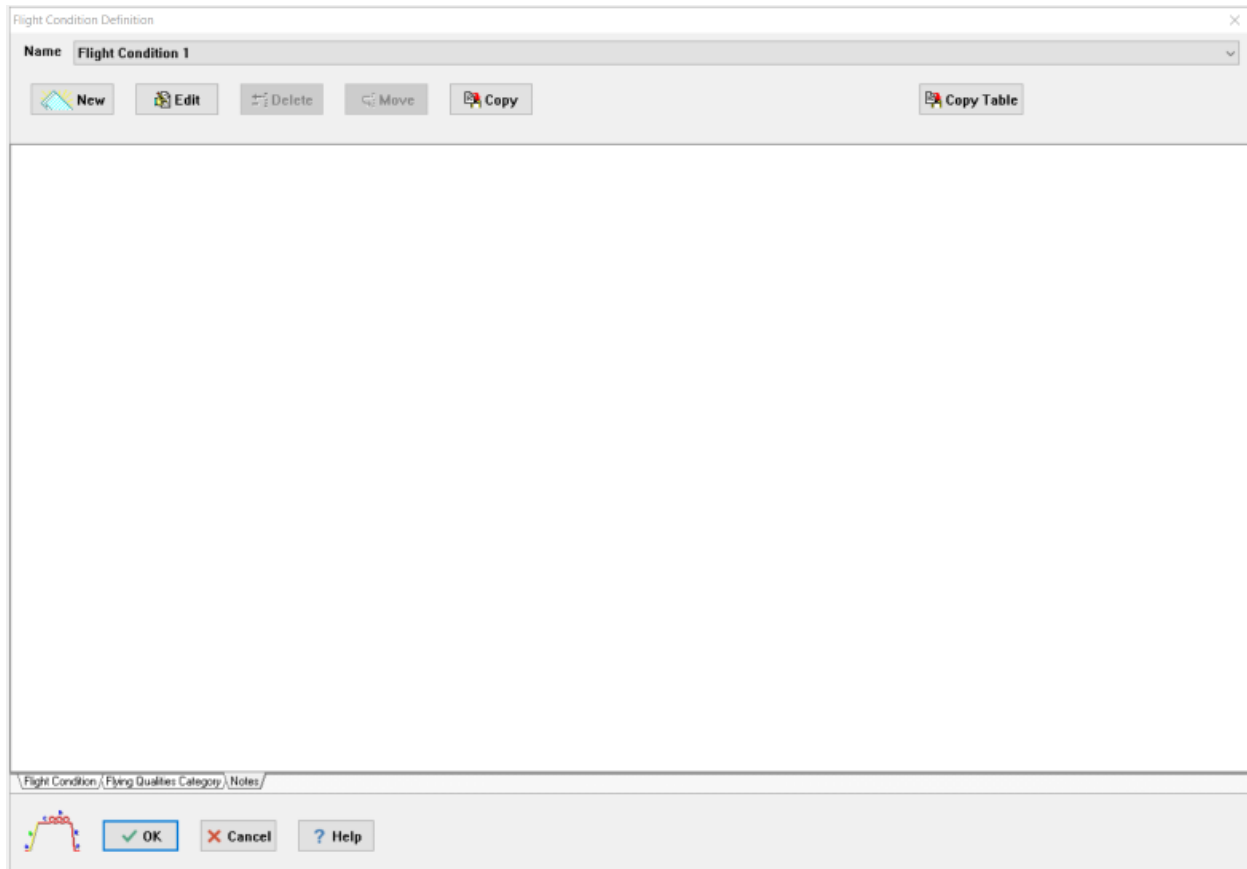


Figure 2.11c Flight Condition Definition Dialog Box, Notes Tab

The options available to the user in the Flight Condition Definition dialog box are described as follows:

- Name: The user can see the current flight condition. The defined flight conditions appear in the drop-down list to be selected by the user. Only one flight condition can be analyzed at one time. The program can handle up to 95 different flight phases.
- New: The user can define a new flight condition.
- Edit: The user can change the name of the current flight condition.
- Delete: The user can delete a flight condition from the current project. All information associated with the selected flight condition will be deleted.
- Move: The user can move a flight condition within the current project.
- Copy: The user can create a copy of a flight condition within the current project.
- Copy Table: The user can copy information stored in tables to other flight conditions. The tables that are copied are: Fuel, Crew, Passengers, Bags, Troops, Cargo, Removable Weapons and Removable Stores. Tilttable geometry tables can be copied as well.

- Altitude: The user enters the altitude corresponding to the defined flight condition.
- Temperature Offset: The user can enter a temperature offset from standard atmosphere.
- Flight Speed: The user enters the true air speed for the defined flight condition.
- Mach Number: Either the Mach number is calculated or the user may input a Mach number to calculate true air speed.
- Equivalent Flight Speed: Either the equivalent air speed is calculated or the user may input an equivalent air speed to calculate the true air speed.
- Dynamic Pressure: Either the dynamic pressure is calculated or the user may input a dynamic pressure to calculate the true airspeed.
- Angle of Attack: The user can enter an angle of attack corresponding to the defined flight condition.
- Sideslip Angle: The user can enter a sideslip angle corresponding to the defined flight condition.
- Current Weight: The user enters the current weight of the aircraft corresponding to the defined flight condition.
- C.G. X-Location: The user enters the current Center of Gravity location along the X-axis for the defined flight condition.
- C.G. Y-Location: The user enters the current Center of Gravity location along the Y-axis for the defined flight condition.
- C.G. Z-Location: The user enters the current Center of Gravity location along the Z-axis for the defined flight condition.
- Load Factor: The user enters the load factor corresponding to the defined flight condition.
- Flight Path Angle: The user enters the flight path angle corresponding to the defined flight phase.
- Trailing Edge High Lift Device Deflection: After defining high lift devices in the Flap/Slat dialog box, the user enters the flap deflection angle corresponding to the flight condition for trailing edge high lift devices. This value can also be set in the Flap/Slat dialog box.
- Leading Edge High Lift Device Deflection: After defining high lift devices in the Flap/Slat dialog box, the user enters the flap/slat deflection angle corresponding to the flight condition for leading edge high lift devices. This value can also be set in the Flap/Slat dialog box.
- Longitudinal Trim Surface: The user can indicate which control surface is used for trim longitudinally in the current flight condition.
- Spoiler: After selecting spoiler in the Aircraft Configuration dialog box, the user can specify if the spoiler is retracted or deployed for the corresponding flight phase.

- Ground Effects: The user can indicate whether the ground effects are ON or OFF for the flight condition.
- Lateral Trim Surface: The user can indicate which control surface is used for trim laterally in the current flight condition.
- Directional Trim Surface: The user can indicate which control surface is used for trim directionally in the current flight condition.
- Speed Brake: After selecting speed brake in the Configuration dialog box, the user can specify if the speed brake is retracted or deployed for the corresponding flight phase.
- Power Effects: For propeller driven aircraft, the user can indicate if power effects are ON or OFF for the flight condition.
- Drag Polar: The user can indicate which drag polar is to be used for Trimmed Lift (T from D), Longitudinal Trim, Trim Diagram and Performance > Analysis > Maximum Cruise Speed modules.
- Take-off/Empty Weight: The user can indicate if Class I or Class II take-off/empty weight is used for the matching plot in the **Performance** module.
- C.G.-Location: The user can specify whether the flight condition corresponds to forward C.G., aft C.G., maximum weight C.G. or any other C.G. location.
- The user may select “Include in Excel Export” to include the flight condition in the Excel export if “Export to Excel” is selected in the “Recalculate” Dialog window.
- The user may select “Include in APP Export” to include the flight condition in the APP export if that function is used in **Performance**.
- The user may select “Include in Recalculate” to include the flight condition in recalculation if the “Calculate All Marked Flight Conditions” is selected in the “Recalculate” Dialog window.
- Engine Rating: The user may select the following options using this drop-down list.
 - Take-off
 - Max Continuous
 - Max Cruise
- Steady State: The user may select the following options using this drop-down list to determine what type of maneuver is used.
 - Rectilinear Flight
 - Level Turn
 - Symmetrical Pull-Up
- Air Density: The air density is calculated for the given flight condition based on the inputs entered.

- Air Density Ratio: The ratio of air density at the flight condition altitude to that at sea-level is calculated based on the inputs entered.
- Air Kinematic Viscosity: The air kinematic viscosity is calculated for the given flight condition based on the inputs entered.
- Flight Qualities Category: The flight phase and category (used in flying quality evaluation) can be specified for the flight condition.
- Notes: The user may enter notes that will be saved with the flight condition.

2.2.1.2 Recalculate Dialog Box

The **Recalculate** button (see Figure 2.12) on the main toolbar allows the user to recalculate:

- Geometry
- Class II Structure Weight
- Class II Powerplant Weight
- Class II Fixed Equipment Weight
- Class II Empty/Take-off Weight
- Component C.G.
- Empty Weight C.G.
- Fuel Volume and Weight C.G.
- Forward/Aft C.G.
- Aircraft C.G.
- Component Moment of Inertia
- Empty Weight Moment of Inertia
- Aircraft Moment of Inertia
- Landing Gear Tip Over
- Non-Linear Airfoil Lift
- Maximum Lift
- Lift
- Aerodynamic Center
- Pitching Moment
- Stability & Control Derivatives
- Hingement Derivatives
- Wetted Areas
- Critical Mach Number

- Class II Drag
- Drag Trend Line
- Drag from Trend Line
- Steady State Coefficients
- Trimmed Lift (T = Const)
- Trimmed Lift (T from D)
- Straight Line Trim
- Moment & Stick Force Trim
- Transfer Functions
- Flying Qualities
- Static Margin
- V-n Diagram
- Propulsion > Thrust from Drag
- Plot V-n Diagram
- Plot Trim Diagram
- Plot Stick Force – Speed
- Export Stick Force – Speed Plot Data

This can be done for each flight condition separately where the user can select which features need to be recalculated, or the user can choose to automatically run through a series of flight conditions marked in the Flight Condition window. Trim diagrams can automatically be exported to WMF files and saved for each flight condition. Marked variables can also be exported automatically to Excel spreadsheets. If the word “Warning” shows up in the log window, it is recommended to go to that particular module and press calculate to see the exact warning and how to fix the problem.

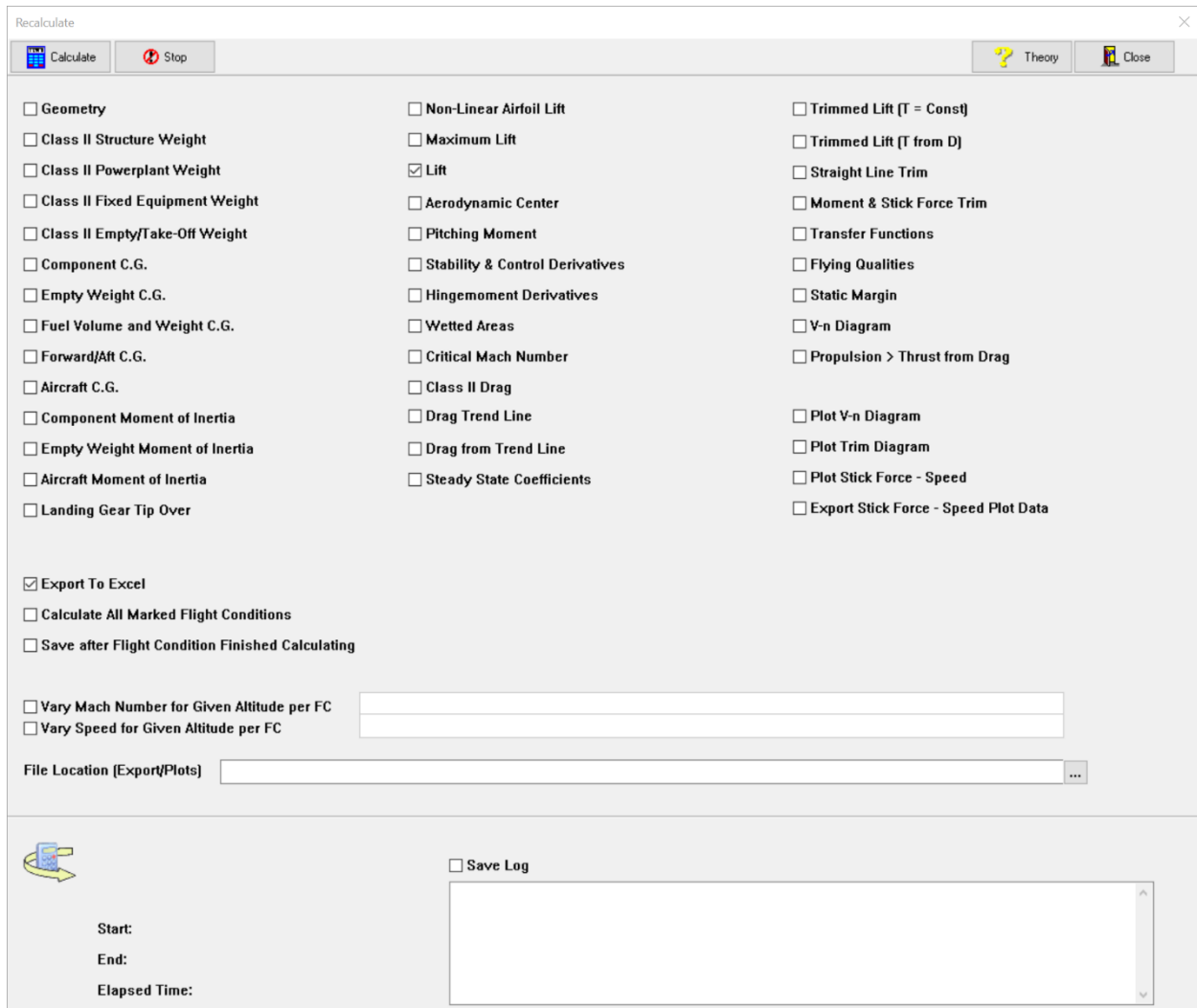


Figure 2.12 Recalculate Dialog Box

2.2.1.3 Project Notes Dialog Box

When the **Notes** button on the main toolbar is selected, the Project Notes dialog box appears shown in Figure 2.13. Notes for the entire project can be typed into the large notes section. If information is typed in the Warning section at the bottom of the dialog box this information will be displayed to the user when they open the file as a user defined warning. An example of this warning is shown in Figure 2.14.

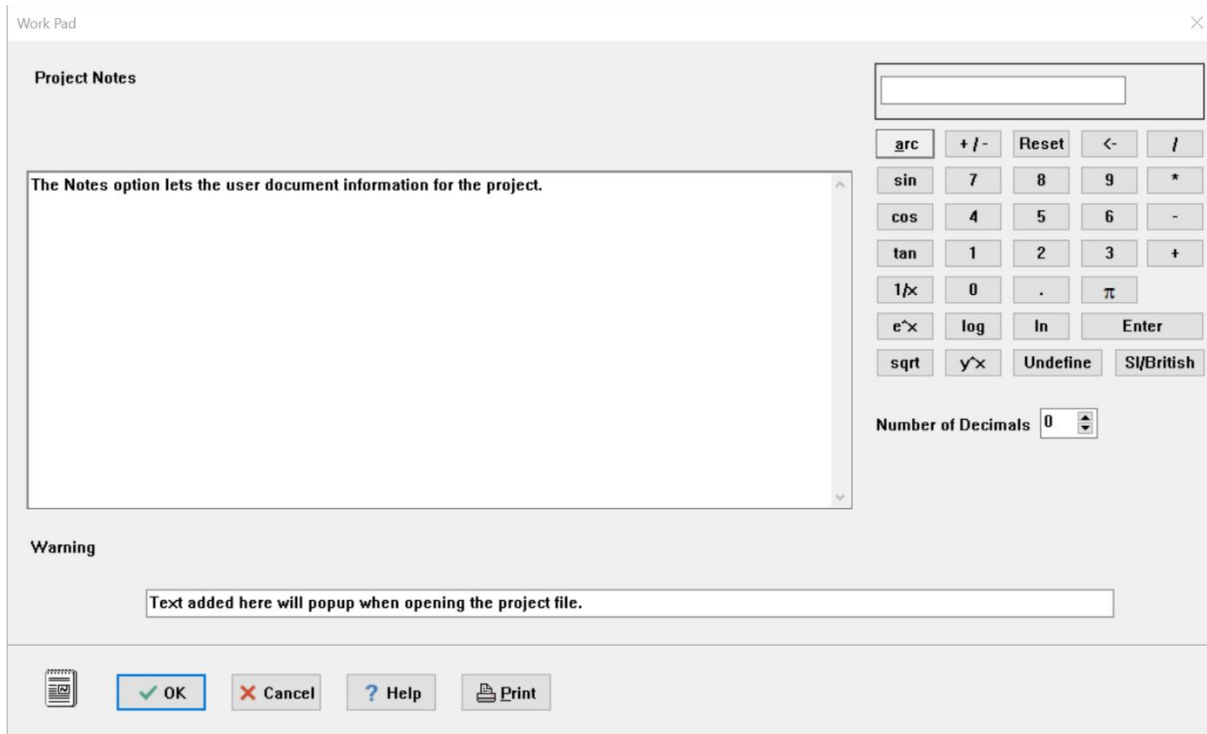


Figure 2.13 Project Notes Dialog Box

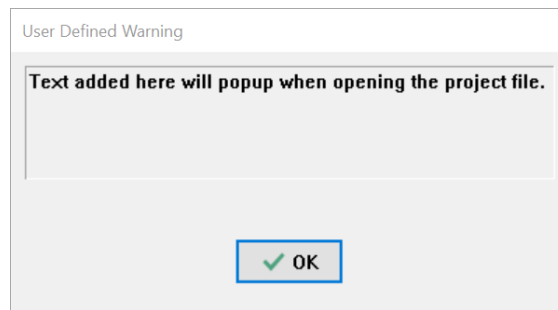


Figure 2.14 File Open Warning

2.2.1.4 Print Dialog Box

When the **Print** button on the main toolbar is selected, the Print dialog box appears shown in Figure 2.15. The current print settings defined in Print Setup are used to print. Using Print Setup under the File menu or Printer in the Setup toolbar, the user can manipulate the print style that is used to print (see Part I Section 2.2.6.5 and Section 4).

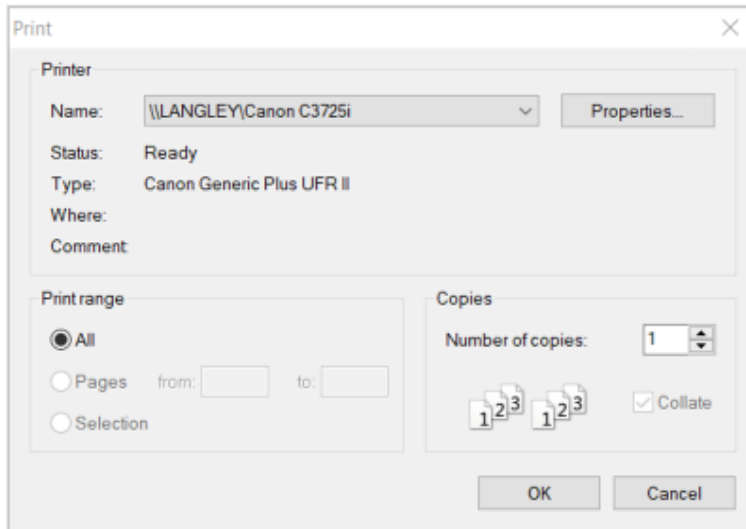


Figure 2.15 The Print Dialog

2.2.1.5 Atmosphere Dialog Box

When the **Atmosphere** button on the main toolbar is selected, the Atmosphere module appears shown in Figure 2.16. In this module the user can input a desired atmosphere, temperature increment, air speed, reference length and distance downstream from the start of the boundary layer. Using these input parameters, variables like pressure ratio, Mach number, Reynolds number and laminar boundary layer thickness can be calculated.

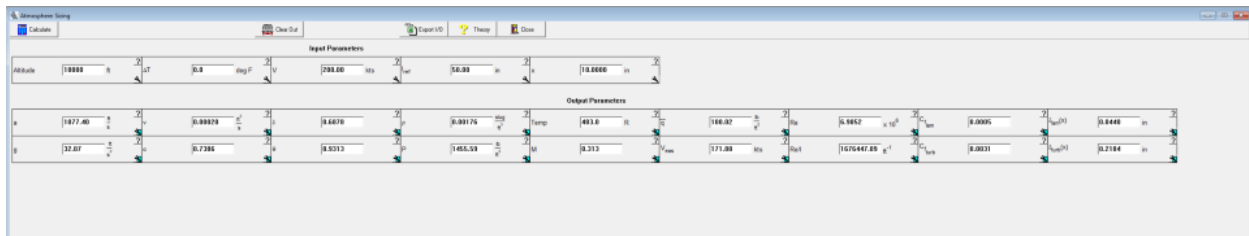


Figure 2.16 Atmosphere Module







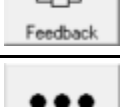
2.2.2 Configuration Toolbar

The Configuration toolbar (Figure 2.17) consists of seven buttons at the bottom of the main window. The Configuration toolbar buttons can be used to define the aircraft configuration for the current project. The functionality of the buttons on the Configuration toolbar is described in Table 2.5.



Figure 2.17 Configuration Toolbar

Table 2.5 Configuration Toolbar Buttons

	Configuration: Define the configuration of the aircraft, which includes fuselage, lifting surfaces, control surfaces, etc.
	Controls: Define longitudinal and lateral-directional control surface balance, nose shape and if they have trim tabs. Define the type of spoiler as well.
	Flap/Slat: Define the number, location, deflection angle and type of leading edge and trailing edge high lift devices per wing.
	Structure: Define lifting surface structure as well as the attachment locations of the root and tip. Define whether the wing is cantilever or strut braced. Define if the hull is amphibious and if the fuselage cabin is pressurized.
	Gear: Define the number, position, retractability and attachment point of landing gears. In the case of retractable landing gear, the gear up or down position is also defined here.
	Feedback: Define the longitudinal and directional feedback control surfaces.
	Miscellaneous: Define if miscellaneous lift, drag, moment, or weight-C.G., is included in calculations. Define if fixed equipment C.G. is flight condition dependent or independent.

Each of the buttons in the Configuration toolbar opens a dialog box when selected. The remainder of this Section will present the dialog boxes opened by the Configuration toolbar buttons.

2.2.2.1 Aircraft Configuration Dialog Box

When the **Configuration** button is selected, the Aircraft Configuration dialog box is displayed. Figure 2.18 shows the Aircraft Configuration dialog box. The user can define the basic configuration of the aircraft using this dialog box. For the vertical tail and ventral fins, the number of devices can be defined and the maximum for each is two. For pylons, floats and tailbooms the number of each device can also be defined and the maximum for each is 500. For lifting surfaces, the stability surface tip shape can be chosen for hingemoment estimations.

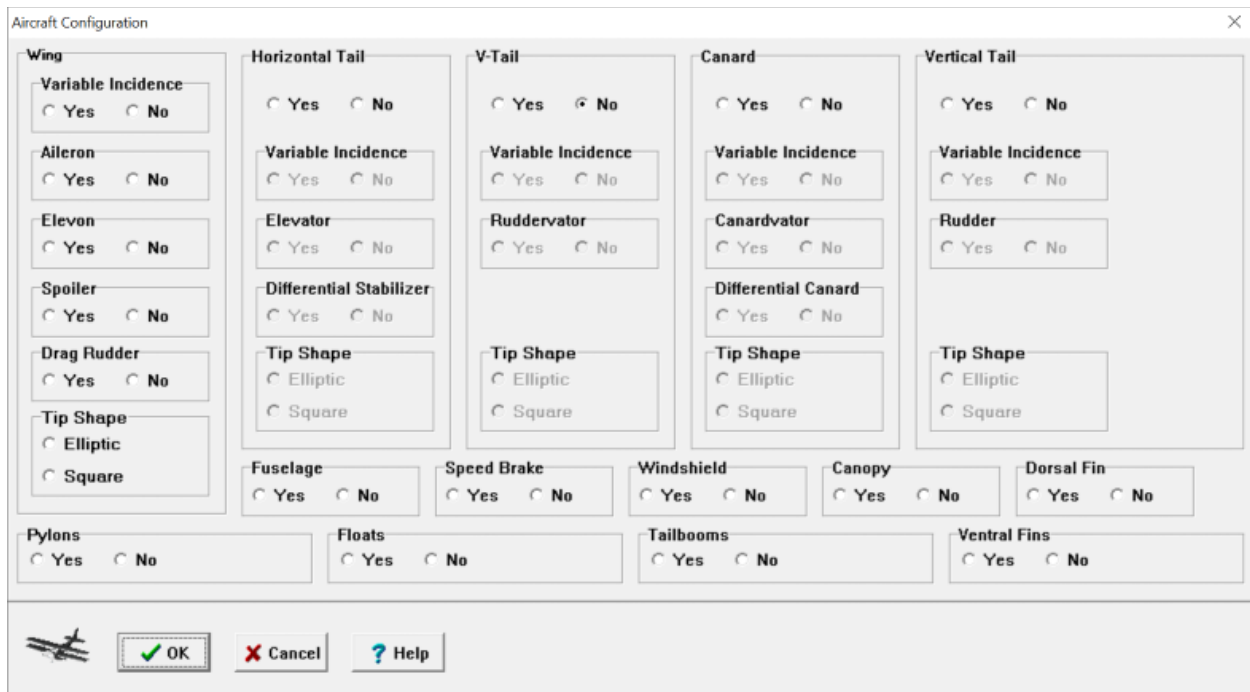


Figure 2.18 Aircraft Configuration Dialog Box

2.2.2.2 Controls Configuration Dialog Box

When the **Controls** button is selected, the Control Surface Configuration dialog box is displayed. The dialog box contains different pages for the aileron, elevon, elevator, canardvator, rudder, ruddervator and spoiler. The user can display different pages by clicking on the corresponding tab at the bottom of the dialog box. Figure 2.19 shows the Control Surface Configuration dialog box with the elevator page displayed. Other tabs are similar to the elevator tab.

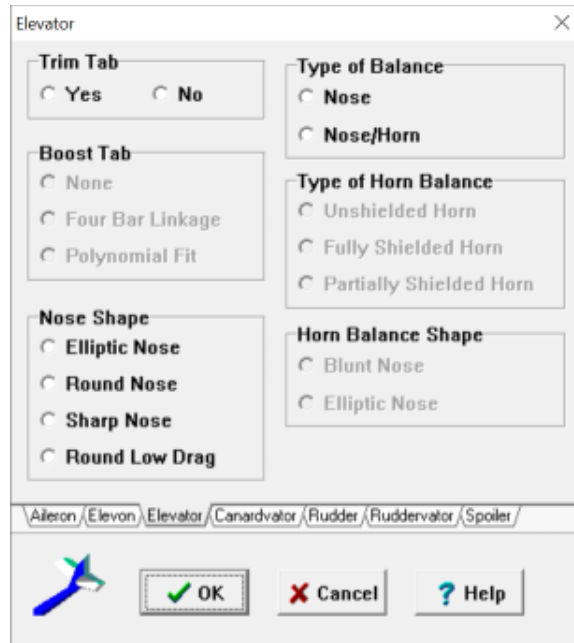


Figure 2.19 Control Surface Configuration Dialog Box

The dialog box displayed in Figure 2.19 allows the user to define the aspects of control surfaces for the aircraft. Respective control surfaces are disabled if they are not defined in the Aircraft Configuration dialog box. Descriptions of the dialog box functions follow.

- Trim Tab: For pages besides the spoiler, the trim tab may be selected.
- Boost Tab: For pages besides aileron and rudder, if a trim tab is present, the user may select if the tab is boosted or what type of mechanism is used.
- Nose Shape: The control surface nose shapes can be chosen for hingemoment estimations.
- Type of Balance: The type of balance of the control surface can be chosen.
- Type of Horn Balance: If the control surface includes a horn balance, the type of horn balance can be chosen.
- Horn Balance Shape: For fully or partially shielded control surface horns, the horn nose shape can be chosen.
- Spoiler Type: For spoilers, the spoiler type can be chosen. Options include plug, flap and slot types.

2.2.2.3 Flap/Slat Dialog Box

When the **Flap/Slat** button is selected, the High Lift Devices dialog box is displayed. The dialog box displayed in Figure 2.20 allows the user to select the number and type of high lift devices per wing. Descriptions of the dialog box follow.

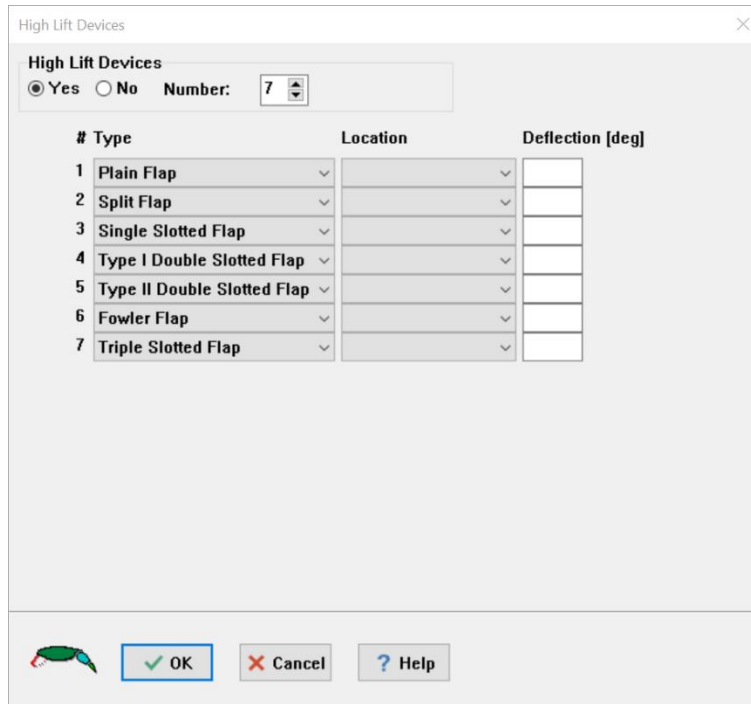


Figure 2.20 High Lift Devices Dialog Box

- High Lift Devices: The user may specify if there are high lift devices and the number of high lift devices. The maximum amount is 500.
- Type: The user may specify the type of leading or trailing edge device. Options include plain flap, split flap, single slotted flap, type I double slotted flap, type II double slotted flap, Fowler flap, tripled slotted flap, drooped aileron, drooped elevon, leading edge slat and Krueger slat.
- Location: The user may specify the location of the high lift device.
- Deflection: The user may define the deflection angle of the high lift device.

2.2.2.4 Structure Dialog Box

When the **Structure** button is selected, the Structure dialog box (Figure 2.21) is displayed. The user can choose from the six different structure types for each surface. The structure type options are single-spar semimonocoque, two-spar semimonocoque, two-spar drag truss, single-spar box, single-spar circular and three-spar. The user can also specify if the root or tip of the surface is attached to fuselage or one of the other surfaces. For the fuselage an amphibious hull can be defined and if the fuselage interior is pressurized can be defined.

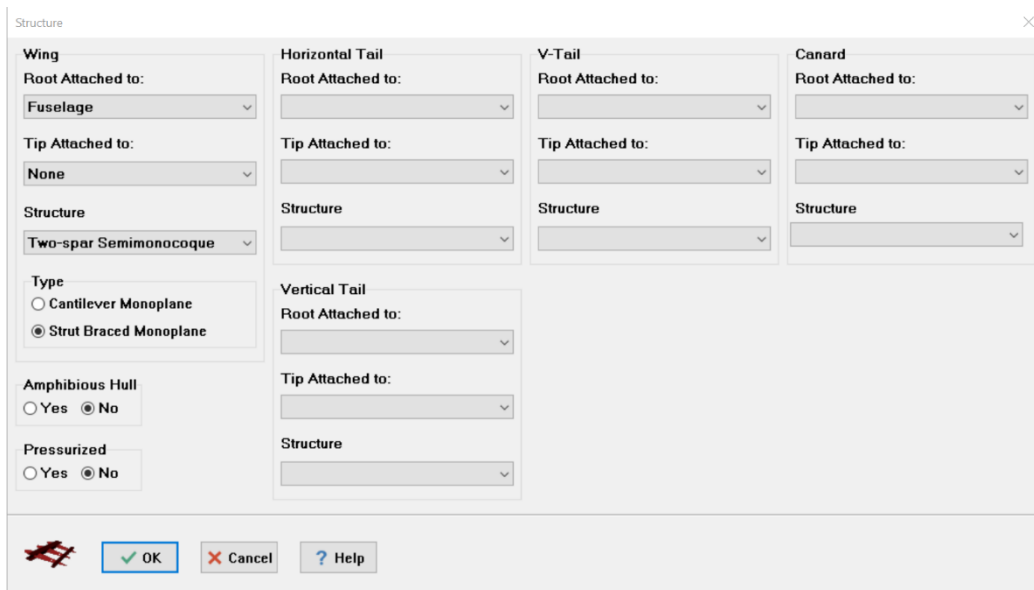


Figure 2.21 Structure Dialog Box

2.2.2.5 Landing Gear Dialog Box

When the **Gear** button is selected, the Landing Gear dialog box (Figure 2.22) is displayed. Descriptions of the dialog box functions follow.

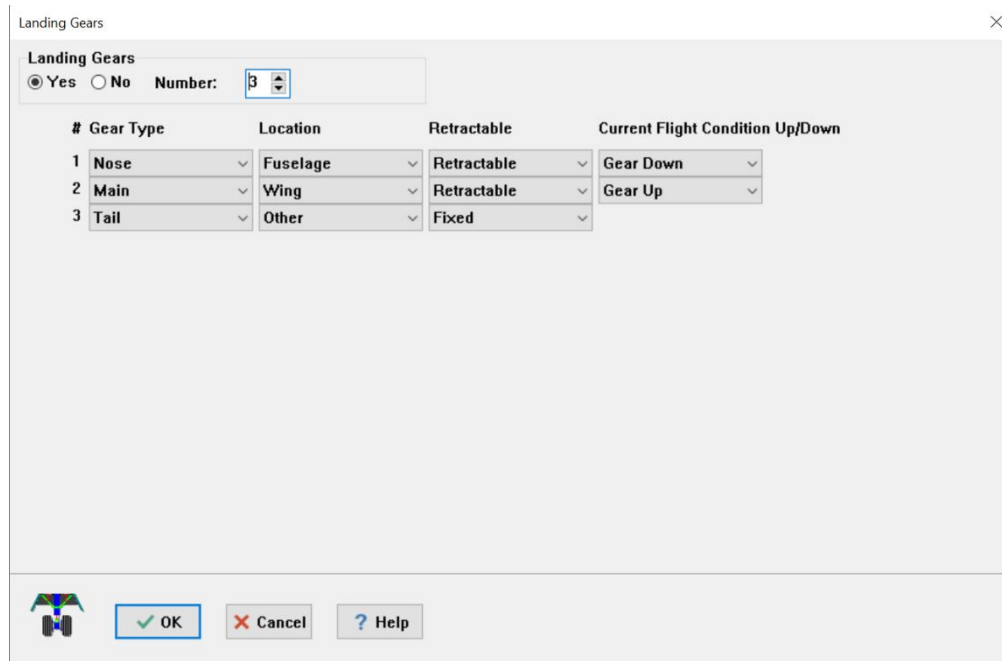


Figure 2.22 Landing Gear Configuration Dialog Box

- Landing Gears: The user may specify if there are landing gears and the number of gears. Each strut should be considered as one landing gear. The maximum amount is 500.
- Gear Type: The landing gear type can be specified. Options include nose, main, tail or outrigger.
- Location: The relative position of each gear can be specified. Options include the wing, fuselage, a defined nacelle or other.
- Retraction: The retraction capability (retractable or fixed) of each gear can be specified.
- Current Flight Condition Up/Down: The state of the retractable landing gear (up or down) can be specified.

2.2.2.6 Feedback Dialog Box

When the **Feedback** button is selected, the Feedback Control System Definition dialog box (Figure 2.23) is displayed. The selected control surfaces will be used in de facto longitudinal and

directional stability. They will also be used in $C_{m\alpha}$ and $C_{n\beta}$ calculations when a feedback control system is used.

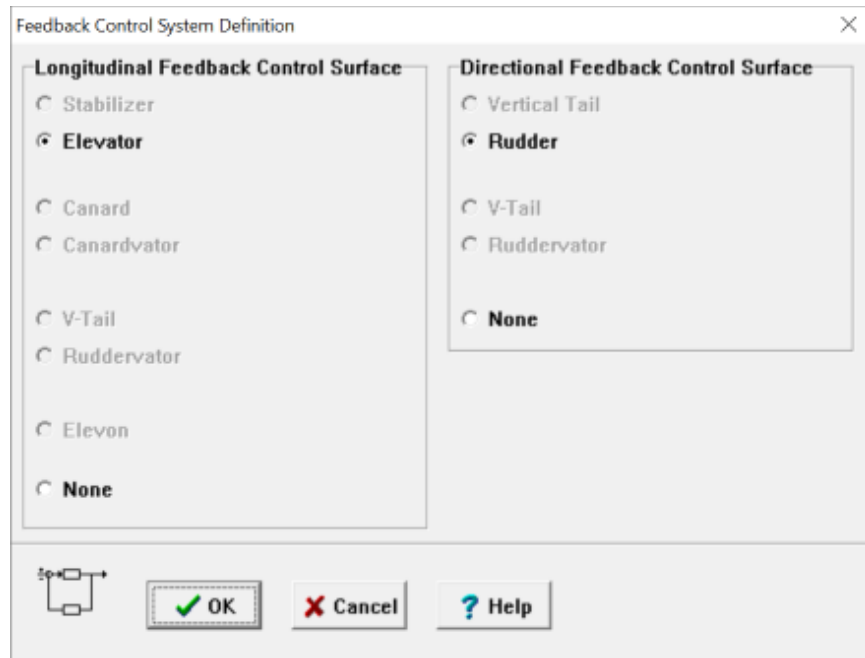


Figure 2.23 Feedback Dialog Box

2.2.2.7 Miscellaneous Dialog Box

When the **Miscellaneous** button is selected, the Miscellaneous Options dialog box (Figure 2.24) is displayed. If Include Miscellaneous Lift Table, Drag, Moment Table or Weight-C.G. table are selected then user defined values for each respective option will be included in relevant calculations. Fixed Equipment C.G. can be defined as independent or dependent on flight condition.

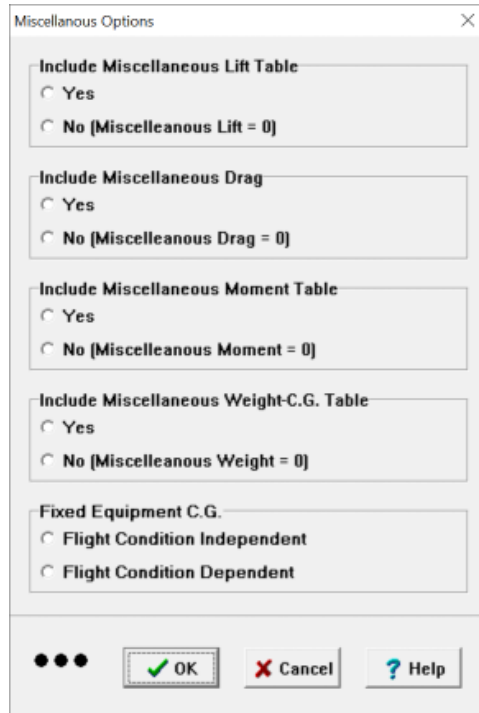


Figure 2.24 Miscellaneous Dialog Box





2.2.3 Propulsion Toolbar

The Propulsion toolbar (Figure 2.25) consists of four buttons at the bottom of the main window. The Propulsion toolbar buttons can be used to define the aircraft propulsion configuration for the current project. The functionality of the buttons on the Propulsion toolbar is described in Table 2.6.



Figure 2.25 Propulsion Toolbar

Table 2.6 Propulsion Toolbar Buttons

 <p>Engine</p>	<p>Engine: Define the number of engines and the engine type and location. The engine operating condition and if the engine is tiltable are also defined here.</p>
 <p>Propeller/Fan</p>	<p>Propeller/Fan: Define propeller number, type, pitch and material. The engine that attaches to the propeller and if the prop is tiltable are also defined here.</p>
 <p>Nacelle</p>	<p>Nacelle: Define the number and location of the nacelles. Engine attachment and if the nacelle is tiltable are also defined here.</p>
 <p>Inlet/Duct</p>	<p>Inlet: Define the number and type of inlets. Engine attachment and if the inlet is tiltable are also defined here.</p>

Each of the buttons in the Propulsion toolbar opens a dialog box when selected. The remainder of this Section will present the dialog boxes opened by the Propulsion toolbar buttons.

2.2.3.1 Engine Dialog Box

When the **Engine** button is selected, the Engine dialog box (Figure 2.26) is displayed. Descriptions of the dialog box functions follow.

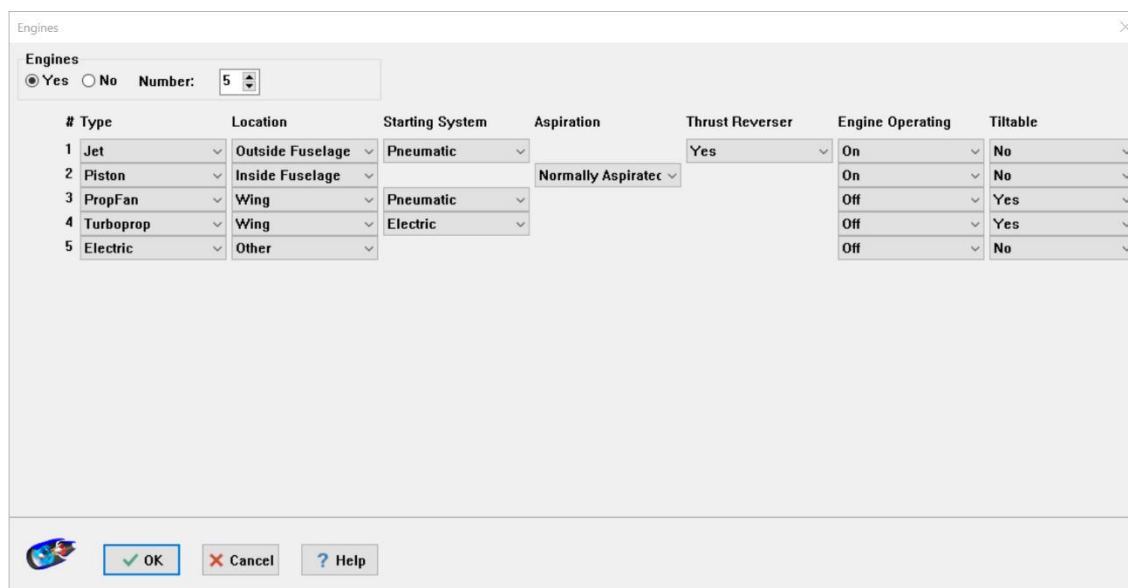


Figure 2.26 Engine Dialog Box

- Engines: The user can specify if there are engines and the number of engines. The maximum is 500.
- Engine Type: The user can specify the type of engine. The five types are: jet, piston, propfan, turboprop, electric
- Engine Location: The user can specify where the engines are located.
- Starting System: For jet, propfan and turboprop engines, the user can specify the starting system used, either electric or pneumatic.
- Aspiration: For piston engines, the user can specify whether the engine is normally aspirated, supercharged or turbocharged.
- Thrust Reverser: For jet engines, the user can specify if there is a thrust reverser installed.
- Engine Operating: For the current flight condition the user can specify whether the engine is operating or not.
- Tilttable: The user can specify if the engine is tilttable.

2.2.3.2 Propeller/Fan Dialog Box

When the **Propeller/Fan** button is selected, the Propeller/Fan/Rotor dialog box (Figure 2.27) is displayed. Descriptions of the dialog box functions follow.

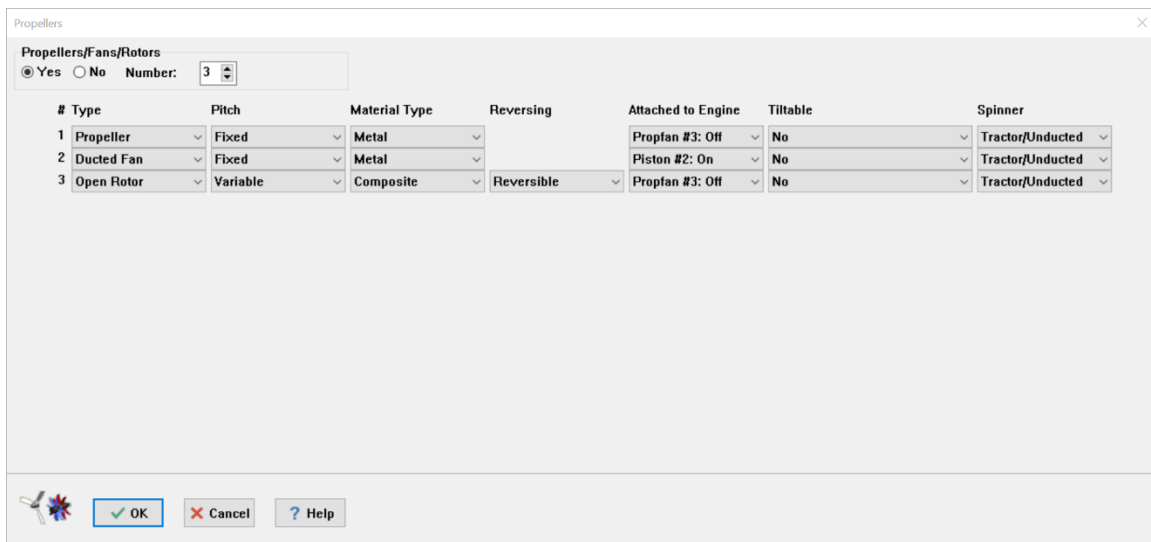


Figure 2.27 Propeller Dialog Box

- Propellers/Fans/Rotors: The user can specify if there are propellers and the number of propellers. The maximum is 500.

- **Type:** The user can specify the type of propeller. Options include propeller, ducted fan and open rotor.
- **Pitch:** The user can specify the type of pitch mechanism the propeller has. Options include fixed and variable pitch.
- **Material Type:** The user can specify the material used to construct the propeller. Options include composite, metal and wood.
- **Reversing:** For variable pitch propellers, the user can specify if the propeller is reversible or non-reversible.
- **Attached to Engine:** The user can specify which engine the propeller is attached to.
- **Tiltable:** The user can specify if the propeller is tiltable. If the engine is tiltable, the user can specify if the tilt axis is the same as the engine.
- **Spinner:** The user can specify what type of spinner the propeller uses. Options include Unducted Tractor, Ducted Tractor and Pusher.

2.2.3.3 Nacelle Dialog Box

When the **Nacelle** button is selected, the Nacelle dialog box (Figure 2.28) is displayed. Descriptions of the dialog box functions follow.

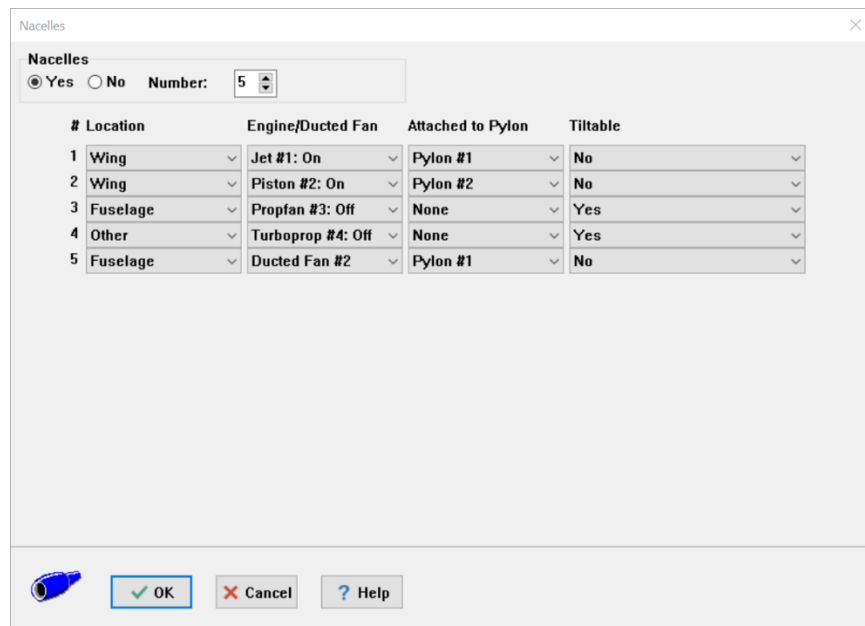


Figure 2.28 Nacelle Dialog Box

- Nacelles: The user can specify if there are nacelles and the number of nacelles. The maximum is 500.
- Nacelle Location: The user can specify where the nacelles are located. Options include wing, fuselage and other.
- Engine: The user can specify which engine the nacelle is connected to.
- Attached to Pylon: The user can specify if the nacelle is attached to a pylon and which pylon the nacelle is attached to.
- Tilttable: The user can specify if the nacelle is tilttable. If the engine is tilttable and the location “Other” is selected, the user can specify if the tilt axis is the same as the engine.

2.2.3.4 Inlet/Duct Selection Dialog Box

When the **Inlet/Duct** button is selected, the Inlet/Duct dialog box (Figure 2.29) is displayed. Descriptions of the dialog box functions follow.

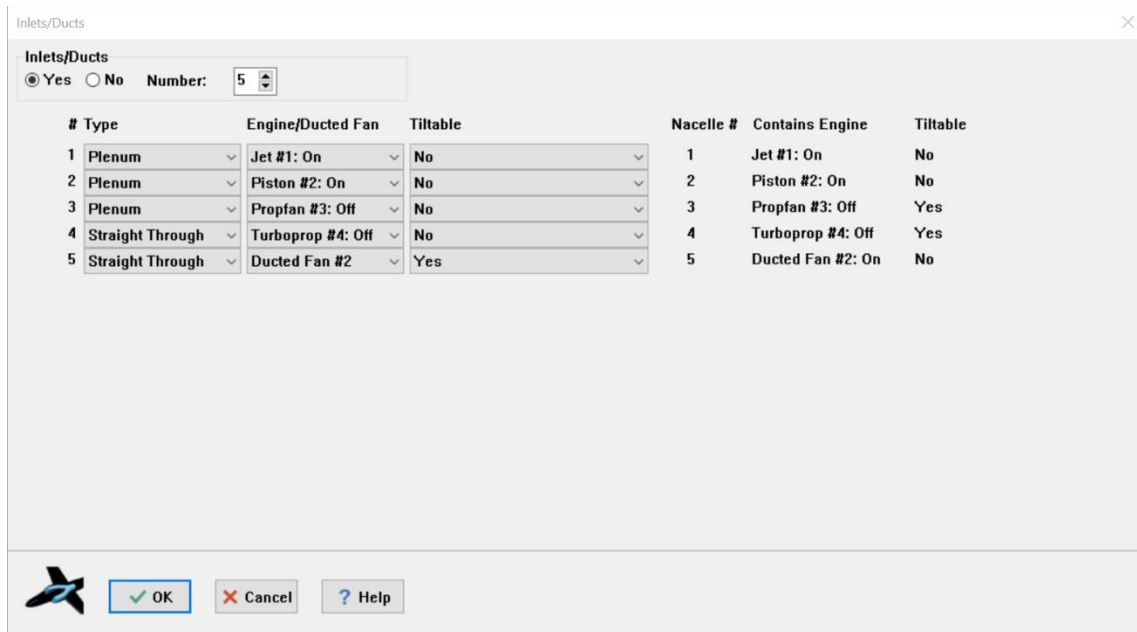


Figure 2.29 Inlet/Duct Dialog Box

- Inlets/Ducts: The user can specify if there are inlets/ducts and the number of inlets/ducts. The maximum is 500.
- Inlet Type: The user can specify the type of inlet/duct. Options include plenum or straight through.

- Engine/Ducted Fan: The user can specify which engine the inlet/duct is attached to.
- Tiltable: The user can specify if the inlet/duct is tiltable or not. If the engine is tiltable and the location of “Other” was selected for the related nacelle, the user can specify if the tilt axis is the same as the engine.

The descriptions for the other columns in the Inlets/Ducts dialog box are shown below. These columns are not editable in this dialog box.

- Nacelle #: This column shows which nacelle the inlet/duct is connected to.
- Contains Engine: This column shows which engine is in the nacelle, if present.
- Tiltable: This column shows if the nacelle is tiltable.

2.2.4 Useful Load Toolbar

The Useful Load toolbar (Figure 2.30) consists of four buttons at the bottom of the main window. The Useful Load toolbar buttons can be used to define the aircraft useful load for the current project. The functionality of the buttons on the Useful Load toolbar is described in Table 2.7.

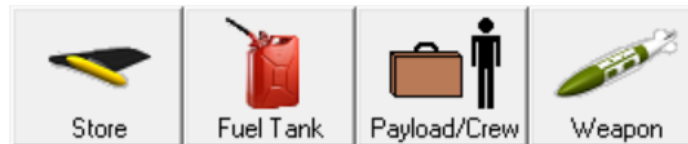






Figure 2.30 Useful Load Toolbar

Table 2.7 Useful Load Toolbar Buttons

 <p>Store</p>	<p>Store: Define the number, description, if the store is fixed or removable, location and whether the store is attached for the current flight condition.</p>
 <p>Fuel Tank</p>	<p>Fuel Tank: Define the number, type and position of the fuel tanks. Also define if the fuel tank is removable or fixed and if the fuel tank is attached for the current flight condition.</p>
 <p>Payload/Crew</p>	<p>Payload/Crew: Define the number of passengers, cargo and baggage holds, the number and type of crew members and the number of troops.</p>
 <p>Weapon</p>	<p>Weapon: Define the number, description, position, if the weapon is fixed or removable and if the weapon is attached for the current flight condition.</p>

Each of the buttons in the Useful Load toolbar opens a dialog box when selected. The remainder of this Section will present the dialog boxes opened by the Useful Load toolbar buttons.

2.2.4.1 Store Dialog Box

When the **Store** button is selected, the Store dialog box (Figure 2.31) is displayed. Descriptions of the dialog box functions follow.

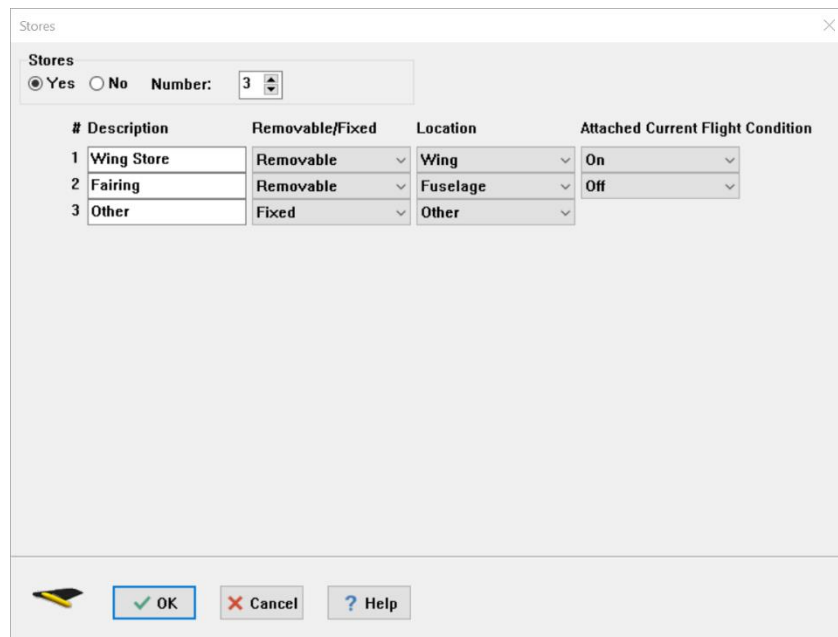


Figure 2.31 Store Dialog Box

- Stores: The user can specify if there are stores and the number of stores. The maximum is 500.
- Description: The user can give a description of each store.
- Removable/Fixed: The user can specify if the store is removable or fixed. If the store is fixed, its weight will be included in the empty weight. If the store is removable, its weight will not be included in the empty weight, and its useful load weight will depend on if it is attached for the current flight condition.
- Location: The user can specify if the store is attached to the fuselage, the wing or another location.
- Attached Current Flight Condition: If the store is removable, for the current flight condition, the user can specify whether the store is attached or not attached to the aircraft.

2.2.4.2 Fuel Tank Dialog Box

When the **Fuel Tank** button is selected, the Fuel Tank dialog box (Figure 2.32) is displayed. Descriptions of the dialog box functions follow.

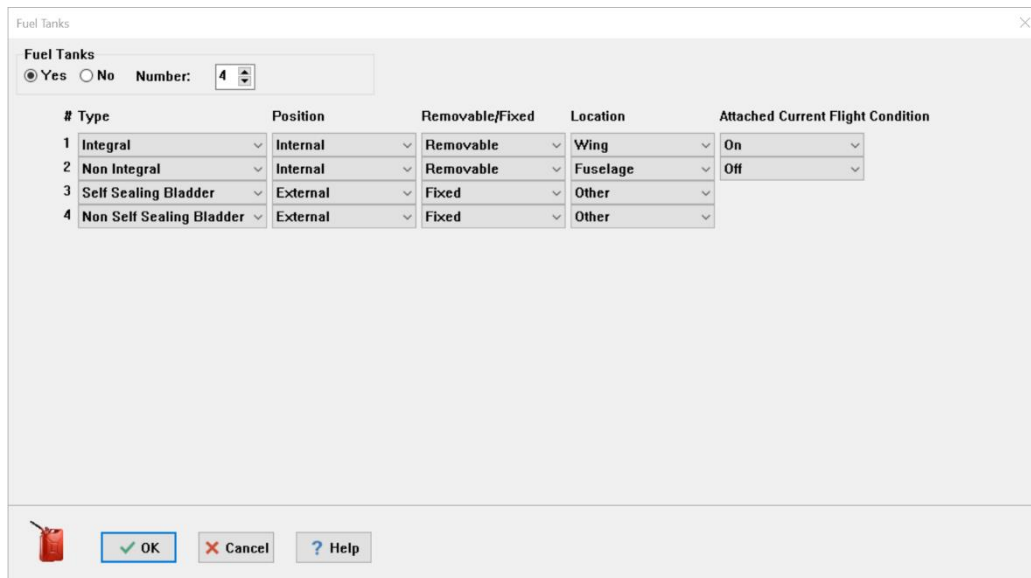


Figure 2.32 Fuel Tank Dialog Box

- Fuel Tank: The user can specify if there are fuel tanks and the number of fuel tanks. The maximum is 500.

- Type: The user can specify the type of fuel tank. Options include Integral, Non Integral, Self Sealing Bladder and Non Self Sealing Bladder.
- Position: The user can specify the position of the fuel tank. Options include Internal or External.
- Removable/Fixed: The user can specify if the fuel tank is removable or fixed.
- Location: The user can specify if the fuel tank is attached to the fuselage, the wing or another location.
- Attached Current Flight Condition: If the fuel tank is removable, for the current flight condition, the user can specify if the removable fuel tank is attached or not attached to the aircraft.

2.2.4.3 Payload/Crew Dialog Box

When the **Payload/Crew** button is selected, the Payload/Crew dialog box (Figure 2.33) is displayed. Descriptions of the dialog box functions follow.

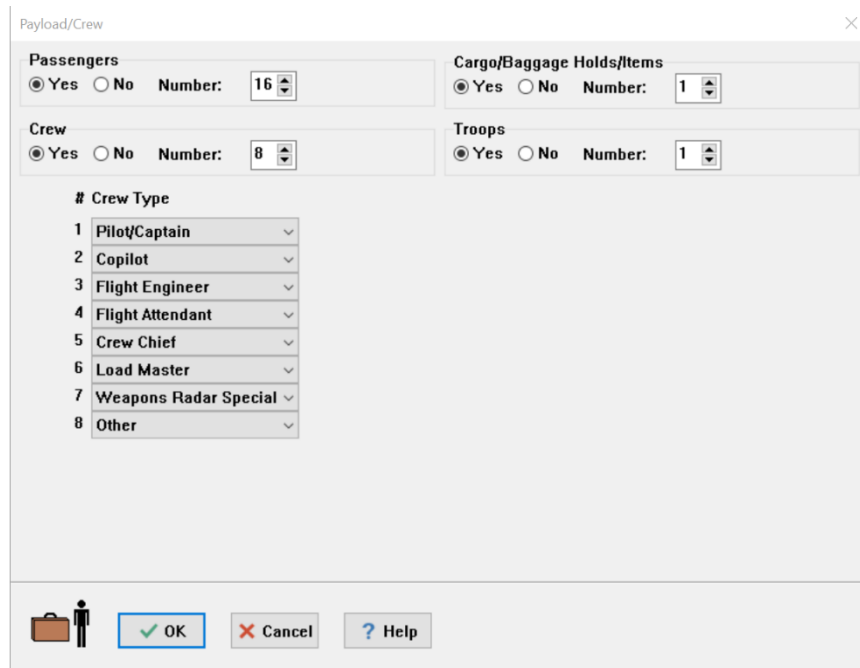


Figure 2.33 Payload/Crew Dialog Box

- Passengers: The user can specify if there are passengers and the number of passengers. The maximum number of passengers is 32,000.

- Cargo/Baggage Holds/Items: The user can specify the number of cargo/baggage holds or any other items. The maximum number is 500.
- Crew: The user can specify if there are crew members and the number of crew members. The maximum number of crew is 500.
 - Crew Type: If crew members are present, the user can specify the role the crew member has. Options include: Pilot/Captain, Copilot, Flight Engineer, Flight Attendant, Crew Chief, Load Master, Weapons and Radar Specialist and Other.
- Troops: The user can specify if there are troops and the number of troops. The maximum number of troops is 32,000.

2.2.4.4 Weapon Dialog Box

When the **Weapon** button is selected, the Weapon dialog box (Figure 2.34) is displayed. Descriptions of the dialog box functions follow.

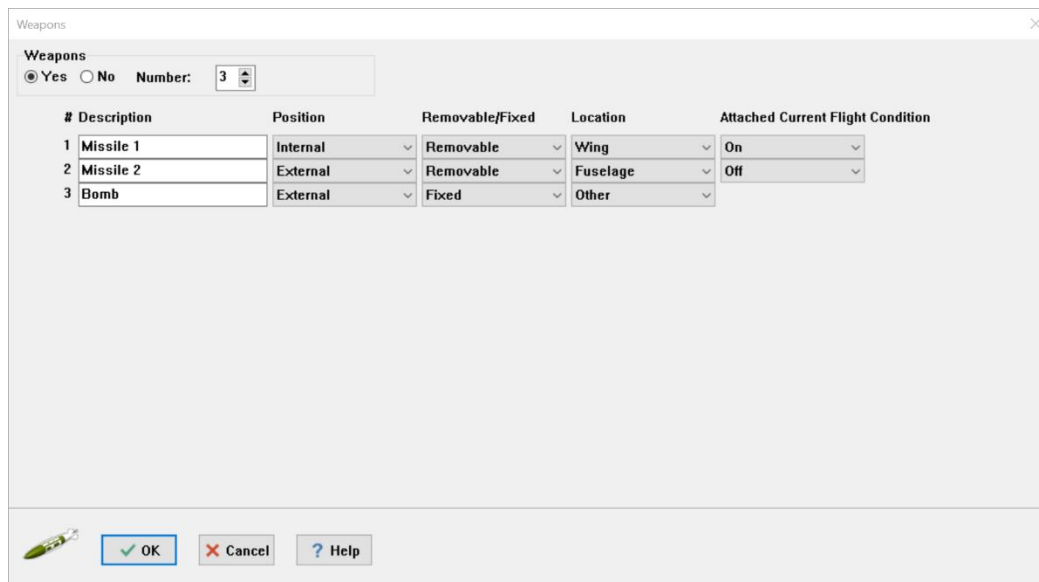


Figure 2.34 Weapon Dialog Box

- Weapons: The user can specify if there are weapons and the number of weapons. The maximum is 500.
- Description: The user can give a description of each weapon.
- Position: The user can specify the position of the weapon. Options include Internal or External.

- Removable/Fixed: The user can specify if the weapon is removable or fixed.
- Location: The user can specify if the weapon is attached to the fuselage, the wing or another location.
- Attached Current Flight Condition: If the weapon is removable, for the current flight condition, the user can specify if the removable weapon is attached or not attached to the aircraft.



2.2.5 Certification Toolbar

The Certification toolbar (Figure 2.35) consists of two buttons at the bottom of the main window. The Certification toolbar buttons can be used to specify aircraft certification type and class. The functionality of the buttons on the Certification toolbar is described in Table 2.8.



Figure 2.35 Certification Toolbar

Table 2.8 Certification Toolbar Buttons

 Certification	Certification: Define the aircraft type, certification and category under civil and military regulations.
 Classification	Classification: Define the class of the aircraft for US military flying qualities regulations to evaluate flying qualities for both civilian and military aircraft.

2.2.5.1 Certification and Type Dialog Box

When the **Certification** button is selected, the Certification and Type dialog box is displayed. Figure 2.36 shows the Certification and Type dialog box for civil aircraft and military aircraft. Descriptions of the dialog box functions follow.



Figure 2.36 Certification and Type Dialog Box

The Certification and Type dialog box offers the user the following options for defining the aircraft categories:

- Military/Civil: The user can select from military or civil, manned or unmanned aircraft types
- Certification: The user can select the following certification standards:
 - FAR 23: Federal Aviation Regulations, Part 23
 - FAR 25: Federal Aviation Regulations, Part 25
 - EASA 23: European Aviation Safety Agency, Part 23
 - EASA 25: European Aviation Safety Agency, Part 25
 - VLA: Very Light Aircraft
 - Mil Specs: Military Specifications (MIL-F-8785C and MIL-STD 1797A)
 - Light Sport: Light Sport Requirements
 - AS Specs: Naval Air Systems Command Specifications
- Category: Under FAR 23 or EASA 23, one of the following aircraft categories can be defined:
 - Normal
 - Utility
 - Acrobatic
 - Commuter
- Base: Under Mil Specs or AS Specs the aircraft base can be selected as land, carrier or both.
- Type: Depending on the Military/Civil choice, the user can choose the aircraft type

- Class II Weight Category: The user can select the weight estimation methods used in Class II weight

2.2.5.2 Classification Dialog Box

When the **Classification** button is selected, the Classification dialog box (Figure 2.37) is displayed. The aircraft type classification for military flying quality evaluation can be specified. The regulations are used to evaluate flying qualities for both civilian and military aircraft.

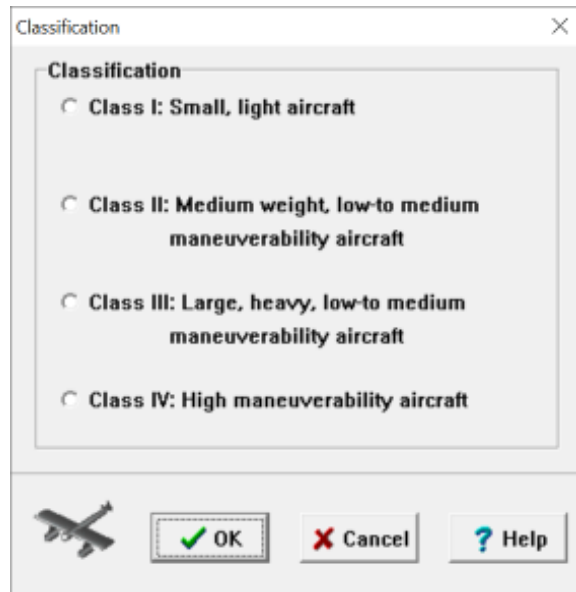


Figure 2.37 Classification Dialog Box

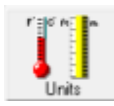
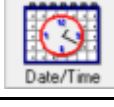



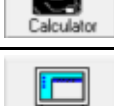

2.2.6 System Setup Toolbar

The System Setup toolbar (Figure 2.38) consists of seven buttons at the bottom of the main window. The System Setup toolbar buttons can be used to manage the program environment. The functionality of the buttons on the System Setup toolbar is described in Table 2.9.



Figure 2.38 System Setup Toolbar

Table 2.9 System Setup Toolbar Buttons

	Units: Select British or S.I. units for the input and output parameters.
	Date/Time: Select the date and time format in the status bar.
	Project: Specify the name of the project to be displayed in the status bar.
	Company: Specify the company name to be displayed in the status bar.
	Printer: Access the printer set up to define various printer attributes.
	Calculator: Select the calculator type: Standard or RPN.
	Options: Choose from various options including default units, default notes color, and calculated variable note color. The auto save recovery interval is defined here.

2.2.6.1 Units Dialog Box

When the **Units** button is selected, the Units dialog box (Figure 2.39) is displayed. The program allows the user to work in the British or SI (Metric) system of units.



Figure 2.39 Units Setup Dialog Box

2.2.6.2 Date and Time Format Dialog Box

When the **Date/Time** button is selected, the Date/Time dialog box (Figure 2.40) is displayed. The dialog box allows the user to choose the format of the date and time displays on the status bar and whether to display them or not.

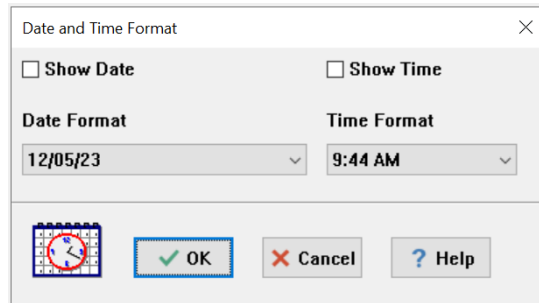


Figure 2.40 Date/Time Setup Dialog Box

2.2.6.3 Project Name Dialog Box

When the **Project** button is selected, the Project Name dialog box (Figure 2.41) is displayed. The dialog box allows the user to specify a project name or other description, which will be displayed on the status bar.

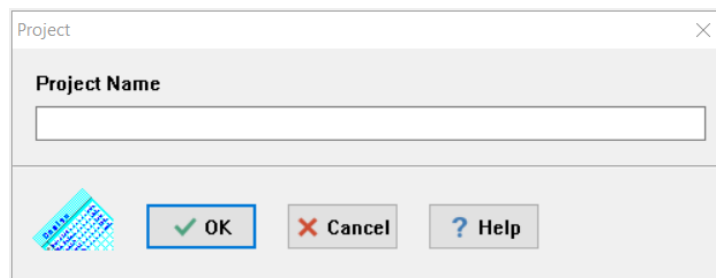


Figure 2.41 Project Name Setup Dialog Box

2.2.6.4 Company Name Dialog Box

When the **Company** button is selected, the Company Name dialog box (Figure 2.42) is displayed. The dialog box allows the user to specify a company name or other description, which will be displayed on the status bar.

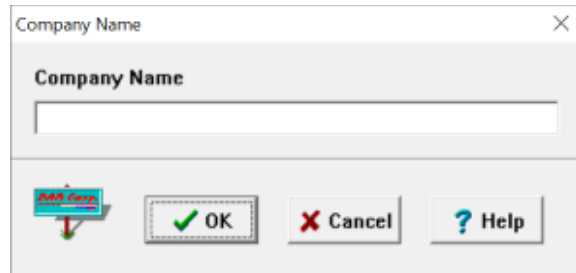


Figure 2.42 Company Name Setup Dialog Box

2.2.6.5 Printer Set Up Dialog Box

When the **Printer** button is selected, the Print Setup dialog box (Figure 2.43) is displayed. The dialog box allows the user to specify the default printer options used when printouts are generated and whether to print page numbers, file name, date or time.

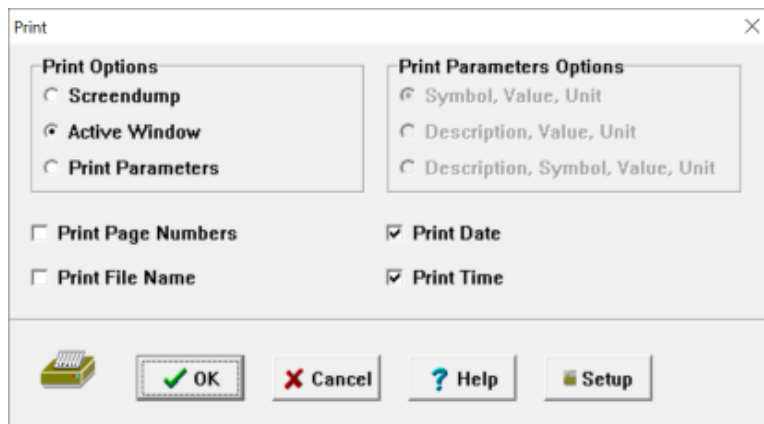


Figure 2.43 Print ex Box

The Print Setup dialog box options are described in Section 4. In brief, the Print Setup dialog box options are:

- **Screendump:** Prints a bitmap representation of the main window and any other open and visible windows.
- **Active Window:** Prints a graphic representation of the active application, input/output, or plot window.
- **Print Parameters:** Prints a list of the input and output parameters in an input/output window.

The Print Parameters option has three options:

- **Symbol, Value, Unit:** Prints the parameter symbol, the value and the unit.

- Description, Value, Unit: Prints the description of the parameter, the value and unit.
- Description, Symbol, Value, Unit: Prints the parameter description, symbol, value and unit
- The user can also choose whether to show the date, time, page number and file name on the print out.

2.2.6.6 Calculator Setup Dialog Box

When the **Calculator** button is selected, the Calculator Setup dialog box (Figure 2.44) is displayed. The calculator is described in Section 3.2. The dialog box allows the user to specify a standard or RPN calculator type.

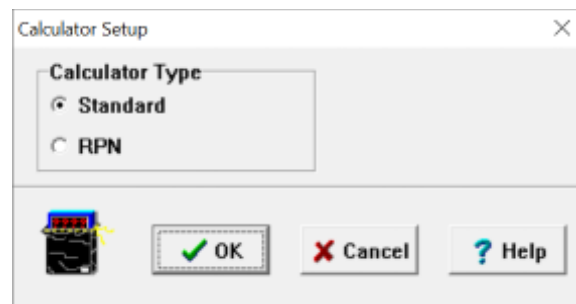


Figure 2.44 Calculator Setup Dialog Box

2.2.6.7 Program Options Dialog Box

When the **Options** button is selected, the Program Options dialog box (Figure 2.45) is displayed. Descriptions of the dialog box functions follow.



Figure 2.45 Program Options Dialog Box

- Show Info Button: The user can toggle on and off the info button shown in Part I Section 2.1.2 Figure 2.3.
- Show Work Pad Button: The user can toggle on and off the work pad button shown in Part I Section 2.1.2 Figure 2.3.
- Tips at Startup: The user can toggle on and off the tips that appear after opening the program.
- Show All Messages: The user can toggle on all the messages displayed by AAA when entering certain modules.
- Export All Values: Allows the user to export all values in the AAA database.
- Save Copy Window to File: The user can choose whether to save the WMF graphics created by the **Copy Window** button to file rather than the clipboard.

- Show Variable Name: Displays the database variable name in the Work Pad dialog window.
- Auto Save Recovery Project: The default interval for auto-saving a recovery project is set to 5 minutes. Users can alter the interval according to individual preference. Detail on the recovery project is presented in Part I Section 5.3.
- Recently Used File List: Allows the user to specify the number of recently used files that appear on the File menu. The default value is 5.
- Flight Condition List: Allows the user to specify the number of flight conditions that appear in the flight condition drop down. The default value is 8.
- Variable Changed Default Color: This option allows the user to define which color the edit box of a variable will change to if their values change when the **Calculate** button is used.
- Calculated Variable Note Color: This option allows the user to define which note color is selected for calculated variables. Calculated variable note colors are changed when the **Calculate** button is pressed and if no notes are present in the variable work pad window.
- Parameter Note Settings: This option allows the user to fill out a parameter's note if there is no note present. The order the boxes are check is the order they will appear in the note.
 - Include Date: Include the data in the format chosen in AAA
 - Include Initials: Include the initials of the Windows user of AAA
 - Custom Note: Include a custom note typed into the box
- Default Note Color, Hint: This allows the user to define which color is the default when notes are entered for a variable. It also allows the user to associate a hint with each color to help identify certain stages of the design process.
- Default Angle Units: This allows the user to define whether degrees or radians will be the default angle unit throughout the project.
- Default 1/Angle Units: This allows the user to define whether or radian^{-1} will be the default 1/angle unit throughout the project. degree^{-1}
- Default Length Units: When British units are in use, this allows the user to define whether inches or feet will be the default length unit throughout the project. When S.I. units are in use, it allows the user to define whether millimeters or meters will be the default length unit throughout the project. Some variables are locked to one length unit for each unit type, such as altitude.
- Default Area Units: When British units are in use, this allows the user to define whether square inches or square feet will be the default area unit throughout the project. When S.I. units are in use, it allows the user to define whether square millimeters or square meters will be the default area unit throughout the project.

- **Default Speed Units:** When British units are in use, this allows the user to define whether feet per second or knots will be the default speed unit throughout the project. When S.I. units are in use, it allows the user to define whether kilometers per hour or meters per second will be the default speed unit throughout the project.
- **Export Flight Condition:** This option allows the user to export flight conditions to a spreadsheet either in rows or in columns.

2.3 Menu Bar

The main window menu bar is located at the top of the main window. Most options in the Menu Bar sub-menus have a corresponding option in the toolbars. The menu bar contains the File, Edit, Window, Airfoil and Help menus. The File menu contains the options described in Table 2.10. The Recently Used File List is also shown in the File menu.

Table 2.10 File Menu Options

File Menu Option	Description
New	Create a new project. Corresponds to the New icon on the File toolbar. Shortcut: <Ctrl+N>
Open...	Open an existing project. Corresponds to the Open icon on the File toolbar. Shortcut: <Ctrl+O>
Save	Save the current project. Corresponds to the Save icon on the File toolbar. Shortcut <Ctrl+S>
Save As...	Save the current project under a different name or location. Corresponds to the Save As... icon on the File toolbar.
Import	Import a supported file type (See Part I Section 2.3.1).
Export	Export a supported file type (See Part I Section 2.3.2).
Print...	Make a printout. Corresponds to the Print icon on the main toolbar. Shortcut: <Ctrl+P>
Print Setup...	Set the default printer options. Corresponds to the Printer icon on the System Setup toolbar.
Properties	Displays the various properties of the current project.
Preferences	Set default preferences that are used when starting a new project.
Exit	Exit the program. Corresponds to the Exit icon on the main toolbar.

The Edit menu options can be used after highlighting text in an edit box. The three options are described in Table 2.11.

Table 2.11 Edit Menu Options

Edit Menu Option	Description
Cut	Delete the selected text and place in the Windows clipboard. Shortcut: <Ctrl+X>
Copy	Copy the selected text into the Windows clipboard. Shortcut: Ctrl+C
Paste	Paste the current text from the Windows clipboard into the edit box. Shortcut: <Ctrl+V>

The Window menu options can be used to arrange application, input/output and plot windows within the main window. In addition, the Window menu displays a list of all open windows within the main window. Selecting a window name within the list will cause that window to be displayed and become active. The three Window menu options are described in Table 2.12.

Table 2.12 Window Menu Options

Window Menu Option	Description
Tile	Size and arrange the open windows so that all of the windows can be seen on the screen.
Cascade	Arrange all of the open windows so that the title bar of each window can be seen.
Arrange All	If any windows are minimized within the main window, this option will arrange them at the bottom of the main window.

The Airfoil menu allows the user to specify the file location AAA accesses when selecting airfoils in the **Geometry** and **Aerodynamics** module. The Airfoil menu options is described in Table 2.13.

Table 2.13 Airfoil Menu Options

Window Menu Option	Description
Folder Location	Select the default file location for airfoils.

The Help menu options can be used to access the software help system and online manual. The nine Help menu options are described in Table 2.14.

Table 2.14 Help Menu Options

Help Menu Option	Description
Help	Displays the help topic relating to the currently active window. This corresponds to the Help button on the main toolbar or the Theory button on the input/output window. Shortcut: <F1>
Online Help Manual	Displays the help on the internal layout of AAA, displays the support and services and description on how to use the online help.
Tip of the Day	Displays the tip of the day.
Using AAA Help	Displays the various help formats used in AAA.
What's New in AAA	Displays the WhatsNew50.pdf file.
e-mail Tech Support	Opens the user e-mail account to send an email to the tech support.
FAQ Online	Displays the DARcorporation Frequently Asked Questions web page.
Check for Updates	Checks the DARcorporation website for latest updates
About...	Displays a window describing the software version.

2.3.1 File Import

The following file types are supported for import into the software:

- **Weight Table:** Take-off vs. Empty Weight regression coefficient tables from AAA versions 1.0 through 1.7. These files have the extension “.rc”.
- **Geometry:** Geometry parameter files for use in AeroPack. These ASCII files have the extension “.geo”.
- **ASCII:** Parameter files from the program ACE!IT, by Tecolote Research. These files have the extension “.txt”.
- **Excel:** Parameter files for use in tables from the program Excel by Microsoft. These files have the extension “.xls” and “.xlsx”.
- **All Data (CSV):** Comma-separated values file containing configuration information, input and output information and tables for use by all modules. These files have the extension “.csv”.

- Mission Profile (CSV): Comma-separated values file containing input and output information to generate a mission profile under Weight > Weight Sizing > Mission Profile. These files have the extension “.csv”.

2.3.2 File Export

The following file types are possible exports for the software.

- Weight Table: Take-off vs. Empty Weight regression coefficient table. These files have the extension “.rc”.
- Geometry: Geometry parameter file for use in AeroPack. These ASCII files have the extension “.geo”.
- ASCII: Parameter file from the program ACE!IT, by Tecolote Research. These files have the extension “.txt”.
- S&C Derivatives: Excel spreadsheet containing all Stability and Control Derivatives and Data for all flight conditions of the current project. These files have the extension “.xlsx”.
- Aerodynamics: Excel spreadsheet containing all Aerodynamic data for all flight conditions of the current project. These files have the extension “.xlsx”.
- All Checked Parameters: Excel spreadsheet containing parameter values that have been check marked in the Work Pad window. These files have the extension “.xlsx”.
- All Defined Parameters: Excel spreadsheet containing all parameters that have values. These files have the extension “.xlsx”.
- All Defined Notes: Excel spreadsheet containing all defined notes. These files have the extension “.xlsx”.
- All Locked Parameters: Excel spreadsheet containing parameter values that have been locked in the Work Pad window. These files have the extension “.xlsx”.
- All Flight Co Changed Parameters: Excel spreadsheet containing all variable names for variables that change with flight condition. These files have the extension “.xlsx”.
- AAA 4.0 Format: AAA file that is compatible with AAA 4.0. These files have the extension “.aaa”.
- All Data (CSV): Comma-separated values file containing configuration information, input and output information and tables for use by all modules. These files have the extension “.csv”.

- Mission Profile (CSV): Comma-separated values file containing input and output information to generate a mission profile under Weight > Weight Sizing > Mission Profile. These files have the extension “.csv”.

3. Input Devices for the Software

The following devices are used as input for the software: mouse, calculator and keyboard. The devices are described in this Section.

3.1 Operation of the Mouse and Cursor

The cursor usually appears as an arrow on the screen. The arrow will change to the Windows ‘busy’ icon while the software is auto-saving or during operations that take more time to perform. The left mouse button is used to select all buttons in the program.

When the cursor is placed over an input/output element, it will change to a calculator. Also, a brief description, or hint, will be displayed for that element. The calculator can be displayed by clicking the left mouse button while the cursor is displayed as a calculator. The calculator is described in Section 3.2. When the cursor is placed over an edit box in an input/output element, it will change to a bar. If the left mouse button is clicked, an insertion bar will appear in the edit box, and the keyboard can be used to input a number.

3.2 Operation of the Calculator

The calculator is activated (displayed on the screen) by clicking the left mouse button when the cursor appears as a calculator. The user may then use the calculator to input the value of the variable, or the user may instead choose to use the number keypad on the keyboard to enter the data. The calculator pad performs similar to an electronic calculator. The buttons are selected with the left mouse button. To deselect the calculator, close the calculator window using the system menu, or choose the **Cancel** button. A number will be entered in the software database when the **OK** button on the calculator or **Enter** on the keyboard is selected. The calculator is shown in Figure 3.1.

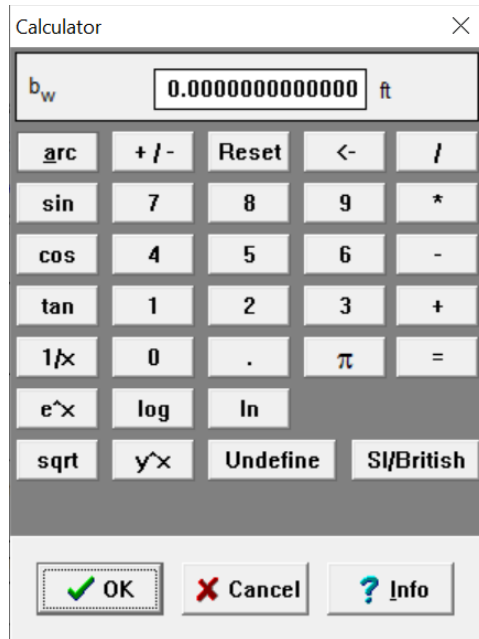


Figure 3.1 The Calculator

The calculator is equipped with special buttons. The functions of these special buttons are:

- **Info:** The **Info** button shows information about the current variable. The **Info** button always provides the user with the definition of the variable and, whenever possible, with a typical value or an approximate range for that variable. The user may select the typical value or range by moving the cursor to the line containing that value and pressing the left mouse button. The typical value will be entered into the calculator display, or a dialog box will appear allowing the user to choose a number within the suggested range. Some variable descriptions include a graph or diagram, which can be displayed by choosing “See Graphic.”
- **Undefine:** The **Undefine** button allows the user to make a variable temporarily undefined. This button is designed for those cases where the user has the intention of removing the parameter for the calculation but not from the database. To restore the value of the parameter, invoke the calculator and press the **OK** button. An undefined variable appears blank in the input/output parameter.
- **Reset:** Selecting this button will erase the current number from the calculator display. The number will then revert to the original number displayed when selecting the calculator. The number will not be cleared in the database.
- **SI/British:** Selecting this button will cause the displayed unit to switch between the British and SI units. The displayed value will also be converted to the selected unit. In the

input/output element, the value will be shown in the units set during the software installation or with the **Units** button in the System Setup toolbar.

3.3 Operation of the Keyboard

The keyboard can be used in the software when the user is prompted for text input within a dialog window, entering a number once the calculator is displayed, or entering data directly into an input/output element. If the keyboard is used to enter data directly into an input/output element, selecting the **<Enter>** or **<Tab>** key will enter the currently displayed number into the database, and move the cursor to the next element in the input or output group. Keyboard shortcuts exist for the **Calculate** and **Close** button found in the input/output windows. The **<F9>** key will perform the calculation, and **<F4>** will close the active input/output window.

3.4 System Messages

There are two types of messages, which warn the user of possible pitfalls in the design process or demonstrate methods of performing certain actions. The first type of message is informative. The second type of system message is automatically given by the system. These messages usually contain critiques of user input. These contain warnings or guidelines. The user still has the option to ignore such warnings or guidelines. However, in the case where such an act could lead to a mathematical problem (i.e. divide by zero), the system ignores the user's request.

3.5 Flexible Input

One of the features of the program is the capability to bypass certain computation sequences. The software is designed to ignore the computation sequence and make use of user defined values instead. This feature is not always available and should be used with caution. Using this feature demands a clear understanding of the computation sequence in the application module. For example:

- I A, B and C are input values into the calculation module
- II D and E are output values of the calculation module
- III D is calculated by: $D=f(A,B)$
- IV E is calculated by: $E=f(C,D)$

In a normal case, the user provides all input values (A, B and C) and the application module calculates the output parameters (D and E) with equations III and IV. Consider the case where the user does not want to calculate D from equation III but wishes to provide their own value and still wants to use the system logic to calculate E. To do this, it is sufficient to define the C value in the input group and the desired D value in the output group. The A and B values should be left undefined. If A and B are already defined, they should temporarily be made undefined by using the **Undefine** button on the calculator described in Section 3.2. When the user clicks the **Calculate** button on the input/output window command bar, the system checks all the variables in the input group. Since A and B are undefined, the program logic ignores the part related to the calculation of D. Then it checks the database for the required parameters for calculation of E. In this case, it will find that D and C are given and E can be calculated from equation IV. In this example, the system ignores its internal logic to calculate D and gives authority to the user to supply the desired D value.

4. Generating Hardcopy Output

To create a hardcopy select the **Print** button on the main toolbar or print in the menu bar. To alter the form of the hard copy select the **Printer** option in the setup toolbar or Print Setup in the menu toolbar. Hardcopy output in the software can be in one of the following formats:

- **Screendump**: This is format is used by selecting the **Screendump** option in the Print dialog box (See Part I Section 2.2.6.5). The format is a bitmap representation of the main window. The print may take one or two minutes on slower printers.
- **Active Window**: This is format is used by selecting **Active Window** option in the Print dialog box (see Part I Section 2.2.6.5). This option is only applied to application windows, input/output windows or plot windows. The format is a direct representation of the active window. This option is faster than the **Screendump** option.
- **Print Parameters**: This is format is used by selecting the **Print Parameters** option in the Printer dialog box (See Part I Section 2.2.6.5). Once print parameters are selected, the user is prompted with the three options on the format of the output file (See Part I Section 2.2.6.5). Table 4.1 lists the resultant output for the three options.

Table 4.1 Resulting Output for the Three Formatting Options in Print Parameters

Print Parameters Option	Resulting Output
Symbol, Value, Unit	Advanced Aircraft Analysis Project Straight Tapered Wing Geometry $AR_w = 10$ $S_w = 500\text{ft}^2$ $\lambda_w = 0.40$ $\Lambda_{c/4_w} = 25\text{deg}$
Description, Value, Unit	Advanced Aircraft Analysis Project Straight Tapered Wing Geometry Wing Aspect Ratio = 10 Wing Area = 500ft^2 Wing Taper Ratio = 0.40 Wing Quarter-chord Line Sweep Angle = 25deg
Description, Symbol, Value, Unit	Advanced Aircraft Analysis Project Straight Tapered Wing Geometry Wing Aspect Ratio $AR_w = 10$ Wing Area $S_w = 500\text{ft}^2$ Wing Taper Ratio $\lambda_w = 0.40$ Wing Quarter-chord Line Sweep Angle $\Lambda_{c/4_w} = 25\text{deg}$

5. Software Databases and Projects

The system features a database structure to store and retrieve aircraft design and analysis project parameters. Two types of databases are used. The first type of database is fixed and used by the program to retrieve information that does not change with use of the program. The first type of database is discussed in Part I Sections 5.1 and 5.2.

The second type of database is used to store parameter values and characteristics that change with use of the program. A project consists of a collection of these types of databases. Projects and their individual databases are described in Part I Section 5.3.

5.1 The System Database

The system database is used to store information about parameters that do not change. The system database is located by default in <C:\Program Files (x86)\DARcorporation\AAA51\Database>. The system database should never be deleted or modified in any way. The system database stores the following information about every numeric parameter used in the software:

- Name of the variable
- Engineering Symbol of the variable
- Name of the info topic for the variable
- Conversion factor between British and SI units
- Number of decimal places to display for the variable
- Minimum allowable value for the variable
- Maximum allowable value for the variable
- Short definition of the variable that is displayed as described in Part I Section 2.1.2

5.2 File Compatibility with Previous Versions

Files created with AAA versions 1.0 through 5.1 and other aircraft design software by DARcorporation can be opened with this version of the software. The file can then be saved as a project in this version. This version does not support saving projects as files for use with previous versions. Files saved with Unix versions (1.0 through 1.7) of AAA can be opened by choosing the ‘.ana, .analys’ option in the **Files of Type** box in the File Open dialog box.

5.3 Projects and Their Databases

A project consists of a project file and multiple databases for flight conditions and aircraft components. While the software is running, the default location for the current project is the folder <C:\Users\'Username'\AppData\Local\Temp\working>, which is called the Working Directory. When the software is started with a new project, the default name is Project1. The new project is kept in the Working Directory until it is saved for the first time. When the project is saved, all of the files in the Working Directory are copied into one AAA project file specified by the user in the Save As dialog box. Projects can be moved by using the **Save As** button in the File toolbar or **Save As** in the main menu.

When an existing project is opened, the project is first copied to the Working Directory where it is used by the program. When the user saves the project, it is copied from the Working Directory back into its original folder. The program has been set to automatically save the recovery file in the Working Directory every 5 minutes. The user can alter the interval in the Program Options dialog box (see Part I Section 2.2.6.7).

When the software is exited normally, the contents of the Working Directory are cleared. If the software exits abnormally due to a program or system crash, the current project will remain in the Working Directory. The next time the program is started, it will attempt to recover the contents of the Working Directory as a recovery project. It is strongly recommended that the user save the recovered project as a new project until it is confirmed that the recovery was successful and complete.

Warning:

The Working Directory should be reserved for use only by the software. The user should not attempt to save projects or copy files from other locations to the Working directory.

6. Help System

The Help system is an online system of help topics that give the user information about the use of the program and the theory and definitions behind the calculations. The online help system can be accessed in six ways:

- Select the User's Manual icon in the Aircraft Design and Analysis Program group.
- Select the **Help** button on the main toolbar (see Part I Section 2.2.1).
- Select an item in the **Help** menu on the main window menu bar (see Part I Section 2.3).
- Select the **Info** button on the calculator or any other dialog that includes a **Help** button.
- Select the **?** button on an input/output element (see Part I Section 2.1.2).
- Select the **Theory** button on an input/output window.

The online help system consists of three types of help topics. The three types of help topics and the method of accessing them are described in the following sections:

- 6.1 User's Manual topics
- 6.2 Variable Info topics
- 6.3 Theory topics

6.1 User's Manual Topics

These topics describe the functionality of the various windows, toolbars and dialog boxes described in Part I Section 2 of this part of the User's Manual. These topics can be accessed in the following ways:

- When there are no application, input/output or plot windows open in the main window, select the **Help** button on the main toolbar (see Part I Section 2.2.1).
- When there are no application, input/output or plot windows open in the main Window, select an item in the **Help** menu on the main window menu bar (see Part I Section 2.3).
- Select the **Help** button on any dialog (see Part I Section 2.1.2).

6.2 Variable Info Topics

Every variable that is displayed in an input/output element (see Part I Section 2.1.2) has a topic that defines that variable. Whenever possible, typical values for the variable and a graphical depiction of the variable are shown in the variable info topic. The variable info topic can be displayed in two ways:

- Select the **Info (?)** button on the input/output element (see Part I Section 2.1.2). If the **Info (?)** button is not visible on the input/output element, the **Options** button on the System Setup toolbar (see Part I Section 2.2.6.7) can be selected to change the input/output elements display properties.
- Select the **Info** button on the calculator (see Part I Section 3.2).

6.3 Theory Topics

Every calculation module of the software has a theory topic, which explains the methods behind the calculation. The theory topic can be displayed in two ways:

- Select the **Theory** button on the command bar of the input/output window.
- Select the **Help** button on the main toolbar (see Part I Section 2.2.1) when the calculation module's input/output window is open and active

Application Modules

This part describes the function and use of the application modules. The application modules are based on References 1 through 9.

1. Weight Module

1.1 General Description

The purpose of this module is to estimate aircraft component weights and to determine whether or not the center of gravity of the aircraft is within the desirable range for different loading and unloading scenarios. The methods are based on Section 2, Sections 2.1 to 2.5 and Section 2.7 of Reference 1, Section 10 of Reference 2 and Section 2 of Reference 3. This module also contains the moments of inertia calculation, based on Section 3 of Reference 3. Use of the **Weight** module options will be described in the following sections.

1.2 Weight Main Window

After selecting the **Weight** module, the user can choose from the four options displayed which will be explained in the following sections:

- 1.3 **Weight Sizing** The **Weight Sizing** module can be used for Class I weight estimation based on a defined mission
- 1.4 **Class I** The **Class I** weight module can be used for Class I weight estimation using weight fractions
- 1.5 **Class II** The **Class II** weight module can be used for Class II weight estimation
- 1.6 **Radii of Gyration** The **Radii of Gyration** module can be used for radii of gyration estimation

1.3 Weight Sizing

The purpose of the **Weight Sizing** module is to rapidly estimate the following weight components and/or sensitivity coefficients:

- Take-off weight, W_{TO}
- Empty weight, W_E
- Mission fuel weight, W_F
- Sensitivity of take-off weight to aerodynamic, propulsion and mission parameters These parameters are estimated on the basis of the following inputs:
 - A mission profile/specification (optional)
 - Statistical relations between empty weight and take-off weight of existing aircraft.

Once this selection has been made, a new menu appears with seven options. The seven options displayed are:

- | | | |
|-------|----------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.3.1 | Mission Profile | Allows the user to calculate the overall mission fuel fraction by entering the flight segments from the start to the end of the mission. |
| 1.3.2 | W_{TO}, W_E, W_F | Calculates mission fuel weight, take-off weight and empty weight. A plot showing the iteration process is provided. |
| 1.3.3 | W_{TO}, W_F, given W_E | Calculates mission fuel weight and take-off weight based on a given empty weight. |
| 1.3.4 | L/D from Weights | Calculates the climb, cruise, turn and loiter lift-to-drag ratios, based on corresponding segment weights. It iterates between Weight Sizing and Class I Drag (since the wetted area is calculated from take-off weight) to obtain a converged solution for the take-off weight. |
| 1.3.5 | Regression | With this option, the user can enter statistical data by providing empty weights and take-off weights in a table and calculate the regression coefficients A and B. A logarithmic plot of the entered data is also provided. |
| 1.3.6 | Sensitivity | After performing Mission Profile and Take-off Weight , sensitivities of take-off weight for changes in aerodynamic, propulsion and mission parameters can be calculated. |

1.3.7 Payload-Range This module calculates the range for different payload scenarios starting with a minimum of 1 pilot and ending with the amount of payload specified by the user in the module.

1.3.1 Mission Profile

This option shows the “Segment Input and Fuel-Fraction Calculation” menu. This menu consists of four command buttons:

- **New Segment** This command is used to enter a new segment of the mission specification. A selection can be constructed from the fourteen mission segments. The newly specified flight segment is added at the end of the previously defined segments. After choosing the desired segment, an input/output window is displayed. For some flight segments, the **Calculate** button must be selected to get the fuel-fraction. For other segments, the input will be the fuel-fraction. The selected mission segment will be displayed in a table together with the fuel-fraction for this segment.
- **Delete Segment** With this command, a segment can be deleted from the flight profile. The user selects a segment that is to be deleted. All data related to this segment will be erased. If the user wishes to exit without deleting a segment, any menu can be selected to exit this command.
- **Insert Segment** With this command, a flight segment can be inserted between two previously entered segments. When the **Insert Segment** command is selected, a menu with fourteen flight segments as described in **New Segment** will appear. Upon selection of a new segment to be inserted, the user must select the position of the new segment within the mission profile. The new segment will be inserted before the segment selected as the new position. Inserting at the end of the table is possible by selecting **New Segment** instead of **Insert Segment**. To cancel insert segment, select any button in another menu.
- **Move Segment** A segment in the mission profile table can be moved to another location by selecting it and selecting the flight segment before which

it is to be inserted. If the user wishes to exit without moving a segment, select any menu to exit this command.

Input data in a particular flight segment can be changed by selecting the flight segment from the “Mission Profile” table.

The fourteen flight segments that can be used are: Warmup, Taxi, Take-off, Climb, Cruise, Turn, Loiter, Payload Expend, Refueling, Descent, Land/Taxi, Stall, Payload Reload, and Fuel Expend.

1.3.2 W_{TO} , W_E , W_F

This command is used to calculate the aircraft take-off weight from the mission segment fuel fractions and regression coefficients. Once W_{TO} , W_E , W_F is selected, a display of all mission segments, previously generated in **Mission Profile**, will appear together with an input and output group. The regression coefficients A and B can either be entered in the input section or calculated after invoking **Regression**. After entering all input data and selecting **Calculate**, the empty weight, take-off weight, mission fuel weight, used fuel weight, mission fuel fraction, fuel burned in each flight segment, fuel available during each flight segment and aircraft weight at the beginning of each flight segment will be calculated and displayed.

The calculation leads to one of the following cases:

1. No solutions for take-off weight
2. One solution for take-off weight
3. Two solutions for take-off weight

The mathematical background for the above stated scenarios can be found in Appendix A of Reference 1. A plot function is available to show the iteration process used to arrive at these solutions. For case 1, the input data must be changed to obtain a solution. For case 2, no modifications are necessary. If case 3 occurs, the program automatically chooses the lowest weight solution.

1.3.3 W_{TO} , W_F , given W_E

This command is used to calculate the aircraft take-off weight from the mission segment fuel fractions and a given empty weight. Once **W_{TO} , W_F , Given W_E** is selected, a display of all mission segments, previously generated in **Mission Profile**, will appear together with an input and output group. After entering all input data and selecting **Calculate**, the take-off weight, mission fuel weight, used fuel weight, mission fuel fraction, fuel burned in each flight segment, fuel available during each flight segment and aircraft weight at the beginning of each flight segment will be calculated and displayed.

1.3.4 L/D from Weights

This command calculates the climb, cruise, turn and loiter lift-to-drag ratios, based on corresponding segment weights. It iterates between **Weight Sizing** and **Class I Drag** (since the wetted area is calculated from take-off weight) to obtain a converged solution for the take-off weight. The user can select the weight method used, either “Empty Weight Calculated” or “Empty Weight Fixed” corresponding to Part II Section 1.3.2 or 1.3.3, respectively.

1.3.5 Regression

This command is used to calculate the regression coefficients, A and B, by supplying empty weights and take-off weights of actual aircraft in a table. The number of take-off and empty weight combinations is first specified. An empty table will appear with columns for the aircraft name, take-off weight and empty weight. When all input data are entered, and the user selects **Calculate**, this will calculate the intercept A and slope B for a logarithmic relation between take-off and empty weight using a least squares method. Increasing the spin edit for number of aircraft in weight table adds an empty row at the end of the table, which allows for the addition of a data point to be used in calculating A and B. The maximum number of rows is 50. The spin edit can also be used to delete table rows from the bottom of the table by decreasing its value.

After creating or importing a table (use the **Import** option in the **File** menu), the data can be plotted with a logarithmic scale (A and B must be calculated first). The standard plot options are described in Part I Section 2.1.4. If the take-off weight and empty weight of a design have been calculated

using one of the take-off weight options, they will be plotted with the weight table elements and be designated by a Design Point label.

1.3.6 Sensitivity

This option allows the user to calculate the sensitivity of take-off weight to aerodynamic, propulsion and mission parameters. Once all data from **Mission Profile** and **Take-Off Weight** is available, selecting **Calculate** will display take-off weight sensitivities with respect to payload weight, crew weight and empty weight in the output parameters. The results shown in the table, which will appear with the flight segments, are sensitivities with respect to various fuel weight and aerodynamics parameters.

1.3.7 Payload Range

This module calculates the range for different payload scenarios starting with a minimum of 1 pilot and ending with the amount of payload specified by the user in the module. AAA will not plot if the payload weight results in a fuel weight below zero.

1.3.8 Remarks

1. The payload weight excludes expended payload such as bombs and ammunition. Payload dropped during the mission has to be specified in the **Mission Profile**. Payload, which is not dropped, must be included in payload and crew weights.
2. Refueled fuel weight during the mission must be specified in the **Mission Profile**.
3. A change in expended payload and refueled fuel can only be made in the **Mission Profile** module since the location of the payload expenditure and refueling segment in the flight profile is essential for the calculation of the weights.

1.4 Class I Weight

The **Class I** weight module consists of three separate modules. After invoking **Class I**, a menu appears with the following options:

- 1.4.1 **Weight Fractions** With this option, the user can determine the aircraft component weights by using the weight fraction methods.
- 1.4.2 **Center of Gravity** This option allows the user to calculate the current aircraft and empty weight center of gravity locations.
- 1.4.3 **Inertia Estimate** With this option, the user can calculate the aircraft moments of inertia with radii of gyration methods.

1.4.1 Weight Fractions

This option allows the user to calculate component weights by using the weight fractions method. The data can be provided by the user, or the AAA database of comparable aircraft can be used. After selecting an aircraft category, the user may select aircraft available in that particular category. One or more aircraft can be selected. The Class I component weight estimation is based on the selected aircraft, so the user should choose the most comparable aircraft. The user may add an aircraft more than once to weigh the importance of a particular configuration.

The **Weight Fractions** module contains the options **Add Aircraft**, **Select Aircraft**, **Fractions** and **Weights**, which have the following functions:

- **Add Aircraft** Allows the user to add new aircraft to the already available aircraft appearing in the table. The user has to supply the weight fraction data. This data will automatically be added to the **Select Aircraft** menu under the “Aircraft Category” labeled “User Defined.”
- **Select Aircraft** Allows the user to select existing aircraft from the program database for use in the Class I component weight estimation. All the available aircraft in all categories can be displayed. The user may select any combination of these to use in the weight estimation by adding them to the current selection list. To deselect an aircraft, select the aircraft from the current selection list and remove it.
- **Fractions** After selecting one or more aircraft, this button will show the weight fraction data of the selected aircraft. By pressing **Calculate**, the average weight fractions will be calculated. If a weight component fraction for a selected aircraft is not available, the representative box will be blank, and this component will not be used in determining

the average. By scrolling down the list, the remaining selected aircraft data can be shown in case they did not appear on the current screen.

- **Weights** In this menu, the Class I component weight estimation is completed. The estimation is based on the calculated average weight fractions. By selecting **Calculate** the estimated component weights will be displayed. When the calculated empty weight does not match the user supplied empty weight calculated in **Weight Sizing**, an adjustment is made which is distributed over all items in proportion to their component weight values listed in the last column.

1.4.2 Center of Gravity

This option allows the user to calculate the aircraft center of gravity by entering weight components and their locations in a preformatted table. The **Center of Gravity** module consists of three separate modules. After invoking **Center of Gravity**, a menu appears with the following options:

- **Empty Weight C.G.** With this option, the center of gravity coordinates of empty weight components from Class I Weight Fractions calculations are tabulated. The center of gravity of the empty aircraft will be computed using only the components for which all data is supplied.
- **Aircraft C.G.** With this option, the center of gravity location of the aircraft is calculated from the empty weight center of gravity for the specified loading scenario. The loading scenario includes fuel weights, passenger weights and any other useful load present on the mission.
- **C. G. Excursion** This option allows the user to specify a component weight loading/unloading scenario. Loading starts from the empty weight of the aircraft and successively adds weight components to the aircraft until the maximum take-off weight is reached. At each step, the new location of the aircraft center of gravity is calculated and stored. This procedure is repeated for the unloading case with the starting point at the maximum take-off weight. Mission loads and fuel are successively subtracted from the aircraft weight according

to the unloading scenario until the empty weight is reached. Each component (1 up to 11) can be used only once in each of the loading/unloading columns of the table. Once the loading scenario is provided and the center of gravity travel is calculated, the C.G. excursion diagrams in the X-direction, Y-direction and Z-direction can be displayed with the **Plot** selection.

1.4.3 Inertia Estimate

This option allows the user to estimate the moments of inertia of the aircraft with the radii of gyration method. The user can provide the data or the preloaded database can be used. The user has the option to select data from comparable aircraft. By selecting a category, a choice can be made between several available aircraft appearing in a table. Because the Class I inertia estimation is based on the selected aircraft, the user should choose the most comparable aircraft. The user may add an aircraft more than once to weigh the importance of a particular configuration. The **Inertia Estimate** module contains the options **Add Aircraft**, **Select Aircraft** and **Moment of Inertia**, which will be explained here.

- **Add Aircraft** Allows the user to add inertia data for new aircraft to the already available aircraft appearing in the table. The user has to provide the data for the Radius of Gyration Table. This data is automatically added to the **Select Aircraft** menu under the “Aircraft Category” labeled “User Defined.”
- **Select Aircraft** Allows the user to select existing aircraft from the program database for use in the Class I moment of Inertia estimation. All the available aircraft in all categories can be displayed. The user may select any combination of these to use in the inertia estimation by adding them to the current selection list. To deselect an aircraft, select the aircraft from the current selection list and remove it.
- **Moment of Inertia** After selecting one or more aircraft, this button will display an input/output window. The average radii of gyration are already calculated and will be shown in the input section. If radii of gyration data on certain aircraft is not available, the radii of gyration of these aircraft is not used in averaging. The user needs to supply the

remaining input data and select **Calculate** to generate the moments of inertia.

1.5 Class II Weight

The purpose of this module is to present a Class II method for estimating aircraft component weights. In the **Class II** weight estimate module, the weight estimation methods are identified as follows:

- Cessna method
- USAF method
- General Dynamics (GD) method
- Torenbeek method
- Vought method
- DAR method
- The Fluid Optimization System (FLOPS) method

The estimation methods of Cessna, USAF, General Dynamics, Torenbeek and Vought are described in Reference 3 and Reference 4. The DAR method was developed by DARcorporation. These methods employ empirical equations that relate component weights to aircraft design characteristics.

The Fluid Optimization System (FLOPS) method is from the FLOPS software published by NASA. The values for the method must be filled out manually by the user with data from FLOPS. To gain access to the FLOPS software contact NASA.

The different weight component estimation options will be discussed in Part II Section 1.5.1.1 through 1.5.1.4. Because aircraft component weight modeling in the AAA program is a function of the aircraft take-off weight, W_{TO} , the Class II weight estimation is an iterative process. The weight iteration process will be discussed in Part II Section 1.5.1.6.1.

After selection of **Class II**, the program will choose a weight estimation category based on the user supplied aircraft certification, type and powerplant specifications. This can be adjusted in the Certification toolbar (see Part II Section 2.2.5.2).

The **Class II** module consists of three separate modules. After selecting **Class II**, a menu appears with the following options:

- 1.5.1 **Weight** To estimate the aircraft weight.
- 1.5.2 **Center of Gravity** To estimate the aircraft weight and center of gravity location for the specified loading scenario.
- 1.5.3 **Moment of Inertia** To estimate the aircraft moment of inertia about the body axis.

1.5.1 Weight

This option allows the user to calculate aircraft component weights and iterate the Class II empty/take-off weight estimation. Upon selecting **Weight**, the following options will appear:

- 1.5.1.1 **Structure** To estimate the aircraft structure component weights.
- 1.5.1.2 **Powerplant** To estimate the aircraft powerplant component weights.
- 1.5.1.3 **Fixed Equipment** To estimate the aircraft fixed equipment component weights.
- 1.5.1.4 **Miscellaneous Weight** To estimate the user defined weights.
- 1.5.1.5 **Useful Load Weight** To estimate the useful load weights.
- 1.5.1.6 **Empty/Take-off Weight** To estimate the aircraft empty and take-off weight by iteration of structure, powerplant and fixed equipment component weights.
- 1.5.1.7 **Weight Fractions** To calculate Class II component weight fractions.

1.5.1.1 Structure Component Weight Estimation

In this module, the structure component weights can be estimated with the available methods described in Reference 3. The structure weight components menu consists of the following options:

- **Wing** To estimate the wing weight.
- **Horizontal Tail** To estimate the horizontal tail weight.
- **Vertical Tail** To estimate the vertical tail weight.
- **Canard** To estimate the canard weight.
- **V-Tail** To estimate the V-tail weight.

- **Ventral Fin** To estimate the ventral fin weight.
- **Dorsal Fin** To estimate the dorsal fin weight.
- **Pylon** To estimate the pylon weight.
- **Fuselage** To estimate the fuselage weight.
- **Nacelle** To estimate the nacelle weight.
- **Tailboom** To estimate the tailboom weight.
- **Fixed Store** To estimate the fixed store weight.
- **Float** To estimate the float weight.
- **Fixed Fuel Tank** To estimate the fixed fuel tank weight.
- **Landing Gear** To estimate the landing gear weight.

1.5.1.2 Powerplant Components Weight Estimation

In this module, the powerplant component weights can be estimated with the methods of Reference 3. The powerplant weight components menu consists of the following options:

- **Propeller** To estimate propeller weight. This option is only available for piston, turboprop, propfan and electric engines.
- **Engine** To estimate engine weight. The engine weight includes engine, exhaust, cooling, supercharger, afterburners, thrust reversers and lubrication systems.
- **Fuel System** To estimate fuel system weight.
- **Air Induction** To estimate air induction weight. The air induction component weight includes inlet ducts other than nacelles, ramps, spikes and associated controls.
- **Propulsion System** To estimate propulsion system weight. The propulsion system weight components include engine controls, starting systems, propeller controls and provisions for engine installation.

NOTE: In some aircraft the fuel system is used to control the center of gravity location. Aircraft with relaxed static stability and/or supersonic cruise aircraft frequently require such a system. The weight increment incurred due to such a feature is included in the weight estimation of the flight control system.

1.5.1.3 Fixed Equipment Components Weight Estimation

In this module, the fixed equipment component weights can be found with the methods of Reference 3. The fixed equipment weight components menu consists of the following options:

- **Flight Control** To estimate the weight of the flight controls systems.
- **Instr/Avionics/Electronics** To estimate the weight of the instruments, avionics and electronics. The weight estimation in this module is obsolete for modern EFIS type cockpit installations and for modern computer based flight management and navigation systems.
- **Airco/Pressurization/Icing** To estimate the weight of the air-conditioning, pressurization and anti-icing or de-icing systems.
- **Auxiliary Power** To estimate the weight of the auxiliary power unit.
- **Baggage/Cargo Handling** To estimate the weight of the baggage and cargo handling equipment.
- **Armament** To estimate the weight of the armament. This option is not available for General Aviation or Commercial aircraft.
- **Other Items** To estimate the weight for other, not previously tabularized weight items.
- **Hydraulic/Pneumatic System** To estimate the weight of the hydraulic and pneumatic systems.
- **Electrical System** To estimate the weight of the electrical systems.
- **Oxygen Systems** To estimate the weight of the oxygen systems.
- **Furnishings** To estimate the weight of the furnishings.
- **Operational Items** To estimate the weight of the operational items.
- **Weapon & Provisions** To estimate the weight of fixed weapons such as guns, launchers and weapon provisions.

NOTE: The weight estimation in the **Instr/Avionics/Electronics** module is obsolete for modern EFIS type cockpit installations and for modern computer based flight management and navigation systems.

1.5.1.4 Miscellaneous Weight

This module can only be accessed if in the Miscellaneous dialog box “yes” was selected for “Include Miscellaneous Weight-C.G. Table” (see Part I Section 2.2.2.7). The user defined weights for components that are not listed in the Structure Weight, Fixed Equipment Weight or Powerplant Weight modules, are input in this module.

1.5.1.5 Useful Load Weight

In this module, the useful load weights can be defined. The useful load weight components menu consists of the following options:

- **Crew** To define the weight of the crew.
- **Passengers/Bags** To define the weight of passengers and bags.
- **Troops** To define the weight of troops.
- **Cargo/Baggage** To define the weight of cargo/baggage holds.
- **Fuel** To define the weight of fuel and removable fuel tanks.
- **Removable Weapons** To define the weight of droppable and expendable munitions.
- **Removable Stores** To define the weight of removable stores.

1.5.1.6 Empty/Take-Off Weight

The **Empty/Take-off Weight** module allows the user to iterate the take-off weight. Using an initial take-off weight estimate, usually from Class I take-off weight estimation, the component weights are calculated. The sum of the component weights gives a new empty weight, which in turn gives a Class II take-off weight defined as:

$$W_{TOII} = \frac{W_{fix} + W_{structure} + W_{pp} + W_{crew} + W_{PL} + W_{PLexp} - W_{Frefuel}}{M_{ff} (1 + M_{Fres}) - M_{Fres} - M_{tfo}}$$

Where:

W_{TOII} Aircraft Class II take-off weight in [lb] or [N]

W_{fix}	Aircraft total fixed equipment weight in [lb] or [N]
$W_{structure}$	Aircraft total structure weight in [lb] or [N]
W_{pp}	Aircraft total powerplant weight in [lb] or [N]
W_{crew}	Sum of all crew weights in [lb] or [N]
W_{PL}	Aircraft payload weight in [lb] or [N]
$W_{PL_{exp}}$	Expend payload weight in [lb] or [N]
$W_{F_{refuel}}$	Refueled fuel weight in [lb] or [N]
M_{ff}	Mission fuel fraction
$M_{F_{res}}$	Reserve fuel weight as fraction of fuel weight used in the mission
M_{tfo}	Trapped fuel and oil weight as a fraction of take-off weight

1.5.1.6.1 Weight Calculation Process

Once the Calculate button is clicked the aircraft weight module performs the take-off weight iteration to within an accuracy of 10^{-9} lb. This iteration uses the take-off weight found using the equation above to find new component weights that are in turn used to find a new empty weight. This new empty weight is used to find a new take-off weight using the equation above and the iteration continues as such.

If not all the input parameters in the table are defined, a message will be displayed informing the user that all selected cells (except the **W_{User}** column) must contain data, or be unselected. The error may be a result of undefined data in the **Class II** weight estimation menus or weight fractions not defined in the **Class I** weight estimate module. The **Class II** weight input can be defined in the **Structure, Powerplant** and **Fixed Equipment** weight estimation modules. The **Class I** weight fractions can be estimated in the **Class I** weight estimation module after selection of the **Weight Fraction** option.

The iteration table consists of an input group and a component weight table. The ‘hashed’ cells in the table indicate that weight estimation methods are not available for the specific weight component for the specific aircraft category or engine type. All other cells, except the last column, which represents the average weights, represent a weight component for a specific weight estimation method and can be deselected. Deselecting a component in the table will cause that specific component to not be used in the weight **Class II** iteration process.

The user can deselect a method for a component by excluding the cell of that method for that component. This is done by right clicking the cell and selecting **Exclude in Calculation**. To denote the exclusion an “X” will appear over the cell and when right clicking the cell a check mark will appear next to **Exclude in Calculation**. When the iteration process is initiated by selecting the **Calculate** button, all excluded cells will not be included in the iteration. To include an estimation method that has been excluded right click the cell and select **Exclude in Calculation**. To denote the inclusion the “X” will disappear from the cell and **Exclude in Calculation** will no longer have a check mark next to it when right clicking the cell. When the **Calculate** button is selected, that method will be included in the iteration.

Values that populate the weight iteration table should never be deleted. If a value from the table is missing, it will be recalculated. In some instances, the user will be prompted to return to that specific weight module and recalculate the missing value.

The weight iteration component weight table contains a W_{User} column. This column can be used to fix the weight of a specific component or to influence the average weight of a component. To fix the weight of a component, enter the known weight in the W_{User} column, and unselect the contents of the other estimation method cells for that component. To influence the average, leave one or more weight estimation cells selected, and enter a number in the W_{User} column.

1.5.1.7 Weight Fractions

In this module, Class II weight fractions are calculated using Class II take-off weight and Class I weight fractions.

1.5.2 Center of Gravity

This option allows the user to calculate the aircraft weight and center of gravity location for a specific loading scenario by entering weight components and their corresponding center of gravity locations in a preformatted table. After selecting **Center of Gravity**, a menu with six options appears:

- **Component C.G.** This module calculates the center of gravity location, based on basic geometry and center of gravity input parameters for structural components, powerplant components, and fixed equipment.
- **Misc. Weight C.G.** This module can only be accessed if in the Miscellaneous dialog box “Yes” was selected for “Include Miscellaneous Weight-C.G. Table” (see Part I Section 2.2.2.7). This module allows the user to input the center of gravity locations of user-defined miscellaneous components.
- **Empty Weight C.G.** With this option, empty weight components and the associated center of gravity coordinates can be tabulated. The center of gravity of the empty aircraft will only be computed if all component data is supplied.
- **Useful Load C.G.** With this option, useful load components and the associated center of gravity coordinates can be tabulated. Seven options are available. These options may be selected only if they have been defined in the configuration setup toolbar (Part I Section 2.2.4).
- **Aircraft C.G.** This allows the user to calculate the center of gravity location of the aircraft for the specified loading scenario.
- **Forward-Aft C.G.** This module calculates the most forward, the most aft, and the maximum weight C.G. locations of the aircraft based on minimum and maximum weights specified by the user for each component. It also plots the C.G. envelope.

1.5.3 Moment of Inertia

This option allows the user to calculate the aircraft moment of inertias by entering components and their corresponding weights, center of gravity locations and moments of inertia in a preformatted table. After selecting **Moment of Inertia**, a menu with five modules will appear:

- **Component Inertia** This module calculates the moment of inertia in terms of the aircraft body axis, based on basic geometry and weight input parameters.
- **Miscellaneous Inertia** This module can only be accessed if in the Miscellaneous dialog box “yes” was selected for “Include Miscellaneous Weight-C.G. Table”

(see Part I Section 2.2.2.7). This module allows the user to input the moments of inertia of user-defined miscellaneous components.

- **Empty Weight Inertia** With this option, the empty weight moment of inertia can be calculated. The moment of inertia of the empty aircraft will be computed using only the components for which all data is supplied.
- **Useful Load Inertia** With this option, useful load components and the associated moments of inertia can be tabulated. Seven options are available. These options may be selected only if they have been defined in the configuration setup toolbars. See Section 2.2.4 of Part I of this manual.
- **Aircraft Inertia** This allows the user to calculate the moment of inertia of the aircraft for the specified loading scenario.

1.6 Radii of Gyration

This option allows the user to estimate the radii of gyration of the aircraft using moment of inertia values. The user provides the inertia data, gross weight, span and length and the radii of gyration are calculated for each of the three axes.

2. Aerodynamics Module

2.1 General Description

The purpose of the **Aerodynamics** module is to estimate the aircraft lifting surface coefficients, the total aircraft drag coefficient and total aircraft pitching moment coefficient for different flight conditions. The aircraft aerodynamic center is also found in this module. Use of the **Aerodynamics** module options will be described in the following sections.

2.2 Aerodynamics Main Window

After selecting the **Aerodynamics** module, the user can select from the ten options displayed which will be explained in the following sections:

- 2.3 **Airfoil Characteristics** This module allows the user to select airfoils for all lifting surfaces and define the airfoil aerodynamic characteristics of an airfoil.
- 2.4 **Lift** This module can be used for estimations of the lifting characteristics of aircraft lifting surfaces and high lift devices.
- 2.5 **Drag** This module can be used for estimations of the drag characteristics of the aircraft.
- 2.6 **Pitching Moment** This module can be used for estimations of the moment characteristics of the aircraft.
- 2.7 **Aerodynamic Center** This module can be used to calculate aerodynamic center locations of aircraft and the lifting surfaces.
- 2.8 **Dynamic Press. Ratio** The **Dynamic Pressure Ratio** module can be used to calculate the dynamic pressure at the horizontal tail, canard or V-tail in the linear lift range.
- 2.9 **Power Effects** This module can be used to calculate the effects of power on each lifting surface, on the aircraft lift, drag and pitching moment coefficients and on the aircraft aerodynamic center.
- 2.10 **Ground Effects** This module can be used to calculate the ground effects on aircraft lift, moment and vertical tail downwash.

- 2.11 **Deep Stall Angles** This module can be used to calculate the deep stall angles at the horizontal tail.
- 2.12 **Pitch Break** This module can be used to determine the pitch break stability.

2.3 Airfoil Characteristics

After selecting the **Lift** module in the **Aerodynamics** main window, six options will be displayed which will be explained in the following sections:

- 2.3.1 **Mach Correction** For calculation of Mach effects on airfoil properties.
- 2.3.2 **Wing** For selection of the root and tip airfoil of the wing.
- 2.3.2 **Horizontal Tail** For selection of the root and tip airfoil of a horizontal tail.
- 2.3.2 **Vertical Tail** For selection of the root and tip airfoil of a vertical tail.
- 2.3.2 **Canard** For selection of the root and tip airfoil of a canard.
- 2.3.2 **V-Tail** For selection of the root and tip airfoil of a V-tail.
- 2.3.3 **Airfoil Definition** For definition of new airfoils.

2.3.1 Mach Correction

The Mach Correction module is used to calculate the Prandtl-Glauert Mach Number Correction and the effect of Mach number on Lifting Surface zero-lift pitching moment coefficient for all lifting surfaces.

2.3.2 Wing, Horizontal Tail, Vertical Tail, Canard and V-Tail Airfoil Characteristics

The **Wing**, **Horizontal Tail**, **Vertical Tail**, **Canard** and **V-Tail** modules can be used to load existing airfoils for use in the respective lifting surfaces.

2.3.3 Airfoil Definition

The **Airfoil Definition** module can be used to define new airfoils when known aerodynamic data is available. These airfoils can then be used in any of the lifting surfaces. The **Airfoil Definition** module Command Bar has the following buttons:

- **Plot** The user can plot the airfoil lift vs angle of attack.
- **Load Airfoil** The user can load previously saved airfoil aerodynamic data.
- **Save Airfoil** The user can save airfoil aerodynamic data which may be loaded into the lifting surface airfoil module.

2.4 Lift

After selecting the **Lift** module in the **Aerodynamics** main window, ten options will be displayed which will be explained in the following sections:

- 2.4.1 **Wing** For calculation of the lift coefficient of the clean wing.
- 2.4.1 **Horizontal Tail** For calculation of the lift coefficient of a horizontal tail.
- 2.4.1 **Vertical Tail** For calculation of the sideforce coefficient of a vertical tail.
- 2.4.1 **Canard** For calculation of the lift coefficient of a canard.
- 2.4.1 **V-Tail** For calculation of the lift coefficient of a V-tail.
- 2.4.2 **Pylon** For calculation of the lift coefficients for pylons.
- 2.4.3 **Fuselage** For calculation of the lift coefficient for the fuselage.
- 2.4.4 **Nacelle** For calculation of the lift coefficients for nacelles.
- 2.4.5 **High Lift Device** For calculation of the lift coefficient of the wing with a high lift device deflection.
- 2.4.6 **Aircraft No Empenn.** For calculation of the lift coefficient of the aircraft with no empennage
- 2.4.7 **Propeller** For calculation of the lift coefficient of the aircraft with no empennage
- 2.4.8 **Aircraft** For calculation of the aircraft steady state lift coefficient and angle of attack.

The procedure to use each lift module is presented in the following sections. The methods used in calculating the lift coefficient of all aircraft lifting surfaces are the same.

2.4.1 Wing, Horizontal Tail, Vertical Tail, Canard and V-Tail Lift

The **Wing**, **Horizontal Tail**, **Vertical Tail**, **Canard** and **V-Tail** modules share the following options:

- $C_{L\alpha}$ To determine the lifting surface lift curve slope.

- ε To determine the lifting surface downwash/upwash gradients. The Vertical Tail module includes the sidewash gradient σ in this option.
- C_{L_0} & α_0 To determine the lifting surface zero angle-of-attack lift coefficient and zero-lift angle of attack.
- $C_{L_{max}}$ To determine the lifting surface maximum lift coefficients. This option is described in Part II Section 2.4.1.1.
- α^*, α' To determine the shape of the lift curve.
- $C_L - \alpha$ To determine the lift coefficient for a given angle of attack.
- **Lift Distribution** To determine the lifting surface spanwise lift distribution. This option is described in Part II Section 2.4.1.2. For the Vertical Tail, this button is called **Sideforce Distribution**.

2.4.1.1 Maximum Lift Coefficient

The $C_{L_{max}}$ module calculates the lifting surface planform maximum lift coefficient. An input/output window appears showing the surface planform lift coefficient input and output parameters. The user can supply the data of other airfoils by choosing “user defined” and defining the root and tip airfoil maximum lift coefficients in the input menu for the surface planform maximum lift coefficient.

2.4.1.2 Lift/Sideforce Distribution

The methodology used to determine the lifting surface spanwise lift distribution is based on lifting line theory. To determine the spanwise lift distribution, select the **Lift Distribution** button. An input/output window appears showing the surface planform input parameters. The user can display the lift distribution by selecting the **Plot** button.

2.4.2 Pylon

This module can be used to determine the sideforce coefficients of the pylons and the zero angle of attack lift coefficient of pylons. The **Pylon** module has two options:

- $C_{L_{\alpha_{py}}}$ & $C_{y\beta_{py}}$ To determine the pylon lift curve slope and sideforce curve slope.

- $C_{L_{opy}}$ To determine the pylon zero-angle-of-attack lift coefficient.

2.4.3 Fuselage

This module can be used to determine the fuselage lift curve slope.

2.4.4 Nacelle

This module can be used to determine the lift curve slope the of nacelles and the zero angle of attack lift coefficient of the nacelles. The **Nacelle** module has two options:

- $C_{L_{\alpha_n}}$ To determine the nacelle lift curve slope.
- $C_{L_{o_n}}$ To determine the nacelle zero-angle-of-attack lift coefficient.

2.4.5 High Lift Devices

The function of the **High Lift Device** module is to determine the increase in wing lift coefficient due to deflection of high lift devices.

2.4.6 Aircraft No Empennage

This module can be used to determine the aircraft with no empennage lift characteristics. The **Aircraft No Empennage** module has five options:

- $C_{L_{\alpha_{no\ empennage}}}$ To determine the aircraft with no empennage lift curve slope.
- $C_{L_{o_{no\ empennage}}}$ & $\alpha_{o_{no\ empennage}}$ To determine the aircraft with no empennage zero angle-of-attack lift coefficient and zero-lift angle of attack.
- $\alpha^*_{no\ empennage}, \alpha'_{no\ empennage}$ To determine the shape of the aircraft with no empennage lift curve.
- $C_{L_{no\ empennage}} - \alpha$ To determine the aircraft with no empennage lift curve.
- α from $C_{L_{no\ empennage}}$ To determine the aircraft angle of attack for a given no empennage lift coefficient.

2.4.7 Propeller

This module can be used to determine the effects due to power of the propeller. The **Propeller** module has two options:

- **Gradient** To determine the propeller normal force gradients and thrust coefficient.
- **Downwash/Upwash** To determine the propeller downwash and upwash gradient and angles.

2.4.8 Aircraft

This module can be used to determine the aircraft lift characteristics. The **Aircraft** module has six options:

- $C_{L\alpha}$ To determine the aircraft lift curve slope.
- C_{L_0} & α_0 To determine the aircraft zero-angle-of-attack lift coefficient and zero-lift angle of attack.
- $C_{L_{misc}}$ To determine any miscellaneous lift contributions not included
- $C_{L_1} - \alpha$ To determine the aircraft lift coefficient curve.
- C_{L_1} Build-up To determine the aircraft lift coefficient based on the individual component lift coefficients.
- C_{L_1} given α To determine the aircraft lift coefficient for a given angle of attack.

2.5 Drag

After selecting the **Drag** module in the **Aerodynamics** main window, five options will be displayed which will be explained in the following sections:

- Class I Drag** Class I method for drag estimation.
- Class II Drag** Class II method for drag estimation.
- Drag Distribution** This module can be used to calculate spanwise drag on the wing, horizontal tail, vertical tail, canard, and v-tail. To determine the

spanwise drag distribution, select the lifting surface button. An input/output window appears showing the surface planform input parameters. The user can display the drag distribution by selecting the **Plot** button.

Critical Mach	The Critical Mach module can be used to calculate the Critical Mach number for the aircraft.
Wind Tunnel	The Wind Tunnel module can be used to calculate the drag coefficients based on wind tunnel tests.

2.5.1 Class I Drag

The **Class I Drag** module has the following eight options.

- **Clean** For configuration with no flap deflection and gear up.
- **Take-off Flaps, Gear Up** For flaps in take-off configuration with gear up.
- **Landing Flaps, Gear Up** For flaps in landing configuration with gear up.
- **Current Flight Condition** For the current aircraft flight condition.
- **OEI** For one engine inoperative configuration.
- **Take-off Flaps, Gear Down** For flaps in take-off configuration with gear down.
- **Landing Flaps, Gear Down** For flaps in landing configuration with gear down.
- **All Polars** Calculates all the drag polars for Class I Drag.

The methodology used to calculate the aircraft drag polars is described in References 1 and 5. To calculate the drag polar, the user first selects the option corresponding to the configuration of interest. The other five flight condition options will have similar input and output parameters.

The **Class I Drag** module relates the total aircraft lift coefficient to the total aircraft drag coefficient by the drag polar equation:

$$C_D = C_{D_o\text{clean}} + B_{DP}C_L^2$$

Where:

$$B_{DP} = \frac{1}{\pi AR_{we}}$$

Where C_{D_o} and B_{DP} are coefficients calculated by the program using the methods in Section 3.4.1 of Reference 1. The program allows the user to perform this calculation in different ways. The standard method of computing C_{D_o} and B_{DP} is to specify all the input parameters and select the **Calculate** button.

Equivalent parasite area is a function of the regression coefficients 'a' and 'b' (Reference 1, Section 3.4.1), and are user-defined in the input parameter section. If 'a' and 'b' are defined, the program automatically calculates the value of the equivalent parasite area. However, if the resulting equivalent parasite area is unacceptable, the user has the capability of redefining these quantities by following these steps:

- Input the desired value for equivalent parasite area
- Make 'a' or 'b' undefined
- Select **Calculate**

The same procedure applies to the aircraft wetted area. The wetted area is a function of the regression coefficients 'c' and 'd' (Reference 1, Section 3.4.1) and are user-defined in the input parameter section. To provide a user selectable value for the wetted area, follow these steps for the wetted area:

- Input the desired value for wetted area
- Make 'c' or 'd' undefined
- Select **Calculate**

After calculating the drag polar, a dialog window displays the drag polar equation. This equation is printed with the **Print Parameters** option. After calculating the drag polar equation, the user may display the drag polar by selecting the **Plot** option. After selecting **Plot**, the following graphs will be displayed for the selected condition:

- C_L vs C_D
- C_L vs C_L / C_D
- C_L vs C_L^3 / C_D^2 (For propeller powered configurations)
- C_L vs $C_L^{0.5} / C_D$ (For jet powered configurations)

NOTE: The C_L range must be specified in input parameters. Changing the plot axis will not allow for calculation outside of the specified C_L range (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

2.5.2 Class II Drag

The purpose of the **Class II Drag** module is to supply a Class II method for predicting drag polars of aircraft during the preliminary design phase. After selecting **Class II Drag**, the program requires the definition of the altitude and speed, in the Flight Condition Dialog box (see Part I Section 2.1.1), to determine the flow regime for that particular flight condition. The different flow regimes are divided, according to Mach number ranges:

- **Subsonic** Flow regime for flight Mach numbers not exceeding 0.6.
- **Transonic** Flow regime for flight Mach numbers between 0.6 and not exceeding 1.2.
- **Supersonic** Flow regime for flight Mach numbers between 1.2 and not exceeding 3.0.

NOTE: Drag estimation methods for the hypersonic flow regime, flight Mach numbers greater than 3.0, are not available in this module.

Once the flow regime has been selected, 30 options will be displayed which will be explained in the following sections:

2.5.2.1 Wing	For estimation of the wing drag coefficient.
2.5.2.2 Horizontal Tail	For estimation of the horizontal tail drag coefficient.
2.5.2.3 Vertical Tail	For estimation of the vertical tail drag coefficient.
2.5.2.4 Canard	For estimation of the canard drag coefficient.
2.5.2.5 V-Tail	For estimation of the V-tail drag coefficient.
2.5.2.6 Ventral Fin	For estimation of ventral fin drag coefficient.
2.5.2.7 Dorsal Fin	For estimation of dorsal fin drag coefficient.
2.5.2.8 Pylon	For estimation of the pylon drag coefficient.
2.5.2.9 Fuselage	For estimation of the fuselage drag coefficient.
2.5.2.10 Nacelle	For estimation of the nacelle drag coefficient.
2.5.2.11 Inlet/Duct	For estimation of the inlet/duct drag coefficient.
2.5.2.12 Tailboom	For estimation of the tailboom drag coefficient.
2.5.2.13 Store	For estimation of the stores drag coefficient.
2.5.2.14 Float	For estimation of the float drag coefficient.
2.5.2.15 External Fuel Tank	For estimation of the external fuel tank drag coefficient.
2.5.2.16 External Weapon	For estimation of the external weapon drag coefficient.
2.5.2.17 High Lift Device	For estimation of the high lift device drag coefficient.
2.5.2.18 Spoiler	For estimation of the spoiler drag coefficient.

2.5.2.19 Speed Brake	For estimation of the speed brake drag coefficient.
2.5.2.20 Landing Gear	For estimation of the landing gear drag coefficient.
2.5.2.21 Canopy	For estimation of the canopy drag coefficient.
2.5.2.22 Windshield	For estimation of the windshield drag coefficient.
2.5.2.23 Windmilling	For estimation of the drag coefficient due to windmilling.
2.5.2.24 Nozzle	For estimation of nozzle drag coefficient.
2.5.2.25 Trim	For estimation of the trim drag coefficient.
2.5.2.26 Miscellaneous	For estimation of miscellaneous drag coefficient.
2.5.2.27 Aircraft	For a summation of the different component drag coefficients.
2.5.2.28 Recalculate All	Used to recalculate all of the drag coefficients.
2.5.2.29 Trendline	For calculating a Trendline of the drag polar.
2.5.2.30 Plot	For plotting the Class II drag polars.

2.5.2.1 Wing Drag

In this module, the wing drag coefficient can be calculated for a specific flight condition. The wing drag coefficient consists of a zero lift component and a lift dependent component. The wing drag input/output window depends on the selected flow regime. The methodology used to calculate the wing drag coefficient is described in Section 4.2 of Reference 5.

2.5.2.2 Horizontal Tail Drag

In this module, the horizontal tail drag coefficient can be calculated for a specific flight condition. The horizontal tail drag coefficient consists of a zero lift component and a lift dependent component. The horizontal tail drag input/output window depends on the selected flow regime. The methodology used to calculate the horizontal tail drag coefficient is described in Section 4.4 of Reference 5.

2.5.2.3 Vertical Tail Drag

In this module, the vertical tail drag coefficient can be calculated for a specific flight condition. The vertical tail drag coefficient consists of a zero sideforce component and a sideforce dependent component. The vertical tail drag input/output window depends on the selected flow regime. The methodology used to calculate the vertical tail drag coefficient is described in Section 4.4 of Reference 5.

2.5.2.4 Canard Drag

In this module, the canard drag coefficient can be calculated for a specific flight condition. The canard drag coefficient consists of a zero lift component and a lift dependent component. The canard drag input/output window depends on the selected flow regime. The methodology used to calculate the canard drag coefficient is described in Section 4.4 of Reference 5.

2.5.2.5 V-Tail Drag

In this module, the V-tail drag coefficient can be calculated for a specific flight condition. The V-tail drag coefficient consists of a zero lift component and a lift dependent component. The V-tail drag input/output window depends on the selected flow regime. The methodology used to calculate the V-tail drag coefficient is described in Section 4.4 of Reference 5.

2.5.2.6 Ventral Fin Drag

In this module, the ventral fin drag coefficient can be calculated for a specific flight condition.

2.5.2.7 Dorsal Fin Drag

In this module, the dorsal fin drag coefficient can be calculated for a specific flight condition.

2.5.2.8 Pylon Drag

In this module, the pylon drag coefficient can be estimated. For estimation of the pylon drag coefficient, the pylon drag coefficient consists only of a zero lift component. It is assumed that the lift dependent drag component of a pylon is negligible. The methodology used to calculate the pylon drag coefficient is described in Section 4.5 of Reference 5.

2.5.2.9 Fuselage Drag

In this module, the fuselage drag coefficient can be calculated for a specific flight condition. The fuselage drag coefficient consists of a zero lift component and a lift dependent component. The

fuselage drag input/output window depends on the selected flow regime. The methodology used to calculate the fuselage drag coefficient is described in Section 4.3 of Reference 5.

2.5.2.10 Nacelle Drag

In this module, the nacelle drag coefficient can be estimated. For estimation of the nacelle drag coefficient, the nacelle drag consists of an isolated nacelle component and an interference component. The nacelle drag input/output window depends on the selected flow regime and the propulsion type. If the propeller driven option has been selected, then the supersonic flow regime cannot be used. The methodology used to calculate the nacelle drag coefficient is described in Section 4.5 of Reference 5.

2.5.2.11 Inlet/Duct Drag

In this module, inlet/duct drag coefficient can be estimated. In well-designed piston, turboprop and propfan installations, the inlet extra drag should be negligible. The inlet drag can be manually entered in the **Aircraft** module, if different from zero.

For jet engine inlets the methods used in this module are only valid in the subsonic and transonic speed regimes. In the supersonic speed regime there are four sources for extra inlet drag:

- Spillage or additive drag
- Bypass drag
- Boundary layer diverter drag
- Boundary layer bleed drag

The methodologies for these additional drag sources are not present in AAA. The methodology used to calculate the inlet/duct drag coefficient is describe in Section 6.2 Reference 5.

2.5.2.12 Tailboom Drag

In this module, the tailboom drag coefficient can be estimated. The tailboom input/output window depends on the selected flow regime. The methodology used to calculate the tailboom drag coefficient is described in Sections 4.3 and 4.13 of Reference 5.

2.5.2.13 Store Drag

In this module, the store drag coefficient can be calculated. The stores drag input/output window depends on the selected flow regime. The methodology used to calculate the stores drag coefficient is described in Section 4.9 of Reference 5.

2.5.2.14 Float Drag

In this module, the float drag coefficient can be estimated. The float drag estimation is only valid in the low subsonic speed regime. DARcorporation developed the methodology used to calculate the float drag.

2.5.2.15 External Fuel Tank Drag

In this module, the external fuel tank drag coefficient can be estimated. The external fuel tank drag input/output window depends on the selected flow regime. The methodology used to calculate the stores drag coefficient is described in Section 4.9 of Reference 5.

2.5.2.16 External Weapon Drag

In this module, the external weapon drag coefficient can be estimated. Before entering the External Weapons Drag input/output window, the user will be required to define which of the weapons are on the aircraft for the particular flight condition. The external weapons drag input/output window depends on the selected flow regime. The methodology used to calculate the external weapon drag coefficient is described in Section 4.9 of Reference 5.

2.5.2.17 High Lift Device Drag

In this module, the drag coefficient of wing trailing edge lift generating devices can be estimated. The assumption is made that flap deployment will occur only in the subsonic speed regime. The flap drag estimation is therefore only valid in the subsonic speed regime. The methodology used to calculate the flap drag coefficient is described in Section 4.6 of Reference 5.

2.5.2.18 Spoiler Drag

In this module, the spoiler drag coefficient can be calculated. Before entering the spoiler drag input/output window, the user will be required to define whether the spoiler is retracted or deployed for the particular flight condition. The methodology used to calculate the spoiler drag coefficient is described in Section 4.12 of Reference 5.

2.5.2.19 Speed Brake Drag

In this module, the speed brake drag coefficient can be calculated. Before entering the speed brake drag input/output window, the user will be required to define whether the speed brake is retracted or deployed for the particular flight condition. The methodology used to calculate the speed brake drag coefficient is described in Section 4.12 of Reference 5.

2.5.2.20 Landing Gear Drag

In this module, the drag coefficient for different landing gear types can be estimated. The landing gear drag estimation is only valid in the low subsonic speed regime. The methodology used to calculate the landing gear drag coefficient is described in Section 4.7 of Reference 5. Landing gear estimation methods are available for the following gear types:

- Fixed: For estimation of the fixed gear drag coefficient.
- Retractable: For estimation of the retractable landing gear drag coefficient. Before entering the landing gear drag input/output window, the user will be required to define whether the landing gear is down or up.

2.5.2.21 Canopy Drag

In this module, the canopy drag coefficient can be calculated. The methods used in this module are only valid in the subsonic speed regime. In the transonic and supersonic speed regimes, the wave drag generated by the canopy can be significant. In these speed ranges, it will be necessary to employ area-ruling to reduce the wave drag to a minimum. The methodology used to calculate the canopy drag coefficient is described in Section 4.8 of Reference 5.

2.5.2.22 Windshield Drag

In this module, the windshield drag coefficient can be calculated. The methods used in this module are only valid in the subsonic speed regime. In the transonic and supersonic speed regimes, the wave drag generated by the windshield can be significant. In these speed ranges, it will be necessary to employ area-ruling to reduce the wave drag to a minimum. The methodology used to calculate the windshield drag coefficient is described in Section 4.8 of Reference 5.

2.5.2.23 Windmilling Drag

In this module, the drag coefficient due to a windmilling condition can be estimated. The methods used in this module are not valid for propeller driven aircraft in the supersonic speed regime. The methodology used to calculate the nacelle drag coefficient due to windmilling is described in Section 4.5 of Reference 5.

2.5.2.24 Nozzle Drag

In this module, the nozzle drag coefficient can be estimated. The methods used in this module are not valid in the supersonic speed regime for nacelle mounted jet engine nozzles. In the supersonic speed regime, the drag increment of nozzles is strongly dependent on the method used to “fair” the rear end of the aircraft, especially in the area of the variable geometry nozzle. No simple method can be given for the estimation of nozzle drag increment. The methodology used to calculate the nozzle drag coefficient is described in Section 6.2 of Reference 5.

2.5.2.25 Trim Drag

In this module, the trim drag coefficient can be calculated for a specific flight condition. The methodology used to calculate the trim drag coefficient is described in Section 4.10 of Reference 5.

2.5.2.26 Miscellaneous Drag

In this module, the miscellaneous drag coefficient can be calculated. Miscellaneous drag may consist of drag due to struts, antennas or exhaust nozzle integration, to name a few possibilities. This module can only be accessed if “Yes” is selected for “Include Miscellaneous Drag” in the

Miscellaneous dialog box. The methodology used to calculate the miscellaneous drag coefficient is described in Section 4.12 of Reference 5.

2.5.2.27 Aircraft Drag

In this module, the total drag coefficient can be calculated. The calculation consists of the summation of all previous estimated component drag coefficients.

2.5.2.28 Recalculate All

This module allows the user to recalculate all of the drag coefficients by pressing calculate once. The user can change a parameter in the input and view its effect on the drag coefficients. A drag coefficient will only be recalculated if all of its associated input is complete.

2.5.2.29 Trendline

In this module fifth order polynomial trendline equations are fit to Class II Drag Polar. This drag polar equation may be used in place of the Class I drag polar.

2.5.2.30 Plot

In the **Class II Drag** module, different drag polars can be generated. After selecting **Plot**, the following five options will be displayed:

- $C_L - C_D$ For generating drag polars for a given angle of attack range. After selection of this option the drag component selection list will be displayed. Each drag component selected in this menu will be used for generating the Class II drag polars.
- **Drag Build-Up** For generating drag polars built up of different drag components. After selection of this option, the drag component build-up list will be displayed. The selected order of the drag components in the drag build up menu will determine how the Class II drag polar will be built up.

- $C_D-\alpha$ For generating $C_D-\alpha$ curves using each component selected in this menu.
- C_L-C_L/C_D For generating C_L-C_L/C_D curves using each component selected in this menu.
- $C_L-C_L^{1/2}/C_D$ For generating $C_L-C_L^{1/2}/C_D$ curves using each component selected in this menu (For jet powered configurations).
- $C_L-C_L^3/C_D^2$ For generating $C_L-C_L^3/C_D^2$ curves using each component selected in this menu (For propeller powered configurations).

A component can be selected by clicking on the component name or the selection box to the left of the component. The lift coefficient that is plotted is dependent on which component or combination of components is selected. All selected combinations result in a Class II drag polar plot in terms of the aircraft steady state lift coefficient, with a few exceptions (see Table 2.1).

For the **Drag Build-Up** option, a number is displayed in the selection box indicating the order of plotting. The user can deselect an option by clicking on it again.

Table 2.1 Plot Lift Coefficients Based on Component Selected

Component Selected	Plot Lift Coefficient
Wing only	Clean Wing Lift Coefficient
Horizontal Tail only	Horizontal Tail Lift Coefficient
Canard only	Canard Lift Coefficient
Flap only	Clean Wing Lift Coefficient
Wing and Flap only	Clean Wing Lift Coefficient

2.5.3 Drag Distribution

This module is used for plotting the spanwise drag distribution for lifting surfaces. The methods used in this section are not valid for the supersonic speed regime. The methodology used in this section is described in Appendix E of Reference 11.

2.5.4 Critical Mach Number

This module is used for finding the critical Mach number for which a condition of $M = 1$ is first reached somewhere on the aircraft. The implementation of supercritical airfoils can be accounted for in this section. The methodology used in this section is described in Section 2.1.1 of Reference 5.

2.5.5 Wind Tunnel Drag

This module is used for the correction of wind tunnel drag on the various components. The full-scale zero-lift drag coefficients are scaled using appropriate Reynolds number and Mach number corrections. Drag polars at various control surface deflections are entered and scaled up to full-scale and can be used in Class II trim analysis.

2.6 Pitching Moment

After selecting the **Pitching Moment** module in the **Aerodynamics** main window, 13 options will be displayed which will be explained in the following sections:

- 2.6.1 **Wing** For calculation of spanwise moment distribution on the wing and the wing contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.1 **Horizontal Tail** For calculation of spanwise moment distribution on the horizontal tail and the horizontal tail contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.1 **Vertical Tail** For calculation of the vertical tail contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.1 **Canard** For calculation of spanwise moment distribution on the canard and the canard contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.1 **V-Tail** For calculation of spanwise moment distribution on the V-tail and the V-tail contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.1 **Pylon** For estimation of the pylon contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.2 **Fuselage** For estimation of the fuselage contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.2 **Nacelle** For estimation of the nacelle contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.2 **Tailboom** For estimation of the tailboom contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.2 **Store** For estimation of the store contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.2 **Float** For estimation of the float contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.2 **External Fuel Tank** For estimation of the external fuel tank contribution to aircraft zero-lift pitching moment coefficient.
- 2.6.2 **External Weapon** For estimation of the external weapon contribution to aircraft zero-lift pitching moment coefficient.

2.6.3 **Aircraft No Emp.** For estimation of the aircraft with no empennage pitching moment coefficient.

2.6.4 **Aircraft** For estimation of the aircraft pitching moment coefficients.

2.6.1 Wing, Horizontal Tail, Vertical Tail, Canard, V-Tail, Pylon Pitching Moment

After selecting the wing, horizontal tail, canard or V-tail module, two options are presented as follows:

2.6.1.1 C_{m_0} For calculation of the lifting surface zero-angle-of-attack pitching moment coefficient.

2.6.1.2 **Moment Distr.** For calculation of the aircraft pitching-moment-coefficient-due-to-angle-of-attack derivative.

The button for vertical tail or pylon goes straight into the calculation of the lifting surface zero-angle-of-attack pitching moment coefficient.

2.6.1.1 Lifting Surface Zero-Lift Pitching Moment Coefficient

The wing, horizontal tail, vertical tail, canard, V-tail and pylon moment modules all calculate the surface zero-lift pitching moment coefficient and zero angle-of-attack pitching moment coefficient for the current flight condition.

2.6.1.2 Moment Distribution

This module is unavailable for the vertical tail and pylon. For all other lifting surfaces, the spanwise moment distribution can also be plotted (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options). The methodology used to calculate the surface pitching moment coefficient is described in Section 8.2 of Reference 5.

2.6.2 Fuselage, Nacelle, Tailboom, Store, Float, External Fuel Tank and External Weapon Pitching Moment

After selecting the fuselage, nacelle, tailboom, store, float, external fuel tank or external weapon module, two options are presented as follows:

- 2.6.2.1 C_{m_0} For calculation of the body zero-angle-of-attack pitching moment coefficient.
- 2.6.2.2 C_{m_α} For calculation of the body pitching-moment-coefficient-due-to-angle-of-attack derivative.

2.6.2.1 Body Zero-Lift Pitching Moment Coefficient

This module calculates the body zero-lift pitching moment coefficient for the fuselage, nacelle, tailboom, store, float, external fuel tank and external weapon. The methodology used to calculate the body pitching moment coefficients is described in Section 8.2 of Reference 5.

2.6.2.2 Body Pitching-Moment-Coefficient-due-to-Angle-of-Attack Derivative

This module calculates the body pitching-moment-coefficient-due-to-angle-of-attack derivatives for the fuselage, nacelle, tailboom, store, float, external fuel tank and external weapon. The methodology used to calculate the body pitching moment coefficients is described in Section 8.2 of Reference 5.

2.6.3 Aircraft No Empennage Pitching Moment

In this module the aircraft minus the empennage zero-lift pitching moment coefficient is calculated from the wing-fuselage pitching moment contribution, with and without flap effects.

2.6.4 Aircraft Pitching Moment

After selecting this module, four options are presented as follows:

- | | | |
|---------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------|
| 2.6.4.1 | $C_{m\alpha}$ | For calculation of the aircraft pitching-moment-coefficient-due-to-angle-of-attack derivative. |
| 2.6.4.2 | C_{m_0} & \bar{C}_{m_0} | For calculation of the aircraft zero-angle-of-attack pitching moment coefficient. |
| 2.6.4.3 | $C_{m_{misc}}$ | For calculation of the pitching moment coefficient of any miscellaneous components not included in Part II Section 2.6. |
| 2.6.4.4 | C_{m_l} Build-up | For calculation of the aircraft pitching moment coefficient based on individual component pitching moment coefficients. |
| 2.6.4.5 | C_{m_l} given α | For calculation of the aircraft pitching moment coefficient based on a given angle of attack. |

2.6.4.1 Pitching-Moment-Coefficient due to Angle-of-Attack Derivative

This module can be used to determine the pitching-moment-coefficient-due-to-angle-of-attack derivative. This module includes power effects.

2.6.4.2 Zero-Angle-of-Attack and Zero Lift Pitching Moment Coefficients

This module can be used to determine the zero-lift pitching moment coefficient and zero-angle-of-attack pitching moment coefficients of the aircraft. Flap effects and power effects are included in this module. To account for each aircraft component, the pitching moment coefficient components are calculated separately.

2.6.4.3 Miscellaneous Pitching Moment Coefficient

This module can be used to determine the pitching moment coefficient contribution of miscellaneous components not included in the other modules. The contribution of miscellaneous components to the aircraft pitching moment coefficient is modeled by input of C_m and α in the miscellaneous components pitching moment table.

2.6.4.4 Aircraft Pitching Moment Coefficient based on Components

The C_{m_1} Build-up module determines the aircraft pitching moment coefficient based on the component zero-lift pitching moment coefficients and component lift coefficients. This module includes power effects and ground effects.

2.6.4.5 Aircraft Pitching Moment Coefficient for Given Angle of Attack

The C_m given α module determines the aircraft pitching moment coefficient based on the component pitching moment coefficient derivatives. This module includes power effects and ground effects.

2.7 Aerodynamic Center

After selecting the **Aerodynamic Center** button in the **Aerodynamics** main window, nine options will be displayed which will be explained in the following sections

- | | | |
|-------|----------------------------|----------------------------------------------------------------|
| 2.7.1 | Wing | For calculating the aerodynamic center of the wing. |
| 2.7.1 | Horizontal Tail | For calculating the aerodynamic center of the horizontal tail. |
| 2.7.1 | Vertical Tail | For calculating the aerodynamic center of the vertical tail. |
| 2.7.1 | Canard | For calculating the aerodynamic center of the canard. |
| 2.7.1 | V-Tail | For calculating the aerodynamic center of the V-tail. |
| 2.7.1 | Ventral Fin | For calculating the aerodynamic center of the ventral fin. |
| 2.7.1 | Pylon | For calculating the aerodynamic center of the pylons. |
| 2.7.2 | Fuselage | For calculating the aerodynamic shift due to the fuselage. |
| 2.7.3 | Aircraft No Empenn. | For calculating the aerodynamic center of the aircraft |
| 2.7.4 | Aircraft | For calculating the aerodynamic center of the aircraft |

2.7.1 Wing, Horizontal Tail, Vertical Tail, Canard, V-Tail, Ventral Fin, and Pylon Aerodynamic Center

The wing, horizontal tail, vertical tail, canard, V-tail, ventral fin and pylon aerodynamic center modules calculates the location of the surface aerodynamic center based on the surface geometry. The geometry used is defined in Part II Section 4. The methodology used in this section can be found in Section 8.2 of Reference 5.

2.7.2 Fuselage Aerodynamic Center Shift

When the user selects the **Fuselage** button, an input/output window appears allowing the user to calculate the aerodynamic center shift based on the fuselage geometry defined in Part II Section 4.11. The methodology used in this section can be found in Section 8.2 of Reference 5.

2.7.3 Aircraft No Empennage Aerodynamic Center

This module calculates the aerodynamic center based on lifting surface aerodynamic center locations and shift contributions of other components such as fuselage, stores, etc of the aircraft without the empennage. Power effects are included in this module.

2.7.4 Aircraft Aerodynamic Center

This module calculates the total aircraft aerodynamic center based on lifting surface aerodynamic center locations and shift contributions of other components such as fuselage, stores, etc. Power effects are included in this module.

The **Plot** button allows the user to display the aircraft aerodynamic center as well as the forward, aft, current and empty weight C.G. locations on the top and side view of the aircraft.

NOTE: The Z-location of the aircraft aerodynamic center must be defined by the user before the aircraft aerodynamics center will appear on the plot.

2.8 Dynamic Pressure Ratio

After selecting the **Lift** module in the **Aerodynamics** main window, five options will be displayed which will be explained in the following sections:

- | | |
|------------------------------|---------------------------------------------------------------------|
| 2.8.1 Wing | For calculation of the dynamic pressure ratio of the wing. |
| 2.8.1 Horizontal Tail | For calculation of the dynamic pressure ratio of a horizontal tail. |
| 2.8.1 Vertical Tail | For calculation of the dynamic pressure ratio of a vertical tail. |
| 2.8.1 Canard | For calculation of the dynamic pressure ratio of a canard. |
| 2.8.1 V-Tail | For calculation of the dynamic pressure ratio of a V-tail. |

2.8.1 Wing, Horizontal Tail, Vertical Tail, Canard and V-Tail Dynamic Pressure Ratio

This module allows the user to calculate the dynamic pressure ratio of the wing, horizontal tail, vertical tail, canard and v-tail, depending on the configuration.

2.9 Power Effects

After selecting the **Power Effects** module in the **Aerodynamics** main window, six options will be displayed:

- **Immersed Area** For calculation of the immersed area of all lifting surfaces and landing gear.
- **Lift** For calculation of the lift due to propeller effects.
- **Drag** For calculation of the drag due to propeller effects.
- **Moment** For calculation of the moment due to propeller effects.
- **Aerodynamic Center** For calculation of the shift in aerodynamic center due to propeller effects.
- **Recalculate All** For calculation of all propeller power effects.

The purpose of these modules is to determine the effects an operating engine has on the aircraft. The **Power Effects** module is only available when the “Include Power Effects” field is selected in the Flight Condition Dialog Box. The methodology used for determining Power Effects can be found in Section 8 of Reference 5 and in Reference 12.

2.9.1 Immersed Area

The Immersed Area module has the following options:

- **Wing** To determine the downwash increment due to power effects on the wing, the wing area immersed in the propeller slipstream and the aileron and elevon area immersed in the slipstream.
- **Horizontal Tail** To determine the downwash increment due to power effects on the horizontal tail, the horizontal tail area immersed in the propeller slipstream and the elevator area immersed in the slipstream.

- **Vertical Tail** To determine the downwash increment due to power effects on the vertical tail and the vertical tail area immersed in the propeller slipstream.
- **Canard** To determine the canard area immersed in the propeller slipstream and the canardvator area immersed in the slipstream.
- **V-Tail** To determine the downwash increment due to power effects on the V-Tail, the V-Tail area immersed in the propeller slipstream and the ruddervator area immersed in the slipstream.
- **Landing Gear** To determine the landing gear area immersed in the propeller slipstream.

2.10 Ground Effects

After selecting the **Ground Effects** module in the **Aerodynamics** main window, three options will be displayed which will be explained in the following sections:

- **Lift** For calculation of the ground effects on aircraft lift.
- **Moment** For calculation of the ground effects on aircraft pitching moment.
- **Vert. Tail Downwash** For calculation of the ground effects on vertical tail downwash.

This module calculates the effect of the ground on aircraft lift and pitching moment as well as calculating the effect of variation of the aircraft's height above the ground. This module is available only when the "Include Ground Effects" field is selected in the Flight Condition Dialog Box.

2.11 Deep Stall Angles

This module calculates the deep stall angles seen by the horizontal tail due to the wing.

2.12 Pitch Break

This module determines where the pitch break is stable or unstable based on Reference 5.

3. Performance Module

3.1 General Description

The purpose of the **Sizing** module in the **Performance** main window is to allow for a rapid estimation of those aircraft design parameters having a major impact on aircraft performance. Aircraft are usually required to meet performance objectives in different categories depending on the mission profile. Meeting these performance objectives normally results in the determination of a range of values for:

- Wing loading (W/S)
- Thrust loading (T/W) or power loading (W/P)
- Aircraft maximum lift coefficients ($C_{L_{max}}$, $C_{L_{max_{TO}}}$, and $C_{L_{max_L}}$).

The variables listed above are plotted in the form of a performance-matching plot. These plots depend on the type of aircraft, the applicable specification and the applicable regulations. With the help of such a plot, the combination of the highest possible wing loading and the smallest possible thrust (or highest power) loading, which meets all performance requirements, can be determined. The methodology used for performance sizing can be found in Reference 1.

The purpose of the **Analysis** module is to provide the user with Class II analysis methods for predicting the performance characteristics of an aircraft. The methodology used to analyze the performance characteristics can be found in Section 5 of Reference 6.

Use of the **Performance** module options will be described in the following sections.

3.2 Performance Main Window

After selecting the **Performance** module, the user can select from the three options displayed which will be explained in the following sections:

- | | | |
|-----|----------------------|-----------------------------------|
| 3.3 | Sizing | Class I performance sizing |
| 3.4 | Analysis | Class II performance analysis |
| 3.5 | Export To APP | Export parameters from AAA to APP |

3.3 Performance Sizing

After choosing the **Sizing** module in the **Performance** main window, seven options will be displayed which will be explained in the following sections:

- 3.3.1 **Stall Speed** For sizing to stall speed requirements.
- 3.3.2 **Take-off Distance** For sizing to take-off distance requirements.
- 3.3.3 **Climb** For sizing to climb requirements.
- 3.3.4 **Max Cruise Speed** For sizing to maximum cruise speed requirements.
- 3.3.5 **Maneuver/Turn** For sizing to maneuvering requirements.
- 3.3.6 **Landing Distance** For sizing to landing distance requirements.
- 3.3.7 **Matching Plot** For plotting the performance sizing equations.
- 3.3.7 **Max. Lift Verification** For verifying if the maximum lift is adequate for the flight condition.
- 3.3.7 **Hight Lift Device Siz.** For calculating the required high lift device size.

The user may choose to size an aircraft by using any combination (or all) of the above sizing options. Several of the performance sizing options require input only from the user, while others also provide the user with output. Once all of the inputs for the desired options have been entered and, where applicable, the output has been calculated, the user may select the **Matching Plot** option to plot the performance sizing equations. The procedures to use each performance sizing and matching plot module are presented in the following sections.

3.3.1 Stall Speed Sizing

To size the aircraft to meet stall speed requirements, the user selects the **Stall Speed** module. The input and output data for the **Stall Speed** module are for all aircraft types and specifications. The methodology used in sizing to stall speed requirements can be found in Reference 1, Section 3.1.

3.3.2 Take-Off Distance Sizing

To size the aircraft to take-off distance requirements, the user selects the **Take-off Distance** module. The methodology used in sizing to take-off distance requirements can be found in Reference 1, Section 3.2.

3.3.3 Climb Sizing

To size the aircraft to meet climb requirements, the user selects the **Climb** module. Note that the input elements, which pertain to the specification to be satisfied, contain default values. These values can still be modified by the user as needed. The drag polar parameters can be estimated in the **Class I Drag** module (See Part II Section 2.5.1). The methodology used in sizing to climb requirements can be found in Section 3.4 of Reference 1.

3.3.4 Maximum Cruise Speed Sizing

To size the aircraft to maximum cruise speed requirements, the user selects the **Max Cruise Speed** module. The methodology used in sizing to maximum cruise speed requirements can be found in Section 3.6 of Reference 1.

3.3.5 Maneuvering Sizing

To size the aircraft to meet maneuvering requirements, the user selects the **Maneuver/Turn** module. This module sizes the aircraft for both pull-up (or push-over) load factor and a specific turn rate in the level turn maneuver. The methodology used in sizing to maneuvering requirements can be found in Reference 1, Section 3.5.

3.3.6 Landing Distance Sizing

To size the aircraft to meet landing distance requirements, the user selects the **Landing Distance** option. The methodology used in sizing to landing requirements can be found in Reference 1, Section 3.3.

3.3.7 Matching Plot

After entering the data in the desired performance sizing options, the requirements can be shown in a performance-matching plot by selecting the **Matching Plot** option. When the **Matching Plot** option is selected, the system provides a list for the user to specify which performance-sizing options are to be plotted. The options can be plotted individually or in a group by selecting the desired combination of options. A check mark indicates if an option has been selected. Once the

selection has been made, the user selects the **Continue** button and an input/output window appears with matching graph input parameters. The user now specifies the desired range of take-off wing loading values by defining the minimum and maximum $(W/S)_{TO}$ limits. When the user selects **Plot**, the pre-selected performance sizing options will be graphed. With the help of such a plot, the user may determine the highest possible wing loading and the smallest possible thrust (or highest power) loading which meet the performance (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

3.3.8 Maximum Lift Verification

This module can be used to verify whether the selected high lift devices can produce the desired trimmed aircraft lift coefficient for a specific flight condition. The user needs to supply the aircraft maximum clean lift coefficient. This value will be checked against the calculated wing maximum clean lift coefficient using the two equations shown below:

$$\left| \frac{C_{L_{\max w_{clean}}} - C_{L_{\max clean}}}{f_{couple}} \right| < 0.05$$

$$C_{L_{\max clean}}$$

or

$$\frac{C_{L_{\max w_{clean}}}}{f_{couple}} > C_{L_{\max clean}}$$

Where:

$C_{L_{\max w_{clean}}}$	Maximum wing lift coefficient without flap effects
$C_{L_{\max clean}}$	Maximum aircraft lift coefficient without flap effects
f_{couple}	Coupling factor that accounts for tail down-load trim, or canard up-load trim on the wing

If neither of these equations are satisfied then a message will appear prompting the user to change the aircraft maximum clean lift coefficient input.

3.3.9 High Lift Device Sizing

This module is used for calculating the required high lift device size, the desired values of the trimmed lift coefficients can be determined from the Performance module (see Part II Section 3) or the user may estimate them. The Plot option is used to display the wing geometry including the size and location of the high lift devices. The program determines whether the take-off condition or landing condition sizes the high lift device.

3.4 Performance Analysis

After selecting the **Analysis** module in the **Performance** main window, nine options will be displayed which will be explained in the following sections:

- 3.4.1 **Thrust/Power-Speed** For defining the thrust (or power) versus speed performance curve
- 3.4.2 **Take-off Distance** For evaluating the take-off performance
- 3.4.3 **Cruise** For evaluating the cruise performance
- 3.4.4 **Maneuver** For evaluating the maneuver performance
- 3.4.5 **Landing Distance** For evaluating the landing performance
- 3.4.6 **Stall Speed** For evaluating the stall speed performance
- 3.4.7 **Climb** For evaluating the climb performance
- 3.4.8 **Dive & Descent** For evaluating the dive and descent performance
- 3.4.9 **Glide** For evaluating the maneuver performance

The use of these Class II mission performance analysis modules will be described in the following sections. Many of these modules require the use of Class I drag polar data. There are also numerous plotting options incorporated into these modules (see Part II, Section 2.5 for a description of the **Drag Polar** module)(see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

3.4.1 Thrust-Speed or Power-Speed Performance Curve

For a jet driven aircraft a **Thrust-Speed** curve can be defined. The user needs to know three points on the thrust versus speed curve, and should specify the three known points in the input section of the menu, in addition to the minimum and maximum limits of speed applicable to the curve.

For a propeller driven aircraft a **Power-Speed** curve can be defined. The user needs to know three points on the power versus speed curve, and should specify the three known points in the input section of the menu, in addition to the minimum and maximum limits of speed applicable to the curve.

3.4.2 Take-Off Distance

To run the **Take-off Distance** module, the thrust (or power) versus speed performance curve must first be defined. The take-off gear down drag polar must also be known (See Part II, Section 2.5.1). This module will give the required thrust/power, required speed and take-off distance. The methodology used in the take-off distance analysis can be found in Section 5.2 of Reference 6.

3.4.3 Cruise

To run the **Cruise** module, the thrust (or power) versus speed performance curves must first be defined. The clean configuration drag polar must also be known (See Part II, Section 2.5.1). Once the **Cruise** option has been selected, four options will be displayed which will be explained in the following sections:

3.4.3.1 Maximum Speed

3.4.3.2 Range

3.4.3.3 Endurance

3.4.3.4 Payload-Range

3.4.3.1 Maximum Cruise Speed

The **Maximum Speed** module uses iterative methods to find the maximum cruise speed. The program iterates over thrust/power and speed to solve the cruise equations of motion until the required thrust/power is equal to the available thrust/power. The maximum cruise speed is determined by locating the intersection of the thrust/power required versus speed and thrust/power available versus speed curves. If a solution is not obtained, the plotting option enables the user to quickly see the relative positions of the two curves.

3.4.3.2 Range

The methodology used in the range analysis can be found in Section 5.4 of Reference 6. Once the **Range** module has been selected, another menu appears showing the range options:

- **Constant Speed** For the range at constant speed. The angle of attack is iterated to solve the cruise equations of motion until the velocity matches user supplied input value.
- **Constant Altitude** For the range at a constant altitude. If the lift coefficient in the input group is left undefined, the lift coefficient for maximum range at constant altitude, shown in the output, will be used to determine the range.

3.4.3.3 Endurance

To run the **Endurance** module, the thrust (or power) versus speed performance curves must first be defined. The clean configuration drag polar must also be known. Once the **Endurance** option has been selected, another menu appears showing the endurance and loiter options:

- **Constant Speed** For the endurance at a constant speed. Uses same iteration methodology as **Constant Speed** in Part II Section 3.4.3.2.
- **Constant Altitude** For the endurance at constant altitude. Uses same iteration methodology as **Constant Altitude** in Part II Section 3.4.3.2.

The methodology used in the endurance analysis can be found in Section 5.5 of Reference 6.

3.4.3.4 Payload-Range Diagram

Once the **Payload-Range** module has been selected, another menu appears showing the payload-range diagram options:

- **Constant Speed** For the payload-range diagram for range at constant speed. Uses same iteration methodology as **Constant Speed** in Part II Section 3.4.3.2.

- **Constant Altitude** For the payload-range diagram for range at constant altitude. Uses same iteration methodology as **Constant Altitude** in Part II Section 3.4.3.2.

The methodology used in the payload-range diagram analysis can be found in Section 5.4 of Reference 6.

3.4.4 Maneuver

To run the **Maneuver** module, the thrust (or power) versus speed performance curves must first be defined. The clean configuration drag polar must also be known (see Part II, Section 2.5.1). Once the **Maneuver** module has been selected, another menu appears showing the maneuver options:

- **Pull-Up/Push-Over** For a pull-up or push-over maneuver.
- **Level Turn** For a level turn maneuver.

Once the **Pull-Up/Push-Over** or **Level Turn** module has been selected, another list appears showing the maneuver types:

- **Instantaneous** For an instantaneous maneuver.
- **Sustained** For a sustained maneuver.

When the maneuver option and the maneuver type have been selected, another window appears showing the Class II Maneuver input and output parameters. The methodology used in the maneuver analysis can be found in Section 5.7 of Reference 6.

When the **Plot** option is selected, a plot of the maximum load factor versus speed is generated using the input from either the instantaneous pull-up/push-over or the instantaneous level turn option (the input windows for both cases contain the same information) (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

3.4.5 Landing Distance

To run this module, the landing configuration drag polar must first be known. If the approach speed is known rather than the landing stall speed, the stall speed is left undefined and the approach

velocity is entered in the output. The methodology used in landing distance analysis can be found in Section 5.9 of Reference 6.

3.4.6 Stall Speeds

To run the **Stall Speed** module, the thrust (or power) versus speed performance curve must first be defined. Once the **Stall Speed** option has been selected, four options are displayed:

- **Take-off** For the stall speed in the take-off configuration.
- **Clean** For the stall speed in a clean configuration.
- **Landing** For the stall speed in the landing configuration.
- **Current Flight Cond.** For the current flight condition stall speed.

The **Stall Speed** module option works two ways:

1. The user inputs the thrust (power) at which the stall speed is to be determined.
2. The user leaves the thrust (power) undefined, and the performance curves are used to determine the stall speed. The performance curves should then be defined for the throttle setting in the stall maneuver.

The methodology used in the stall speed analysis can be found in Section 5.1 of Reference 6.

3.4.7 Climb

To run the **Climb** module, the thrust (or power) versus speed performance curves must first be defined. The clean configuration drag polar must also be known (see Part II, Section 2.5.1). Once the **Climb** option has been selected, another menu appears showing the climb options:

- **Climb Performance** Contains rate of climb, climb gradient, and specific excess power.
- **Time to Climb** Represents the time to climb from one altitude to another.

When either the **Climb Performance** or **Time to Climb** options have been selected, the Class II climb input/output window is displayed. The methodology used in the climb analysis can be found in Section 5.3 of Reference 6.

3.4.8 Dive & Descent

To run the **Dive & Descent** module, the thrust (or power) versus speed performance curves must first be defined. The clean configuration drag polar must also be known (see Part II, Section 2.5.1). The purpose of this module is to determine the flight path angle for a given dive speed. The angle of attack is iterated to solve the dive and descent equations of motion until the velocity matches the user supplied input data. The methodology used in the dive and descent analysis can be found in Section 5.6 of Reference 6.

When all the input parameters have been defined and the **Plot** option has been selected, two lines representing the two equations of motion for the dive condition will be shown (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options). The purpose of this is to determine the speed for a given flight path angle in dive. The velocities at the intersections of the two curves represent solutions for the desired flight path angle.

3.4.9 Glide

The **Glide** module runs assuming that no propeller or jet thrust is used during the calculation. The clean configuration drag polar must also be known. Once the **Glide** module has been selected, another menu appears showing the Class II Glide options:

- **Rate of Descent** For aircraft rate of descent at flight condition altitude.
- **Time of Glide** For aircraft time to glide at flight condition altitude.
- **Range of Glide** For aircraft range of glide at flight condition altitude.

The methodology used in the glide analysis can be found in Reference 6.

When the **Plot** option is selected, the selected parameter is plotted with respect to angle of attack. The rate of descent, time in the air, and glide range versus angle of attack plots are generated using the input from each respective input/output window (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

3.5 Export to APP

This module exports aerodynamic and other pertinent data into Aircraft Performance Program (APP) native files. These files can then be used in APP.

4. Geometry Module

4.1 General Description

The purpose of the **Geometry** module is to help the user define the geometry of the aircraft and relevant geometric parameters. This geometry includes the fuselage, lifting surfaces and any other major geometric components present on the aircraft. The methodology used to calculate the geometry of the aircraft components is described in Reference 2. Use of the **Geometry** module options will be described in the following sections.

4.2 Aircraft Geometry Categories

After selecting **Geometry** module, the user can select from the twenty-eight options displayed which will be explained in the following sections:

4.3	Wing	For calculation of the wing geometry.
4.4	Horizontal Tail	For calculation of the horizontal tail geometry.
4.5	Vertical Tail	For calculation of the vertical tail geometry.
4.6	Canard	For calculation of the canard geometry.
4.7	V-Tail	For calculation of the v-tail geometry.
4.8	Ventral Fin	For calculation of the ventral fin geometry.
4.9	Dorsal Fin	For calculation of the dorsal fin geometry.
4.10	Pylon	For calculation of the pylon geometry.
4.11	Fuselage	For calculation of the fuselage geometry.
4.11	Nacelle	For calculation of the nacelle geometry.
4.11	Inlet/Duct	For calculation of the inlet/duct geometry.
4.11	Tailboom	For calculation of the tailboom geometry.
4.11	Store	For calculation of the store geometry.
4.11	Float	For calculation of the float geometry.
4.11	Fuel Tank	For calculation of the fuel tank geometry.
4.11	Weapon	For calculation of the weapon geometry.
4.12	Landing Gear	For calculation of the landing gear geometry.
4.13	Canopy	For calculation of the canopy geometry.

- 4.14 **Propeller** For calculation of the propeller geometry.
- 4.15 **Engine** For calculation of the engine geometry.
- 4.16 **Aircraft Wetted Area** For calculation of the aircraft wetted area.
- 4.17 **Aircraft 3-View** This option can be used to output aircraft three view.
- 4.18 **Angles** This option lists all the pertinent angles.
- 4.19 **Scale/Move** This option can be used to scale an entire aircraft uniformly. Additionally, the aircraft can be translated in the X and Z direction.
- 4.20 **Export** This option can be used to output aircraft geometry that can be shared with SharkCAD Pro-AeroPack or FlightStream.
- 4.21 **Electrical Wire Rout.** This option can be used to manually layout the electrical routing.
- 4.22 **Flight Control Rout.** This option can be used to manually layout the flight control routing.
- 4.23 **Hydraulic Routing** This option can be used to manually layout the hydraulic routing.

4.3 Wing Geometry

The methodology used to calculate the wing geometry related parameters is described in Section 6 of Reference 2. The **Wing Geometry** module has nine options:

- 4.3.1 **Straight Tapered** For calculation of straight tapered wing geometry.
- 4.3.2 **Cranked** For calculation of the equivalent straight tapered wing geometry from a given cranked wing geometry based on the tip chord or mean geometric chord (MGC).
- 4.3.3 **Aileron/Elevon/Tab** For calculation of aileron and elevon geometry.
- 4.3.4 **High Lift Device** For calculation of high lift device geometry.
- 4.3.5 **Spoiler** For calculation of the spoiler parameters.
- 4.3.6 **Fuel Volume** For calculation of the volume of fuel the wing can hold
- 4.3.7 **Chord, Thickness...** For calculation of wing span-wise and chord-wise parameters.
- 4.3.8 **Airfoil** For calculation of wing airfoil parameters.
- 4.3.9 **Exposed** For calculation of exposed wing geometry.

4.3.1 Straight Tapered

The **Straight Tapered** wing geometry module has four different sets of input and output variables. Any one of these data sets can be accessed by using the appropriate menu button. After calculating

the output parameters, the user may display the wing by selecting the **Plot** option (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

4.3.2 Cranked Wing

This module can be used to calculate the equivalent straight tapered wing geometry for a cranked wing. The equivalent wing is defined as a straight tapered wing with the same net wing area as the cranked wing and with the same tip chord length or same mean geometric chord. The user can define a cranked wing by entering input data for all the panels comprising the wing. Once all input is defined, the user can calculate the equivalent straight tapered wing parameters by selection of the **Calculate** button. A plot of the cranked wing can be obtained after selection of the **Plot** option (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

The inputs for the root and tip airfoils of a wing section can be DAT or AIRFOIL files. If an AIRFOIL file is used then aerodynamic information will automatically be populated in **Aerodynamics** wing airfoil module for the wing.

4.3.3 Aileron/Elevon/Tab

In this module, the geometry of the aileron and the elevon is defined.

4.3.4 High Lift Device

In this module, the geometry of the high lift devices is defined.

4.3.5 Spoiler

In this module, the geometry of the spoiler is defined.

4.3.6 Fuel Volume

In the **Class I** module, the volume of fuel that the wing can hold is calculated. It is assumed that the volume between the front and rear spars is used as the useful fuel volume. By multiplying by the density of the fuel, the fuel weight can also be found. The program will compare this weight

to the maximum fuel weight in the fuel tank at any point in the mission to determine if this amount of fuel can be stored in the wing.

The **Class II** module calculates the allowable fuel in the wing by taking into account the following:

- Front Spar Location
- Rear Spar Location
- Inboard and Outboard Tank Stations
- Factor to account for structure
- Factor to account for fuel expansion

The **Cranked Wing** module calculates the allowable fuel in the different panels of the wing. It takes into account the following:

- Front Spar Location
- Rear Spar Location
- Inboard and Outboard Tank Stations
- Factor to account for structure
- Factor to account for fuel expansion
- Thickness ratios of the panels at their root and tip

4.3.7 Chord, Thickness, Twist, Sweep

In this module, the chord length, maximum thickness to chord ratio, local geometric twist, and the location in space of the leading edge of the wing at any span-wise location can be determined by using root chord length, taper ratio and the given span-wise location. The sweep angle of the wing at any chord-wise location can be determined by using taper ratio, the aspect ratio and the chord-wise location.

4.3.8 Airfoil

In this module, the airfoil geometric parameters at the wing mean geometric chord is calculated.

4.3.9 Exposed

In this module, the exposed wing geometry is calculated. The exposed wing is the portion of wing that is outside of the fuselage and is “exposed” to the flow.

4.4 Horizontal Tail Geometry

When the **Horizontal Tail** module is selected, the user is presented with the following options:

- 4.4.1 **Straight Tapered** For calculation of straight tapered horizontal tail geometry.
- 4.4.2 **Cranked** For calculation of the equivalent straight tapered horizontal tail geometry from given cranked horizontal tail geometry.
- 4.4.3 **Volume Coefficient** For calculation of the horizontal tail volume coefficient.
- 4.4.4 **Elevator/Tab** For calculation of the elevator geometry.
- 4.4.5 **Chord, Thickness...** For calculation horizontal tail span-wise and chord-wise parameters.
- 4.4.6 **Airfoil** For calculation of airfoil parameters at the horizontal tail mean geometric chord.
- 4.4.7 **Exposed** For calculation of exposed horizontal tail parameters.

4.4.1 Straight Tapered

The method for determining the geometry of a straight tapered horizontal tail is identical to the method found in Part II Section 4.3.1 of this manual.

4.4.2 Cranked Horizontal Tail

The method for determining the geometry of a cranked horizontal tail is identical to the method found in Part II Section 4.3.2 of this manual.

4.4.3 Volume Coefficient

This module calculates the volume coefficient of a horizontal tail planform. The methodology used to calculate the horizontal tail volume coefficient and related parameters is described in Section 8 of Reference 2. After calculating the output parameters, the user may display the

horizontal tail geometry by selecting the **Plot** option (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

4.4.4 Elevator/Tab

In this module, the geometry of the elevator is defined.

4.4.5 Chord, Thickness, Twist, Sweep

The methods used in this module are identical to the methods found in Part II Section 4.3.7 of this manual.

4.4.6 Airfoil

In this module, the horizontal tail airfoil parameters at the horizontal tail mean geometric chord are calculated.

4.4.7 Exposed

In this module, the exposed horizontal tail parameters are calculated. The exposed horizontal tail is the portion of horizontal tail that is outside of the fuselage and is “exposed” to the flow.

4.5 Vertical Tail Geometry

When the **Vertical Tail** module is selected, the user is presented with the following options:

- 4.5.1 **Straight Tapered** For calculation of straight tapered vertical tail geometry.
- 4.5.2 **Cranked** For calculation of the equivalent straight tapered vertical tail geometry from given cranked vertical tail geometry.
- 4.5.3 **Volume Coefficient** For calculation of the vertical tail volume coefficient.
- 4.5.4 **Rudder/Tab** For calculation of the rudder geometry.
- 4.5.5 **Chord, Thickness...** For calculation of vertical tail span-wise and chord-wise parameters.
- 4.5.6 **Airfoil** For calculation of airfoil parameters at the vertical tail mean geometric chord.

4.5.7 Exposed For calculation of exposed vertical tail parameters.

4.5.1 Straight Tapered

The method for determining the geometry of a straight tapered vertical tail is identical to the method found in Part II Section 4.3.1 of this manual.

4.5.2 Cranked Vertical Tail

The method for determining the geometry of a cranked vertical tail is identical to the method found in Part II Section 4.3.2 of this manual.

4.5.3 Volume Coefficient

This method for determining the volume coefficient of a vertical tail is identical to the method found in Part II Section 4.4.3 of this manual.

4.5.4 Rudder/Tab

In this module, the geometry of the rudder is defined.

4.5.5 Chord, Thickness, Twist, Sweep

The methods used in this module are identical to the methods found in Part II Section 4.3.7 of this manual.

4.5.6 Airfoil

In this module, the vertical tail airfoil parameters at the vertical tail mean geometric chord are calculated.

4.5.7 Exposed

In this module, the exposed vertical tail parameters are calculated. The exposed vertical tail is the portion of vertical tail that is outside of the fuselage and is “exposed” to the flow.

4.6 Canard Geometry

When the **Canard** module is selected, the user is presented with the following options:

- 4.6.1 **Straight Tapered** For calculation of straight tapered canard geometry.
- 4.6.2 **Cranked** For calculation of the equivalent straight tapered canard geometry from given cranked canard tail geometry.
- 4.6.3 **Volume Coefficient** For calculation of the canard volume coefficient.
- 4.6.4 **Canardvator/Tab** For calculation of the canardvator geometry.
- 4.6.5 **Chord, Thickness...** For calculation of canard span-wise and chord-wise parameters.
- 4.6.6 **Airfoil** For calculation of airfoil parameters at the canard mean geometric chord.
- 4.6.7 **Exposed** For calculation of exposed canard parameters.

4.6.1 Straight Tapered

The method for determining the geometry of a straight tapered canard is identical to the method found in Part II Section 4.3.1 of this manual.

4.6.2 Cranked Canard

The method for determining the geometry of a cranked canard is identical to the method found in Part II Section 4.3.2 of this manual.

4.6.3 Volume Coefficient

The method for determining the volume coefficient of a canard is identical to the method found in Part II Section 4.4.3 of this manual.

4.6.4 Canardvator/Tab

In this module, the geometry of the canardvator is defined.

4.6.5 Chord, Thickness, Twist, Sweep

The methods used in this module are identical to the methods found in Part II Section 4.3.7 of this manual.

4.6.6 Airfoil

In this module, the canard airfoil parameters at the canard mean geometric chord are calculated.

4.6.7 Exposed

In this module, the exposed canard parameters are calculated. The exposed canard is the portion of canard that is outside of the fuselage and is “exposed” to the flow.

4.7 V-Tail Geometry

When the **V-Tail** module is selected, the user is presented with the following options:

- 4.7.1 **Straight Tapered** For calculation of straight tapered V-tail geometry.
- 4.7.2 **Cranked** For calculation of the equivalent straight tapered V-tail geometry from given cranked V-tail tail geometry.
- 4.7.3 **Volume Coefficient** For calculation of the V-tail volume coefficient.
- 4.7.4 **Ruddervator/Tab** For calculation of the ruddervator geometry.
- 4.7.5 **Chord, Thickness...** For calculation of V-tail span-wise and chord-wise parameters.
- 4.7.6 **Airfoil** For calculation of airfoil parameters at the V-tail mean geometric chord.
- 4.7.7 **Exposed** For calculation of exposed V-tail parameters.

4.7.1 Straight Tapered

The method for determining the geometry of a straight tapered V-tail is identical to the method found in Part II Section 4.3.1 of this manual.

4.7.2 Cranked V-Tail

The method for determining the geometry of a cranked V-tail is identical to the method found in Part II Section 4.3.2 of this manual.

4.7.3 Volume Coefficient

The method for determining the volume coefficient of a V-tail is identical to the method found in Part II Section 4.4.3 of this manual.

4.7.4 Ruddervator/Tab

In this module, the geometry of the ruddervator is defined.

4.7.5 Chord, Thickness, Twist, Tab

The methods used in this module are identical to the methods found in Part II Section 4.4.7 of this manual.

4.7.6 Airfoil

In this module, the V-tail airfoil parameters at the v-tail mean geometric chord are calculated.

4.7.7 Exposed

In this module, the exposed V-tail parameters are calculated. The exposed V-tail is the portion of V-tail that is outside of the fuselage and is “exposed” to the flow.

4.8 Ventral Fin Geometry

In this module, the ventral fin geometry is defined.

4.9 Dorsal Fin Geometry

In this module, the dorsal fin geometry is defined.

4.10 Pylon Geometry

In this module, the pylon geometry is defined.

4.11 Fuselage, Nacelle, Inlet/Duct, Tailboom, Store, Float, Fuel Tank, Weapon Geometry

The **Fuselage, Nacelle, Inlet/Duct, Tailboom, Store, Float, Fuel Tank** or **Weapon** are all considered **bodies**. When either one of the body modules is selected, the user is presented with the following options:

- 4.7.1 **Simplified Body** For calculation of the body geometry using a simplified cylinder model.
- 4.7.2 **Detailed Body** For calculation of the body geometry using detailed cross-sections.

Where **body** is replaced by the respective body name.

4.11.1 Simplified Body

In case the user does not have data on the cross-sections of a detailed body geometry, the **Simplified Body** module can be used. This approximates any body as a cylinder with Von Karman Ogive curves defining the nose and tail sections. The user can specify the diameter and the length of the nose and tail sections.

4.11.2 Detailed Body

The methodology used to calculate the body geometry and body related parameters is based on the fuselage geometry methods described in Section 4 of Reference 2. The user has to input the body cross-section data. After calculating the output parameters, the user may display the body geometry by selecting the **Plot** option.

4.12 Landing Gear Geometry

In this module, the landing gear geometry is defined. Using this geometry, the lateral angle between the aircraft center of gravity and the landing gear is determined. This angle is useful in determining the risk of lateral tip-over on the ground. It also calculates the angle between the critical gear ground contact angle and the empty weight center of gravity and the current aircraft center of gravity (see Part II Section 1.5.2). This angle is useful in determining the risk of longitudinal tip-over on the ground.

4.13 Canopy Geometry

In this module, the canopy geometry is defined.

4.14 Propeller Geometry

In this module, the propeller geometry is defined.

4.15 Engine

In this module, the engine location and orientation is defined.

4.16 Aircraft Wetted Area

In this module, the total aircraft wetted area is calculated.

4.17 Aircraft 3-View

This option is used to display the front, side and top view of the aircraft. After selecting the **Airplane 3-View** option, the following options are displayed:

- **Wing**
- **Horizontal Tail**
- **Vertical Tail**
- **Canard**
- **V-Tail**
- **Ventral Fin**
- **Dorsal Fin**
- **Pylon**
- **Fuselage**
- **Nacelle**
- **Inlet/Duct**
- **Tailboom**
- **Store**
- **Float**
- **Fuel Tank**
- **Weapon**
- **Landing Gear**
- **Canopy**
- **Propeller**
- **High Lift Device**
- **Aileron**
- **Elevon**
- **Elevator**
- **Rudder**
- **Canardvator**
- **Ruddervator**
- **Spoiler**
- **Speed Brake**

The components that have been completely defined in the **Geometry** module can be selected for exporting.

4.18 Angles

This option presents all the pertinent angles used in the analysis. These angles include the angle of attack, sideslip angle, lifting surface incidence angles, control surface deflection angles and high lift device deflection angles.

4.19 Scale/Move

This option is used to uniformly scale an aircraft component or the entire aircraft using an input scale factor. There is also the option to move the location of aircraft components in 3-Dimensional space. This feature is useful when analyzing a scale model, such as a wind tunnel model.

4.20 Export

When the **Export** module is selected, the user is presented with the following two options:

- | | |
|----------------------------|--------------------------------------------------------------------------------------------------|
| 4.20.1 AeroPack | For exporting the body geometry as a .geo file that can be imported into SharkCAD Pro-AeroPack. |
| 4.20.2 FlightStream | For exporting the body geometry as a .csv file that can be imported as a mesh into FlightStream. |

This module can be used to export 3-Dimensional geometric data to the AeroPack drafting program (Reference 13) or the surface vorticity flow solver FlightStream (Reference 14). After selecting either of the two options, the following options are displayed:

- **Wing**
- **Horizontal Tail**
- **Vertical Tail**
- **Canard**
- **V-Tail**
- **Ventral Fin**
- **Dorsal Fin**
- **Pylon**
- **Fuselage**
- **Nacelle**

- **Inlet/Duct**
- **Tailboom**
- **Store**
- **Float**
- **Fuel Tank**
- **Weapon**
- **Landing Gear**
- **Canopy**
- **Propeller**
- **High Lift Device**
- **Aileron**
- **Elevon**
- **Elevator**
- **Rudder**
- **Canardvator**
- **Ruddervator**
- **Spoiler**
- **Speed Brake**

The components that have been completely defined in the **Geometry** module can be selected for exporting.

4.20.1 Exporting to SharkCAD Pro-AeroPack

After selecting the **Export AeroPack** option, a dialog is displayed which allows the user to save the exported data as a .geo file. Specify the folder and file name, and click 'OK' to save the file. The file can then be imported into SharkCAD Pro-AeroPack. See the SharkCAD Pro-AeroPack manual for import instructions.

4.20.2 Exporting to FlightStream

After selecting the **Export FlightStream** option, a module opens where the user can specify specific mesh settings for each lifting surface, body and the fuselage. These can be left empty, in which case default settings will be used. After hitting the **Calculate** button, a dialog is displayed which allows the user to save the exported data as a Component Cross Section Geometry File Format file

with a .csv extension. Specify the folder and file name, and click 'OK' to save the file. The file can then be imported into FlightStream. See the **Mesh** section of the FlightStream manual for import instructions and details on the Component Cross Section Geometry File Format.

4.21 Electrical Wire Routing

In this module, the electrical wire routing length can be manually defined as an input, or a layout of the routing can be supplied by selecting the **Plot** button. This layout is done on a 3-view of the aircraft.

4.22 Flight Control Routing

In this module, the flight control routing length can be manually defined as an input, or a layout of the routing can be supplied by selecting the **Plot** button. This layout is done on a 3-view of the aircraft.

4.23 Hydraulic Routing

In this module, the hydraulic routing length can be manually defined as an input, or a layout of the routing can be supplied by selecting the **Plot** button. This layout is done on a 3-view of the aircraft.

5. Propulsion Module

5.1 General Description

In this module the installed power/thrust of aircraft can be calculated. In addition to the installed power/thrust estimation, this module also provides options for:

- Inlet and nozzle sizing
- Estimation of inlet pressure recovery
- Propeller Power and Thrust
- Jet Engine Thrust

Calculations in this module are based on the methodologies outlined in Section 6 of Reference 5. Use of the **Propulsion** module options will be described in the following sections.

The assumption will be made that the following uninstalled propulsion characteristics are known:

- Piston Engines Shaft horsepower data for a specific flight condition.
- Turboprop Engines Shaft horsepower and thrust data for a specific flight condition.
- Propfan Engines Shaft horsepower and thrust data for a specific flight condition.
- Jet Engines Thrust data and engine mass flow data for a specific flight condition.
- Propeller Driven Aircraft Power coefficient and propeller efficiency or thrust coefficient for a specific flight condition.

5.2 Type of Propulsion

Before the **Propulsion** module can be accessed, some basic parameters must be defined. The user is required to specify the type of engine from the Engine dialog box. The options are as follows:

- Jet Engine For jet engine driven aircraft
- Piston Engine For piston engine driven aircraft

- Propfan Engine For propfan engine driven aircraft
- Turboprop Engine For turboprop engine driven aircraft
- Electric Engine For electric engine driven aircraft

In the case of a Jet Engine, a flight condition must be specified to define the type of jet from the following options:

- Subsonic Jet
- Supersonic Jet

5.3 Propulsion Main Window

After selecting the **Propulsion** module, the user can select from the seven options displayed which will be explained in the following sections:

- 5.4 **Power Extraction** Calculate power extraction and power extraction requirements
- 5.5 **Inlet Design** Calculate inlet related parameters
- 5.6 **Nozzle Design** Calculate nozzle related parameters
- 5.7 **Engine** Calculate engine performance
- 5.8 **Propeller** Calculate propeller performance
- 5.9 **Thrust from Drag** Calculate available power or thrust from drag
- 5.10 **Thrust Forces & Mo.** Calculate moments caused by thrust

5.4 Power Extraction

In this module, the user can define and calculate the quantity of the total extracted power. This quantity is needed for installed thrust or installed power estimation. The next menu displays the following options:

- **Mechanical** For estimation of extracted mechanical power. The user should prepare a list of those systems, which require mechanical power (i.e., fuel pumps, hydraulic pumps, etc.).
- **Electrical** For estimation of extracted electrical power. To determine electrical power requirements, the user should prepare an "Electrical Power Load Profile" as described in Section 7.2 in Reference 7.

- **Pneumatic** For estimation of extracted pneumatic power (This option will not be offered for a piston engine selection). A list of aircraft services that require bleed air as the source of power must be prepared.
- **Total** For estimation of the power required for mechanical, electrical and pneumatic operation of the aircraft.

5.5 Inlet Design

The purpose of the **Inlet Design** module is to estimate the streamtube cross-section at the inlet, the inlet pressure recovery, and the inlet extra drag. The methods used in this section are determined by what type of inlet, plenum or straight through, was defined in the Inlets/Ducts dialog box (see Part I Section 2.2.3.4). After selecting **Inlet Design**, the following options will be displayed:

- **Inlet Area** To calculate the required inlet area.
- **Pressure Loss** To calculate the pressure loss in the inlet. Before selecting **Pressure Loss**, the inlet type must be specified in the inlet/duct dialog box as follows:
- **Manifold Pressure** To calculate the manifold pressure.

NOTE: The definitions of the inlet geometric parameters depending on engine and inlet choice are shown in Section 6.2 of Reference 5.

5.6 Nozzle Design

In this module, some nozzle design objectives are provided. After selecting **Nozzle Design**, the exhaust exit area window appears, asking for take-off shaft horsepower.

5.7 Engine

After selecting the **Engine** module, the following options will be displayed:

- **Jet Engine** To calculate jet thrust-related stability derivatives.
- **Installed Data** To calculate the installed performance of the jet propulsion system. This requires uninstalled engine performance data.

5.8 Propeller

After selecting the **Propeller** module, the following options will be displayed:

- **Efficiency Charts** To determine uninstalled propeller performance based on a provided propeller map file.
- **Installed Data** To calculate the installed performance of the propeller propulsion system. This requires uninstalled engine and propeller performance data.

5.9 Thrust from Drag

In this module, the power or thrust required to balance the drag of the aircraft is estimated for the current flight condition. The drag from Class II Drag is used in this section (see Part II Section 2.5.2).

5.10 Thrust Forces and Moments

In this module, the propeller and jet thrust forces and moments are estimated for the current flight condition. Moments due to a windmilling or stopped engine/propeller are also determined.

6. Stability and Control Module

6.1 General Description

The purpose of the **Stability & Control** module is to compute the non-dimensional aerodynamic steady state coefficients, stability and control derivatives and hingemoment derivatives for an aircraft in a given flight condition. Using these coefficient and derivatives modules can help the user rapidly determine whether a proposed aircraft configuration will have satisfactory stability and control characteristics. The **Stability & Control** module also allows the user to calculate the required horizontal tail, canard, V-tail and vertical tail surface area needed to satisfy user defined stability and control characteristics.

The mathematical equations used to compute stability and control derivatives can be found in Reference 5.

6.2 Stability & Control Main Window

After selecting the **Stability & Control** module, the user can choose from nine options displayed which will be explained in the following sections:

- 6.3 **Steady State** For calculating aircraft steady state coefficients
- 6.4 **Derivatives** For calculating aircraft stability and control derivatives and hingemoment derivatives
- 6.5 **Longitudinal Stability** For evaluating aircraft longitudinal stability
- 6.6 **Longitudinal Trim** For determining the aircraft longitudinal trim values
- 6.7 **Directional Stability** For evaluating aircraft directional stability
- 6.8 **Lateral-Direct. Trim** For determining the aircraft lateral-directional trim values
- 6.9 **Control Forces/Hinge.** For calculating the control forces and hingemoments
- 6.10 **Wind Tunnel** For estimation of all longitudinal and lateral-directional stability, longitudinal and lateral-directional control derivatives and aerodynamic center based on wind tunnel data.
- 6.11 **Angular Rates** For estimation of angular rates and bank angle during a level turn or symmetric pull-up.

6.12 **6 DOF Coefficients** For calculating all coefficients and derivatives required for a six-degrees-of-freedom simulator.

6.3 Steady State

This module is used to find aircraft steady state coefficients. The methodology used to calculate the steady state coefficients can be found in Section 10.1 of Reference 5 and Section 3 of Reference 8. After selecting the **Steady State** module, the following options will be displayed:

- **Drag** This module is used to estimate the aircraft steady state drag coefficient C_{D1} .
- **Lift** This module is used to estimate the aircraft steady state lift coefficient C_{L1} .
- **Pitching Moment** This module is used to estimate the aircraft steady state moment coefficient C_{m1} .
- **Thrust** This module is used to estimate the aircraft steady state thrust coefficients. This is further explained in Section 6.3.1
- **Sideforce** This module is used to estimate the aircraft steady state sideforce coefficient C_{y1} .
- **Rolling Moment** This module is used to estimate the aircraft steady state rolling moment coefficient C_{l1} .
- **Yawing Moment** This module is used to estimate the aircraft steady state yawing moment coefficient C_{n1} .

6.3.1 Thrust

This module is used to find the steady state thrust coefficients. After selecting the **Thrust** module, the following options will be displayed:

- C_{xT1} Calculate aircraft steady state X-force coefficient due to thrust force
- C_{yT1} Calculate aircraft steady state Sideforce coefficient due to thrust force
- C_{zT1} Calculate aircraft steady state Z-force coefficient due to thrust force
- C_{lT1} Calculate aircraft steady state rolling moment coefficient due to thrust force

- C_{nT_1} Calculate aircraft steady state yawing moment coefficient due to thrust force
- C_{LT_1} Calculate aircraft steady state lift coefficient due to thrust force
- C_{mT_1} Calculate aircraft steady state pitching moment coefficient due to thrust force
- C_{LN_1} Calculate aircraft steady state lift coefficient due to normal force
- C_{xN_1} Calculate aircraft steady state X-force coefficient due to normal force
- C_{mN_1} Calculate aircraft steady state pitching moment coefficient due to normal force
- C_{lIE} Calculate change in aircraft rolling moment coefficient due to inoperative windmilling or stopped engine/propeller
- C_{mIE} Calculate change in aircraft pitching moment coefficient due to inoperative windmilling or stopped engine/propeller
- C_{nIE} Calculate change in aircraft yawing moment coefficient due to inoperative windmilling or stopped engine/propeller
- $\Delta C_{L_{power}}$ Calculate change in aircraft lift coefficient due to thrust and power effects
- $\Delta C_{m_{power}}$ Calculate change in aircraft pitching moment coefficient due to thrust and power effects

If the aircraft configuration features both an engine with a propeller or ducted fan and a jet engine then these modules will have new sub-options when selected. For all of the thrust force and inoperative engine modules there will be a submodule for the propeller/ducted fan contribution, a submodule for the jet engine contribution and a submodule for the total value. For the normal force modules there will be a submodule for the propeller contribution, a submodule for the engine/ducted fan contribution and a submodule for the total value. For the last two modules in the list, there is no change.

6.4 Derivatives

This module is used to find the aircraft derivatives. After selecting the **Derivatives** module, the following options will be displayed:

6.4.1 **Longitudinal Stability** For estimation of the longitudinal stability derivatives.

6.4.2 **Lateral-Direc. Stability** For estimation of the lateral-directional derivatives.

- 6.4.3 **Longitudinal Control** For estimation of the longitudinal control derivatives.
- 6.4.4 **Lateral Control** For estimation of the lateral control derivatives.
- 6.4.5 **Directional Control** For estimation of directional control derivatives.
- 6.4.6 **Hingement** For estimation of hingement derivatives.
- 6.4.7 **Recalculate All** For recalculation of all derivative outputs in the **Derivatives** module

6.4.1 Longitudinal Stability Derivatives

The methodology used to calculate the longitudinal stability derivatives can be found in Section 10.2 of Reference 5. After selecting the **Longitudinal Stability** module, the following options will be displayed:

- **Speed** This module is used to estimate the aircraft drag, lift, pitching moment, thrust and thrust pitching moment coefficients due to speed derivatives C_{D_u} , C_{L_u} , C_{m_u} , C_{xT_u} and C_{mT_u} respectively.
- **Angle of Attack** This module is used to estimate the aircraft drag, lift, pitching moment and thrust coefficients due to angle of attack derivatives C_{D_α} , C_{L_α} , C_{m_α} , C_{mT_α} , C_{mN_α} , $\Delta(dC_m/dC_L)_T$, $\Delta(dC_m/dC_L)_N$ and $\Delta(dC_m/dC_L)_{TN}$ respectively.
- **Angle of Attack Rate** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to angle of attack rate derivatives $C_{D_{\dot{\alpha}}}$, $C_{L_{\dot{\alpha}}}$ and $C_{m_{\dot{\alpha}}}$ respectively.
- **Pitch Rate** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to pitch rate derivatives C_{D_q} , C_{L_q} and C_{m_q} respectively.

For the derivatives C_{xT_u} , C_{mT_u} and C_{mT_α} if the aircraft configuration features both an engine with a propeller and a jet engine then these modules will be further broken down into the contributions of the propeller thrust, jet thrust and the total coefficient due to thrust.

6.4.2 Lateral-Directional Stability Derivatives

The methodology used to calculate the lateral-directional stability derivatives can be found in Section 10.2 of Reference 5. After selecting the **Lateral-Directional Stability** module, the following options will be displayed.

- **Sideslip** This module is used to estimate the aircraft sideforce, rolling moment, yawing moment, thrust sideforce and thrust yawing moment coefficients due to sideslip derivatives $C_{y\beta}$, $C_{l\beta}$, $C_{n\beta}$, $C_{yT\beta}$ and $C_{nT\beta}$ respectively.
- **Sideslip Rate** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to sideslip rate derivatives $C_{y\dot{\beta}}$, $C_{l\dot{\beta}}$ and $C_{n\dot{\beta}}$ respectively.
- **Roll Rate** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to roll rate derivatives C_{yp} , C_{lp} and C_{np} respectively.
- **Yaw Rate** This module is used to estimate the aircraft sideforce, rolling moment, and yawing moment coefficients due to yaw rate derivatives C_{yr} , C_{lr} and C_{nr} respectively.

For the derivatives $C_{yT\beta}$ and $C_{nT\beta}$ if the aircraft configuration features both an engine with a propeller and a jet engine then these modules will be further broken down into the contributions of the propeller thrust, jet thrust and the total coefficient due to thrust.

6.4.3 Longitudinal Control Derivatives

The methodology used to calculate the longitudinal control derivatives can be found in Section 10.3 of Reference 5. After selecting the **Longitudinal Control Derivatives** module, the following options will be displayed:

- **Stabilizer** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to horizontal stabilizer incidence derivatives C_{Di_h} , C_{Li_h} and C_{mi_h} respectively.

- **Elevator** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to elevator deflection derivatives $C_{D\delta_e}$, $C_{L\delta_e}$ and $C_{m\delta_e}$ respectively.
- **Elevator Tab** This module is used to estimate the aircraft lift and pitching moment coefficients due to elevator trim tab deflection derivatives $C_{L\delta_{et}}$ and $C_{m\delta_{et}}$ respectively.
- **Canard** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to canard incidence derivatives C_{Di_c} , C_{Li_c} and C_{mi_c} respectively.
- **Canardvator** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to canardvator deflection derivatives $C_{D_{cv}}$, $C_{L_{cv}}$ and $C_{m_{cv}}$ respectively.
- **Canardvator Tab** This module is used to estimate the aircraft lift and pitching moment coefficients due to canardvator trim tab deflection derivatives $C_{D_{cvt}}$, $C_{L_{cvt}}$ and $C_{m_{cvt}}$ respectively.
- **V-Tail** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to V-tail incidence derivatives $C_{Di_{vee}}$, $C_{Li_{vee}}$ and $C_{mi_{vee}}$ respectively.
- **Ruddervator** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to ruddervator deflection derivatives $C_{D\delta_{rv}}$, $C_{L\delta_{rv}}$ and $C_{m\delta_{rv}}$ respectively.
- **Ruddervator Tab** This module is used to estimate the aircraft lift and pitching moment coefficients due to ruddervator trim tab deflection derivatives $C_{D\delta_{rvt}}$, $C_{L\delta_{rvt}}$ and $C_{m\delta_{rvt}}$ respectively.
- **Flying Wing** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to angle of attack derivatives $C_{D\alpha}$, $C_{L\alpha}$ and $C_{m\alpha}$ respectively.
- **Elevon** This module is used to estimate the aircraft drag, lift and pitching moment coefficients due to elevon deflection derivatives $C_{D\delta_{el}}$, $C_{L\delta_{el}}$ and $C_{m\delta_{el}}$ respectively.

- **Elevon Tab** This module is used to estimate the aircraft lift and pitching moment coefficients due to elevon trim tab deflection derivatives $C_{D\delta_{elt}}$, $C_{L\delta_{elt}}$ and $C_{m\delta_{elt}}$ respectively.

NOTE: The flying wing derivatives due to wing incidence are the same as the angle of attack derivatives. That is why derivatives due to angle of attack are shown for the **Flying Wing** module.

6.4.4 Lateral Control Derivatives

The methodology used to calculate the lateral control derivatives can be found in Section 10.3 of Reference 5. After selecting the **Lateral Control Derivatives** module, the following options will be displayed:

- **Aileron** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to aileron deflection derivatives $C_{y\delta_a}$, $C_{l\delta_a}$ and $C_{n\delta_a}$ respectively.
- **Aileron Tab** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to aileron trim tab deflection derivatives $C_{y\delta_{at}}$, $C_{l\delta_{at}}$ and $C_{n\delta_{at}}$ respectively.
- **Elevon** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to elevon deflection derivatives $C_{y\delta_{el}}$, $C_{l\delta_{el}}$ and $C_{n\delta_{el}}$ respectively.
- **Elevon Tab** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to elevon trim tab deflection derivatives $C_{y\delta_{elt}}$, $C_{l\delta_{elt}}$ and $C_{n\delta_{elt}}$ respectively.
- **Spoiler** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to spoiler deflection derivatives $C_{y\delta_{sp}}$, $C_{l\delta_{sp}}$ and $C_{n\delta_{sp}}$ respectively.
- **Differential Stabilizer** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to differential stabilizer incidence derivatives $C_{y\delta_h}$, $C_{l\delta_h}$ and $C_{n\delta_h}$ respectively.

- **Differential Canard** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to differential canard incidence derivatives $C_{y\delta_c}$, $C_{l\delta_c}$ and $C_{n\delta_c}$ respectively.

6.4.5 Directional Control Derivatives

The methodology used to calculate the directional control derivatives can be found in Section 10.3 of Reference 5. After selecting the **Directional Control Derivatives** module, the following options will be displayed:

- **Vertical Tail** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to vertical tail incidence derivatives C_{yi_v} , C_{li_v} and C_{ni_v} respectively.
- **Rudder** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to rudder deflection derivatives $C_{y\delta_r}$, $C_{l\delta_r}$ and $C_{n\delta_r}$ respectively.
- **Rudder Tab** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to rudder trim tab deflection $C_{y\delta_{rt}}$, $C_{l\delta_{rt}}$ and $C_{n\delta_{rt}}$ respectively.
- **V-Tail** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to V-tail incidence derivatives $C_{yi_{vee}}$, $C_{li_{vee}}$ and $C_{ni_{vee}}$ respectively.
- **Ruddervator** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to ruddervator deflection derivatives $C_{y\delta_{rv}}$, $C_{l\delta_{rv}}$ and $C_{n\delta_{rv}}$ respectively.
- **Ruddervator Tab** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to ruddervator trim tab deflection derivatives $C_{y\delta_{rvt}}$, $C_{l\delta_{rvt}}$ and $C_{n\delta_{rvt}}$ respectively.
- **Drag Rudder** This module is used to estimate the aircraft sideforce, rolling moment and yawing moment coefficients due to drag rudder deflection derivatives $C_{y\delta_{dr}}$, $C_{l\delta_{dr}}$ and $C_{n\delta_{dr}}$ respectively.

6.4.6 Hingemoment Derivatives

The methodology used to calculate the longitudinal control derivatives can be found in Section 10.4 of Reference 5. After selecting the **Hingemoments Derivatives** module, the following options will be displayed:

- **Elevator** This module is used to estimate the aircraft elevator hingemoment coefficient due to elevator deflection derivative $C_{h\delta_e}$.
- **Elevator Tab** This module is used to estimate the aircraft elevator hingemoment coefficient due to elevator trim tab deflection derivative $C_{h\delta_{et}}$.
- **Rudder** This module is used to estimate the aircraft rudder hingemoment coefficient due to rudder deflection derivative $C_{h\delta_r}$.
- **Rudder Tab** This module is used to estimate the aircraft rudder hingemoment coefficient due to rudder trim tab deflection derivative $C_{h\delta_{rt}}$.
- **Aileron** This module is used to estimate the aircraft aileron hingemoment coefficient due to aileron deflection derivative $C_{h\delta_a}$.
- **Aileron Tab** This module is used to estimate the aircraft aileron hingemoment coefficient due to aileron trim tab deflection derivative $C_{h\delta_{at}}$.
- **Canardvator** This module is used to estimate the aircraft canardvator hingemoment coefficient due to canardvator deflection derivative $C_{h\delta_{cv}}$.
- **Canardvator Tab** This module is used to estimate the aircraft canardvator hingemoment coefficient due to canardvator trim tab deflection derivative $C_{h\delta_{cvt}}$.
- **Ruddervator** This module is used to estimate the aircraft ruddervator hingemoment coefficient due to ruddervator deflection derivative $C_{h\delta_{rv}}$.
- **Ruddervator Tab** This module is used to estimate the aircraft ruddervator hingemoment coefficient due to ruddervator trim tab deflection derivative $C_{h\delta_{rvt}}$.
- **Elevon** This module is used to estimate the aircraft elevon hingemoment coefficient due to elevon deflection derivative $C_{h\delta_{el}}$.

- **Elevon Tab** This module is used to estimate the aircraft elevon hingemoment coefficient due to elevon trim tab deflection derivative $C_{h\delta_{elt}}$.
- **Trailing Edge Flap** This module is used to estimate the flap hingemoment coefficient due to wing angle of attack and flap deflection derivative $C_{h\delta}$. The methods in this module are only applicable to plain flaps, drooped ailerons and drooped elevons.

6.4.7 Recalculate All

This module allows the user to recalculate all of the stability and control steady state coefficients and derivatives by pressing calculate once. The user can change a parameter in the input and view its effect on the stability and control derivatives. A stability or control derivative will only be recalculated if all of its associated inputs are defined.

6.5 Longitudinal Stability

This module is used to find and quantify the longitudinal stability of the aircraft including the static margin (SM) of the aircraft. After selecting the **Longitudinal Stability** module, the following options will be displayed:

- 6.5.1 **Surface Area Sizing** Size the area of the horizontal tail, canard or V-tail
- 6.5.2 **Stick Fixed SM** Calculate the stick fixed static margin of the aircraft
- 6.5.2 **Stick Free SM** Calculate the stick free static margin of the aircraft
- 6.5.3 **Wing Location** Evaluate the impact of wing location on the aircraft

6.5.1 Surface Area Sizing

The methodology used to evaluate surface area sizing of the horizontal tail, canard or V-tail can be found in Reference 2 and 11. After selecting **Surface Area Sizing** module, the following options will be displayed:

- **Volume Method** Represents the sizing method based on volume coefficients. The user has two options: **Quarter Chord**, which sizes the lifting surface

based on its position in reference to the wing, or **A.C. – C.G.**, which sizes the lifting surface based on its aerodynamic center.

- **Inherent** Represents inherent stability, which is required of all aircraft that do not rely on a feedback augmentation system for their stability.
- **De Facto** Represents de facto stability, which is required of all aircraft that are stable only with a feedback augmentation system in place. If the static margin is greater than the required static margin, no feedback augmentation system is required and the feedback gain in this condition will be set to zero.

6.5.2 Stick Fixed and Stick Free Static Margin

The **Stick Fixed Static Margin** module calculates the static margin of the aircraft while the pilot is holding the control column at a fixed position. The **Stick Free Static Margin** module calculates the static margin of the aircraft while the pilot is not holding the control column. The methodology used in these sections can be found in Reference 2 and 8.

6.5.3 Wing Location

The **Wing Location** module calculates the impact of the wing location on the aircraft center of gravity, aerodynamic center, static margin and critical gear contact point.

6.6 Longitudinal Trim

This module is used to find and quantify the longitudinal trim of the aircraft. After selecting the **Longitudinal Trim** module, the following options will be displayed:

- 6.6.1 C_L, α given W, U_1 Calculate the aircraft lift coefficient and angle of attack for a given weight and speed
- 6.6.2 C_L given W, U_1 Calculate the aircraft lift coefficient for a given weight and speed at a particular angle of attack
- 6.6.3 **Trim Diagram** Plot the trim diagram of the aircraft at the current flight condition
- 6.6.4 **Matrix Method** Trim the aircraft according to two control variables solving relevant trim equations simultaneously

- 6.6.5 **Take-off Rotation** Calculate the horizontal tail, canard or V-tail area required for take-off rotation
- 6.6.6 **Trimmed Lift (T from D)** Trim the aircraft for the current flight condition find thrust from drag
- 6.6.7 **Trimmed Lift (T=Const)** Trim the aircraft for the current flight condition keeping thrust constant

6.6.1 C_L, α given W, U_1

This module calculates the aircraft lift coefficient and angle of attack for a given weight and speed. It does not guarantee the aircraft is in trimmed or level flight.

6.6.2 C_L given W, U_1

This module calculates the aircraft lift coefficient for a given weight and speed by solving the lift equation. It does not pose any requirements on trim or angle of attack.

6.6.3 Trim Diagram

The **Trim Diagram** module is used to determine the trim characteristics of an aircraft. The methodology used to generate the trim diagram can be found in Section 4 of Reference 8, and Section 8.3 of Reference 5.

In the Flight Condition dialog box the user has to select the “Drag Polar” module and “Lift Curve” to be used for the trim diagram (see Part I Section 2.2.1). It is not possible to generate a trim diagram without defining all input data. The input window is different for each aircraft configuration and moving surface combination.

When all the input parameters are defined, the trim diagram can be displayed by selecting the **Plot** button. The plot may be altered using the conventional plot control buttons (see Part I Section 2.1.4 and Section 2.1.5).

6.6.4 Matrix Method for Longitudinal Trim

After selecting the **Matrix Method** module the user must select the first and second control variables to be used before selecting **Continue**. The possible selection of control variables is dependent on aircraft configuration. The procedure used in this module considers the coupling between the lift, pitching moment and stick-force equations by solving them simultaneously using a matrix method approach. The methodology used in this section is described in Section 4.7 of Reference 8.

6.6.5 Take-off Rotation

The **Take-off Rotation** module can be used to determine the horizontal tail, canard, or V-tail area and lift coefficient required for take-off rotation based on landing gear and center of gravity locations as well as pitch attitude acceleration requirements. It is recommended to turn on ground effects before using this module (see Part I Section 2.2.1). The methodology used in this section is described in Section 4.7 of Reference 8.

6.6.6 Trimmed Lift (T from D)

This module is used for the determination of the aircraft trimmed lift coefficients, angle of attack and control surface deflections calculated using thrust required based on drag. The module iterates through a series of other modules to converge to a solution.

6.6.7 Trimmed Lift (T=Const)

This module is used for the determination of the aircraft trimmed lift coefficients, angle of attack and control surface deflections calculated using a constant value for thrust. This module allows the user to quickly determine the trimmed condition of the aircraft as it does not use iterative methods.

6.7 Directional Stability

The methodology used to evaluate surface area sizing of the vertical tail or V-tail can be found in Reference 2 and 11. After selecting **Directional Stability** module, the following directional surface area sizing options will be displayed:

- **Volume Method** Represents the sizing method based on volume coefficients. The user has two options: **Quarter Chord**, which sizes the lifting surface based on its position in reference to the wing, or **A.C. – C.G.**, which sizes the lifting surface based on its aerodynamic center.
- **Inherent** Represents inherent stability, which is required of all aircraft that do not rely on a feedback augmentation system for their stability.
- **De Facto** Represents de facto stability, which is required of all aircraft that are stable only with a feedback augmentation system in place. If the static margin is greater than the required static margin, no feedback augmentation system is required and the feedback gain in this condition will be set to zero.

6.8 Lateral-Directional Trim

This module is used to find and quantify the lateral-directional trim of the aircraft. After selecting the **Lateral-Directional Trim** module the following options will be displayed:

- 6.8.1 **Matrix Method** Trim the aircraft according to three control variables solving the relevant trim equations simultaneously.
- 6.8.2 **Straight Line Flight Trim** Trim the aircraft using straight line equations of motion

6.8.1 Matrix Method for Lateral-Directional Trim

After selecting the **Matrix Method** module the user must select the first, second and third control variables to be used before selecting **Continue**. The possible selection of control variables is dependent on aircraft configuration. If the aircraft lateral-directional control surfaces do not have trim tabs this will reduce the number of variables the user must select. For each lateral-directional control surface lacking a trim tab the number of variables the user needs to select is reduced by one. The procedure used in this module considers the coupling between the sideforce, rolling moment, yawing moment, aileron stick or wheel force and rudder pedal force equations by solving them simultaneously using a matrix method approach. The methodology used in this section is described in Section 4.8 of Reference 8.

6.8.2 Straight Line Flight Trim

This module is used for the determination of the aircraft lateral-directional trimmed life coefficients, sideslip angle and control surface deflections using lateral-directional steady state, straight line equations of motion.

6.9 Control Forces/Hingemoments

This module is used to find the control forces required by the pilot and the hingemoments experienced by the control surfaces. After selecting the **Control Forces/Hingemoments** module the following options will be displayed:

- | | | |
|-------|-----------------------------|----------------------------------------------------------------------------|
| 6.9.1 | Stick Force | Calculate the stick forces of the aircraft |
| 6.9.2 | Pedal Force | Calculate the pedal forces of the aircraft |
| 6.9.3 | Aileron/Elevon Force | Calculate the aileron/elevon stick or wheel force |
| 6.9.4 | Long. Hingemoments | Determine the hingemoment about the longitudinal control surface hingeline |
| 6.9.5 | Dir. Hingemoments | Determine the hingemoment about the directional control surface hingeline |
| 6.9.6 | Aileron Hingemoments | Determine the hingemoment about the aileron control surface hingeline |

6.9.1 Stick Force

This module is used for calculating stick forces and related parameters. The methodology used in this module can be found in Section 4.2 Reference 8. After selecting the **Stick Force** module the following options will be displayed:

- **Stick Force** This module is used to estimate the longitudinal and control stick force for given control surface and trim tab deflections.
- **Stick Force Trim** This module is used to estimate the longitudinal control surface trim tab deflection required to set longitudinal control stick force to zero for a given control surface deflection.

- **Pitching Moment & ...** This module is used to trim the aircraft using the methods in Part II Section 6.6.6 while calculating trim tab deflection required to set longitudinal control stick force to zero.
- **Stick Force Gradients** This module is used to estimate the longitudinal stick force versus speed and load factor gradients.
- **Pitching Moment Trim** This module is used to trim the aircraft using the methods in Part II Section 6.6.6 while accounting for trim tab deflection. Stick Force versus Velocity can be plotted here.

6.9.2 Pedal Force

This module is used to determine the lateral-directional pedal force and the rudder or ruddervator pedal force versus sideslip angle. The methodology used in this section is described in Section 4.8 of Reference 8.

6.9.3 Aileron/Elevon Force

This module is used to determine the aileron or elevon stick (or wheel) force. The methodology used in this section is described in Section 4.8 of Reference 8.

6.9.4 Longitudinal Hingemoments

This module is used to determine the hingemoment about the longitudinal control surface hingeline.

6.9.5 Directional Hingemoments

This module is used to determine the hingemoment about the directional control surface hingeline.

6.9.6 Aileron Hingemoments

This module is used to determine the hingemoment about the aileron hingeline.

6.10 Wind Tunnel

This module is used for calculating aircraft steady state and derivative coefficients using wind tunnel data as inputs. After selecting the **Wind Tunnel** module the following options will be displayed:

- **Longitudinal** This module allows the calculation of longitudinal stability and control derivatives using wind tunnel data as inputs.
- **Lateral-Directional** This module allows the calculation of lateral-directional stability and control derivatives using wind tunnel data as inputs.
- **Aerodynamic Center** This module calculates the aerodynamic center of the wind tunnel model using wind tunnel data and AAA calculated wind tunnel stability and control derivatives as inputs.

6.11 Angular Rates

This module is used to calculate the steady state pitch rate, steady state yaw rate and bank angle for the current flight condition.

6.12 6 DOF Coefficients

This module will calculate all coefficients and derivatives required for a six-degrees-of-freedom simulator for a given flight condition.

7. Dynamics Module

7.1 General Description

The purpose of the **Dynamics** module is to help the user analyze the open loop dynamic characteristics of the aircraft in a given flight condition, and to help the user analyze single and double loop feedback control systems of the aircraft. If the open loop dynamic characteristics of the aircraft are known, the **Control** analysis module can be used to perform root locus analyses. The **Control** analysis can also be used to analyze a system open loop transfer function in the frequency domain. The methodology used to analyze open loop dynamic characteristics can be found in Reference 8. The methodology used to analyze feedback control systems can be found in Reference 9.

Use of the **Dynamics** module options will be described in the following sections.

7.2 Dynamics Main Window

After selecting the **Dynamics** module, the user can choose from two options displayed which will be explained in the following sections:

- 7.3 **Dynamics** For analyzing the aircraft open loop dynamic characteristics for a given flight condition.
- 7.4 **Control** For analyzing feedback control systems.

7.3 Dynamics

After selecting the **Dynamics** module the following options will be displayed:

- 7.3.1 **Longitudinal** For estimation of the longitudinal dynamic characteristics.
- 7.3.2 **Lateral-Direction** For estimation of the lateral-directional dynamic characteristics.
- 7.3.3 **Roll Coupling** For the roll-pitch yaw coupling effect of the dynamic analysis.

7.3.1 Longitudinal Dynamics

After selecting the **Longitudinal** module the following options will be displayed:

- 7.3.1.1 **Transfer Function** For transfer function computation.
- 7.3.1.2 **Flying Qualities** For evaluating flying qualities
- 7.3.1.3 **Sensitivity** For longitudinal derivative sensitivity analysis

7.3.1.1 Transfer Function – Longitudinal

Transfer Function is used to calculate the longitudinal characteristic equations, associated modes (including frequencies and damping ratios) and the associated transfer functions. After choosing **Transfer Function**, the user is presented with the following options:

- **Stabilizer** For calculating the stabilizer open loop transfer function.
- **Elevator** For calculating the elevator open loop transfer function.
- **Canard** For calculating the canard open loop transfer function.
- **Canardvator** For calculating the canardvator open loop transfer function.
- **V-Tail** For calculating the v-tail open loop transfer function.
- **Ruddervator** For calculating the ruddervator open loop transfer function.
- **Elevon** For calculating the elevon open loop transfer function.
- **None** For calculating the aircraft modes without a longitudinal control surface.

NOTE: The corresponding control surface must be defined by the user in the Control Surfaces Configuration dialog box before the dynamic analysis can be conducted (see Part I Section 2.2.2.2).

After the **Calculate** button is selected, the longitudinal transfer function output parameters will be displayed, and the transfer function will be shown in dialog boxes. When certain output variables such as time constants, damping ratios or frequencies cannot be calculated, the program leaves a blank in the appropriate output box. The transfer functions will be redisplayed when selecting the **Calculate** option. These transfer functions can be printed either directly from the dialog box or by selecting the **Print Parameters** options in the Print Setup dialog box (see Part I Section 2.2.6.5).

NOTE: If “Do not display this message” has been checked for any of the transfer function pop-up windows and the user wishes to re-enable the pop-up window access the Program Options dialog box and check the box next to “Show All Messages” (see Part I Section 2.2.6.7).

7.3.1.2 Flying Qualities – Longitudinal

Flying Qualities performs a check on the calculated longitudinal modes against the relevant regulations. The flying qualities of the aircraft are compared with the flying qualities as specified in the regulations chosen by the user in the Certification and Type dialog box. Where no specifications are available for 14 CFR part 23 or 14 CFR part 25, MIL-F-8785C specifications are used. If the user chooses MIL-Specs as the certification, one of the following options must be chosen:

- Land Based For land based aircraft
- Carrier Based For aircraft carrier based aircraft
- Land & Carrier Based For land and carrier based aircraft

After selecting the aircraft certification type, the flight phase category must be defined in the Flight Condition Definition dialog box. The user has the following options:

- Flight Phase A Non-terminal flight phases that require rapid maneuvering, precision tracking or precise flight-path control.
- Flight Phase B Non-terminal flight phases that are normally accomplished using gradual maneuvers and without precision tracking, although accurate flight-path control may be required.
- Flight Phase C Terminal flight phases that are normally accomplished using gradual maneuvers and usually require accurate flight-path control.

The user also needs to define the aircraft class from the following options in the Classification dialog box:

- Class I Small, light aircraft
- Class II Medium weight, low-to-medium maneuverability aircraft
- Class III Large, heavy, low-to-medium maneuverability aircraft

- Class IV High-maneuverability aircraft

Once the aircraft certification type, aircraft flight phase and aircraft class have been selected, the input/output window for the longitudinal mode checking is displayed. In this module the user can compare the phugoid and short period mode with flying qualities as specified in MIL-F-8785C. After the input is defined, the output group will be filled. The output group displays data for the selected flight phase category. Information concerning that parameter and specifications can be accessed by selecting **Help** for a variable (see Part I Section 6.2).

Once the longitudinal mode checking has been performed, the user can get a plot of the short period frequency requirements as specified in MIL-F-8785C by selecting the **Plot** button. A description of the standard plot options can be found in Sections 2.1.4 and 2.1.5 of Part I of this user's manual. The short period frequency characteristic of the current aircraft configuration is also plotted.

7.3.1.3 Sensitivity – Longitudinal

The **Sensitivity** option provides the capability to perform a sensitivity analysis for all longitudinal derivatives, weight and inertia parameters. The resulting sensitivity graphs show how different modes of an aircraft may vary if one of the derivatives, weight or inertia parameters is varied.

Once the user has selected one of the sensitivity analysis options, an input window will appear asking the user to define the lower and upper limit of the variable to be investigated. The sensitivity plot is displayed after these limits are defined and the **Plot** option is selected (see Part I Section 2.1.4 for plot options).

7.3.2 Lateral-Directional Dynamics

After selecting the **Longitudinal** module the following options will be displayed:

- 7.3.2.1 **Transfer Function** For transfer function computation.
- 7.3.2.2 **Flying Qualities** For evaluating flying qualities
- 7.3.2.3 **Sensitivity** For lateral-directional derivative sensitivity analysis

7.3.2.1 Transfer Function – Lateral-Directional

Transfer Function is used to calculate the lateral-directional characteristic equations, associated modes (including frequencies and damping ratios) and the associated transfer functions. After choosing **Transfer Function**, the user is presented with the following options:

- **Aileron** For calculating the aileron open loop transfer function.
- **Spoiler** For calculating the spoiler open loop transfer function.
- **Vertical Tail** For calculating the vertical tail open loop transfer function.
- **Rudder** For calculating the rudder open loop transfer function.
- **V-Tail** For calculating the v-tail open loop transfer function.
- **Ruddervator** For calculating the ruddervator open loop transfer function.
- **Differential Stabilizer** For calculating the differential stabilizer open loop transfer function.
- **Elevon** For calculating the elevon open loop transfer function.
- **Differential Canard** For calculating the differential canard open loop transfer function.
- **Drag Rudder** For calculating the drag rudder open loop transfer function.
- **None** For calculating the aircraft modes without a lateral-directional control surface.

NOTE: The corresponding control surface must be defined by the user in the Control Surfaces Configuration dialog box before the dynamic analysis can be conducted (see Part I Section 2.2.2.2).

After all input parameters are defined and the **Calculate** option is selected, the lateral-directional transfer function output parameters will be displayed, and the transfer function will be shown in dialog boxes. When certain output variables such as time constants, damping ratios or frequencies cannot be calculated, the program leaves a blank in the appropriate output box. The transfer functions will be redisplayed when selecting the **Calculate** option. These transfer functions can be printed either directly from the dialog box or by selecting the **Print Parameters** options in the Print Setup dialog box (see Part I Section 2.2.6.5).

NOTE: If the “Do not display this message” has been checked for any of the transfer function pop-up windows and the user wishes to re-enable the pop-up window the Program Options dialog box is used “Show All Messages” option must be checked (see Part I Section 2.2.6.7).

7.3.2.2 Flying Qualities – Lateral Directional

Before invoking the **Flying Qualities** option, the user must select the aircraft certification category in the Certification and Type dialog box for which the flying qualities of the aircraft configuration are to be checked. For FAR 23 certified aircraft, the FAR 23.157 regulations are used for roll mode checking and MIL-F-8785C regulations are used for spiral and Dutch roll mode checking. Because the FAR 25 regulations do not have lateral-directional flying quality requirements, the MIL-F-8785C for land-based aircraft are used for FAR 25 certified aircraft. In case of a MIL-F-8785C certified aircraft, the user selects the aircraft base:

- Land Based For land based aircraft
- Carrier Based For aircraft carrier based aircraft
- Land & Carrier Based For land and carrier based aircraft

The user also needs to define the aircraft class from the following options in the Classification dialog box:

- Class I Small, light aircraft
- Class II Medium weight, low-to-medium maneuverability aircraft
- Class III Large, heavy, low-to-medium maneuverability aircraft
- Class IV High-maneuverability aircraft (only for MIL-F-8785C)

After selecting the aircraft category, the flight phase category must be defined in the flight condition dialog box. The user has the following options:

- Flight Phase A Plot the requirements for non-terminal flight phases that require rapid maneuvering, precision tracking or precise flight-path control.
- Flight Phase B Plot the requirements for non-terminal flight phases that are normally accomplished using gradual maneuvers and without precision tracking, although accurate flight-path control may be required.
- Flight Phase C Plot the requirements for terminal flight phases that are normally accomplished using gradual maneuvers and usually require accurate flight-path control.

Once the aircraft certification category has been completely defined, the user can choose from the following two options:

- **Roll Performance** Examine the flying qualities of the roll performance of the aircraft.
- **Spiral, Dutch Roll** Examine the flying qualities of the spiral and Dutch roll performance of the aircraft. The user can plot the Dutch roll frequency and damping ratio requirements as specified in MIL-F-8785C in this module as well.

7.3.2.3 Sensitivity – Lateral-Directional

The **Sensitivity** option provides the capability to perform a sensitivity analysis for all lateral-directional derivatives, weight and inertia parameters. The resulting sensitivity graphs show how different modes of an aircraft may vary if one of the derivatives, weight or inertia parameters is varied.

Once the user has selected one of the sensitivity analysis options, an input window will appear asking the user to define the lower and upper limit of the variable to be investigated. The sensitivity plot is displayed after these limits are defined and the **Plot** option is selected (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

7.3.3 Roll Coupling

The purpose of the roll rate-coupling module is to analyze the roll-pitch-yaw coupling effect. This allows the designer to determine whether or not the aircraft will be stable during steady roll, and to adjust the level of longitudinal and/or lateral-directional stability if needed. Once the **Roll Coupling** option is selected, an input/output window appears showing the roll-pitch-yaw coupling parameters. This option is used to calculate the parameters associated with the critical roll rate. After the **Calculate** option has been selected, the user may see a roll rate-coupling plot by selecting the **Plot** option. The range of the variable to be investigated may be entered in the input parameter list. The plot displays the current configuration along with symbols marking the points of steady state roll rate, yaw divergence and pitch divergence.

7.4 Control

After selecting the **Control** module the following options will be displayed:

- 7.4.1 **Root Locus (s)** For analysis of a single and double loop feedback control system.
- 7.4.2 **Bode Method** For development of an aircraft frequency response Bode plot.
- 7.4.3 **Human Pilot** For estimation of a human pilot transfer function.
- 7.4.4 **Time Delay** For estimation of a time delay transfer function.
- 7.4.5 **Erase T.F.** For erasing one or all of the calculated transfer functions.

7.4.1 Root Locus (s) S-Plane Analysis

Using the **Root Locus (s)** module, the user can generate a root locus plot in the S-plane, for continuous systems. After selecting the module the following options will be displayed:

- 7.4.1.1 **Single Loop** For single loop feedback control systems.
- 7.4.1.1 **Double Loop K:fwp** For double loop control systems with the inner loop gain in the forward path.
- 7.4.1.1 **Double Loop K:fbp** For double loop control systems with the inner loop gain in the feedback path.
- 7.4.1.2 **Gyro Tilt** To analyze the gyro tilt angle effect.

7.4.1.1 Single and Double Loop S-Plane Analysis

After selecting a single or double control loop analysis and defining all required transfer functions (see Sections 7.3.1.1 and 7.3.2.1), the **Plot Open Loop** button is selected to calculate the root locus of the control loop. An input/output window will be displayed in which the lower and upper limit for the system gain, the lower and upper limit for damping ratio lines, the lower and upper limit for natural frequency arcs, the number of gain points, the number of damping ratio lines, the number of natural frequency arcs and the design gain can be specified. In a double loop control system, the user is also asked to define the inner loop gain. If the user only wishes to see the root locus plot for a range of system gains, the design gain, damping ratio lower and upper limits and natural frequency upper and lower limits may be left undefined. If the design gain is defined it is

displayed in the root locus plot. After selection of the Plot option, the root locus plot is displayed (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

7.4.1.2 Gyro Tilt S-Plane Analysis

An important consideration in the analysis of single loop control systems is the study of gyro tilt angle effect. This study is essential in the design of yaw dampers. After selecting the **Gyro Tilt** module, the gyro tilt angle analysis window appears. This new window consists of six separate transfer function (T.F.) boxes in addition to the **Plot Open Loop** button. The required transfer functions must be defined by methods described in Sections 7.3.1.1 and 7.3.2.1.

It should be noted that there are additional constraints when defining transfer functions in the Gyro Tilt module, which are described below:

1. For gyro tilt analysis, the inner loop is not a feedback loop. To analyze the gyro tilt effect, the yaw rate and roll rate transfer functions must be defined in the inner loop.
2. In addition, the yaw-rate-to-rudder transfer function must be defined in T.F. box 5 and the roll-rate-to-rudder transfer function must be defined in T.F. box 7 according to **Gyro Tilt** analysis theory (see Section 13.1.1.2 of Reference 9).
3. Yaw-rate-to-rudder and roll-rate-to-rudder are not part of the standard aircraft transfer functions and must be defined using the **User Defined** option (see Sections 7.3.1.1 and 7.3.2.1 in Part II of the user's manual).

After all the required transfer functions have been defined, the **Plot Open Loop** button is selected to calculate the root locus of the control loop. A new input menu will appear on the screen, asking the user to specify the steady state angle of attack plus the angle between the gyro sensitive axis and the Z-axis of the body system, ($\alpha + a_r$). In addition, the user is asked to define the lower and upper limits for the system gain, damping ratio and natural frequency, the number of gain, damping ratio and natural frequency points, and the design gain. If desired, the design gain, number of damping ratio points and number of natural frequency points may be left undefined. After selection of the **Plot** option, the root locus figure will be displayed (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

7.4.2 Bode Method

The function of the Bode analysis module is to develop a frequency response of an aircraft in the form of a Bode plot. On a Bode plot, the frequency is plotted as the logarithm of frequency and the amplitude is plotted as twenty times the logarithm of the amplitude ratio, or decibels (see Section 11.4 of Reference 9). After selecting the **Bode Method** option, the single feedback loop control system window appears. This new window consists of eight separate transfer function (T.F.) boxes in addition to the **Plot Open Loop** button. After all the required transfer functions have been defined, the **Plot Open Loop** button is selected to calculate the open loop dynamic characteristics of the control system. After the user defines a frequency range, the **Plot** button is used to generate the Bode plot (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

7.4.3 Human Pilot

The **Human Pilot** module can be used to estimate a human pilot transfer function for use in the open loop control system analysis. The **Human Pilot** module can be used to model pilots of differing abilities, reaction times and physical fitness. This module can even be used to show the dangers of a drunken pilot in the loop. The methodology used to analyze a human pilot transfer function can be found in Section 10 of Reference 9.

7.4.4 Time Delay

The Time Delay calculation can be used to account for time delays and bus transmission delays due to flight control computer systems.

7.4.5 Erase T.F.

The user should be aware that the program database is structured so that the transfer functions, which are loaded into the T.F. boxes, will be passed from one control analysis option to another. That is, if the user has defined transfer functions in T.F. boxes 1 and 3 in the single loop root locus option, these same transfer functions will remain in T.F. boxes 1 and 3 should the user quit the single loop option and execute the double loop, gyro tilt analysis, or Bode method option. This saves the user from having to define these same transfer functions again should the need arise to use another root locus option. If the user does not wish to pass the transfer functions defined in

one control system to another, the **Erase T. F.** button may be used. This option initializes all the user-defined transfer functions to a unity transfer function.

In addition to using the **Erase T. F.** button, the transfer function can also be deleted by right clicking on each T.F. box and selecting **Erase T.F.**

8. Loads Module

8.1 General Description

The purpose of this module is to estimate loads placed on aircraft components and to determine important information for structural design and sizing. The **Loads** module consists of three modules: **V-n Diagram**, **Structural Loads** and **Lateral Gust Loads**. The purpose of the **V-n Diagram** module is to determine load factors and their corresponding speeds. These methods are based on Section 4.2 of Reference 3. The purpose of the **Structural Loads** module is to calculate the internal forces and moments in the structural components of an aircraft. Use of the **Loads** module options will be described in the following sections.

8.2 Loads Main Window

After selecting the **Loads** module, the user can choose from three options displayed which will be explained in the following sections:

- 8.3 **V-n Diagram** In this module, velocity vs. load factor (V-n) diagrams can be constructed for the following types of aircraft: FAR 23 certified, FAR 25 certified and MIL-A-8861 (ASG) certified aircraft (Reference 15).
- 8.4 **Structural** In this module the total internal loads for each structural component can be calculated in any combination that the user desires.
- 8.5 **Lateral Gust Loads** In this module the lateral gust loads for different speeds is calculated.

8.3 V-n Diagram

Before entering **V-n Diagram** module, the user must choose one of three certification options from the Certification and Type dialog box. The options are as follows:

- **FAR 23** V-n diagrams can be constructed for FAR 23 certified aircraft. After selecting FAR 23 in the certification dialog box, a selection between the following FAR 23 aircraft categories.
- **FAR 25** V-n diagrams can be constructed for FAR 25 certified aircraft.
- **MIL Specs** V-n diagrams can be constructed for military certified aircraft according to the MIL-8861 (ASG) regulations (Reference 12).

The V-n diagram output parameters are generated after all input data are provided and the **Calculate** option is selected. Once the V-n diagram input and output parameters are defined in the V-n Input window, the user can use the **Plot** option (see Part I Sections 2.1.4 and 2.1.5 for an explanation of plot options).

8.4 Structural Loads

After selecting the **Structural** module the following options will be displayed:

- 8.4.1 **Wing** For estimation of the structural loads on the wing.
- 8.4.1 **Horizontal Tail** For estimation of the structural loads on the horizontal tail.
- 8.4.1 **Vertical Tail** For estimation of the structural loads on the vertical tail.
- 8.4.1 **Canard** For estimation of the structural loads on the canard.
- 8.4.1 **V-Tail** For estimation of the structural loads on the V-tail.
- 8.4.1 **Fuselage** For estimation of the structural loads on the fuselage.
- 8.4.2 **Load Factors** For estimation of the accelerations and rates acting on the aircraft.

8.4.1 Wing, Horizontal Tail, Vertical Tail, Canard, V-Tail, Fuselage

After selecting the **Wing, Horizontal Tail, Vertical Tail, Canard, V-Tail or Fuselage** module the following options will be displayed:

- 8.4.1.1 **Concent. Weights** For calculation of loads due to a mass placed at one concentrated point on the structural component
- 8.4.1.2 **Distributed Weights** For calculation of loads due to a mass that is distributed over the structural component

- 8.4.1.3 **Aerodynamic** For calculation of the aerodynamic loads acting on a structural component. Used for the **Wing, Horizontal Tail, Vertical Tail, Canard and V-Tail** modules.
- 8.4.1.4 **User Loads** For calculation of user specified loads acting on a structural component. Used for only the **Fuselage** module.
- 8.4.1.5 **Load Stations** For calculation of the load stations used for each structural component.
- 8.4.1.6 **Gear/Engine/Misc** For calculation of the loads that result from landing gear, engine or miscellaneous reactions.
- 8.4.1.7 **Total Internal** For calculation of the total internal loads acting on the structural component.

8.4.1.1 Concentrated Weights

The **Concentrated Weights** module is used to define the weight and location of masses acting at concentrated positions on a structural component. When **Concentrated Weights** is selected the following options will appear:

- **Add Component** This option is used to define weight components other than those found in the weight and balance tables of the **Class II** weight module (see Part II Section 1.5). The number of new objects is chosen, and then the name, weight and center of gravity positions can be entered for each mass.
- **Select Component** This option is used to select components to be used as a concentrated weight to act on the structural component. The dialog box contains all of the weight items used in the Class II weight and balance (see Part II Section 1.5). Components that are defined using the **Add Component** option) can be found in the “User Defined” category.
- **Copy Table** This option is used to copy a concentrated weight table from another flight condition. A list of all of the flight conditions will be displayed. By choosing one of the flight conditions, all of the items in the “Current Selection” list from that flight condition will replace all of those in the current flight condition.
- **Concentrated Weights** This option is used to show a list of the selected concentrated weights and the corresponding center of gravity locations. If the

weight and center of gravity data have not already been entered into the **Center of Gravity** module in **Weight** (see Part II Section 1.5) then they should be entered here. This data will be used to calculate the internal loads due to concentrated weights in the **Total Internal** loads module.

8.4.1.2 Distributed Weights

The **Distributed Weights** module is used to define the location and weight of masses that are distributed over the structural component. When **Distributed Weights** is selected the following options will appear:

- **Add Component** This option is used to define weight components other than those found in the weight and balance tables of the Class II **Weight** module (see Part II Section 1.5). The number of new objects is chosen, and then the name, weight and center of gravity positions can be entered for each mass.
- **Select Component** This option is used to select components to be used as a distributed weight to act on the structural component. The dialog box contains all of the weight items used in the Class II weight and balance (see Part II Section 1.5). Components that are defined using the **Add Component** option) can be found in the “User Defined” category.
- **Copy Table** This option is used to copy a distributed weight table from another flight condition. A list of all of the flight conditions will be displayed. By choosing one of the flight conditions, all of the items in the “Current Selection” list from that flight condition will replace all of those in the current flight condition.
- **Distributed Weights** This option is provided to calculate and display the distributed weights from masses chosen in the **Select Component** option. There are two choices in this section. First option is and this option uses the defined Class II weight and distributes it over the structural component to result in the specified center of gravity. Second option is which uses the defined beginning and ending locations and a components weight per unit length. The program assumes the

weight per unit length varies linearly over the length of the component.

For the **Distributed Weights** module the fuselage distributed weights are assumed to be located along the centerline. When the **Calculate** button is selected, the program will check the input of the distributed weight. The program checks whether the distributed weight input is defined completely and logically. If there are any errors, the program will display a message indicating what the error is. The program will check both **Distributed Weights** options. The distributed weights table is flight condition dependent, and will be reset for each new flight condition. The internal loads generated by each of the distributed weights selected can be calculated in the **Total Internal** loads module using the data contained in the distributed weights table.

8.4.1.3 Aerodynamic

Any aerodynamic, control surface, flap, or user defined loads acting on structural components can be defined in the **Aerodynamic** module for the wing, horizontal tail, vertical tail, canard or V-tail. The following options are available when selected:

- **Steady State** The steady state aerodynamic loads acting on each lifting surface are defined separately as lift, drag, and pitching moment. They can be defined in the **Lift** module, **Drag** module, and the **Moment** modules (Part II, Sections 2.3, 2.5 and 2.6).
- **Control/Flap Defl.** Control surface and flap deflection loads can be defined as changes in the surface coefficients or as dimensional forces and moments. The **Coefficients** module is used to define the change in coefficients of the surface created by the control surface deflection. It is also used to calculate dimensional loads from the coefficients. The **Forces** module and **Moments** module can be used to directly define the dimensional loads created by a control surface deflection.
- **Concentrated** The **Concentrated** module can be used to define any loads acting on lifting surfaces as pure concentrated forces or moments. These forces and moments may be defined in terms of changes in the coefficients of the surface in the **Concentrated Coefficients**. Forces may be defined in the **Concentrated Forces** module. Moments may be defined in the **Concentrated Moments** module.

- **Distributed** The **Distributed** module can be used to define any loads acting on lifting surfaces as pure distributed forces or moments. These forces and moments may be defined in terms of changes in the coefficients of the surface in the **Distributed Coefficients**. Forces may be defined in the **Distributed Forces** module. Moments may be defined in the **Distributed Moments** module.

8.4.1.4 User Loads

For the fuselage, user defined loads can be defined in the **User Loads** module. The following options are available when selected:

- **Concentrated** The **Concentrated** module can be used to define any loads acting on the fuselage as pure concentrated forces or moments. Forces may be defined in the **Concentrated Forces** module. Moments may be defined in the **Concentrated Moments** module.
- **Distributed** The **Distributed** module can be used to define any loads acting on the fuselage as pure distributed forces or moments. Forces may be defined in the **Distributed Forces** module. Moments may be defined in the **Distributed Moments** module.

8.4.1.5 Load Stations

Before the **Total Internal** loads module may be accessed, the load stations of the structural component must be defined. The **Load Stations** module simply divides the span of the surface (or length of the fuselage) into equal segments. The location of each load station is displayed in the load station table. All load stations are defined in the weight and balance axis system. For horizontal surfaces (including a V-tail), the load station locations are defined in the Y-direction to represent spanwise locations. Vertical tail load stations are defined in the Z-direction to represent spanwise locations. Fuselage load stations are defined along the length of the fuselage in the X-direction. The number of load stations may be selected in the input parameter list, with a maximum of 21 load stations. The location of each load station may be changed in the load station table, with the exception of the first. The location of the first load station must be zero, and the location of the last load station may not be larger than the span of the surface (or length of the fuselage). All other loads stations must be in sequential order.

8.4.1.6 Gear/Engine/Misc

The **Gear/Engine/Misc** module can be used to define any landing gear reactions, engine thrust forces, or miscellaneous loads not defined elsewhere. These reactions can be specified outside of the structural component. These are similar to the **Concentrated Forces** and **Concentrated Moments** defined in the **User Loads** and **Aerodynamic Loads** modules. The structural component onto which each **Gear/Engine/Misc** load acts must be chosen. The locations of these loads are defined by coordinates in the weight and balance axis system. This module is flight condition dependent and will be reset for each flight condition.

8.4.1.7 Total Internal

The **Total Internal** loads module calculates all forces and moments acting on the structural component at each of the load stations defined in the **Load Stations** module. All external loads selected to act on the structural component must be defined in the **Concentrated Weights**, **Distributed Weights**, **Aerodynamic**, **User Loads** or **Gear/Engine/Misc** loads modules. **Total Internal** loads must have already been calculated for all surfaces for which surface reactions have been selected. The internal loads are calculated in the Libove Coordinate System. Horizontal surfaces are split into right and left halves. The **Total Internal** loads table is flight condition dependent, and will be reset for each new flight condition.

8.4.2 Load Factors

The accelerations acting on the aircraft structure are found by solving the aircraft equations of motion. The kinematic and force equations in the aircraft stability axis system are solved for the aircraft linear accelerations, angular rates, and angular accelerations in the body fixed axis system. By solving the angular rate and angular acceleration equations first, the force equations can then be solved for the linear accelerations. This module must be completed before **Total Internal** loads can be calculated for any structural component.

8.5 Lateral Gust Loads

The lateral gust loads for the current flight condition according to FAR 23.443 are calculated in this section.

9. Structures Module

9.1 General Description

The purpose of this module is to estimate the size and weight of the structural components. This is done using material properties and the results of the calculation of the **Total Internal** loads for the component (see Part II Section 8.4.1.7). Use of the **Structures** module will be described in the following sections.

9.2 Structures Main Window

After selecting the **Structures** module, the user can choose from two options which will be explained in the following sections:

- 9.3 **User Materials** In this module, material properties that are not listed in the “Available Materials” table may be added and have their characteristics defined.
- 9.4 **Class I** In this module the weight and size of a structural component can be estimated.

9.3 User Materials

The **User Materials** module is used to add material and their properties to be used in Class I structures. The material properties that can be defined are list below:

- σ_{tu} the material ultimate tensile stress
- τ_u the material ultimate shear stress
- σ_{yt} the material tensile yield stress
- σ_{yc} the material compressive yield stress
- ρ_{mat} the material density

These materials will be added to the “User Defined” category of the “Available Materials” table.

9.4 Class I

This module is used to calculate the size and weight of a structural component to withstand the loads calculated in the **Loads** module based on the characteristics of the materials used. Before these calculations can be done the component must be defined in the Aircraft Configuration dialog box (Part I Section 2.2.2.1), the **Total Internal** loads must be calculated and the structure of the lifting surfaces must be defined.

The structure for the fuselage does not need to be defined and the structure for a lifting surface is defined in the Structure dialog box (Part I Section 2.2.2.4), which has the following options:

- Single-Spar Semimonocoque
- Two-Spar Semimonocoque
- Two-Spar Drag Truss
- Single-Spar Box
- Single-Spar Circular
- Three-Spar

When a structural component is selected, the following options will become available:

- **Comp. Materials** To select the materials used for different parts of the component. The “Component Material Properties” must be defined before **Weight Estimate** can be performed. When the Material Name column is selected for a section of a component, the “Available Materials” table dialog is displayed.
- **Section Properties** To calculate the effective width and height of the structure at each load station by entering spar and surface locations. The effective width and height are calculated differently for the different types of structures. For the fuselage, the structure type must be defined at each load station.
- **Weight Estimate** To size the component structure to the loads calculated in the **Loads** module (see Part II Section 8). The **Class I** method calculates an effective width and effective height of the structure at each load station and sizes the structural materials to withstand the loads.

10. Cost Module

10.1 General Description

The purpose of this module is to estimate various costs of aircraft design programs. The estimation methods are presented in such a manner that they can be applied to civil and military aircraft of all types. The various cost definitions and cost estimation methods used for this module are as discussed in Sections 1 through 7 of Reference 10. Use of the **Cost** module options will be described in the following sections.

10.2 Cost Main Window

After selecting the **Cost** module, the user can choose from seven options displayed which will be explained in the following sections.

- | | | |
|------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10.3 | AMPR Weight | For estimation of the Aeronautical Manufacturers Planning Report (AMPR) weight. This weight parameter is needed for estimation of the various costs in an aircraft program. |
| 10.4 | R.D.T.E. Cost | For estimation of the Research, Development, Test and Evaluation (R.D.T.E) cost. |
| 10.5 | Acquisition Cost | For estimation of the manufacturing and acquisition costs. The difference between these costs is the profit made by the manufacturer. |
| 10.6 | Operating Cost | For estimation of the civil and military aircraft operating costs. |
| 10.7 | Life Cycle Cost | For estimation of the life cycle cost of an aircraft program. The life cycle cost is defined as the sum of R.D.T.E. cost, acquisition cost, operating cost and disposal cost. |
| 10.8 | Prototype Cost | For estimation of the cost of development, manufacturing and flight-testing of the prototypes. This module is to be used only for those aircraft programs that are not intended for eventual production. |
| 10.9 | Price Data | For estimation of the engine price, propeller price and aircraft price as well as a rapid method for estimating prices of future designs. |

10.3 AMPR Weight

After selecting the **AMPR Weight** module, the user is presented with two options:

- **Detailed** Application of this method requires a detailed knowledge of the aircraft component weights.
- **Alternate** In case detailed data of the aircraft component weights is lacking, this module estimates the AMPR weight for a given take-off weight.

10.4 R.D.T.E. Cost

Selecting the **R.D.T.E. Cost** module will display the following five options:

- **Engineering & Design** For estimation of the airframe engineering and design cost.
- **Dev. Sup. & Test** For estimation of the development support and testing cost.
- **Test Aircraft** For estimation of the flight-test aircraft cost.
- **Test Operations** For estimation of the flight-test operation cost.
- **Total Cost** For estimation of the total R.D.T.E. cost, the test and simulation facilities cost, the R.D.T.E. profit, and the cost to finance the R.T.D.E. phases.

10.5 Acquisition Cost

After selecting the **Acquisition Cost** module, a menu is displayed with the following four options:

- **Engineering & Design** For estimation of the airframe engineering and design cost.
- **Program Production** For estimation of the aircraft program production cost.
- **Test Operations** For estimation of program production flight-test operations cost.
- **Total Cost** For estimation of the total acquisition cost, the cost to finance the manufacturing phase, and the profit.

10.6 Operating Cost

Before selecting the **Operating Cost** button, the user must specify the aircraft civil/military designation. For civil aircraft, a menu is displayed for estimating the operating cost of commercial aircraft. The menu has the following options:

- 10.6.1 **Block Data** For estimation of the time, speed and distances corresponding to the mission from the point of beginning taxi before take-off to ending taxi after landing.
- 10.6.2 **Direct** For estimation of direct operating cost.
- 10.6.3 **Indirect** For estimation of indirect operating cost.
- 10.6.4 **Program** For estimation of total program operating cost.

For military aircraft, a menu is displayed for estimating the operating cost of military aircraft in peacetime. The menu shows the following options:

- **Fuel, Oil, & Lub.** For estimation of the program cost of fuel, oil and lubricants.
- **Direct Personnel** For estimation of the program cost of direct personnel.
- **Consumable Mat.** For estimation of the program cost of consumable materials.
- **Total Operating** For estimation of the total program operating cost.

10.6.1 Block Data

After selecting the **Block Data** module, two options are displayed:

- **Time & Speed** For calculating speed, range and time parameters used in the operating cost estimation method.
- **Utilization** In this module, the annual utilization and total annual block distance can be calculated.

10.6.2 Direct

In the **Direct Operating** module, the user can estimate the direct operating cost, DOC, in US\$/nm incurred while operating commercial aircraft. After selecting the **Direct Operating** cost module, five options are displayed:

- **Flying** Select this option for estimation of the direct operating cost of flying. After invoking the **Flying** button, a menu appears with options for estimating **Crew, Fuel & Oil, Insurance** and **Total Cost** of flying.
- **Maintenance** Select this option for estimation of the direct operating cost of maintenance.
- **Depreciation** Select this option for estimation of the direct operating cost of depreciation.
- **Fees** Select this option for estimation of the direct operating costs of landing fees, navigation fees and registry taxes.
- **Total** Select this option for estimation of the total direct operating cost.

10.6.3 Indirect

In this module the indirect operating cost can be estimated. After selecting the **Indirect** operating cost module, two options are displayed:

- **Detailed** The indirect operating cost is a summation of the individual components.
- **Alternate** Because the aircraft designer has very little influence over this cost category, the indirect operating cost is expressed as a fraction of the direct operating cost. For this method the user need only define the fraction parameter and the direct operating cost.

10.6.4 Program

After invoking the Total Program option, the total program operating cost can be estimated.

10.7 Life Cycle Cost

The assumption is made that the R.T.D.E., program acquisition and program operating costs are estimated before entering this menu, therefore the only input parameter needed to estimate the life

cycle cost is the program disposal cost. Program disposal cost is entered as a fraction of life cycle cost. It is also possible in this window to redefine the other **Life Cycle Cost** components.

10.8 Prototype Cost

The function of this option is to estimate the cost of development, manufacturing and flight-testing of prototype aircraft. This module is to be used only for those aircraft programs that are not aimed at eventual mass production. Estimation of the prototype cost should be applied only to prototype programs where 1-4 aircraft are constructed. If more than 4 prototypes are to be constructed, the **R.D.T.E. Cost** option should be used for calculation of the prototype cost.

10.9 Price Data

After the selection of the **Price Data** option, a menu is displayed with the following options:

- **Aircraft** Before invoking the **Aircraft** option, a type of aircraft must be defined in the certification dialog box. The aircraft price can be calculated after selecting the aircraft category. The aircraft cost for a certain calendar year can be estimated in US\$.
- **Engine** Before selecting this option, the user must specify the engine type in the engine dialog box from the following option.
- **Propeller** Before selecting this option, an engine other than a jet must be defined, and the propeller type must be chosen in the engine dialog box.

11. References

1. Roskam, J.; *Airplane Design Part I: Preliminary Sizing of Airplanes*. DARcorporation, Lawrence, Kansas, 2005.
2. Roskam, J.; *Airplane Design Part II: Preliminary Configuration Design and Integration of the Propulsion System*. DARcorporation, Lawrence, Kansas, 2004.
3. Roskam, J.; *Airplane Design Part V: Component Weight Estimation*. DARcorporation, Lawrence, Kansas, 2003.
4. Raymer, D.; *Aircraft Design: A Conceptual Approach 4th Edition*. American Institute of Aeronautics and Astronautics, Inc., Reston, Virginia, 2006
5. Roskam, J.; *Airplane Design Part VI: Preliminary Calculation of Aerodynamic, Thrust and Power Characteristics*. DARcorporation, Lawrence, Kansas, 2004.
6. Roskam, J.; *Aircraft Design Part VII: Determination of Stability, Control and Performance Characteristics: FAR and Military Requirements*. DARcorporation, Lawrence, Kansas, 2006.
7. Roskam, J.; *Airplane Design Part IV: Layout Design of Landing Gear and Systems*. DARcorporation, Lawrence, Kansas, 2004.
8. Roskam, J.; *Airplane Flight Dynamics and Automatic Flight Controls: Part I*. DARcorporation, Lawrence, Kansas, 2003.
9. Roskam, J.; *Airplane Flight Dynamics and Automatic Flight Controls: Part II*. DARcorporation, Lawrence, Kansas, 2003.
10. Roskam, J.; *Aircraft Design Part VIII: Airplane Cost Estimation: Design, Development, Manufacturing and Operating*. DARcorporation, Lawrence, Kansas, 2006.

NOTE:

References 1 through 5 and 7 through 12 are published by: DARcorporation, 1440 Wakarusa Drive, Suite 500, Lawrence, Kansas 66049, USA, Phone (785) 832-0434, www.darcorp.com.

11. Torenbeek, E.; *Synthesis of Subsonic Airplane Design*. Delft University Press, Delft, Netherlands, 1981.
12. MIL-A-8861 (ASG); *Military Specifications, Airplane Strength and Rigidity, Flight Loads*. May 1960.
13. DARcorporation; *AeroPack User's Manual*. DARcorporation, Lawrence, Kansas, August 2006.
14. Research in Flight; *FlightStream User's Manual*. Research in Flight, Austin, Texas, May

2023.

15. Crandall, S. M., Swanson, R. S.; *Lifting-Surface-Theory Aspect-Ratio Corrections to the Lift and Hinge-Moment Parameters for Full Span Elevators on Horizontal Tail Surfaces*. NACA Technical Note 1175, 1947.