Aircraft Modeling Tool

for the

FAA Target Generation Facility

User Manual

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1 Introduction

The purpose of this document is to provide the user with guidelines on using the Aircraft Modeling Tool to generate aircraft input files for the Target Generation Facility's (TGF) NextGen simulator. Aircraft Modeling Tool is written in Matlab® 12.0. It is a combination of three major modules:

1. The Base of Aircraft Data (BADA) Processor
2. Manual Aircraft Generator
3. TGF Input Writer

The remainder of this document presents a detailed description of these modules and their use. A description of the theoretical approach to calculating aircraft parameters is outside of the scope of this document.

2 Aircraft Modeling Tool

2.1 The Base of Aircraft Data (BADA) Processor

2.1.1 BADA Overview

BADA provides a set of ASCII files containing performance and operating procedure coefficients for 186 different aircraft types. The coefficients include those used to calculate thrust, drag and fuel flow and those to specify nominal cruise, climb and descent speeds. The *User Manual for BADA Revision 3.3* (EUROCONTROL Experimental Centre, 2000) provides definitions of each of the coefficients and then explains the file formats. This manual, along with instructions for remotely accessing the files via Internet, is available through the following site: http://www.eurocontrol.fr/projects/bada/.

The BADA Processor module of the Aircraft Modeling Tool uses aircraft designators and performance information from http://www.aopa.org in assessing some of the aircraft flight performance data. A sample BADA file is given in Appendix B.

As mentioned above, BADA 3.3 provides operations and procedures data for a total of 186 aircraft types. For 71 of these aircraft types, data are provided directly in files. These aircraft are referred to as being directly supported. For the other 115 aircraft types, the data are specified to be the same as one of the directly supported 71 aircraft types. The second set of aircraft types is referred to as being supported through equivalence.

With one exception, each supported aircraft type is identified by a 4-character designation code assigned by the International Civil Aviation Organization (ICAO). The exception is the model representing a generic military fighter, which uses the designator FGTR.

The list of aircraft types supported by BADA 3.3 is given in Appendix C. In this Appendix the supported aircraft types are listed alphabetically by their designation code. For each aircraft type the aircraft name and type of BADA support (either direct or equivalence) is specified. Also, for each aircraft, which is supported through equivalence, the corresponding equivalent aircraft type is specified. A separate document, *Equivalences Report for BADA* (EUROCONTROL Experimental Centre, 1996), describes the procedure for identifying equivalent aircraft types and investigating the percentage of European traffic covered by aircraft types represented in BADA. This document shows that 71 aircraft types within BADA 3.3 cover about 90% of European air traffic. Separate analysis of National Airspace (NAS) traffic shows that BADA 3.3 covers about 80% of domestic air traffic.

The following table shows all jet aircraft represented in BADA 3.3.

Table 2.1.1-1 BADA Jet Aircraft Models

##	Aircraft Code (BADA)	Name or Model	Equivalences
1	A306	Airbus A300-B4-622	A30B IL76
2	A30B	Airbus A300-B4-203	A306
3	A310	Airbus A310-203	A310
4	A319	Airbus A319-131	A319
5	A320	Airbus A320-111	A320
6	A321	Airbus A321-111	A321
7	A330	Airbus A330	A330
8	A340	Airbus A340-300	A340
9	B703	Boeing B707-300	B703 C135 E3CF B701 IL62 VC10 B720 E3TF
10	B722	Boeing B727-228	B722 B721
11	B732	Boeing B737-228	B732 B731
12	B733	Boeing B737-300QC/B737-300	B733 B734 B735
13	B738	Boeing B737-800	B738 B736 B737
14	B742	Boeing B747-228	B742 B741 B743 C5
15	B744	Boeing B747-400	B744 B74S
16	B752	Boeing B757-200	B752 B753
17	B763	Boeing B767-300ER	B763 B762 B764
18	B772	Boeing B772-200	B772 B773
19	BA11	BAC 1.11/400	BA11
20	BA46	BAE146	BA46 YK42
21	C550	Cessna Citation II-CE 550	C550 C551 C500 C525 MU30 S601 SK60
22	C560	Cessna Citation V	C560
23	CL60	Canadair Challenger CL600/601	CL60 L29A GLF2 GLF3 GLF4
24	CRJ1	Canadair Regional Jet	CRJ1 CRJ2 E145
25	DC10	DC10-30	DC10
26	DC87	DC8-72CF	DC87 DC85 DC87 IL86 C141
27	DC9	DC9-40	DC9
28	F100	FOKKER 100	F100
29	F28	Fokker F28	F28
30	F70	FOKKER 70	F70
31	F900	Dassault 900-100	F900
32	FA10	DASSAULT FALCON 10	FA10
33	FA20	DASSAULT FALCON 20	FA20 SBR1
34	FA50	Dassault DA50	FA50
35	FGTR	Generic Fighter	FGTR TOR F16 JAGR HAR HAWK F4 F15 F18 MG21 MG23 MG25 MG29 CONC MRF1 MIR2 MIR4 A10 A6 F14 SB32 SB35 SB37 SB39
36	H25B	BAe 125 Dominie	H25B WW24
37	L101	Lockheed L-1011	L101

##	Aircraft Code (BADA)	Name or Model	Equivalences
38	LJ35	Learjet 35A	LJ35 C650 LJ31 LJ55
39	MD11	McDonnell-Douglas MD-11	MD11
40	MD80	Douglas MD83	MD80 MD90
41	T134	Tupolev TU 134A-3	T134
42	T154	Tupolev TU-154M	T154

The entire list of BADA aircraft along with equivalent aircraft types mapped using various sources of information is listed in Appendix C.

2.1.2 BADA Aircraft Performance Data

Aircraft performance data are contained in the Operations Performance Files (.OPF) of BADA. The .OPF file is in ASCII format and a sample of this file for the Boeing 747-400 (aircraft designator B744) is listed in Appendix B of this report with detailed description of parameters listed in Appendix A. The data are organized into a total of eight blocks listed below and described in further detail in subsections below.

- File identification block
- Aircraft type block
- Mass block
- Flight envelope block
- Aerodynamics block
- Engine thrust block
- Fuel consumption block
- Ground movements block

2.1.2.1 File Identification Block

The file identification block provides information on the file name, revision number and identification date. The last modification revision number and date indicate when the contents of the file were last modified.

2.1.2.2 Aircraft Type Block

This block specifies the following aircraft type parameters:

- ICAO aircraft code
- Number of engines, n_{eng}
- Engine type
- Wake category

The engine type can be one of the following three values: Jet, Turboprop or Piston. The wake category can be one of the three values: H (heavy), M (medium) or L (light).

2.1.2.3 Mass Block

This block specifies the following BADA mass model parameters (in tones):

- Reference mass, m_{ref}
- Minimum mass, m_{min}
- Maximum mass, m_{mass}
- Payload mass, m_{pyld}
- Mass gradient, G_w

2.1.2.4 Flight Envelope Block

The .OPF flight envelope block specifies the following BADA altitude-speed envelope parameters:

- Maximum operating speed, CAS (knots), V_{MO}
- Maximum operating Mach number, M_{MO}
- Maximum operating altitude (feet), h_{MO}
- Temperature gradient, G_t

2.1.2.5 Aerodynamics Block

This block specifies the following BADA aerodynamic model parameters:

- Wing (reference) area (sq. m), S
- Compressibility drag coefficient, C_{M16}
- Stall speed for five flight configurations (knots), V_{stall}
- Parasite drag coefficient for five flight configurations, C_{D0}
- Induced drag coefficient for five flight configurations, C_{D2}

The five flight configurations modeled in BADA are:

1. CR – cruise
2. IC – initial climb
3. TO – take-off

4. AP – approach
5. LD – landing

2.1.2.6 Engine Thrust Block

The .OPF engine thrust block specifies the following BADA parameters:

- BADA engine coefficients used to calculate the maximum climb thrust, $C_{Tc,1}, C_{Tc,2}, C_{Tc,3}, C_{Tc,4}, C_{Tc,5}$
- BADA parameters used to calculate cruise and descent thrust, $C_{Tdes,\,low}, C_{Tdes,\,high}, h_{des}, C_{Tdes,\,app}, C_{Tdes,\,ld}$

2.1.2.7 Fuel Consumption Block

This block specifies the following BADA fuel consumption model parameters:

- BADA parameters for thrust specific fuel consumption, C_{f1} and C_{f2}
- BADA parameters for descent fuel flow, C_{f3} and C_{f4}
- The cruise fuel flow correction factor, C_{fcr}

2.1.2.8 Ground Movement Block

The .OPF ground movement block is the last block in the .OPF file and specifies BADA parameters for the ground movements not used in TGF.

2.1.3 Installing and Running

The following steps outline BADA Processor installation and running procedures:

1. Unzip file **TGFwork.zip** and save all unzipped files into the same directory (for example **TGFwork**)
2. Start Matlab
3. In Matlab go to File Menu and select Set Path
4. In Set Path Menu click on Add with Subfolders button and browse to find TGFwork directory
5. Select TGFwork directory and click OK button
6. Click Save button in Set Path Menu

Steps 1-6 are implemented only once, i.e. the first time you install the software

7. Download BADA data in ZIP format from corresponding Eurocontrol's ftp site accessed from http://www.eurocontrol.fr/projects/bada/.
8. Unzip this data and save it in **BADA** folder within **TGFwork** directory in a single folder **badaX.X**, where X.X is the version of the data (for example 3.3)

Steps 7-8 are implemented each time the new version of BADA aircraft data are available from Eurocontrol (usually once a year)

9. In Matlab command prompt type **AircraftFileGenerator.** Type the full path of the working directory, i.e. of TGFwork. To find out the full path of the working directory right click on its folder and select **Properties**, directory's full path will be listed under **Location**. Do not forget to add the name of the working directory with slash to its path (Matlab command prompt will have an example).
10. Press enter and type aircraft type to process BADA for – all, jet, turboprop, or piston (lower case, case sensitive)
11. Press enter and enter input directory within working directory that contains BADA data, for example **BADA\bada3.3.**
12. Press enter and type output directory name within working directory, for example **ALL, JET, PROP,** or **PISTON**.
13. Press enter and choose to update or not to update comments to the new file (**Y/N**).
14. Press enter and if Y is selected in 13 type the comment and the author name.
15. Press enter. The program will run on Pentium III – 750 MHz for about 30 seconds to generate chosen files in selected folder.

Once program is running, the following run time screen is displayed.

Upon completion of the program the new screen (shown below) will appear

Steps 9-15 are implemented each time one needs to run parser.

Newly created output directory will contain **aircraft_baseline.xml** file with all corresponding aircraft models for use in TGF simulator.

2.2 Manual Aircraft Generator

2.2.1 Overview

Not all aircraft types are represented in BADA, directly or through equivalence types; therefore, there is a need for a fully manual method in generating necessary input files for TGF. As mentioned before, the theoretical background behind the derivation of the aircraft parameters representing aircraft models in TGF is beyond the scope of this document. It is necessary though for the user to estimate the value of the aircraft parameters shown in Table 2.2-1 to create an input file for generating the required aircraft model. Table 2.2-1 also lists units of the corresponding parameters and sources to obtain these parameters.

Table 2.2.1-1 Input Parameters

Variable	Parameter	Units	Alternative Calculation	Example
Aircraft Type				
AcType	Aircraft Type	-	-	B744
EngType	Engine Type	-	-	jet
Flight Envelope				
h	Cruise altitude (economical for long range), H_{cruise}	ft	Last reservation - use 35,000 ft	35000
hmax	Operating ceiling, H_{max}	ft	Last reservation - use 41,000 ft	45000

Variable	Parameter	Units	Alternative Calculation	Example
M	Cruise Mach number (economical for long range), M_{cruise}	-	Literature usually gives economical cruising speed in knots rather than Mach number. In this case use function StandardAtmosphere.m to obtain corresponding Mach number for input file (See (*))	0.85
			Weights	
Wmax	Maximum take-off weight, W_{max}	lbs	-	372*1000/.454
Wnom	Nominal weight, W_{nom}	lbs	From statistical observations $W_{nom} = 0.8 \cdot W_{max}$	300*1000/.454
Wmin	Operating empty weight, W_{min}	lbs	-	180*1000/.454
Wload	Maximum payload weight, W_{load}	lbs	From statistical observations $W_{nom} = 0.2 \cdot W_{max}$	61.64*1000/.454
			Wing Geometry	
Sref	Reference area, S_{ref}	sq. ft	Calculate by breaking plan form view, if necessary, into several trapezoids	525*10.7626
AR	Aspect ratio, A	-	Calculate using (2.2.1-2)	7.39
lambda	Taper ratio, λ	-	Calculate using (2.2.1-1)	0.275
SWEEPq	¼ Chord sweep, $\Lambda_{C/4}$	deg	Calculate using (2.2.1-3)	37.5
t_c	Thickness ratio, $t/\bar{c}$	-	From statistical observations $t/\bar{c} \approx 0.1$	9.40/100
h_wlt	Winglet height, $h_{winglet}$	ft	From aircraft front view, use 0 if there are no winglets	0
			Fuselage Geometry	
Df	Fuselage diameter, $D_{fuselage}$	ft	Measured from aircraft plan form view (Figure 2.2.1-2)	8.10*3.2808
Lf	Fuselage length, $L_{fuselage}$	ft	Measured from aircraft plan form view (Figure 2.2.1-2)	68.63*3.2808
Lnf	Nose section length, L_{nose}	ft	Measured from aircraft plan form view (Figure 2.2.1-2)	0.2*Lf
Ltf	Tail section length, L_{tail}	ft	Measured from aircraft plan form view (Figure 2.2.1-2)	0.3*Lf
			Horizontal Tail Geometry	
S_ht	Reference area, S_{HT}	sq. ft	Calculate by breaking plan form view, if necessary, into several trapezoids	136.6*10.7626
AR_ht	Aspect ratio, A	-	Calculate using (2.2.1-2)	3.57
lambda_ht	Taper ratio, λ	-	Calculate using (2.2.1-1)	0.265
SWEEPq_ht	¼ Chord sweep, $\Lambda_{C/4}$	deg	Calculate using (2.2.1-3)	32
t_c_ht	Thickness ratio, $t/\bar{c}$	-	Use the same value as for the wing	t_c

Variable	Parameter	Units	Alternative Calculation	Example
Vertical Tail Geometry				
S_vt	Reference area, S_{VT}	sq. ft	Calculate by breaking plan form view, if necessary, into several trapezoids	77.10*10.7626
AR_vt	Aspect ratio, A	-	Calculate using (2.2.1-2), b in this case is the horizontal tail height	1.34
lambda_vt	Taper ratio, λ	-	Calculate using (2.2.1-1)	0.33
SWEEPq_vt	¼ Chord sweep, $\Lambda_{C/4}$	deg	Calculate using (2.2.1-3)	45
t_c_vt	Thickness ratio, t/c	-	Use the same value as for the wing	t_c
Engine Data				
n_eng	Number of engines	-	-	4
Dn	Nacelle diameter, $D_{nacelle}$	ft	From aircraft front view	2.9*3.2808
Ln	Nacelle length, $L_{nacelle}$	ft	From aircraft side view	5.64*3.2808
MaxThrust	Maximum static thrust per engine, T_{max}	lbs	-	57900

For definition of parameters in (2.2.1-1)-(2.2.1-3) refer to Figure 2.2.1-1.

$$\lambda = \frac{C_{tip}}{C_{root}} \tag{2.2.1-1}$$

$$A = \frac{b^2}{S_{ref}} \tag{2.2.1-2}$$

$$\tan\Lambda_{C/4} = \tan\Lambda_{LE} - \frac{(1-\lambda)}{(1+\lambda)\cdot A} \tag{2.2.1-3}$$

[*]Determining cruise Mach number given cruise speed in knots using Matlab®:

```
>> [rho,pres_o,pres,Temp,astar,visc,kvisc] = StandardAtmosphere(h)

% [rho,pres_o,pres,Temp,astar,visc,kvisc] = StandardAtmosphere(h)
%
%  Determines atmospheric conditions for a given altitude
%
%  Input:
%   h ........Altitude (ft)
%  Output:
%   rho  ........ Air density (slugs/ft^3)
%   pres_o ...... Sea level Pressure (psf)
%   pres ........ Ambient pressure  (psf)
%   Temp ........ Ambient temperature (R)
%   astar ....... Speed of Sound  (ft/sec)
%   visc  ....... Viscosity (slugs/ft/sec)
```

```
%   kvisc ....... Kinematic Viscosity (ft^2/sec)
```

Note that h is long-range cruise altitude in feet.
If cruise speed V is given in knots than cruise Mach number is calculated in Matlab® by using the following formula:

```
>> M = V*1.15*5280/3600/astar
```

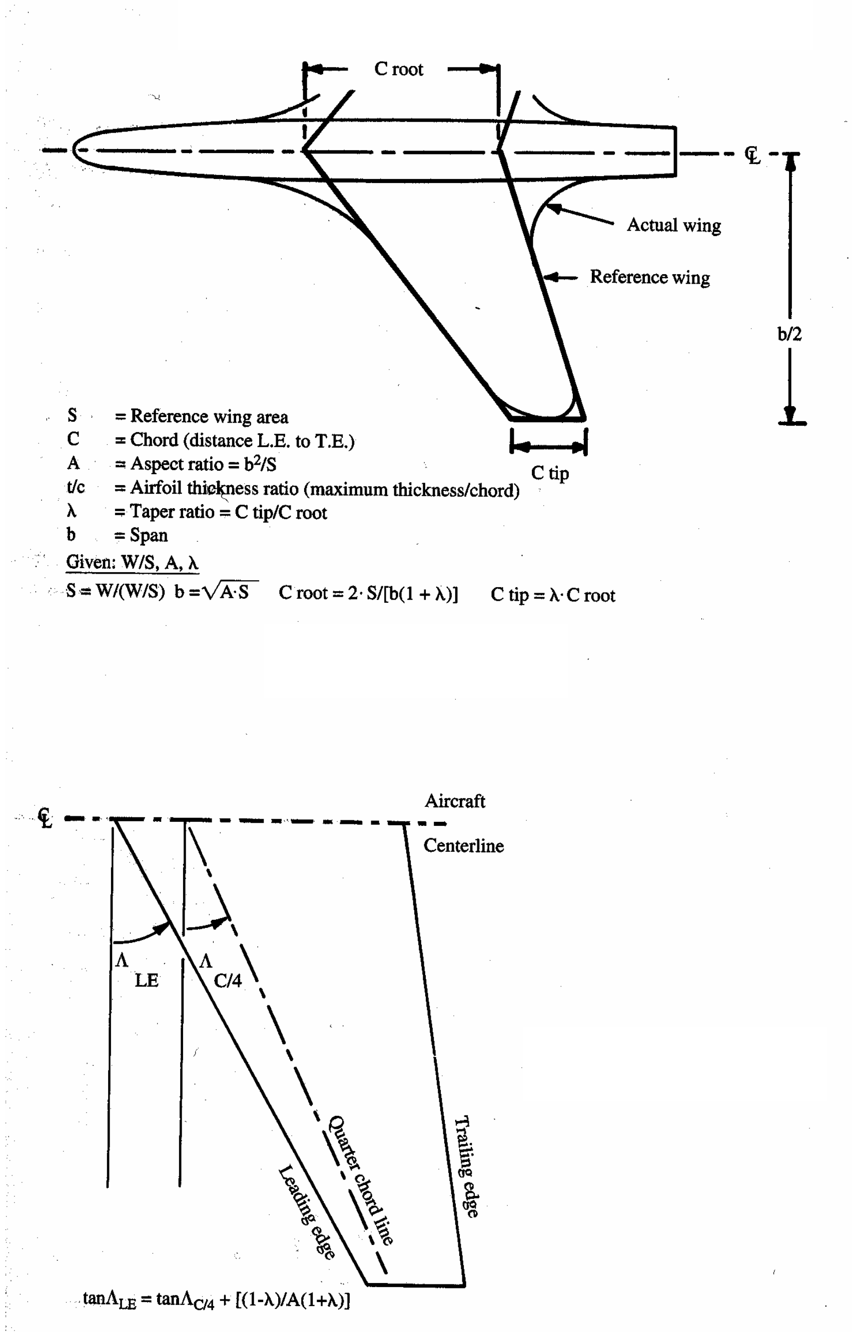

Figure 2.2.1-1 Aircraft Geometry (1)[1]

[1] Courtesy of Raymer, D. (1999), Aircraft Design: A Conceptual Approach (Third Edition). American Institute of Aeronautics and Astronautics, Inc., Reston, VA.

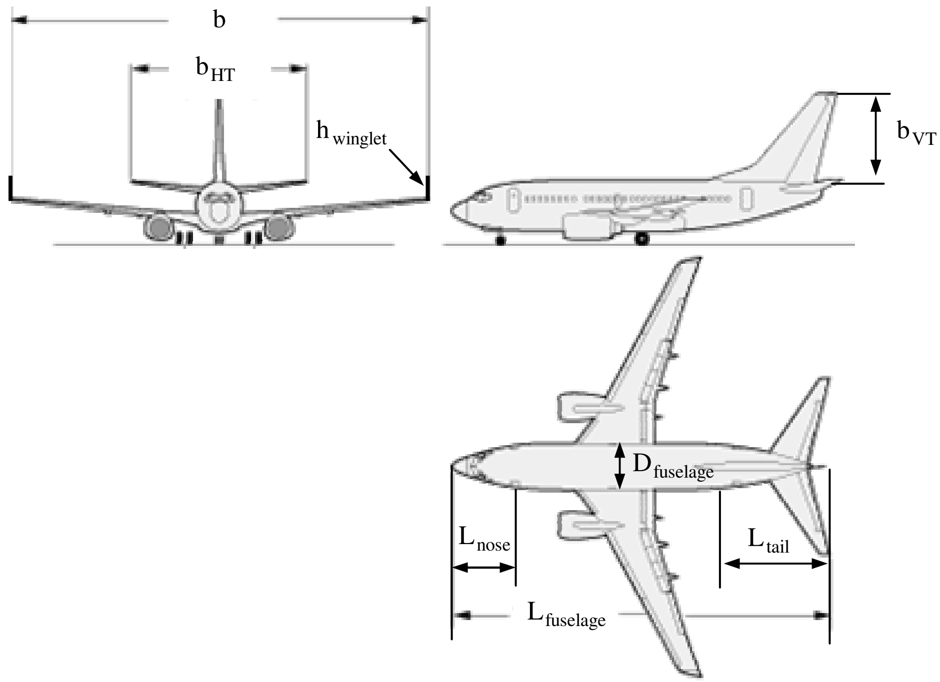

Figure 2.2.1-2 Aircraft Geometry (2)

2.2.2 Manual Aircraft Generator Functions and their Description

The following section of this report outlines all major functions of Manual Aircraft Generator Tool. It should be noted that this tool allows for generating only jet aircraft models. Further adjustments need to be made to make this tool suitable for modeling turboprop and piston engine aircraft performance parameters.

Table 2.2.2-1 Manual Aircraft Generator Functions

Function	Purpose	Input	Output
ACFTparam	Aircraft input file that contains all the necessary parameters to generate XML file	See Table 1	See Input
AircraftModel	Main program that runs Aircraft Modeling Tool. To run tool, type AircraftModel in Matlab command prompt	-	-
AircraftParameters	Main program that calls all the functions to calculate aircraft parameters from the data from ACFTparam	ACFTparam data	-
DragCalculator	Main program that calculates aircraft parasite, induced, and compressibility drag coefficients	ACFTparam data	**Cdp** – Parasite drag coefficient Cdi – Induced drag coefficient **Cdc** – Compressibility drag coefficient **Cm16** – Compressibility drag coefficient (for BADA drag polar representation)
StandardAtmosphere	This function calculates standard atmosphere parameters	**h** – Altitude (ft)	**rho** - Air density (slugs/ft^3) **pres_o** - Sea level Pressure (psf) **pres** - Ambient pressure (psf) Temp - Ambient temperature (R) **astar** - Speed of Sound (ft/sec) **visc** -Viscosity (slugs/ft/sec) **kvisc** - Kinematic Viscosity (ft^2/sec)

Function	Purpose	Input	Output
WingGeometry	This function calculates some wing, horizontal and vertical tail geometry parameters	**Sref** - Reference area (ft^2) **AR** - Aspect ratio, i.e. b^2/Sref **lambda** - Taper ratio, i.e. Ct/Cr **SWEEPq** - Sweep along quarter chord line (deg) **Df** - Diameter of the fuselage (ft)	**b** - Span (ft) **Cr** - Root chord (ft) **Ct** - Tip chord (ft) **SWEEPle** - Sweep along leading edge (deg) **MAC** - Mean aerodynamic chord **Swet** - Wetted area (ft^2)
EffectiveAspectRatio	This function calculates effective aspect ratio of the wing with winglets	**AR** - Geometric Aspect Ratio **h_wlt** - Height of winglet (ft) **b** - wing span (ft)	**ARe** - Effective Aspect Ratio
WingFormFactor	This function calculates form factor for the wing, horizontal and vertical tail	**M** - Mach number **SWEEPq** - Sweep along quarter chord line (deg) **t_c** - Thickness ratio	**K** – Form factor
ReynoldsNumber	This function calculates Reynolds number	**kvisc** - Kinematic viscosity (ft^2/sec) **TAS** - True airspeed (ft/sec) **L** - Body length (ft)	**RN** - Reynolds number
SkinFrictionCoefficient	This function calculates skin friction coefficient	**RN** - Reynolds number **M** - Mach number	**Cf** - Skin friction coefficient
FuselageGeometry	This function calculates some fuselage and nacelle geometry parameters	**D** - Diameter (ft) **L** - Length (ft) **Lnose** - Length of the nose section (ft) **Ltail** - Length of the tail section (ft)	**Swet** - Wetted area (ft^2)
FuselageFormFactor	This function calculates fuselage form factor	**f** - Fineness ratio, i.e. L/D	**Kf** - Form factor
NacelleFormFactor	This function calculates nacelle form factor	**f** - Fineness ratio, i.e. L/D	**Kn** - Form factor
OswaldEfficiency	This function calculates Oswald efficiency factor	**SWEEPle** - Sweep along leading edge (deg) **AR** - Aspect ratio	**e** - Oswald Efficiency

Function	Purpose	Input	Output
CompressibilityDrag	This function calculates compressibility drag	**Cdp** – Parasite drag coefficient **Cdi** – Induced drag coefficient **t_c** - Thickness ratio **SWEEPq** - Sweep along quarter chord line (deg) **Sref** - Reference area (ft^2) **M** - Mach number **Wnom** – Nominal weight (lbs) **h** – Altitude (ft)	**Cdc** – Compressibility drag coefficient **Cm16** – Compressibility drag coefficient (for BADA drag polar representation)
DragCoefficients	This function calculates parasite and induced drag coefficient for 5 flight configurations	**Cdp** – Parasite drag coefficient **Cdi** – Induced drag coefficient	**Cd1_lift, Cd2_lift, Cd3_lift, Cd4_lift, Cd5_lift** – Parasite drag coefficients for 5 flight configurations **K1_drag, K2_drag, K3_drag, K4_drag, K5_drag** – Induced drag coefficients for 5 flight configurations
WeightCalc	This function calculates different weight parameters of the aircraft	**Wmax** - Maximum weight (lbs) **Wmin** - Minimum weight (lbs) **Wload** - Maximum payload weight (lbs)	**Wgross** - Gross weight (lbs) **Wfuel** - Fuel weight (lbs)
LandingGearDrag	This function calculates the landing gear drag	**Wnom** – Nominal weight (lbs) **Sref** - Reference area (ft^2)	**Cd_gear** - Landing gear drag coefficient
EngineData	This function maps engine thrust and fuel burn coefficients	**Wgross** - Gross weight (lbs) **MaxThrust** - Max (static) thrust per engine (lbs) **n_eng** -Number of engines	**Ctc1, Ctc2, Ctc3** – Thrust coefficients **Cf1, Cf2, Cf3, Cf4** – Fuel burn coefficients **delta_t** – Thrust precision factor (%) **delta_w** – Weight precision factor (%)
StallSpeed	This function calculates aircraft stall speed for 5 flight configurations	**Wmax** - Maximum weight (lbs) **Sref** - Reference area (ft^2)	**V_stall** - Stall speed for 5 flight configurations (knots)
MaxLift	This function calculates maximum lift coefficient for 5 flight configurations	**V_stall** - Stall speed for 5 flight configurations (knots) **Wmax** - Maximum weight (lbs) **Sref** - Reference area (ft^2)	**CL_max** - Maximum lift coefficient for 5 configurations

Function	Purpose	Input	Output
AC_input	This function creates input file to calculate control logic gains	-	-
Ac_file_maker_new	This function calculates control logic gains	AC_input data	16 Control logic coefficients
GuidancePerformance	This function assigns some guidance performance parameters of the aircraft	**AcType** – Aircraft type **M** - Mach number	Guidance performance parameters
Type_rate	This .mat data file is loaded by GuidancePerformance function to calculate some parameters	-	-
WriteXML	This function writes XML input file	AircraftParameters data	XML file (TYPEfile.xml)

2.2.3 Installing and Running

The following steps outline Manual Aircraft Generator installation and running procedures:

1. Unzip file **AircraftModel.zip** and save all unzipped files into the same directory (for example **AircraftModel**)
2. Start Matlab
3. In Matlab go to File Menu and select Set Path
4. In Set Path Menu click on Add with Subfolders button and browse to find **AircraftModel** directory
5. Select **AircraftModel** directory and click OK button
6. Click Save button in Set Path Menu

Steps 1-6 are implemented only once, i.e. the first time you install the tool

7. Open folder **ACINPUT** within **AircraftModel**
8. Open file **ACFTparam** within **ACINPUT**
9. Follow instructions in this document along with three provided examples for B744, B732, and MD80 to input all the required parameters (pay attention to units!)
10. Save file ACFTparam in the same folder ACINPUT as TYPEparam, where TYPE is an aircraft type under consideration (say if it is C17, save ACFTparam as C17param)
11. In Matlab command prompt type **AircraftModel**. Type the full path of the working directory, i.e. of **AircraftModel**. To find out the full path of the working directory right click on its folder and select **Properties**, directory's full path will

be listed under **Location**. Do not forget to add the name of the working directory with slash to its path (Matlab command prompt will have an example).

12. Press enter and type aircraft type for which you just generated TYPEparam file (for example, C17)
13. Press enter and enter output directory name within working directory, for example **OUTPUT**
14. Press enter. The program will run on Pentium III – 750 MHz for about 2 seconds to generate 2 files: TYPEfile.xml and TYPEfullsim.txt in selected output directory.

Steps 7-14 are implemented each time one needs to generate new aircraft model.

2.3 TGF Input Writer

TGF Input Writer allows processing output of both BADA Processor and Manual Aircraft Generator outputs into a .xml file used in TGF. This TGF Input Writer is automatically called from within BADA Processor and Manual Aircraft Generator to generate **aircraft_baseline.xml** file. Currently, calling TGF Input Writer through BADA Processor will generate a .xml file containing all selected (jet, turboprop, or piston) aircraft types contained in BADA. Calling TGF Input Writer from Manual Aircraft Generator will generate a .xml file with performance data for a particular modeled aircraft.

When generating **aircraft_baseline.xml** file it is necessary to include aircraft equivalencies statements in the beginning of the file to cover aircraft types not directly represented in BADA or not modeled manually. Aircraft Type Processor is utilized within TGF Input Writer to handle this procedure in automated fashion. Operational Enhanced Traffic Management System (ETMS) data is used to extract all aircraft types currently operating in the National Airspace System (NAS). All aircraft types directly represented in BADA or modeled manually are listed in the separate file. Other aircraft types are then matched against these models based on ref. 2 and included in the same file as synonym (equivalent) types. Aircraft types, derived from ETMS data, are compared then with BADA aircraft types. If ETMS aircraft type has an exact match with any aircraft type directly represented in BADA, then its parameters will be explicitly listed in **aircraft_baseline.xml** file. If ETMS aircraft type matched with BADA synonym aircraft type, then equivalence statement will be included in the beginning of **aircraft_baseline.xml** file. If ETMS aircraft type has no match with either aircraft types directly represented in BADA or represented in BADA through synonym types, then Manual Aircraft Generator needs to be utilized in order to generate the necessary data.

The following table describes the parameters contained in **aircraft_baseline.xml** file, the aircraft model input file for TGF. Note that all the references (equations and figures) are made to Peters, 1999 (ref. 3).

Table 3.2-1 XML File Parameters

Name	Var	Description	Units
History/Revision			
date	-	Date of update	-
author	-	Author	-
commentary	-	Comment(s) (if any)	-
ADMAircraft			
aircraft_type	-	Aircraft designator agreed between the FAA, ICAO, NAV CANADA, and Eurocontrol	-
equivalent_type	-	Aircraft designator agreed between the FAA, ICAO, NAV CANADA, and Eurocontrol	-
empty_weight	W_e	Aircraft Empty Weight	lbs
fuel_weight	W_f	Aircraft Fuel Weight	lbs

Name	Var	Description	Units
payload_weight	W_p	Aircraft Payload Weight	lbs
lp	L_p	Roll damping	$\frac{1}{sec}$
la	L_{δ_a}	Ailerons effectiveness	$\frac{1}{sec^2}$
k1	k_1 (k_p)	Pitch rate feedback gain	sec
k2	k_2 (k_φ)	Roll angle feedback gain	-
		Engine	
coeff1	$C_{T_{c,1}}$	Thrust coefficient used to calculate maximum thrust in climb	N
coeff2	$C_{T_{c,2}}$	Thrust coefficient used to calculate maximum thrust in climb	ft
coeff3	$C_{T_{c,3}}$	Thrust coefficient used to calculate maximum thrust in climb	$\frac{1}{ft^2}$
f1	C_{f_1}	Fuel coefficient used to calculate thrust specific fuel consumption	$\frac{kg}{min \cdot kN}$
f2	C_{f_2}	Fuel coefficient used to calculate thrust specific fuel consumption	kts
f3	C_{f_3}	Fuel coefficient used to calculate minimum fuel flow	$\frac{kg}{min}$
f4	C_{f_4}	Fuel coefficient used to calculate minimum fuel flow	ft
		Airframe	
wing_area	S_{ref}	Aircraft wing area	ft^2
compress	$C_{M_{16}}$	Compressibility coefficient	-
Cd_spoiler	$C_{D_{spoiler}}$	Spoilers drag coefficient	-
Cd_gear	$C_{D_{gear}}$	Landing gear drag coefficient	-
Cd_brakes	$C_{D_{brakes}}$	Brakes drag coefficient	-
Cd1_lift	$C_{D_{0\,1}}$	Zero lift drag coefficient for Cruise flap setting	-
Cd2_lift	$C_{D_{0\,2}}$	Zero lift drag coefficient for Initial Climb flap setting	-
Cd3_lift	$C_{D_{0\,3}}$	Zero lift drag coefficient for Take-off flap setting	-
Cd4_lift	$C_{D_{0\,4}}$	Zero lift drag coefficient for Approach flap setting	-
Cd5_lift	$C_{D_{0\,5}}$	Zero lift drag coefficient for Landing flap setting	-
K1_drag	K_1	Induced drag coefficient for Cruise flap setting	-
K2_drag	K_2	Induced drag coefficient for Initial Climb flap setting	-
K3_drag	K_3	Induced drag coefficient for Take-off flap setting	-

Name	Var	Description	Units
K4_drag	K_4	Induced drag coefficient for Approach flap setting	-
K5_drag	K_5	Induced drag coefficient for Landing flap setting	-
CL_max1	$C_{L_{max\ 1}}$	Maximum lift coefficient for Cruise flap setting	-
CL_max2	$C_{L_{max\ 2}}$	Maximum lift coefficient for Initial Climb flap setting	-
CL_max3	$C_{L_{max\ 3}}$	Maximum lift coefficient for Take-off flap setting	-
CL_max4	$C_{L_{max\ 4}}$	Maximum lift coefficient for Approach flap setting	-
CL_max5	$C_{L_{max\ 5}}$	Maximum lift coefficient for Landing flap setting	-
CL_min	$C_{L_{min}}$	Minimum lift coefficient	-
ControlLogic			
ias_error	IAS_{error}	Indicate airspeed error used to define the speed-altitude plane	kts
mach_error	M_{error}	Mach error used to define the Mach speed-altitude plane	-
alt_error	h_{error}	Altitude error used to define the speed-altitude plane	ft
kh_dot	$K_{\dot{h}}$	Altitude error gain to command an altitude rate	$\frac{1}{min}$
ControlLogicGains			
Regions1245			
R1245_Kp14	k_{p14}	Proportional gain of PI (proportional + integral) controller (Fig 5.1) for Altitude Rate to Lift Coefficient feedback (5.7) for Regions 1, 2, 4, and 5	-
R1245_Ki14	k_{i14}	Integral gain of PI controller (Fig 5.1) for Altitude Rate to Lift Coefficient feedback (5.7) for Regions 1, 2, 4, and 5	-
Regions36_MachBased			
R36Mach_Kb14	k_{b14}	Feedback gain (Fig 5.1) for altitude rate (5.7) for Regions 3 and 6 Mach based	-
R36Mach_Kp12	k_{p12}	Proportional gain of PI controller (Fig 5.1) for Mach Speed to Lift Coefficient feedback (5.7) for Regions 3 and 6 Mach based	-
R36Mach_Ki12	k_{i12}	Integral gain of PI controller (Fig 5.1) for Mach Speed to Lift Coefficient feedback (5.7) for Regions 3 and 6 Mach based	-
Regions36_IasBased			
R36Ias_Kb14	k_{b14}	Feedback gain (Fig 5.1) for Altitude Rate to Lift Coefficient feedback (5.7) for Regions 3 and 6 IAS (indicated airspeed) based	-
R36Ias_Kp11	k_{p11}	Proportional gain of PI controller (Fig 5.1) for IAS to Lift Coefficient feedback (5.7) for Regions 3 and 6 IAS based	-

Name	Var	Description	Units
R36Ias_Ki11	k_{i11}	Integral gain of PI controller (Fig 5.1) for IAS to Lift Coefficient feedback (5.7) for Regions 3 and 6 IAS based	-
		Region7_MachBased	
R7Mach_Kp22	k_{p22}	Proportional gain of PI controller (Fig 5.1) for Mach Speed to Throttle feedback (5.7) for Region 7 Mach based	-
R7Mach_Kp14	k_{p14}	Proportional gain of PI controller (Fig 5.1) for Altitude Rate to Lift Coefficient feedback (5.7) for Region 7 Mach based	-
R7Mach_Ki14	k_{i14}	Integral gain of PI controller (Fig 5.1) for Altitude Rate to Lift Coefficient feedback (5.7) for Region 7 Mach based	-
R7Mach_Ki22	k_{i22}	Integral gain of PI controller (Fig 5.1) for Mach Speed to Throttle feedback (5.7) for Region 7 Mach based	-
		Region7_IasBased	
R7Ias_Kp21	k_{p21}	Proportional gain of PI controller (Fig 5.1) for IAS to Throttle feedback (5.7) for Region 7 IAS based	-
R7Ias_Kp14	k_{p14}	Proportional gain of PI controller (Fig 5.1) for Altitude Rate to Lift Coefficient feedback (5.7) for Region 7 IAS based	-
R7Ias_Ki14	k_{i14}	Integral gain of PI controller (Fig 5.1) for Altitude Rate to Lift Coefficient feedback (5.7) for Region 7 IAS based	-
R7Ias_Ki21	k_{i21}	Integral gain of PI controller (Fig 5.1) for IAS to Throttle feedback (5.7) for Region 7 IAS based	-
		RegionGS_IasBased	
RgsIas_Kp21	k_{p21}	Proportional gain of PI controller for IAS to Throttle feedback for Region ILS	-
RgsIas_Kp14	k_{p14}	Proportional gain of PI controller for Altitude Rate to Lift Coefficient feedback for Region ILS	-
RgsIas_Kp13	k_{p13}	Proportional gain of PI controller for Altitude to Lift Coefficient feedback for Region ILS	-
RgsIas_Ki13	k_{i13}	Integral gain of PI controller for Altitude to Lift Coefficient feedback for Region ILS	-
RgsIas_Ki21	k_{i21}	Integral gain of PI controller for IAS to Throttle feedback for Region ILS	-
		Guidance_System	
		Guidance_Performance_Parameters	
Descent_Ias	$V_{IAS_{con}}$	Descent IAS used in vertical constraint logic for strategies 7-9 (Chapter 10.2.2)	kts
Descent_Mach	M_{con}	Descent Mach speed used in vertical constraint logic for strategies 7-9 (Chapter 10.2.2)	-
Descent_Rate_Fpm	-	Aircraft nominal descent rate	fpm
Deceleration_Rate_Mach	-	Aircraft Mach speed deceleration rate	$\frac{1}{sec}$

Name	Var	Description	Units
Deceleration_Rate_Ias	-	Aircraft IAS deceleration rate	$\frac{kts}{sec}$
Climb_Ias	$V_{IAS_{con}}$	Climb IAS used in vertical constraint logic for strategies 4-6 (Chapter 10.2.2)	kts
Climb_Mach	M_{con}	Climb Mach speed used in vertical constraint logic for strategies 1-3 (Chapter 10.2.2)	-
Cruise_Ias_Low	$V_{IAS_{cr,low}}$	Cruise IAS at low altitudes	kts
Cruise_Ias_High	$V_{IAS_{cr,high}}$	Cruise IAS at high altitudes	kts
Cruise_Mach	M_{cr}	Cruise Mach	-
Transition_Altitude_Climb	h_{climb}	IAS/Mach transition altitude for climb	ft
Transition_Altitude_Descent	$h_{descent}$	Mach/IAS transition altitude for descent	ft

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Appendix A BADA Operations Performance Parameters Summary

A.1 Aircraft Performance Parameters

Table A.1-1 BADA Aircraft Performance Parameters

Model Category	Symbols	Units	Description
Aircraft Type	n_{eng}	dimensionless	number of engines
	engine type	string	Jet, Turboprop or Piston
	wake category	string	Heavy, Medium or Light
Mass	m_{ref}	tonnes	reference mass
	m_{min}	tones	minimum mass
	m_{max}	tonnes	maximum mass
	m_{pyld}	tonnes	maximum payload mass
Flight Envelope	V_{MO}	knots (CAS)	maximum operating speed
	M_{MO}	dimensionless	maximum operating Mach number
	h_{MO}	feet	maximum operating altitude
	h_{max}	feet	maximum altitude at MTOW and ISA
	G_w	feet/kg	weight gradient on maximum altitude temperature
	G_t	feet/C	gradient on maximum altitude
Aerodynamics	S	m^2	reference wing surface area

Model Category	Symbols	Units	Description
	$C_{D0,CR}$	dimensionless	parasite drag coefficient (cruise)
	$C_{D2,CR}$	dimensionless	induced drag coefficient (cruise)
	$C_{D0,AP}$	dimensionless	parasite drag coefficient (approach)
	$C_{D2,AP}$	dimensionless	induced drag coefficient (approach)
	$C_{D0,LD}$	dimensionless	parasite drag coefficient (landing)
	$C_{D2,LD}$	dimensionless	induced drag coefficient (landing)
	$C_{D0,\Delta LDG}$	dimensionless	parasite drag coefficient (landing gear)
	C_{M16}	dimensionless	Mach (compressibility) drag coefficient
	$(V_{stall})_i$	knots (CAS)	stall speed (Take-off, Initial Climb, Cruise, Approach, Landing)
	$C_{Lbo(M=0)}$	dimensionless	buffet onset lift coefficient (jet only)
	K	[1/M]	buffeting gradient (jet only)
Engine Thrust	$C_{Tc,1}$	Newton (jet/piston)	1st max climb thrust coefficient

Model Category	Symbols	Units	Description
		knot-Newton (turborpop)	
	$C_{Tc,2}$	feet	2nd max climb coefficient
	$C_{Tc,3}$	1/ft ^{2} (jet) Newton (turboprop) knot-Newton (piston)	3rd max climb coefficient
	$C_{Tc,4}$	deg.C	1st thrust temperature coefficient
	$C_{Tc,5}$	1/deg.C	2nd thrust temperature coefficient
	$C_{Tdes,low}$	dimensionless	low altitude descent thrust coefficient
	$C_{Tdes,high}$	dimensionless	high altitude descent thrust coefficient
	h_{des}	feet	transition altitude for calculation of descent thrust
	$C_{Tdes,app}$	dimensionless	approach thrust coefficient
	$C_{Tdes,ld}$	dimensionless	landing thrust coefficient
	$V_{des,ref}$	knots	reference descent speed(CAS)
	$M_{des,ref}$	dimensionless	reference descent Mach
Fuel Flow	C_{f1}	Kg/min/kN (jet) kg/min/kN/knot (turboprop) kg/min (piston)	1st thrust specific fuel consumption coefficient

Model Category	Symbols	Units	Description
	C_{f2}	Knots	2nd thrust specific fuel consumption coefficient
	C_{f3}	Kg/min	1st descent fuel flow coefficient
	C_{f4}	Feet	2nd descent fuel flow coefficient
	C_{fcr}	dimensionless	cruise fuel flow correction coefficient
Ground Movement	TOL	m	take-off length
	LDL	m	landing length
	span	m	wingspan
	length	m	length

A.2 Airline Procedures

BADA procedure models parameterize standard airline procedures for climb, cruise and descent flight phases. Airline procedures, reflected in BADA, include:

- Standard climb CAS (knots) between 1,500/6,000 and 10,000 feet
- Standard climb CAS (knots) between 10,000 feet and Mach transition altitude
- Standard climb Mach number above Mach transition altitude
- Standard cruise CAS (knots) between 3,000 and 10,000 feet
- Standard cruise CAS (knots) above 10,000 ft until Mach transition altitude
- Standard cruise Mach number above transition altitude
- Standard descent CAS (knots) between 3,000/6,000 and 10,000 feet
- Standard descent CAS (knots) above 10,000 feet until Mach transition altitude
- Standard descent Mach number above transition altitude

A.3 Global Parameters

A number of parameters in BADA have values that are independent of the aircraft type or model for which they are used. The values of these parameters are included in the General Parameters and can be changed or adjusted by the user. These parameters are listed in the following table.

Table A.3-1 BADA Global Parameters

Model Category	Symbols	Units	Description
Maximum Acceleration	$a_{l,max(civ)}$	fps^2	maximum longitudinal acceleration for civil flights
	$a_{n,max(civ)}$	fps^2	maximum normal acceleration for civil flights
Bank Angles	$\varphi_{nom,civ(TO,LD)}$	degrees	nominal bank angles for civil flight during TO and LD
	$\varphi_{nom,civ(OTHERS)}$	degrees	nominal bank angles for civil flight during all other phases
	$\varphi_{nom,\ mil}$	degrees	nominal bank angles for military flight during all phases
	$\varphi_{max,civ(TO,LD)}$	degrees	maximum bank angles for civil flight during TO and LD
	$\varphi_{max,civ(HOLD)}$	degrees	maximum bank angles for civil flight during HOLD
	$\varphi_{max,civ(OTHERS)}$	degrees	maximum bank angles for civil flight during all other phases
	$\varphi_{max,mil}$	degrees	maximum bank angles for military flight during all phases

Model Category	Symbols	Units	Description
Expedited Descent	$C_{des,exp}$	dimensionless	expedited descent factor
Thrust Factors	$C_{Th,to}$	dimensionless	take-off thrust coefficient
	$C_{Th,cr}$	dimensionless	maximum cruise thrust coefficient
Configuration Altitude Threshold	$H_{max,TO}$	feet	maximum altitude threshold for take-off
	$H_{max,IC}$	feet	maximum altitude threshold for initial climb
	$H_{max,AP}$	feet	maximum altitude threshold for approach
	$H_{max,LD}$	feet	maximum altitude threshold for landing
Minimum Speed Coefficients	$C_{Vmin,TO}$	dimensionless	minimum speed coefficient for take-off
	C_{Vmin}	dimensionless	minimum speed coefficient for all other phases
Speed Schedules	$Vd_{CL,1}$	knots	climb speed increment below 1,500 feet (jet)
	$Vd_{CL,2}$	knots	climb speed increment below 3,000 feet (jet)
	$Vd_{CL,3}$	knots	climb speed increment below 4,000 feet (jet)
	$Vd_{CL,4}$	knots	climb speed increment below 5,000 feet (jet)
	$Vd_{CL,5}$	knots	climb speed increment below 6,000 feet (jet)
	$Vd_{CL,6}$	knots	climb speed increment below 500 feet (turboprop/piston)

Model Category	Symbols	Units	Description
	$Vd_{CL,7}$	knots	climb speed increment below 1000 feet (turboprop/piston)
	$Vd_{CL,8}$	knots	climb speed increment below 1,500 feet (turboprop/piston)
	$Vd_{DES,1}$	knots	descent speed increment below 1,000 feet (jet/turboprop)
	$Vd_{DES,2}$	knots	descent speed increment below 1,500 feet (jet/turboprop)
	$Vd_{DES,3}$	knots	descent speed increment below 2,000 feet (jet/turboprop)
	$Vd_{DES,4}$	knots	descent speed increment below 3,000 feet (jet/turboprop)
	$Vd_{DES,5}$	knots	descent speed increment below 500 feet (piston)
	$Vd_{DES,6}$	knots	descent speed increment below 1,000 feet (piston)
	$Vd_{DES,7}$	knots	descent speed increment below 1,500 feet (piston)
Holding Speed	$V_{hold,1}$	knots	holding speed below FL 140
	$V_{hold,2}$	knots	holding speed between FL 140 and FL 200
	$V_{hold,3}$	knots	holding speed between FL 200 and FL 340
	$V_{hold,4}$	Mach	holding speed above FL 340

Model Category	Symbols	Units	Description
Ground Speeds	$V_{backtrack}$ V_{taxi} V_{apron} V_{gate}	knots knots knots knots	runway backtrack speed taxi speed apron speed gate speed
Reduced Power Coefficient	$C_{red,turbo}$ $C_{red,piston}$ $C_{red,jet}$	dimensionless dimensionless dimensionless	Maximum reduction in power for turboprops Maximum reduction in power for pistons Maximum reduction in power for jets

Appendix B BADA Sample File

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CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC B744__.OPF CCCCCCCCCCCCCC/
CC                                                                    /
CC                AIRCRAFT PERFORMANCE                                /
CC                operational    files                                /
CC                                                                    /
CC     BADA RCS File Id                                               /
CC    File Name        Current Revision      Last Modification        /
CC                     revision    date      revision     date        /
CC    B744__.OPF         3.3   2000/12/06    3.1.1.1   2000/08/01     /
CC                                                                    /
CC   BADA Revision:                                                   /
CD   Rev  3.3                                                         /
CC====== Actype ======================================================/
CD   B744__          4 engines    Jet                      H          /
CC          B747-400 with CF6_80C2B1F engines             wake        /
CC                 (source = Air France OPS manual)                   /
CC====== Mass (t) ====================================================/
CC    reference      minimum      maximum     max payload  mass grad  /
CD     .30000E+03   .18000E+03   .37200E+03   .61640E+02   .60000E-01 /
CC====== Flight envelope =============================================/
CC     VMO(KCAS)        MMO        Max.Alt       Hmax       temp grad  /
CD     .36500E+03   .90000E+00   .45000E+05   .35400E+05  -.20000E+03 /
CC====== Aerodynamics ================================================/
CC Wing Area and Buffet coefficients (SIM)                            /
CCndrst Surf(m2)     Clbo(M=0)       k           CM16                 /
CD 5   .51200E+03   .99000E+00   .33500E+00   .00000E+00              /
CC   Configuration characteristics                                    /
CC n Phase  Name    Vstall(KCAS)    CD0          CD2        unused    /
CD 1 CR   Clean     .18000E+03   .22000E-01   .45000E-01   .00000E+00 /
CD 2 IC   Flap05    .14900E+03   .00000E+00   .00000E+00   .00000E+00 /
CD 3 TO   Flap20    .14000E+03   .00000E+00   .00000E+00   .00000E+00 /
CD 4 AP   Flap20    .14000E+03   .00000E+00   .00000E+00   .00000E+00 /
CD 5 LD   Flap30    .12800E+03   .00000E+00   .00000E+00   .00000E+00 /
CC   Spoiler                                                          /
CD 1      RET                                                         /
CD 2      EXT                                 .00000E+00   .00000E+00 /
CC   Gear                                                             /
CD 1      UP                                                          /
CD 2      DOWN                   .00000E+00   .00000E+00   .00000E+00 /
CC   Brakes                                                           /
CD 1      OFF                                                         /
CD 2      ON                                  .00000E+00   .00000E+00 /
CC====== Engine Thrust ===============================================/
CC         Max climb thrust coefficients (SIM)                        /
CD     .62668E+06   .59557E+05   .00000E+00   .30258E+01   .42770E-02 /
CC      Desc(low)    Desc(high)   Desc level   Desc(app)    Desc(ld)  /
CD     .12247E+00   .79764E-01   .20000E+05   .00000E+00   .00000E+00 /
CC      Desc CAS     Desc Mach    unused       unused       unused    /
CD     .28000E+03   .85000E+00   .00000E+00   .00000E+00   .00000E+00 /
CC====== Fuel Consumption ============================================/
CC   Thrust Specific Fuel Consumption Coefficients                    /
CD     .86709E+00   .53904E+04                                        /
CC   Descent Fuel Flow Coefficients                                   /
CD     .39007E+02   .75715E+05                                        /
CC   Cruise Corr.    unused       unused       unused       unused    /
CD     .89880E+00   .00000E+00   .00000E+00   .00000E+00   .00000E+00 /
CC====== Ground ======================================================/
CC        TOL          LDL        span         length       unused    /
CD     .33200E+04   .21300E+04   .64300E+02   .70700E+02   .00000E+00 /
CC====================================================================/
FI
```

Appendix C Aircraft Equivalents

Table C-1 Aircraft Types and Equivalents

Aircraft Type Modeled in BADA	Cat	Equivalents
A306	J	A306 A300
A30B	J	A30B IL76
A310	J	A310
A319	J	A319
A320	J	A320
A321	J	A321
A330	J	A330
A340	J	A340
AT43	T	AT43 AT44 AT45 ATR
AT72	T	AT72 A748
ATP	T	ATP E2
B703	J	B701 B703 B707 B720 C135 K35A K35E K35R R135 E3TF E3CF E3 E6 KE3 VC10 IL62
B722	J	B721 B722 B72Q B727 TRID COMT CV99
B732	J	B712 B731 B732 B73Q B73A
B733	J	B733 B734 B735 B73B B73S
B738	J	B736 B737 B738 B73C
B742	J	B741 B742 B743 C5 B747
B744	J	B52 B744 B74R B74A B74B B74S C17 B1
B752	J	B752 B753 B757
B763	J	B762 B763 B767
B772	J	B772 B773 B777
BA11	J	BA11
BA46	J	AR7 BA46
BE20	T	B350 BE20 BE30 STAR N260 N262 AC6T
BE99	T	TBM7 BE99 T34T BN2T C208 DH2T DHC6 D28T G64T STLN P68T VTOR PC7 PC12 AC80 SC7 F26T BE90
BE9L	T	BE10 BE9L U21 B18T V10 F600
C130	T	SGUP VISC DHC7 C130 L188 P3
C160	T	C160
C421	P	C97 BU20 C320 C404 C411 C414 C421 L18 AC95
C550	J	S601 BE40 C500 C501 C525 C526 C550 C551 C750 T37 HF20 MU30
C560	J	C560
CL60	J	CL60 GLF2 GLF3 GLF4 GLF5 GULF L29A L29B

Aircraft Type Modeled in BADA	Cat	Equivalents
CRJ1	J	CARJ E145
D228	T	D228 E110
D328	T	D328 G159
DC10	J	DC10 KC10
DC87	J	C141 DC85 DC86 DC87 DC8Q DC8
DC9	J	DC9
DH8C	T	F406 DHC5 DH8A DH8B DH8C DHC8 PC6T CVLT C2 YS11 DH8 CV58
E120	T	E120
F100	J	S210 F100 VF14
F27	T	F27
F28	J	F28
F50	T	F50 F60
F70	J	F70
F900	J	F900
FA10	J	FA10
FA20	J	FA20 F2TH ASTR P808 JCOM SBR1
FA50	J	FA50
FGTR	J	CONC HAR A37 A10 F111 F16 A6 F14 F104 S3 R33 TR1 U2 A3 A4 F15 F18 F4 F5 T38 F86 SSAB T2 A7
H25B	J	H25A H25B H25C WW23 WW24
JS31	T	B190 JS1 JS20 JS3 JS31 JS32 JSTA V1 JS1 JS20 JSTA
JS41	T	JS41 JSTB
L101	J	L101
LJ35	J	C650 LJ23 LJ24 LJ25 LJ28 LJ31 LJ35 LJ60
MD11	J	MD11
MD80	J	MD80
MD90	J	MD90
MU2	T	C441 M7T MU2
P28A	P	RALL TAMP TOBA ERCO PUP BE19 BE23 BE24 B14A BL17 BL8 CH7A CH7B C120 C140 C150 C152 C170 C172 C72R C175 C177 C77R C180 C182 C82R C185 C188 C190 C195 C205 C206 C207 C210 P210 O1 DHC1 DHC2 DHC3 DHC4 DV20 DO27 E200 E230 E300 E400 FA62 PC6P CAT VALI G109 G115 AA1 AA5 G164 COUR DG15 LA25 LA4 M4 M5 M6 M7 B209 RANG NORS OSCR PA11 PA12 PA14 PA15 PA16 PA17 PA18 PA20 PA22 PA24 PA25 P28A PA8B PA28 P28T PA32 P32R P32T PA36 PA38 PA46 PAT4 PA42 PILL S108 AC11 CM11 LARK T6 VO10 R90F R90R L8 L5 RELI S10 S108 TA15 TF19 TA20 TF21 GC1 CH2T
PA27	P	BE50 BE55 BE58 HUSK DOVE P66P AEST PA23 PA27 C310

Aircraft Type Modeled in BADA	Cat	Equivalents
		AEST
PA31	P	CP10 CP20 BE60 BE65 BE76 BE77 BE80 BE95 BN2P TRIS TNAV C303 C310 C335 C340 C402 HERN DO28 D28D G21 G44 G73 GA7 U16 M404 TNAV NORA PA30 PA31 PTS1 PTS2 P51 T28
PA34	P	BASS BE17 BE18 BE33 BE35 BE36 T34P CH40 C336 C337 P337 C46 C119 C123 CVLP TCOU CONI B26 DC3 DC3S DC4 DC6 DC7 P68 P136 PA34 PA44 AC50 AC52 AC56 AC68 AC6L AC72 B25 M200
PAY2	T	C425 P46T PAY1 PAY2 P31T
PAY3	T	PAY3 PAY4 AC90
SF34	T	SF34
SH36	T	C212 ARVA PC6T SH33 SH36
SW3	T	SW2 SW3 SW4
TRIN	P	TRIN AT3P AR11 AR15 ST75 ME08 MITE M10 M20P M20T M20 M22 PC6P P28R NAVI J2 J3 J4 J5

Appendix D Sample Input File

```
%This file contains data for Boeing 747-400 with CF6-80C2B4 engines

%Aircraft type designator per FAA/ICAO/NAV CANADA and Eurocontrol

AcType  = 'B744';
EngType = 'jet';

%Cruise flight conditions

h       = 35000;            % Cruise altitude (ft)
hmax    = 45000;            % Max altitude (ft), operating ceiling
M       = 0.85;             % Cruise Mach

%Weight data

Wmax    = 372*1000/.454;    % Aircraft maximum take-off weight (lbs)
Wnom    = 300*1000/.454;    % Aircraft nominal weight (lbs)
Wmin    = 180*1000/.454;    % Aircraft operating empty weight (lbs)
Wload   = 61.64*1000/.454;  % Aircraft maximum payload weight (lbs))

%Wing data

Sref    = 525*10.7626;      % Wing plan form area (ft^2)
AR      = 7.39;             % Aspect ratio
lambda  = 0.275;            % Taper ratio
SWEEPq  = 37.5;             % 1/4 Chord sweep (deg)
t_c     = 9.40/100;         % Thickness ratio
h_wlt   = 0;                % Winglet height (ft), 0 (no winglets)

%Fuselage data

Df      = 8.10*3.2808;      % Fuselage diameter (ft)
Lf      = 68.63*3.2808;     % Fuselage length (ft)
Lnf     = 0.2*Lf;           % Fuselage nose section length (ft)
Ltf     = 0.3*Lf;           % Fuselage tail section length (ft)

%Horizontal Tail data

S_ht       = 136.6*10.7626; % Horizontal tail plan form area (ft^2)
AR_ht      = 3.57;          % Aspect ratio
lambda_ht  = 0.265;         % Taper ratio
SWEEPq_ht  = 32;            % 1/4 Chord sweep (deg)
t_c_ht     = t_c;           % Thickness ratio

%Vertical Tail data

S_vt       = 77.10*10.7626; % Vertical tail plan form area (ft^2)
AR_vt      = 1.34;          % Aspect ratio
lambda_vt  = 0.330;         % Taper ratio
SWEEPq_vt  = 45;            % 1/4 Chord sweep (deg)
t_c_vt     = t_c;           % Thickness ratio

%Engine data

n_eng      = 4;             % Number of engines
Dn         = 2.9*3.2808;    % Nacelle diameter (ft)
Ln         = 5.64*3.2808;   % Nacelle length (ft)
MaxThrust  = 57900;         % Maximum (static) thrust per engine (lbs)
```

Appendix E Sample XML Output File


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    <fuel_weight>2.8731344e+005</fuel_weight>
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    <k2>50.0</k2>
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    -<Jet>
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        <coeff2>5.9557000e+004</coeff2>
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        <f2>5.3904000e+003</f2>
        <f3>3.9007000e+001</f3>
        <f4>7.5715000e+004</f4>
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    </Engine>
  -<Airframe>
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      <Cd_brakes>0.0000000e+000</Cd_brakes>
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      <Cd2_lift>2.7964200e-002</Cd2_lift>
      <Cd3_lift>3.2865800e-002</Cd3_lift>
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      <Cd5_lift>7.5922000e-002</Cd5_lift>
      <K1_drag>4.5000000e-002</K1_drag>
      <K2_drag>4.3591500e-002</K2_drag>
      <K3_drag>4.0810500e-002</K3_drag>
      <K4_drag>4.0531500e-002</K4_drag>
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      <CL_max2>1.9884876e+000</CL_max2>
      <CL_max3>2.2523680e+000</CL_max3>
      <CL_max4>2.2523680e+000</CL_max4>
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      <alt_error>500.0</alt_error>
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          <R1245_Ki14>2.0935634e-005</R1245_Ki14>
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      -<Regions36_MachBased>
```

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        <R36Mach_Ki12>-5.4633643e+000</R36Mach_Ki12>
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    -<RegionGS_IasBased>
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        <RgsIas_Kp14>1.0633606e-003</RgsIas_Kp14>
        <RgsIas_Kp13>3.0838633e-002</RgsIas_Kp13>
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        <RgsIas_Ki21>8.0044333e+003</RgsIas_Ki21>
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      <Descent_Mach>0.85</Descent_Mach>
      <Descent_Rate_Fpm>1800</Descent_Rate_Fpm>
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      <Deceleration_Rate_Ias>1</Deceleration_Rate_Ias>
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      <Climb_Mach>0.85</Climb_Mach>
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      <Cruise_Ias_High>340</Cruise_Ias_High>
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     <Transition_Altitude_Climb>27861</Transition_Altitude_Climb>
     <Transition_Altitude_Descent>36672</Transition_Altitude_Descent>
    </Guidance_Performance_Parameters>
  </Guidance_System>
</ADMAircraft>
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