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USER MANUAL FOR THE BASE OF AIRCRAFT DATA (BADA) REVISION 3.6

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TITLE:

User Manual for the Base of Aircraft Data (BADA) - Revision 3.6

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Abstract:

The Base of Aircraft Data (BADA) provides a set of ASCII files containing performance and operating procedure coefficients for 295 different aircraft types. The coefficients include those used to calculate thrust, drag and fuel flow and those used to specify nominal cruise, climb and descent speeds. User Manual for Revision 3.6 of BADA provides definitions of each of the coefficients and then explains the file formats. Instructions for remotely accessing the files via Internet are also given.

User Manual
for the
Base of Aircraft Data (BADA)
Revision 3.6

Summary

The Base of Aircraft Data (BADA) provides a set of ASCII files containing performance and operating procedure coefficients for 295 different aircraft types. The coefficients include those used to calculate thrust, drag and fuel flow and those used to specify nominal cruise, climb and descent speeds. The User Manual for Revision 3.6 of BADA provides definitions of each of the coefficients and then explains the file formats. Instructions for remotely accessing the files via Internet are also given.

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User Manual Modification History

Issue Number	Release Date	Comments
Revision 2.1 Issue 1.0	31.05.94	First release of document
Revision 2.2 Issue 1.0	25.01.95	Released with BADA Revision 2.2 - 8 new aircraft models - 2 modified aircraft models - 2 modified equivalences - 6 removed equivalences - 14 new equivalences - modified file formats - additional Synonym File - corrections to formulas in previous version of document - additional description of total-energy and standard atmosphere equations
Revision 2.3 Issue 1.0	08.06.95	Released with BADA Revision 2.3 - document format modified to be consistent with EEC Technical Note standards - new A/C models for B73V and D328 - MD11 changed from equivalence to direct support - generic military fighter model, FGTR, replaces specific fighter models - maximum payload parameter added to all OPF files - Performance Tables Files (*.PTF) introduced - ISA equations used for TAS/CAS conversions instead of approximations (Section 3.2) - use only one formula for correction of speeds at mass values different from reference mass (Section 3.3) - add specification of minimum speed as function of stall speed (Section 3.4) - specification of transition altitude calculated added (Section 4.1) - speed schedules modified for climb (Section 4.1) and descent (Section 4.3) - modify Internet address for remote access and Eurocontrol contact person (Section 6) - removed Section 7 (General Comments)

User Manual Modification History (cont'd)

Issue Number	Release Date	Comments
Revision 2.4 Issue 1.0	04.01.96	Released with BADA Revision 2.4 - new A/C model for FK70 - C421 changed from equivalence to directly supported - 10 new equivalences - 1 modified equivalence - 3 re-developed models - introduction of dynamic maximum altitude - new temperature correction on thrust - modified max.alt for 4 models - modified minimum weight for 2 models - modified temperature coefficients for 12 models - esf calculation for constant CAS below tropopause changed from binomial approximation to exact formula - cruise Mach numbers changed for 4 models - change in altitude limit for descent speed
Revision 2.5 Issue 1.0	20.01.97	- re-developed models: EA32, B737, B73S, AT42, B767, DC9, BA46, FK10, MD80. - new model: CL65, DH83 - change of minimum speeds - change of climb/descent speed schedules - cruise fuel flow correction - buffeting speed for jet a/c - addition of BADA.GPF file - definition of acceleration limits, bank angles and holding speeds - 38 new equivalences added (SA4, SA5, SweDen 96) - 1 modified equivalence (B74S) - modified climb/cruise speeds (BE90, BE99, E120, PA42, FK50, B73F, B767,B747, B727, DA20) - Format changes in OPF file - Header changes in PTF file - Temperature influence on thrust limitation changed - Unit of Vstall in OPF file changed to KCAS - Correction of typing errors - Correction of APF file format explanation

User Manual Modification History (cont'd)

Issue Number	Release Date	Comments
Revision 2.6 Issue 1.0	01.09.97	- Added non-clean drag and thrust data for: EA32, B73S, MD80, B737, B747, FK10, AT42, B767 and CL65 models - All models mentioned above were re-developed using new clean drag data. - ND16, E120 and FK50 were re-modelled to correct the cruise speed capability. - Change of speed schedule in the take-off / initial climb phase and approach / landing phase - Change in descent thrust algorithm - Use of exact formula for density below tropopause instead of approximation. - Addition of formula for pressure above tropopause - Change of buffeting limit to 1.2g (was 1.3g) - Change of OPF file format - Buffeting coefficients for B757 and MD80 were corrected. - Hmo for B747 model was corrected to 45,000 ft - Low altitude descent behaviour corrected for: SW3, PAYE, DA50, DA10, D328, C421, BE99, BE20 and BE90 models - Correction of some minor typing errors - dynamic maximum altitude coefficients changed for B747, B74F, C130 and EA30 - Saab 2000 (SB20) added as equivalent of D328 - Modified algorithm for lift coefficient
Revision 3.0 Issue 1.0	01.03.98	- Climb speed law changed for jet aircraft - Descent speed law changed for jet, turbo and piston - Reduced power climbs - B777, SB20 and B73X models were added - DA01 model was removed - Use of ICAO doc. 8643/25 standard, which resulted in the removal of 4 additional models - B73F and B757 remodelled - MD90 added as equivalenced model - Cruise and descent speeds for several turboprops changed - Climb thrust for several a/c changed - Removal of C_{m16} from drag expression

User Manual Modification History (cont'd)

Issue Number	Release Date	Comments
Revision 3.1 Issue 1.0	01.10.98	Released with BADA Revision 3.1 - Descent & cruise speeds for several jet aircraft changed : DC9, BA46, CL60 - Descent, cruise & climb speeds for several turboprops changed : D228, SH36 - Maximum Operating speed for several a/c changed : PA42 - Stalling speed for several a/c changed : DC8, T154 - Removed formula for air density calculation above tropopause - Addition of Appendix D : Solutions for buffeting limit algtorithm - Removed Section 3.7.2 : Maximum Take-Off Thrust - Description for C_{red} parameter added - Correction of some minor typing errors - Modified PTF File format (Flight Level): Section 6.6 - Cruise CAS schedule for jet & turbo aircraft (Section 4.2) -
Revision 3.3 Issue 1.0		Released with BADA Revision 3.3 - Standard atmosphere explanation added - Correction of some typing errors, minor changes in the layout and equations presentation. - Several aircraft types have changed ICAO's designator according to the ICAO doc.8643/27. Aircraft types affected by the RD3 are as follows: A300, ATR, B707, B727, B73A, B73B, B73C, B74A, B74B, B757, B767, B777, CARJ, DC8, DHC8, JSTA, JSTB, P31T, PA28, PA42. That resulted in: modification of the name of the OPF and APF files, addition of new models as synonyms, modification of Synonym.NEW and Synonym.LST files. - B73A, B757, MD80, B73B, F100, B727, CARJ, FA20, FA50, D228, T154 aircraft models have been re-modelled - A319, A321, A306, AT72 models have been added - Climb, cruise and descent speeds changed for several models

User Manual Modification History (cont'd)

Issue Number	Release Date	Comments
Revision 3.3 Issue 1.0		- Ground TOL for B73C has been modified. - MD80: Cd0 and Cd2 for IC and TO added, maximum altitude at MTOW, ISA weight gradient on maximum altitude Gw and temperature gradient Gt on maximum altitude have been changed - BA46 maximum altitude at MTOW, ISA weight gradient on maximum altitude Gw have been changed - E145 was added as equivalent of CRJ1 - A478 was added as equivalent of AT72
Revision 3.4 Issue 1.0	June 2002	Released with BADA Revision 3.4 - correction of some typing errors - in chapter 3.5 configuration threshold altitude values replaced with $H_{max,i}$,while the corresponding numbers are listed in chapter 5.6 - Appendix B: a new column is added to the table; providing the information on maximum altitude that an aircraft can reach at MTOW (h_{max}) - FGTN aircraft model added - FGTH aircraft model added - FGTL aircraft model added - FGTR aircraft model removed - DC-9 aircraft model re-modelled - D228 cruise and descent speed modified - SH36 cruise and descent speed modified - B738 maximum operational altitude modified - AT72 cruise speed corrected - PA34 minimum mass modified - B734 aircraft model added - B735 aircraft model added - E145 aircraft model added - B737 aircraft model added - AT45 aircraft model added - B762 aircraft model added - B743 aircraft model added - Removal of several existing OPF and APF files

		due to the change of ICAO aircraft designators according to RD3: A330, A340, BA46, DC9, MD80 - Addition of several new OPF and APF files due to the change of ICAO aircraft designators according to RD3: A333, A343, B461, DC94, MD83 - Addition of new equivalence aircraft types: A332, A342, A345, A346, B461, B462, B463, DC91, DC92, DC93, DC95, MD81, MD82, MD87, MD88, A124, AC80, AC90, AC95, AJET, AMX, AN72, ATLA, B1, B350, B739, B74D, BDOG, BE10, BE40, BE76, BER4, C17, C72R, C77R, C82R, C210, C212, C337, C526, C56X, CRJ7, E135, EUFI, F1, FT2H, F104, G222, GLF5, HAWK, H25A, H25C, IL96, JS1, JS3, JS20, LJ24, M20T, M20P, K35R, N262, P28T, P28B, PA32, PAY4, P68, PA44, SB05, T204, TBM7 - Modification of the value for Maximum bank angles for civil flight during HOLD in BADA.GPF file - Configuration Management of BADA files have been changed; files have been migrated from RCS to Continuus Configuration Management System. That resulted in the modification of the “identification” part of all BADA files given in the header.
Revision 3.5 Issue 1.0	July 2003	Released with BADA Revision 3.5 - correction of some typing errors - B712 aircraft model added - LJ45 aircraft model added - C750 aircraft model added - RJ85 aircraft model added - B736 aircraft model added - B753 aircraft model added - A332 aircraft model added - B772 re-modelled - B738 re-modelled - B763 re-modelled - B703 WTC modified - JS41 WTC modified - Addition of new synonym aircraft types:

		P180, GLEX, C30J, J328, A7, B52, ETAR, F117, L159 - Modification of BADA models for existing synonym aircraft types: C17, GLF3, GLF3, GLF4, GLF5 - SYNONYM_ALL.LST file added
Revision 3.6 Issue 1.0	July 2004	Released with BADA Revision 3.6 The following models of aircraft added in BADA 3.6: - Dash 8-100: **DH8A** - Boeing MD82: **MD82** - Boeing B767-400: **B764** - Boeing B777-300: **B773** - BAE 146-200: **B462** The following models of aircraft have been re-modelled in BADA 3.6: - Airbus A300B4-203: **A30B** - Airbus A310: **A310** - Airbus A319: **A319** - Airbus A320: **A320** - Airbus A321: **A321** - Airbus A330-301: **A333** - Airbus A340-313: **A343** - Boeing B737-200: **B732** - Boeing B737-300: **B733** - Boeing B747-200: **B742** - Boeing B747-400: **B744** - Boeing B757-200: **B752** Addition of new synonym aircraft types: A3ST, ASTR, B701, C441, GALX, J728, K35A, K35E, L29B, LJ25, LJ60, NIM, PC12, R135, RJ1H, RJ70, P32R, C208, AA5, S76, DC3, BLAS, AEST, EC35, PAY1, PA18, BE55, C170, B461 Correction of syntax errors in BADA files: - Boeing B777-200: **B772** - ATR42-500: **AT45**

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Table of Contents

1 IDENTIFICATION

1.1 Identification

This document is the User Manual for the Base of Aircraft Data (BADA) Revision 3.6. This manual replaces the previous User Manual for BADA Revision 3.5 [RD1].

1.2 Purpose

BADA is a collection of ASCII files which specifies operation performance parameters, airline procedure parameters and performance summary tables for 295 aircraft types. This information is designed for use in trajectory simulation and prediction algorithms within the domain of Air Traffic Management (ATM). All files are maintained within a configuration management system at the Eurocontrol Experimental Centre (EEC) in Brétigny-sur-Orge, France.

This document describes the mathematical models on which the data is based and specifies the format of the files which contain the data. In addition, this document describes how the files can be remotely accessed from the EEC.

1.3 Document Organisation

This document consists of seven sections including Section 1, the Introduction. A list of referenced documents along with a glossary of acronyms and symbols are included in this section.

Section 2, Revision Summary, summarises the differences between BADA 3.6 and the previous revision BADA 3.5.

Section 3, Operation Performance Models, defines the set of equations, which are used to parameterise aircraft performance. This includes models of aerodynamic drag, engine thrust, and fuel consumption.

Section 4, Airline Procedure Models, defines the set of parameters which is used to characterise standard airline speed procedures for climb, cruise, and descent.

Section 5, Global Aircraft Parameters, defines the set of global aircraft parameters that are valid for all, or a group of, aircraft.

Section 6, File Structure, describes the files in which the BADA aircraft parameters are maintained. Five types of files are identified:

- Synonym Files listing the supported aircraft types;
- Operations Performance Files (OPF) containing the performance parameters for a specific aircraft type;
- Airline Procedures Files (APF) containing speed procedure parameters for a specific aircraft type;

- Performance Table Files (PTF) containing summary performance tables of true air speed. climb/descent rates and fuel consumption at various flight levels for a specific aircraft type;
- Global Parameters File (GPF) containing parameters that are valid for all aircraft or a group of aircraft for instance all turboprops or all military a/c.

Section 7, Remote File Access to BADA, provides instructions on how to remotely access BADA files from the EEC computing facilities over the Internet.

Three appendices are also provided with this document. Appendix A presents a summary list of all files contained in BADA Revision 3.6. Appendix B provides a list of the aircraft types supported by BADA 3.6 and Appendix C gives solutions for a buffeting limit algorithm.

1.4 Referenced Documents

RD1 User Manual for the Base of Aircraft Data (BADA) Revision 3.5; EEC Note No. 11/03;

RD2 Aircraft Type Designators, ICAO Document 8643/31, November, 2003

RD3 Aircraft Modelling Standards for Future ATC Systems; Eurocontrol Division E1 Document No. 872003, July 1987

RD4 Manual of the ICAO Standard Atmosphere; ICAO Document No. 7488, 2nd Edition, 1964.

RD5 BADA Configuration Management Manual; Internal EEC Note 1/ERIS/2002; April 2002.

RD6 Design and User Manual for BADA Excel Spreadsheets, Issue 2.0; EEC Note 13/98; May 1998.

RD7 Memo on the Calculation of Energy Share Factor; EEC/FAS/BYR/95/50; 22 November 1995

RD8 Revision Summary Document for the Base of Aircraft Data (BADA) Revision 3.6; EEC Note 11/04; July 2004.

RD9 Aircraft Performance Summary Tables for the Base of Aircraft Data (BADA) Revision 3.6; EEC Note 12/04; July 2004.

RD10 Aircraft Type Designators, ICAO Document 8643, Version 24-30

RD11 Introduction to Continuus/ CM; Continuus Software Corporation, California

1.5 Glossary of Acronyms

AGL	Above Ground Level
APF	Airlines Procedures File
APO	Centre for Aircraft Performance and Operations
ASCII	American Standard Code for the Interchange of Information
ATM	Air Traffic Management
BADA	Base of Aircraft Data
CAS	Calibrated Airspeed
CRCO	Central Route Charges Office
EEC	Eurocontrol Experimental Centre
ESF	Energy Share Factor
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organisation
ISA	International Standard Atmosphere
MASS	Multi-Aircraft Simplified Simulator
MLW	Maximum Landing Weight
MTOW	Maximum Take-off Weight
OPF	Operations Performance File
OWE	Operational Weight Empty
PTF	Performance Table File
RCS	Revision Control System
ROCD	Rate of Climb or Descent
TAS	True Airspeed
TEM	Total-Energy Model

1.6 Glossary of Symbols

A list of the symbols used in equations throughout this document is given below along with a description. Where appropriate, the engineering units typically associated with the symbol are also given.

a	speed of sound	[m/s]
d	distance	[nautical miles]
f	fuel flow	[kg/min]
g	gravitational acceleration	[m/s^2]
$\frac{dh}{dt}$	rate of climb or descent	[m/s] or [ft/min]
h	altitude above sea level	[metres] or [ft]
C	general coefficient	
D	drag force	[Newtons]
m	aircraft mass	[tonnes] or [kg]
M	Mach number	
P	Actual pressure	[Pa]
P_0	Pressure at Sea level	[Pa]
R	real gas constant for air	[m^2/Ks^2]
S	reference wing surface area	[m^2]
T	thrust temperature	[N] [Kelvin]
V	speed	[m/s] or [knots]
ΔT	temperature difference	[Kelvin]
W	weight	[N]
η	thrust specific fuel flow	[kg/min/kN]
ρ	air density	[kg/m^3]

2 REVISION SUMMARY

This section summarises the aircraft types that are supported in BADA Revision 3.6 along with the updates that have been made from the previous release, BADA Revision 3.5.

2.1 Supported Aircraft

BADA 3.6 provides operations and procedures data for a total of 295 aircraft types. For 91 of these aircraft types, data is provided directly in files. These aircraft types are referred to as being directly supported. For the other 204 aircraft types, the data is specified to be the same as one of the directly supported 91 aircraft types. This second set of aircraft types is referred to as being supported through equivalence.

With three exception, each supported aircraft type is identified by a 4-character designation code assigned by the International Civil Aviation Organisation (ICAO) [RD2]. The exceptions are the model representing generic military fighters, which use the designators: FGTH, FGTL, FGTN.

The list of aircraft types supported by BADA 3.6 is given in Appendix B. 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.

2.2 Updates for BADA Revision 3.6

Updates made to BADA Revision 3.6 from the previous revision 3.5 are listed below:

(a) Some editing changes

(b) Implementation of new ICAO aircraft designators according to the ICAO doc. 8643/ 31

(c) Addition of 5 new aircraft models

(d) Addition of 29 new aircraft models as equivalence

(e) Re-modelling of 12 aircraft models

(f) Correction of syntax error in 2 BADA files

A more complete overview of all changes can be found in [RD8].

3 OPERATIONS PERFORMANCE MODEL

This section defines the various equations and coefficients used by the BADA operations performance model.

The first two subsections describe the Total-Energy Model (TEM) equations and standard atmosphere equations respectively.

The remaining eight subsections define the aircraft model in terms of the eight categories listed below.

- aircraft type,
- mass,
- flight envelope,
- aerodynamics,
- engine thrust,
- reduced power,
- fuel consumption and
- ground movement

3.1 Total-Energy Model

The Total-Energy Model equates the rate of work done by forces acting on the aircraft to the rate of increase in potential and kinetic energy, that is:

$$(T - D)\, V_{TAS} = mg\frac{dh}{dt} + mV_{TAS}\frac{dV_{TAS}}{dt} \qquad (3.1\text{-}1)$$

The symbols are defined below with metric units specified:

T	-	thrust acting parallel to the aircraft velocity vector	[Newtons]
D	-	aerodynamic drag	[Newtons]
m	-	aircraft mass	[kilograms]
h	-	altitude	[m]
g	-	gravitational acceleration	[9.81 m/s^2]
V_{TAS}	-	true airspeed	[m/s]
$\frac{d}{dt}$	-	time derivative	[s^{-1}]

Note that true airspeed is often calculated in knots and altitude calculated in feet thus requiring the appropriate conversion factors.

Without considering the use of devices such as spoilers, leading-edge slats or trailing-edge flaps, there are two independent control inputs available for affecting the aircraft trajectory in the vertical plane. These are the throttle and the elevator.

These inputs allow any two of the three variables of thrust, speed, or ROCD to be controlled. The other variable is then determined by equation 3.1-1. The three resulting control possibilities are elaborated on below.

(a) Speed and Throttle Controlled - Calculation of Rate of Climb or Descent

Assuming that velocity and thrust are independently controlled, then equation 3.1-1 is used to calculate the resulting rate of climb or descent (ROCD). This is a fairly common case for climbs and descents in which the throttle is set to some fixed position (maximum climb thrust or idle for descent) and the speed is maintained at some constant value of calibrated airspeed (CAS) or Mach number.

(b) ROCD and Throttle Controlled - Calculation of Speed

Assuming that the ROCD and thrust are independently controlled, then equation 3.1-1 is used to calculate the resulting speed.

(c) Speed and ROCD Controlled - Calculation of Thrust

Assuming that both ROCD and speed are controlled, then equation 3.1-1 can be used to calculate the necessary thrust. This thrust must be within the available limits for the desired ROCD and speed to be maintained.

Case (a), above, is the most common such that equation 3.1-1 is most often used to calculate the rate of climb or descent. To facilitate this calculation, equation 3.1-1 can be rearranged as follows:

$$(T - D) \times V_{TAS} = mg\frac{dh}{dt} + m\, V_{TAS}\left(\frac{dV_{TAS}}{dh}\right)\left(\frac{dh}{dt}\right) \qquad (3.1\text{-}2)$$

Isolating the rate of climb or descent on the left hand side gives:

$$\frac{dh}{dt} = \frac{(T - D)V_{TAS}}{mg}\left[1 + \left(\frac{V_{TAS}}{g}\right)\left(\frac{dV_{TAS}}{dh}\right)\right]^{-1} \qquad (3.1\text{-}3)$$

It has been shown by Renteux [RD3] that the last term can be replaced by an energy share factor as a function of Mach number, f {M}.

$$f\{M\} = \left[1 + \left(\frac{V_{TAS}}{g}\right)\cdot\left(\frac{dV_{TAS}}{dh}\right)\right]^{-1}$$

This leads to.

$$\frac{dh}{dt} = \left[\frac{(T - D)V_{TAS}}{mg}\right] f\{M\} \qquad (3.1\text{-}4)$$

This energy share factor f {M} specifies how much of the available power is allocated to climb as opposed to acceleration while following a selected speed profile during climb.

For several common flight conditions equation 3.1-4 can be rewritten as is done below. A more comprehensive description of this process can be found in RD7:

(a) Constant Mach number in stratosphere (i.e. above tropopause)

$$\boxed{f\{M\} = 1.0} \quad (3.1\text{-}5)$$

Note that above the tropopause (approximately 11000 metres under ISA conditions) the air temperature and the speed of sound are constant. Maintaining a constant Mach number therefore requires no acceleration and all available power can be allocated to a change in altitude.

(b) Constant Mach number below tropopause:

$$\boxed{f\{M\} = \left[1 + \frac{\gamma R\, k_T}{2\,g} M^2\right]^{-1}} \quad (3.1\text{-}6)$$

where,

R	is the real gas constant for air, $R = 287.04\ m^2/Ks^2$
g	is the gravitational acceleration, $g = 9.81$ m/s2
k_T	is the ISA temperature gradient with altitude below the tropopause, $k_T = -0.0065$ °K/m
M	is the Mach number
γ	is the isentropic expansion coefficient for air, $\gamma = 1.4$

In this case, for a typical Mach number of 0.8 the energy share factor allocated to climb is 1.09.

This number is greater than 1 because below the tropopause, the temperature and thus, speed of sound decreases with altitude. Maintaining a constant Mach number during climb thus means that the true air speed decreases with altitude. Consequently, the rate of climb benefits from not only all the available power but also a transfer of kinetic energy to potential energy.

(c) Constant Calibrated Airspeed (CAS) below tropopause

$$\boxed{f\{M\} = \left\{1 + \frac{\gamma R\, k_T}{2\,g} M^2 + \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{-1}{\gamma-1}} \left\{\left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{\gamma}{\gamma-1}} - 1\right\}\right\}^{-1}} \quad (3.1\text{-}7)$$

In this case the energy share factor is less than one. A Mach number of 0.6 for example yields an energy share factor of 0.85.

This number is less than 1 because as density decreases with altitude, maintaining a constant CAS during climb requires maintaining a continual increase in true air speed. Thus, some of the available power needs to be allocated to acceleration leaving the remainder for climb.

(d) Constant Calibrated Airspeed (CAS) above tropopause

$$f\{M\} = \left\{ 1 + \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{-1}{\gamma-1}} \left[\left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{\gamma}{\gamma-1}} - 1 \right] \right\}^{-1} \quad (3.1\text{-}8)$$

This is a very uncommon situation that would only occur at very low temperatures (ISA -20 or below) and it is therefore not incorporated in BADA, but merely mentioned for the sake of completeness.

The energy share factors given above apply equally well to descent as to climb. The difference being that the available power is negative for descent.

In cases where neither constant Mach number nor constant CAS is maintained, the following energy share factors are used.

acceleration in climb	f{M} = 0.3
deceleration in descent	f{M} = 0.3
deceleration in climb	f{M} = 1.7
acceleration in descent	f{M} = 1.7

Note, for the cases of acceleration in climb or deceleration in descent, the majority of the available power is devoted to a change in speed.

For the cases of deceleration in climb or acceleration in descent, the energy share factor is greater than 1 since the change of altitude benefits from a transfer of kinetic energy.

3.2 Standard Atmosphere

Calculations for lift, drag, and conversions from CAS to TAS and Mach number require the determination of several atmospheric properties as a function of altitude.

The equations used by BADA for the standard atmosphere and CAS/TAS conversion are summarised below. These equations are based on the International Standard Atmosphere (ISA) [RD4].

(a) Determination of the Tropopause

$$\boxed{h_{trop} = 11000 + 1000 \ \Delta T_{ISA} / 6.5} \qquad (3.2\text{-}1)$$

Here the tropopause altitude, h_{trop}, is specified in metres.

ΔT_{ISA} is the temperature difference from the International Standard Atmosphere (ISA). That is, the temperature at sea level, T_0 , would be:

$$T_0 = (T_0)_{ISA} + \Delta T_{ISA} \qquad (3.2\text{-}2)$$

with

$$(T_0)_{ISA} = 288.15 \text{ K} \qquad (3.2\text{-}3)$$

For standard atmosphere conditions, ($\Delta T_{ISA} = 0$) the tropopause is at 11000 metres altitude.

(b) Determination of Temperature

Above the tropopause, the temperature is a constant, that is,

$$\boxed{T_{trop} = 216.65 \text{ K}} \qquad (3.2\text{-}4)$$

Below the tropopause, the temperature is calculated as a function of altitude as follows:

$$T = T_0 - 6.5*h/1000 \qquad (3.2\text{-}5)$$

Here the altitude, h, is specified in metres.

(c) Determination of Air Density

Below the tropopause, the air density, ρ , in kg/m^3 is calculated as function of temperature as follows:

$$\boxed{\rho = \rho_0 \left[\frac{T}{T_0}\right]^{-\frac{g}{K_T R}-1}} \qquad -\frac{g}{K_T R} - 1 \approx 4.25864 \qquad (3.2\text{-}6)$$

where,

R	is the real gas constant for air, R = 287.04 m^2/Ks^2
g	is the gravitational acceleration, g = 9.81 m/s2
k_T	is the ISA temperature gradient with altitude below the tropopause, k_T = -0.0065 °K/m

Here ρ_0 is the air density at sea level:

$$\rho_0 = (\rho_0)_{ISA}\,(T_0)_{ISA} / T_0 \tag{3.2-7}$$

and $(\rho_0)_{ISA}$ is the standard atmosphere air density at sea level:

$$(\rho_0)_{ISA} = 1.225 \text{ kg/m}^3 \tag{3.2-8}$$

Above the tropopause, the air density, ρ, in kg/m^3 is calculated as follows [RD4]:

$$\rho = \rho_{Trop} \cdot e^{-\left(\frac{g}{R \cdot T_{Trop}}\right)\cdot(h - h_{trop})} \tag{3.2-9}$$

Here h represents the altitude in meters.

(d) Determination of Speed of Sound

Above the tropopause the speed of sound, a , is a constant:

$$\boxed{a_{trop} = \sqrt{\gamma\, R\, T_{trop}}}$$

where:

$\gamma = 1.4$
$R = 287.04\ m^2 / K\, s^2$
$T_{trop} = 216.65$ °K

leads to

$$a_{trop} = 295.07 \text{ m/s} \tag{3.2-10}$$

Below the tropopause, the speed of sound is calculated as a function of temperature:

$$a = 340.29\sqrt{\frac{T}{(T_0)_{ISA}}} \tag{3.2-11}$$

(e) CAS/TAS Conversion

The true air speed, V_{TAS}, is calculated as a function of the calibrated air speed, V_{CAS}, as follows:

$$V_{TAS} = \left[\frac{2}{\mu} \frac{P}{\rho} \left\{ \left(1 + \frac{(P_0)_{ISA}}{P} \left[\left(1 + \frac{\mu}{2} \frac{(\rho_0)_{ISA}}{(P_0)_{ISA}} V_{CAS}^{\ 2} \right)^{1/\mu} - 1 \right] \right)^{\mu} - 1 \right\} \right]^{1/2} \qquad (3.2\text{-}12)$$

Similarly, V_{CAS} is calculated as a function of V_{TAS} as follows:

$$V_{CAS} = \left[\frac{2}{\mu} \frac{(P_0)_{ISA}}{(\rho_0)_{ISA}} \left\{ \left(1 + \frac{P}{(P_0)_{ISA}} \left[\left(1 + \frac{\mu}{2} \frac{\rho}{P} V_{TAS}^{\ 2} \right)^{1/\mu} - 1 \right] \right)^{\mu} - 1 \right\} \right]^{1/2} \qquad (3.2\text{-}13)$$

where symbols not previously defined are explained below:

$$\mu = \frac{(\gamma - 1)}{\gamma} \qquad (\mu = 1 / 3.5 \text{ if } \gamma = 1.4) \qquad (3.2\text{-}14)$$

γ is the isentropic expansion coefficient for air = 1.4 [dimensionless]
P is the pressure at altitude [Pa]

$(P_0)_{ISA}$ is the ISA pressure at sea level = 101325 Pa

Also note that for these conversion formulas above, the speeds V_{TAS} and V_{CAS} must be specified in m/s.

The pressure at altitude, P, can be determined from the temperature at altitude, T, by the following formula, which is valid for altitudes below the tropopause:

$$P = (P_0)_{ISA} \cdot \left(\frac{T}{T_0} \right)^{-\frac{g}{K_T R}} \qquad -\frac{g}{K_T \cdot R} \approx 5.25791 \qquad (3.2\text{-}15)$$

where,

R is the real gas constant for air, R = 287.04 m^2/Ks^2
g is the gravitational acceleration, g = 9.81 m/s2
k_T is the ISA temperature gradient with altitude below the tropopause, k_T = -0.0065 °K/m

For altitudes above the tropopause, the following formula should be used:

$$P = P_{Trop} \cdot e^{-\left(\frac{g}{R \cdot T_{Trop}} \right) \cdot (h - h_{trop})} \qquad (3.2\text{-}16)$$

Where h represents the altitude in meters.

(f) Mach/TAS conversion

$$\boxed{V_{TAS} = M \times \sqrt{\gamma \cdot R \cdot T}} \qquad (3.2\text{-}17)$$

where,

M	is the Mach number,
T	is the local temperature at altitude,
R	is the universal gas constant for air = 287.04 [m^2/Ks^2], and
γ	is the isentropic expansion coefficient for air = 1.4

3.3 Aircraft Type

Three values are specified for aircraft type, these being the number of engines, n_{eng} , the engine type and the wake category.

The engine type can be one of three values:

- Jet,
- Turboprop, or,
- Piston.

The wake category can also be one of three values:

H	- heavy
M	- medium
L	- light

Note that ICAO associates a wake category with each aircraft type designator [RD2].

3.4 Mass

Four mass values are specified for each aircraft in tonnes:

m_{ref}	- reference mass	
m_{max}	- maximum mass	(maximum take-off weight)
m_{min}	- minimum mass	(operational weight empty)
m_{pyld}	- maximum payload mass	

Aircraft operating speeds vary with the aircraft mass. This variation is calculated according to the formula below:

$$V = V_{ref} \times \sqrt{\frac{m}{m_{ref}}} \qquad (3.4\text{-}1)$$

In this formula, the aircraft reference speed V_{ref} is given for the reference mass m_{ref}. The speed at another mass, m, is then calculated as V.

An example of an aircraft speed, which can be calculated via this formula is the stall speed, V_{stall}.

3.5 Flight Envelope

(a) Maximum Speed and Altitude

The maximum speed and altitude for the aircraft is expressed in terms of the following six parameters:

V_{MO} - maximum operating speed (CAS), in knots

M_{MO} - maximum operational Mach number

h_{MO} - maximum operational height, in feet above sea level

h_{max} - maximum altitude at MTOW under ISA conditions for maximum mass (allowing residual 300 fpm ROC)

G_w - mass gradient on maximum altitude

G_t - temperature gradient on maximum altitude

where the maximum altitude for any given mass is:

$$h_{max/act} = MIN[\, h_{MO}\, , h_{max} + G_t \times (\Delta T_{ISA} - C_{Tc,4}) + G_w \times (\, m_{max} - m_{act}\,)\,] \quad (3.5\text{-}1)$$

with: $G_w \geq 0$;
$G_t \leq 0$;
if $(\Delta T_{ISA} - C_{tc4}) < 0$, then : $(\Delta T_{ISA} - C_{tc4}) = 0$;

with ΔT_{ISA} being the temperature deviation from ISA and m_{act} being the actual aircraft mass (kg). Formula 3.5-1 should not be executed when the h_{max} value in the .OPF file is set to 0 (zero). In that case the maximum altitude is always h_{MO}.

(b) Minimum Speed

The minimum speed for the aircraft is specified as follows:

$$V_{min} = C_{Vmin,TO} \times V_{stall} \quad \text{if in take-off} \quad (3.5\text{-}2)$$

$$V_{min} = C_{Vmin} \times V_{stall} \quad \text{otherwise} \quad (3.5\text{-}3)$$

Note: See 3.6.2 for minimum speed at high altitude for jet aircraft and Section 5.7 for the values of the minimum speed coefficients.

Here the speeds are specified in terms of CAS. The stall speed depends upon the configuration.

Specifically, five different configurations are specified with a stall speed [$(V_{stall})_i$] and configuration threshold altitude [$H_{max,\,i}$] given for each:

TO - take-off configuration $(V_{stall})_{TO}$
(up to $H_{max,\,TO}$ AGL)

IC - initial climb configuration $(V_{stall})_{IC}$
(between $H_{max,\,TO}$ and $H_{max,\,IC}$ AGL)

CR - cruise (clean) configuration $(V_{stall})_{CR}$
(above $H_{max,\,IC}$ AGL in climb,
in descent above $H_{max,\,AP}$ and,
in descent below $H_{max,\,AP}$ as long
as $V > Vmin_{Cruise} + 10$ kts)

AP - approach configuration $(V_{stall})_{AP}$
(in descent below $H_{max,\,AP}$ when
$V < Vmin_{Cruise} + 10$ kts)

LD - landing configuration $(V_{stall})_{LD}$
(in descent below $H_{max,\,LD}$ when
$V < Vmin_{Approach} + 10$ kts)

The values of the configuration threshold altitudes [$H_{max,\,i}$] are listed in Section 5.6.
Note that these stall speeds correspond to a minimum stall speed and not a 1-g stall speed.
Also, the BADA model assumes that for any aircraft these stall speeds have the following relationship:

$$(V_{stall})_{CR} \geq (V_{stall})_{IC} \geq (V_{stall})_{TO} \geq (V_{stall})_{AP} \geq (V_{stall})_{LD}$$

3.6 Aerodynamics

3.6.1 Aerodynamic Drag

Under nominal conditions, the drag coefficient, C_D is specified as a function of the lift coefficient C_L as follows:

$$C_D = C_{D0,CR} + C_{D2,CR} \times (C_L)^2 \quad (3.6\text{-}1)$$

Formula 3.6-1 is valid for all situations except for the approach and landing where other drag coefficients are to be used.

In the approach phase a different flap setting is used. Formula 3.6-2 should be applied below 8,000 ft when the aircraft descends and the speed falls below $Vmin_{Cruise}$ + 10 kts for the clean configuration (corrected for aircraft mass). Note that $Vmin_{Cruise}$ = 1.3 * $Vstall_{Cruise}$.

$$C_D = C_{D0,AP} + C_{D2,AP} \times (C_L)^2 \quad (3.6\text{-}2)$$

In the landing phase Formula 3.6-3 is used. This formula is applied below 3,000 ft when the aircraft descends and as soon as the speed falls below $Vmin_{Approach}$ + 10 kts, where $Vmin_{Approach}$ = 1.3*$Vstall_{Approach}$.

$$C_D = C_{D0,LDG} + C_{D0,\Delta LDG} + C_{D2,LDG} \times (C_L)^2 \quad (3.6\text{-}3)$$

The value of $C_{D0,\,\Delta LDG}$ represents drag increase due to the landing gear. The values of $C_{D0,\,LD}$ in the <A/C>__.OPF files were all determined for the landing flap setting mentioned in the OPF file.

The drag force (in Newtons) is then determined from the drag coefficient in the standard manner:

$$D = \frac{C_D \cdot \rho \cdot V_{TAS}{}^2 \cdot S}{2} \quad (3.6\text{-}4)$$

where

ρ is the air density (kg/m^3)
S is the wing reference area (m^2)
V_{TAS} is the true airspeed (m/s).

Note that the air density is a function of altitude as described in subsection 3.2.

The lift coefficient, C_L , is determined assuming that the flight path angle is zero. However, a correction for a bank angle is made.

$$C_L = \frac{2 \cdot m \cdot g}{\rho \cdot V_{TAS}{}^2 \cdot S \cdot \cos\phi} \quad (3.6\text{-}5)$$

The above equations thus result in nine coefficients for the specification of drag:

S	
$C_{D0,CR}$	$C_{D2,CR}$
$C_{D0,AP}$	$C_{D2,AP}$
$C_{D0,LD}$	$C_{D2,LD}$
$C_{D0,\Delta LDG}$	
C_{M16}	(set to 0)

In case the $C_{D0,AP}$, $C_{D2,AP}$, $C_{D0,LD}$, $C_{D2,LD}$ and $C_{D0,\Delta LDG}$ coefficients are set to 0 (zero) in the OPF file, expression 3.6-1 will be used in all cases.

3.6.2 Low Speed Buffeting Limit (jet aircraft only)

For jet aircraft a low speed buffeting limit has been introduced. This buffeting limit is expressed as a Mach number and can be determined using the following equation:

$$k \times M^3 - C_{Lb0\,(M=0)} \times M^2 + \frac{W}{S \cdot P \cdot 0.583} = 0 \qquad (3.6\text{-}6)$$

where:

k is lift coefficient gradient
$C_{Lbo\,(M=0)}$ is initial buffet onset lift coefficient for M=0
P is actual pressure (Pa)
M is Mach number
S is the wing reference area (m^2)
W is aircraft weight (N)

The k and $C_{Lbo\,(M=0)}$ parameters have been determined for nearly all jet aircraft in BADA 3.6. Note that the factor of 0.583 gives a 0.2g margin.

The solution for M in Formula 3.6-6 can be obtained using the method given in Appendix D. The buffeting limit should be applied as a minimum speed in the following way:

If (Altitude > 15,000 ft) then: V_{min}= MAX(1.3* V_{stall}, M_b)
If (Altitude < 15,000 ft) then V_{min}= expressions 3.5-2, 3.5-3

where M_b is the lowest positive solution of expression 3.6-6.

Note that the units of the two values (V_{stall} and M_b) inside the MAX() expression should be the same.

If the k and $C_{Lbo\,(M=0)}$ parameters in the OPF file are set to 0 (zero), the minimum speed above 15,000 ft is 1.3*V_{stall}.

3.7 Engine Thrust

The BADA model provides coefficients that allow the calculation of the following thrust levels:

- maximum climb
- nominal climb
- maximum take-off
- maximum cruise
- descent

The thrust is calculated in Newtons and includes the contribution from all engines. The subsections below provide the equations for each of the four thrust conditions.

3.7.1 Maximum Climb and Take-Off Thrust

The maximum climb thrust at standard atmosphere conditions, $(T_{max\ climb})_{ISA}$, is calculated in Newtons as a function of the following information:

- engine type: either Jet, Turboprop or Piston;
- altitude above sea level, h, in feet;
- true air speed, V_{TAS} , in knots;
- temperature deviation from standard atmosphere, ΔT_{ISA}, in degrees Celsius.

The equations corresponding to the three engine types are given below.

Jet:

$$\left(T_{max\ climb}\right)_{ISA} = C_{Tc1} \times \left(1 - \frac{h}{C_{Tc2}} + C_{Tc3} \times h^2\right) \tag{3.7-1}$$

Turboprop:

$$\left(T_{max\ climb}\right)_{ISA} = C_{Tc1} \times \left(1 - \frac{h}{C_{Tc2}}\right) \Big/ V_{TAS} + C_{Tc3} \tag{3.7-2}$$

Piston:

$$\left(T_{max\ climb}\right)_{ISA} = C_{Tc1} \times \left(1 - \frac{h}{C_{Tc2}}\right) + \frac{C_{Tc3}}{V_{TAS}} \tag{3.7-3}$$

For all engine types, the maximum climb thrust is corrected for temperature deviations from standard atmosphere, ΔT_{ISA} , in the following manner:

$$T_{max\ climb} = (T_{max\ climb})_{ISA} \times \left(1 - C_{Tc5} \cdot (\Delta T_{ISA})_{eff}\right) \tag{3.7-4}$$

where

$$(\Delta T_{ISA})_{eff} = \Delta T_{ISA} - C_{Tc,4} \tag{3.7-5}$$

with the limit:

$$0.0 \le (\Delta T_{ISA})_{eff} \times C_{Tc,5} \le 0.4 \tag{3.7-6}$$

and:

$$C_{Tc,5} \geq 0.0 \tag{3.7-7}$$

3.7.2 Maximum Cruise Thrust

The normal cruise thrust is by definition set equal to drag (T = D). However, the maximum amount of thrust available in cruise situation is limited. The maximum cruise thrust is calculated as a ratio of the maximum climb thrust given in section 3.7.1, that is:

$$\boxed{(T_{cruise})_{MAX} = C_{Tcr} \times T_{max\ climb}} \tag{3.7-8}$$

The coefficient C_{Tcr} is currently uniformly set to 0.95 for all aircraft. (see Global Aircraft Parameters section 5.5)

3.7.3 Descent Thrust

Descent thrust is calculated similarly as cruise thrust with different correction factors used for high and low altitude and approach and landing configurations, that is:

if $h > h_{des}$

$$\boxed{T_{des,high} = C_{Tdes,high} \times T_{max\ climb}} \tag{3.7-9}$$

if $h < h_{des}$

$$\boxed{T_{des,low} = C_{Tdes,low} \times T_{max\ climb}} \tag{3.7-10}$$

Once the aircraft has descended below 8,000 ft it changes configuration as soon as the airspeed falls below a certain threshold (Section 3.5). At the same time the thrust setting is changed as well as detailed below:

if $h < 8{,}000$ ft and $V < Vmin_{Cruise} + 10$ kts

$$\boxed{T_{des,app} = C_{Tdes,app} \times T_{max\ climb}} \tag{3.7-11}$$

if $h < 3{,}000$ ft and $V < Vmin_{Approach} + 10$ kts

$$\boxed{T_{des,ld} = C_{Tdes,ld} \times T_{max\ climb}} \tag{3.7-12}$$

In case the $C_{Tdes,app}$ and $C_{Tdes,\ ld}$ are set to 0 (zero) in the OPF file, expression 3.7-10 must be used in all cases where $h < h_{des}$. For those models where non-clean data is available, h_{des} cannot be below 8,000 ft. Note that the speeds (V) used during the descent, approach and landing phase are defined in Section 4.3.

3.8 Reduced Climb Power

The reduced climb power has been introduced to allow the simulation of climbs using less than the maximum climb setting. In day-to-day operations, many aircraft use a reduced setting during climb in order to extend engine life and save cost. The correction factors that are used to calculate the reduction in power have been obtained in an empirical way and have been validated with the help of air traffic controllers.

In BADA, climbs that are performed using the full climb power will result in profiles that match the reference data that is found in the Flight Manual of the aircraft. Climbs with reduced power will give a realistic profile.

$$C_{pow,\,red} = 1 - C_{red} \times \frac{m_{max} - m_{act}}{m_{max} - m_{min}} \qquad (3.8\text{-}1)$$

The value of C_{red} is a function of the aircraft type and is given in the BADA.GPF file (see Section 5.11).

Nevertheless:

If $h < (0.8 * h_{max})$

$C_{red} = f$ (aircraft type) see Section 5.11

Else

$C_{red} = 0$ [dimensionless]

$C_{pow,\,red}$ is to be used in the following expression:

$$P = (T_{max,\,climb} - D) \times V \times C_{pow,red} \qquad (3.8\text{-}2)$$

The power reduction is to be applied in the Initial Climb and Climb phases.

3.8 Fuel Consumption

The thrust specific fuel consumption, η, in kg/minute/kN is specified as a function of true airspeed, V_{TAS} (knots) for the jet and turboprop engines. The nominal fuel flow, f_{nom} (kg/minute), can then be calculated using the thrust, T:

jet: $$\eta = C_{f1} \times \left(1 + \frac{V_{TAS}}{C_{f2}}\right) \quad (3.9\text{-}1)$$

with: $$f_{nom} = \eta \times T \quad (3.9\text{-}2)$$

turboprop: $$\eta = C_{f1} \times \left(1 - \frac{V_{TAS}}{C_{f2}}\right) \times \left(V_{TAS} / 1000\right) \quad (3.9\text{-}3)$$

with: $$f_{nom} = \eta \times T \quad (3.9\text{-}4)$$

These expressions are used in all flight phases except during cruise and for descent/idle conditions.

Minimum fuel flow, f_{min}, corresponding to idle thrust or descent conditions for both jet and turboprop engines is specified in kg/minute as a function of altitude above sea level, h (ft), that is:

jet/turboprop: $$f_{min} = C_{f3} \left(1 - \frac{h}{C_{f4}}\right) \quad (3.9\text{-}5)$$

Cruise fuel flow, f_{cr}, is calculated using the thrust specific fuel consumption η and a cruise fuel flow factor:C_{fcr}

jet/turboprop: $$f_{cr} = \eta \times T \times C_{fcr} \quad (3.9\text{-}6)$$

For piston engines the fuel flow, f, in kg/minutes is specified to be a constant, that is,

$$f_{cr} = C_{f1} \times C_{fcr} \quad \text{(cruise)} \quad (3.9\text{-}7)$$

$$f_{min} = C_{f3} \quad \text{(idle/descent)} \quad (3.9\text{-}8)$$

$$f_{nom} = C_{f1} \quad \text{(all other phases)} \quad (3.9\text{-}9)$$

For the moment the cruise fuel flow correction factor has been established for a number of aircraft. This factor has been set to 1 (one) for all the other aircraft models.

3.9 Ground Movement

Four values are specified that can be of use when simulating ground movements. These parameters are:

- TOL: - FAR Take-Off Length with MTOW on a dry, hard, level runway under ISA conditions and no wind [m].
- LDL: - FAR Landing Length with MLW on a dry, hard, level runway under ISA conditions and no wind [m].
- span: - Aircraft wingspan [m]
- length: - Aircraft length [m]

Note that currently the value of the MLW is not defined in BADA. Apart from these model specific parameters, there are also a number of ground speeds defined as general parameters in the BADA.GPF file, see Section 5.10.

3.10 Summary of Operations Performance Parameters

A summary of the parameters specified by the BADA operations performance model is supplied in Table 3.11-1 below. This table excludes those parameters that have been set to zero.

Table 3.11-1: BADA Operations Performance Parameter Summary

Model Category	Symbols	Units	Description
aircraft type (3 values)	n_{eng} engine type wake category	dimensionless string string	number of engines either Jet, Turboprop or Piston either H (heavy), M (medium) or L (light)
mass (4 values) see def. p25	m_{ref} m_{min} m_{max} m_{pyld}	tonnes tonnes tonnes tonnes	reference mass minimum mass maximum mass maximum payload mass
flight envelope (6 values)	V_{MO} M_{MO} h_{MO} h_{max} G_W G_t	knots (CAS) dimensionless feet feet feet/kg feet/C	maximum operating speed maximum operating Mach number maximum operating altitude maximum altitude at MTOW and ISA weight gradient on maximum altitude temperature gradient on maximum altitude

Table 3.11-1: BADA Operations Performance Parameter Summary (continued)

Model Category	Symbols	Units	Description
Aerodynamics (14 values) (16 values for jet aircraft)	S	m^2	reference wing surface area
	$C_{D0,CR}$	dimensionless	parasitic drag coefficient (cruise)
	$C_{D2,CR}$	dimensionless	induced drag coefficient (cruise)
	$C_{D0,AP}$	dimensionless	parasitic drag coefficient (approach)
	$C_{D2,AP}$	dimensionless	induced drag coefficient (approach)
	$C_{D0,LD}$	dimensionless	parasitic drag coefficient (landing)
	$C_{D2,LD}$	dimensionless	induced drag coefficient (landing)
	$C_{D0,\Delta LDG}$	dimensionless	parasite drag coef. (landing gear)
	C_{M16}	dimensionless	Mach drag coefficient
	$(V_{stall})_i$	knots (CAS)	stall speed [TO, IC, CR, AP, LD]
	$C_{Lbo(M=0)}$	dimensionless	Buffet onset lift coef. (jet only)
	K	[1/M]	Buffeting gradient (jet only)
engine thrust (12 values)	$C_{Tc,1}$	Newton (jet/piston) knot-Newton (turboprop)	1st max. climb thrust coefficient
	$C_{Tc,2}$	feet	2nd max climb thrust coefficient
	$C_{Tc3,}$	$1/feet^2$ (jet) Newton (turboprop) knot-Newton (piston)	3rd max. climb thrust 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 number

Table 3.11-1: BADA Operations Performance Parameter Summary (continued)

Model Category	Symbols	Units	Description
fuel flow (5 values)	C_{f1}	kg/min/kN (jet) kg/min/kN/knot (turboprop) kg/min (piston)	1st thrust specific fuel consumption coefficient
	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 (4 values)	TOL	m	take-off length
	LDL	m	landing length
	span	m	wingspan
	length	m	length

The total number of BADA performance coefficients summarised in the above table is 51.

4 AIRLINE PROCEDURE MODELS

This section defines the standard airline procedures, which are parameterised by the BADA procedure models. Three separate flight phases are considered:

- climb
- cruise
- descent

Each of these phases is described in the subsections below. Note that C_{Vmin} in the sections below always has the value of 1.3 unless the aircraft is in the take-off phase (below 400 ft) in which case the value is 1.2 (see also Section 5.7).

4.1 Climb

The following parameters are defined for each aircraft type to characterise the climb phase:

$V_{cl,1}$ - standard climb CAS (knots) between 1,500 / 6,000 and 10,000 ft

$V_{cl,2}$ - standard climb CAS (knots) between 10,000 ft and Mach transition altitude

M_{cl} - standard climb Mach number above Mach transition altitude

Note that the Mach transition altitude is defined to be the altitude where a CAS value corresponding to $V_{cl,2}$ results in a Mach number of M_{cl}. That is, M_{cl} imposes an upper limit on the Mach number during climb.

- For jet aircraft the following CAS schedule is assumed, based on the parameters mentioned above and the take-off stall speed:

from 0 to 1,499 ft	$C_{Vmin}*(V_{stall})_{TO} + Vd_{CL,1}$	(4.1-1)
from 1,500 to 2,999 ft	$C_{Vmin}*(V_{stall})_{TO} + Vd_{CL,2}$	(4.1-2)
from 3,000 to 3,999 ft	$C_{Vmin}*(V_{stall})_{TO} + Vd_{CL,3}$	(4.1-3)
from 4,000 to 4,999 ft	$C_{Vmin}*(V_{stall})_{TO} + Vd_{CL,4}$	(4.1-4)
from 5,000 to 5,999 ft	$C_{Vmin}*(V_{stall})_{TO} + Vd_{CL,5}$	(4.1-5)
from 6,000 to 9,999 ft	$\min(V_{cl,1}, 250\text{ kt})$	
from 10,000 ft to transition	$V_{cl,2}$	
above transition	M_{cl}	

- For turboprop and piston aircraft the following CAS schedule is assumed:

from 0 to 499 ft	$C_{Vmin}*(V_{stall})_{TO} + Vd_{CL,6}$	(4.1-6)
from 500 to 999 ft	$C_{Vmin}*(V_{stall})_{TO} + Vd_{CL,7}$	(4.1-7)
from 1,000 to 1,499 ft	$C_{Vmin}*(V_{stall})_{TO} + Vd_{CL,8}$	(4.1-8)
from 1,500 to 9 ,999 ft	min ($V_{cl,1}$, 250 kt)	
from 10,000 ft to transition	$V_{cl,2}$	
above transition	M_{cl}	

The take-off stall speed, $(V_{stall})_{TO}$, must be corrected for the difference in aircraft mass from the reference mass using the formula as described in Section 3.4.

The transition altitude, h_{trans}, in feet from a given V_{CAS} (in m/s), and a Mach number, M, can be calculated as follows:

$$h_{trans} = \left(\frac{1000}{(.3048)\cdot(6.5)}\right)\cdot\left[T_0\cdot(1-\theta_{trans})\right] \qquad (4.1\text{-}9)$$

where,

T_0 is the temperature at sea level in Kelvin,
$(T_0)_{ISA}$ is the ISA temperature at sea level = 288.15 K,
θ_{trans} is the temperature ratio at the transition altitude,

$$\theta_{trans} = (\delta_{trans})^{-\frac{K_T\cdot R}{g}} \qquad (4.1\text{-}10)$$

where,

R is the real gas constant for air, R = 287.04 m^2/Ks^2
g is the gravitational acceleration, g = 9.81 m/s2
k_T is the ISA temperature gradient with altitude below the tropopause, k_T = -0.0065 °K/m

δ_{trans} is the pressure ratio at the transition altitude,

$$\delta_{trans} = \frac{\left[1+\left(\frac{\gamma-1}{2}\right)\left(\frac{V_{CAS}}{(a_0)_{ISA}}\right)^2\right]^{\frac{\gamma}{\gamma-1}}-1}{\left[1+\frac{\gamma-1}{2}M^2\right]^{\frac{\gamma}{\gamma-1}}-1} \qquad (4.1\text{-}11)$$

$(a_0)_{ISA}$ is the ISA speed of sound at sea level = 340.29 $m.s^{-1}$

4.2 Cruise

The following parameters are defined for each aircraft type to characterise the cruise phase:

$V_{cr,1}$	-	standard cruise CAS (knots) between 3,000 and 10,000 feet
$V_{cr,2}$	-	standard cruise CAS (knots) above 10,000 ft until Mach transition altitude
M_{cr}	-	standard cruise Mach number above transition altitude

- For jet aircraft the following CAS schedule is assumed:

from 0 to 2,999 ft	170 kt
from 3,000 to 5,999 ft	min (V_{cr1} , 220 kt)
from 6,000 to 13,999 ft	min (V_{cr1} , 250 kt)
from 14,000 to transition	V_{cr2}
above transition	M_{cr}

- For turboprop aircraft the following CAS schedule is assumed:

from 0 to 2,999 ft	150 kt
from 3,000 to 5,999 ft	min (V_{cr1} , 180 kt)
from 6,000 to 9,999 ft	min (V_{cr1} , 250 kt)
from 10,000 to transition	V_{cr2}
above transition	M_{cr}

4.3 Descent

The following parameters are defined for each aircraft type to characterise the descent phase:

$V_{des,1}$	-	standard descent CAS (knots) between 3,000 / 6,000 and 10,000 ft
$V_{des,2}$	-	standard descent CAS (knots) above 10,000 ft until Mach transition
M_{des}	-	standard descent Mach number above transition altitude

- For jet and turboprop aircraft the following CAS schedule is assumed, based on the above parameters and the landing stall speed:

from 0 to 999 ft	$C_{Vmin}*(V_{stall})_{LD} + Vd_{DES,1}$	(4.3-1)
from 1,000 to 1,499 ft	$C_{Vmin}*(V_{stall})_{LD} + Vd_{DES,2}$	(4.3-2)
from 1,500 to 1,999 ft	$C_{Vmin}*(V_{stall})_{LD} + Vd_{DES,3}$	(4.3-3)
from 2,000 to 2,999 ft	$C_{Vmin}*(V_{stall})_{LD} + Vd_{DES,4}$	(4.3-4)
from 3,000 to 5,999 ft	$MIN(V_{des,1}, 220)$	(4.3-5)
from 6,000 to 9,999 ft	$MIN(V_{des,1}, 250)$	(4.3-6)
above 10,000 ft to transition	$V_{des,2}$	
above transition	M_{des}	

- For piston aircraft the following CAS schedule is assumed:

from 0 to 499 ft	$C_{Vmin}*(V_{stall})_{LD} + Vd_{DES,5}$	(4.3-7)
from 500 to 999 ft	$C_{Vmin}*(V_{stall})_{LD} + Vd_{DES,6}$	(4.3-8)
from 1000 to 1,499 ft	$C_{Vmin}*(V_{stall})_{LD} + Vd_{DES,7}$	(4.3-9)
above 1,500 ft to 9,999 ft	$V_{des,1}$	
above 10,000 ft to transition	$V_{des,2}$	
above transition	M_{des}	

The landing stall speed, $(V_{stall})_{LD}$, must be corrected for the difference in aircraft mass from the reference mass using formula 3.4-1. The values for Vd_{DES} ,can be found in Section 5.

5 GLOBAL AIRCRAFT PARAMETERS

5.1 Introduction

A number of parameters that have been described in Section 3 (Operations Performance Model) and Section 4 (Airline Procedure Model) have values that are independent of the aircraft type or model for which they are used. The values of these and other parameters that up to BADA 2.4 were hard-coded in the aircraft navigator (MASS at the EEC), have been put in the General Parameters File (BADA.GPF). This increases the flexibility and allows an easier evaluation of the values that are used.

The next section gives an overview of the parameters that are defined in the Global Parameters File. If relevant, it also indicates the formula in which the parameter should be used.

5.2 Maximum Acceleration

Maximum acceleration parameters are used to limit the increment in TAS (longitudinal) or ROCD (normal). 2 parameters are defined:

Name:	**Description:**	**Value [fps^2]:**
$a_{l,\ max\ (civ)}$	maximum longitudinal acceleration for civil flights	2.0
$a_{n,\ max\ (civ)}$	maximum normal acceleration for civil flights	5.0

The two acceleration limits are to be used in the following way:

- longitudinal acceleration: $\left| V_k - V_{k-1} \right| \leq a_{l\,max\,(civ)}\ \Delta t$ (5.2-1)

- normal acceleration: $\left| \gamma_k - \gamma_{k-1} \right| \leq \dfrac{a_{n\,max\,(civ)}\ \Delta t}{V}$ (5.2-2)

where,

$$\gamma = \sin^{-1}\left(\frac{\dot{h}}{V}\right) \quad (5.2\text{-}3)$$

and,

γ	is the climb/descent angle,
V	is the True Air Speed,
k, k-1	indicates values at update intervals k and k-1,and,
Δt	is the time interval between k and k-1

The values for $a_{l,\ max\ (mil)}$ (maximum longitudinal acceleration for military flights) and $a_{n,\ max\ (mil)}$ (maximum normal acceleration for military flights) are currently undefined.

5.3 Bank Angles

Nominal and maximum bank angles are defined separately for military and civil flights. These bank angles can be used to calculate nominal and maximum rate of turns.

Name:	Description:	Value [degr.]:
$\phi_{nom,\ civ\ (TO,\ LD)}$	Nominal bank angles for civil flight during TO and LD	15
$\phi_{nom,\ civ\ (OTHERS)}$	Nominal bank angles for civil flight during all other phases	35
$\phi_{nom,\ mil}$	Nominal bank angles for military flight (all phases)	50
$\phi_{max,\ civ\ (TO,\ LD)}$	Maximum bank angles for civil flight during TO and LD	25
$\phi_{max,\ civ\ (HOLD)}$	Maximum bank angles for civil flight during HOLD	35
$\phi_{max,\ civ\ (OTHERS)}$	Maximum bank angles for civil flight during all other phases	45
$\phi_{max,\ mil}$	Maximum bank angles for military flight (all phases)	70

The rate of turn ($\dot{\varphi}$) is calculated as a function of bank angle:

$$\dot{\varphi} = \frac{g}{V_{TAS}} \times \tan(\phi) \qquad (5.3\text{-}1)$$

5.4 Expedited Descent

The expedited descent factor is to be used as a drag multiplication factor during expedited descents in order to simulate use of spoilers:

Name:	Description:	Value [-]:
$C_{des,\ exp}$	Expedited descent factor	1.6

The drag during an expedited descent is calculated using the nominal drag (see 3.6.1):

$$D_{des,\ exp} = C_{des,\ exp} * D_{nom} \qquad (5.4\text{-}1)$$

5.5 Thrust Factors

Maximum take-off and maximum cruise thrust factors have been specified. The $C_{Th,TO}$ factor is no longer used since Bada 3.0. The $C_{Th,cr}$ factors is to be used in expressions 3.7-8.

Name:	Description:	Value [-]:
$C_{Th\ ,\ to}$	Take-off thrust coefficient	1.2
$C_{Th\ ,\ cr}$	Maximum cruise thrust coefficient	0.95

5.6 Configuration Altitude Threshold

For 4 configurations, altitude thresholds have been specified in BADA: take-off (TO), initial climb (IC), approach (AP) and landing (LD). Note that the selection of the take-off and initial climb configuration is defined only with the altitude. The selection of the approach and landing configurations is done through the use of air speed and altitude (see Section 3.5), while the altitudes at which the configuration change takes place should not be higher than the ones given below.

Name:	Description:	Value [ft]:
$H_{max,\ TO}$	Maximum altitude threshold for take-off	400
$H_{max,\ IC}$	Maximum altitude threshold for initial climb	2,000
$H_{max,\ AP}$	Maximum altitude threshold for approach	8,000
$H_{max,\ LD}$	Maximum altitude threshold for landing	3,000

5.7 Minimum Speed Coefficients

Two minimum speed coefficients are specified, which are to be used in expressions 3.5-2 and 3.5-3 and in Section 4.1, 4.2 and 4.3:

Name:	Description:	Value [-]:
$C_{Vmin,\ TO}$	Minimum speed coefficient for take-off	1.2
C_{Vmin}	Minimum speed coefficient (all other phases)	1.3

5.8 Speed Schedules

The speed schedules for climb and descent are based on a factored stall speed plus increment valid for a specified altitude range:

Name:	Description:	Value[KCAS]:
$Vd_{CL,\ 1}$	Climb speed increment below 1500 ft (jet)	5
$Vd_{CL,\ 2}$	Climb speed increment below 3000 ft (jet)	10
$Vd_{CL,\ 3}$	Climb speed increment below 4000 ft (jet)	30
$Vd_{CL,\ 4}$	Climb speed increment below 5000 ft (jet)	60
$Vd_{CL,\ 5}$	Climb speed increment below 6000 ft (jet)	80
$Vd_{CL,\ 6}$	Climb speed increment below 500 ft (turbo/piston)	20
$Vd_{CL,\ 7}$	Climb speed increment below 1000 ft (turbo/piston)	30
$Vd_{CL,\ 8}$	Climb speed increment below 1500 ft (turbo/piston)	35
$Vd_{DES,\ 1}$	Descent speed increment below 1000 ft (jet/turboprop)	5
$Vd_{DES,\ 2}$	Descent speed increment below 1500 ft (jet/turboprop)	10
$Vd_{DES,\ 3}$	Descent speed increment below 2000 ft (jet/turboprop)	20
$Vd_{DES,\ 4}$	Descent speed increment below 3000 ft (jet/turboprop)	50
$Vd_{DES,\ 5}$	Descent speed increment below 500 ft (piston)	5
$Vd_{DES,\ 6}$	Descent speed increment below 1000 ft (piston)	10
$Vd_{DES,\ 7}$	Descent speed increment below 1500 ft (piston)	20

These values are to be used in the expressions in Section 4.1, 4.2 and 4.3

5.9 Holding Speeds

The holding speeds that are to be used to calculate holding areas are defined according to the ICAO standards:

Name:	Description:	Value[KCAS]:
$V_{hold,1}$	Holding speed below FL140	230
$V_{hold,2}$	Holding speed between FL140 and FL200	240
$V_{hold,3}$	Holding speed between FL200 and FL340	265
$V_{hold,4}$	Holding speed above FL340 [Mach]	0.83

Note that the holding speeds that are used by individual aircraft may vary between types.

5.10 Ground Speeds

A number of ground speeds are defined for the simulation of ground movement. For the moment, no distinction between aircraft type or engine type is made. The following speeds have been defined:

Name:	Description:	Value[KCAS]:
$V_{backtrack}$	Runway backtrack speed	35
V_{taxi}	Taxi speed	15
V_{apron}	Apron speed	10
V_{gate}	Gate speed	5

The runway backtrack speed is the speed the aircraft will maintain when it backtracks across the runway. The taxi speed is used anywhere between the runway and the apron area. The apron speed is used in the apron area while the gate speed is used for all manoeuvring between the gate position and the apron.

5.11 Reduced Power Coefficient

The reduced power coefficients are defined for the three different engine types. Within the jet engines a further distinction is made between MTOWs. It is stressed that the values given below where found in an empirical way and have been validated with the help of air traffic controllers:

Name:	Description:	Value[-]:
$C_{red,turbo}$	Maximum reduction in power for turboprops	0.25
$C_{red,piston}$	Maximum reduction in power for pistons	0.0
$C_{red,jet}$	Maximum reduction in power for jets	0.15

The coefficients should be used in Formula 3.8-1.

6 FILE STRUCTURE

6.1 File Types

All data provided by BADA Revision 3.4 is organised into five types of files:

- three Synonym Files,
- a set of Operations Performance Files,
- a set of Airline Procedure Files,
- a set of Performance Table Files, and,
- a Global Parameter File

▪ Three Synonym Files have the names:

SYNONYM.LST
SYNONYM.NEW
SYNONYM_ALL.LST

The files provide a list of all the aircraft types which are supported by BADA and indicate whether the aircraft type is supported directly (through provision of parameters in other files) or supported by equivalence (through indicating an equivalent aircraft type that is supported directly). In addition to that, SYNONYM_ALL.LST file provides the information on history and evolution of the ICAO aircraft designators over the years. The format of the files is described in Section 6.3.

▪ There is one Operations Performance File (OPF) provided for each aircraft type which is directly supported. This file specifies parameter values for the mass, flight envelope, drag, engine thrust and fuel consumption that are described in Section 3. Details on the format of the OPF file are given in Section 6.4.

▪ There is one Airline Procedures File (APF) for each directly supported aircraft type. This file specifies the nominal manoeuvre speeds that are described in Section 4. Details on the format of the APF file are given in Section 6.5.

▪ There is also one Performance Table File (PTF) for each directly supported aircraft type. This file contains a summary table of speeds, climb/descent rates and fuel consumption at various flight levels. Details on the format of the PTF file are given in Section 6.6.

▪ Finally there is one Global Parameter File which is named BADA.GPF. This file contains parameters that are described in Section 5 and are valid for all aircraft or a group of aircraft (for instance all civil flights or all jet aircraft). Details on the format of the GPF file are given in Section 6.7.

The names of the OPF, APF and PTF files are based on the ICAO designation code for the aircraft type. With only the exception of the generic military fighter aircraft types (FGTH, FGTL, FGTN), this code is the same as the International Civil Aviation Organisation (ICAO) designator code for the aircraft type [RD2]. That is:

Operations Performance File name: <ICAO_code>__.OPF

Airline Procedures File name: <ICAO_code>__.APF

Performance Table File name: <ICAO_code>__.PTF

Note that there are at least two underscore characters between the ICAO code and the file extension such that the length of the file name without the extension is six characters. Most ICAO codes are four characters in length and thus have two underscore characters. Some ICAO codes, however, can be shorter (e.g. F50) and thus require more underscore characters. For example, an Airbus 310 which has the ICAO code of A310 is represented in BADA 3.6 by the following files:

Operations Performance File: A310__.OPF

Airline Procedures File: A310__.APF

Performance Table File: A310__.PTF

The Fokker F50, which has the ICAO code of F50 is represented in BADA 3.6 by the following files:

Operations Performance File: F50____.OPF

Airline Procedures File: F50____.APF

Performance Table File: F50____.PTF

All files belonging to BADA Revision 3.6, that is the Synonym Files, the GPF file and all APF and OPF files are controlled within a configuration management system. This system is described in Section 6.2.

6.2 File Configuration Management

Starting with the BADA 3.4 release, the BADA Synonym Files, GPF and all APF, OPF and PTF files are placed and managed under the UNIX-based Change Management Synergy (CM Synergy) tool at EEC.

This section briefly describes some of the CM Synergy features that will be used for the management of the BADA files.

CM Synergy provides a complete change management environment in which development and management of the files can be done easily, quickly, and securely. It maintains control of file versions and allows management of project releases with some of the benefits listed below:

- workflow management, which enables easy identification of the files modified to implement the change and to review of the reason for a change
- project reproducibility by accurately creating baseline configurations
- role-based security

- Distributed Change Management (DCM) which allows files sharing among any number of CM Synergy databases. With DCM transfer of an entire database or a subset of a database can be done, either automatically or manually

The CM Synergy automated migration facilities feature complete version history migration from RCS system archives. This has enabled all the BADA files with their history have been successfully brought under the CM Synergy control. A CM Synergy database is created for BADA project. Such a database represents a data repository that stores all controlled data, including data files, their properties and relationships to one another.

The following BADA files are placed in the CM Synergy database:

- the two Synonym Files
- the GPF file
- all APF, OPF and PTF files

Within the CM Synergy, different methodologies in the way the files are managed are used. For BADA database, the task-based methodology is chosen which enables the tracking of the changes by using tasks, rather than individual files, as the basic unit of work.

The specific procedures used for configuration management are specified in the BADA Configuration Management Manual [RD5].

6.2.1 File identification

Any file managed in a CM Synergy database is uniquely identified by the following attributes: *name, version, type, and instance.* By default, the four-part name (also called full name) is written like this: *name-version:type:instance* .

A file name can be up to 151 characters long, and the version can be any 32-character combination. The type can be any of the default types (e.g., *csrc, ascii*, etc.), or any BADA type that is created (APF, OPF, PTF, GPF).

The name, version, and type are designated by the user, but the instance is calculated by CM Synergy.

The version of a file corresponds to the evolution of the file in time. By default, CM Synergy creates version numbers, starting with 1, for each file that is created in the CM Synergy database. Each time the object is modified, CM Synergy increments the version.

The instance is used to distinguish between multiple objects with the same name and type, but that are not versions of each other.

It is important to notice that, following the CM Synergy approach of the file identification, no information on the file version is provided in the BADA file itself.

A new layout of the header of BADA files has been developed and it will be described in more details in the following sections.

6.2.2 History

The history of a file shows all the existing versions and the relationships between the versions. By history, CM Synergy means all of the file versions created before the current file version (called predecessors) and all of the file versions created after the current file version (called successors). This functionality allows for the tracking of all modifications to a file.

6.2.3 Release

The release is a label that indicates the version of the project, in this case the release of BADA files. BADA Releases are usually identified by a two digit number, e.g. 3.3 or 3.4. However, the name of release in CM Synergy can be made out of any combination of alphabetic and numerical characters.

Like in the case of the file version, no information on the current BADA release is given in the BADA files.

6.2.4 Release Summary File

The ReleaseSummary File provides a list of all files provided as part of the BADA Release. A copy of the file for BADA Revision 3.6 is included in this document as Appendix A. The ReleaseSummary file lists for each BADA file: file name, release date, file version and BADA release identification .

6.3 Synonym File Format

6.3.1 SYNONYM.LST File

The SYNONYM.LST file is an ASCII file which lists all aircraft types which are supported by the BADA revision. An example of the SYNONYM.LST file is given below (partial listing).

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC SYNONYM.LST CCCCCCCCCCCCCC/
CC                                                                    /
CC                BADA SYNONYM FILE                                   /
CC                                                                    /
CC                                                                    /
CC      File_name: SYNONYM.LST                                        /
CC                                                                    /
CC      Creation_date: Mar 26 2002                                    /
CC                                                                    /
CC      Modification_date: Mar 26 2002                               /
CC                                                                    /
CD                                                                    /
CC====== Aircraft List ==============================================/
CC                                                                    /
CC   A/C    NAME OR MODEL        FILE                SYNONYMS         /
CC   CODE                                                             /
CC                                                                    /
 - A306__  AIRBUS A300B4-600    A306__              A306
 - A30B__  AIRBUS A300B4-200    A30B__              A30B   IL76
 - A310__  AIRBUS A310          A310__              A310
 - A319__  AIRBUS A319          A319__              A319
 - A320__  AIRBUS A320          A320__              A320   C17
 - A321__  AIRBUS A321          A321__              A321
 - A333__  AIRBUS A330-300      A333__              A333   A332
 - A343__  AIRBUS A340-300      A343__              A343   A342   A345
                                                           A346
 - AT43__  ATR ATR 42-300       AT43__              AT43   CN35   CVLT
                                                    AT44
 - AT45__  ATR ATR 42-500       AT45__              AT45
 - AT72__  ATR ATR 72           AT72__              AT72   A748
 - ATP___  ADVANCED TURBOPROP   ATP___              ATP    G222
 - B461__  BAE 146-100/RJ       B461__              B461   B462   B463
                                                    YK42
 - B703__  BOEING 707-300       B703__              B703   B720   K35R
                                                    E3TF   E3CF   C135
                                                    VC10   IL62
 - B722__  BOEING 727-100       B722__              B722   B721   BER4
 - B732__  BOEING 737-228       B732__              B732   B731   A124
 - B733__  BOEING 737-300       B733__              B733
 - B734__  BOEING 737-400       B734__              B734
 - B735__  BOEING 737-500       B735__              B735   B736
 - B737__  BOEING 737-700       B737__              B737
```

There are three types of lines in the SYNONYM.LST file with the line type identified by the first two characters in the line. These line types with their associated leading characters are listed below.

CC	comment line
CD	data line
-	synonym line

The data is organised into two blocks separated by a comment line consisting of equal signs "=":

- file identification block
- aircraft list block

Each of these blocks is described in the subsections below.

6.3.2 File Identification Block

The file identification block provides information on the file name, creation and modification date. The block consists of 11 comment lines.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC SYNONYM.LST CCCCCCCCCCCCCC/
CC                                                                    /
CC                BADA SYNONYM FILE                                   /
CC                                                                    /
CC                                                                    /
CC      File_name: SYNONYM.LST                                        /
CC                                                                    /
CC      Creation_date: Mar 26 2002                                    /
CC                                                                    /
CC      Modification_date: Mar 26 2002                                /
```

The comment lines specify the file name along with the creation and the modification date. The creation date indicates the date when the file was created for the first time. The modification date indicates when the contents of the file were last modified.

The data line gives the BADA Revision Id to which the file belongs. This value is specified in the following fixed format (Fortran notation):

‘CD’, 8X, F3.1

6.3.3 Aircraft Listing Block

The aircraft listing block consists of 5 comment lines with additional synonym lines for each aircraft supported by the BADA Revision. A partial listing of this block is shown below.

```
CC====== Aircraft List ===============================================/
CC                                                                    /
CC   A/C    NAME OR MODEL       FILE                 SYNONYMS         /
CC   CODE                                                             /
CC                                                                    /
 - A306__  AIRBUS A300B4-600    A306__               A306
 - A30B__  AIRBUS A300B4-200    A30B__               A30B   IL76
 - A310__  AIRBUS A310          A310__               A310
 - A319__  AIRBUS A319          A319__               A319
 - A320__  AIRBUS A320          A320__               A320   C17
 - A321__  AIRBUS A321          A321__               A321
 - A333__  AIRBUS A330-300      A333__               A333   A332
 - A343__  AIRBUS A340-300      A343__               A343   A342
 - AT43__  ATR ATR 42-300       AT43__               AT43   CN35   CVLT
                                                     AT44
 - AT45__  ATR ATR 42-500       AT45__               AT45
 - AT72__  ATR ATR 72           AT72__               AT72   A748
 - ATP___  ADVANCED TURBOPROP   ATP___               ATP    G222
 - B461__  BAE 146-100/RJ       B461__               B461   B462   B463
                                                     YK42
 - B703__  BOEING 707-300       B703__               B703   B720   K35R
                                                     E3TF   E3CF   C135
                                                     VC10   IL62
 - B722__  BOEING 727-100       B722__               B722   B721   BER4
 - B732__  BOEING 737-228       B732__               B732   B731   A124
 - B733__  BOEING 737-300       B733__               B733
 - B734__  BOEING 737-400       B734__               B734
 - B735__  BOEING 737-500       B735__               B735   B736
 - B737__  BOEING 737-700       B737__               B737
```

There is one synonym line for each of the directly supported aircraft within the BADA release. Each such line consists of 4 fields as described below:

(a) Aircraft Code Field

This field identifies the aircraft type. It consists of a three or four-character ICAO code followed by two or more underscore characters.

(b) Name or Model Field

This field identifies the manufacturer and model of the aircraft.

(c) File Name Field

This field identifies the file name for the APF, OPF or PTF files associated with the aircraft (minus the file extension). For each aircraft this is the same as the A/C code.

(d) Equivalence Field

This field lists any equivalences associated with the aircraft. By default, each aircraft has at least one equivalence to itself.

Note that in some cases the name or model or equivalence fields may be continued onto the next line as it is the case with the B703 model.

6.3.4 SYNONYM.NEW File

The SYNONYM.NEW file is an ASCII file, which lists all aircraft types, which are supported by the BADA revision. Its format differs from the SYNONYM.LST file in that all supported aircraft are listed alphabetically in the file whether they are supported directly or by equivalence. An example of the SYNONYM.NEW file is given below (partial listing).

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC SYNONYM.NEW CCCCCCCCCCCCCCC/
CC                                                                    /
CC                BADA SYNONYM FILE                                   /
CC                                                                    /
CC                                                                    /
CC      File_name: SYNONYM.NEW                                        /
CC                                                                    /
CC      Creation_date: Mar 26 2002                                    /
CC                                                                    /
CC      Modification_date: Mar 26 2002                                /
CC                                                                    /
CD                                                                    /
CC====== Aircraft List ===============================================/
CC                                                                    /
CC   A/C    MANUFACTURER        NAME OR MODEL            FILE    OLD  /
CC   CODE                                                        CODE /
CC                                                                    /
CD * A10    FAIRCHILD           THUNDERBOLT II           FGTN__  A10A /
CD * A124   ANTONOV             ANTONOV AN-124           B732__  AN4R /
CD - A306   AIRBUS              A300B4-600               A306__  A306 /
CD - A30B   AIRBUS              A300B4-200               A30B__  A300 /
CD - A310   AIRBUS              A310                     A310__  A310 /
CD - A319   AIRBUS              A319                     A319__  A319 /
CD - A320   AIRBUS              A320                     A320__  EA32 /
CD - A321   AIRBUS              A321                     A321__  A321 /
CD * A332   AIRBUS              A330-200                 A333__  A332 /
CD - A333   AIRBUS              A330-300                 A333__  A330 /
CD * A342   AIRBUS              A340-200                 A343__  A342 /
CD - A343   AIRBUS              A340-300                 A343__  A340 /
CD * A345   AIRBUS              A340-500                 A343__  A345 /
CD * A346   AIRBUS              A340-600                 A343__  A346 /
CD * A4     MCDONNELL-DOUGLAS   SKYHAWK                  FGTN__  A4   /
CD * A6     GRUMMAN             INTRUDER                 FGTN__  EA6B /
CD * A748   BAE                 BAE 748                  AT72__  HN74 /
CD * AC80   ROCKWELL            TURBO COMMANDER          BE20__  AC6T /
CD * AC90   ROCKWELL            TURBO COMMANDER          BE20__  AC90 /
```

```
CD * AC95   ROCKWELL            TURBO COMMANDER          BE20__   AC95 /
CD * AJET   DASSAULT            ALPHA JET                FGTN__   AJET /
CD * AMX    EMBRAER             AMX                      FGTN__   AMX  /
CD * AN12   ANTONOV             AN-12                    C130__   AN12 /
CD * AN24   ANTONOV             AN-124                   F27___   AN24 /
CD * AN26   ANTONOV             AN-26                    F27___   AN26 /
```

There are three types of lines in the SYNONYM.NEW file with the line type identified by the first two characters in the line. These line types with their associated two leading characters are listed below.

CC comment line

CD data line

FI end-of-file line

The data is organised into a two blocks separated by a comment line consisting of equal signs "=":

- file identification block
- aircraft list block

Each of these blocks is described in the subsections below.

6.3.5 File Identification Block

The file identification block provides information on the file name, creation and modification date. The block consists of 11 comment lines as shown below.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC SYNONYM.NEW CCCCCCCCCCCCCCC/
CC                                                                     /
CC                BADA SYNONYM FILE                                    /
CC                                                                     /
CC                                                                     /
CC      File_name: SYNONYM.NEW                                         /
CC                                                                     /
CC      Creation_date: Mar 26 2002                                     /
CC                                                                     /
CC      Modification_date: Mar 26 2002                                 /
CC                                                                     /
```

The comment lines specify the file name along with the creation and last modification date. The creation date indicates the date when the file was created for the first time. The modification date indicates when the contents of the file were last modified.

6.3.2.2 Aircraft Listing Block

The aircraft listing block consists of 5 comment lines and at least one data line for each aircraft supported by the BADA Revision. Some aircraft have more than one data line, see under (f). A partial listing of this block is shown below.

```
CD * A10    FAIRCHILD           THUNDERBOLT II           FGTN__   A10A /
CD * A124   ANTONOV             ANTONOV AN-124           B732__   AN4R /
CD - A306   AIRBUS              A300B4-600               A306__   A306 /
CD - A30B   AIRBUS              A300B4-200               A30B__   A300 /
```

Each data line consists of 5 fields as described below:

(a) Support Type Field

This field is one character in length being one of the following two values:

"-" to indicate an aircraft type directly supported, and,
"*" to indicate an aircraft type supported by equivalence with another directly supported aircraft

(b) Aircraft Code Field

This field identifies the aircraft type. It consists of a three or four-character ICAO code.

(c) Manufacturer Field

This field identifies the manufacturer of the aircraft. Examples are Boeing, Airbus or Fokker.

(d) Name or Model Field

This field identifies the name or model for the aircraft type. Examples are the 747-400 series or Learjet 35.

(e) File Field

This field indicates the name of the OPF, APF or PTF file, which contains the parameters for the aircraft type (minus the file extension).

For an aircraft type which is directly supported this file name will be the same as the ICAO code with an additional two or more underscore characters to form a string of six characters in length. For example, the file name corresponding to the A333 will be A333__. This indicates an OPF file A333__.OPF, an APF file A333__.APF and a PTF file A333__.PTF. For the Fokker F-27 with an ICAO code of F27, the file names include three underscore characters, that is, F27___.OPF, F27___.APF and F27___.PTF.

For an aircraft type which is supported through an equivalence the file name will indicate the file for the equivalent aircraft type which should be used. As an example, the Antonov 12 (AN12) is equivalent to the Lockheed C-130 Hercules (C130). Thus the files C130__.OPF, C130__.APF and C130__.PTF should be used.

(f) Old Code field

The old code field gives the name of the aircraft that refers to the formerly known aircraft designator as published in one of the previous editions of the ICAO document 8643 [RD10]. This allows the BADA 3.6 user to continue to use the old ICAO standard and to establish a link between the old and the new aircraft designators.

The above fields are specified in the following fixed format (Fortran notation):

'CD', 1X, A1, 1X, A4, 3X, A18, 1X, A25, 1X, A6, 2X, A4

6.3.6 SYNONYM_ALL.LST File

The SYNONYM_ALL.LST file is an ASCII file, which lists all aircraft types, which are supported by the BADA revision. Like in the SYNONYM.NEW file, all supported aircraft are listed alphabetically in the file whether they are supported directly or by equivalence. An example of the SYNONYM_ALL.LST file is given below (partial listing).

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC SYNONYM_ALL.LST CCCCCCCCCCCCCCCC/
CC                                                                    /
CC                BADA SYNONYM_ALL FILE                               /
CC                                                                    /
CC                                                                    /
CC      File_name: SYNONYM_ALL.LST                                    /
CC                                                                    /
CC      Creation_date: May 22 2003                                    /
CC                                                                    /
CC      Modification_date: May 22 2003                               /
CC                                                                    /
CC                                                                    /
CC                                                                    /
CC====================================================================/
CC                                                                    /
CC                                                                    /
CC                                                     ICAO    ICAO     ICAO     ICAO     ICAO     ICAO     ICAO
CC   A/C    NAME OR MODEL    MANUFACTURER  FILE        CODE    CODE     CODE     CODE     CODE     CODE     CODE
CC                                      BADA 3.5        V24     V25      V26      V27      V28      V29      V30
CC
CD * A10    THUNDERBOLT II    FAIRCHILD    FGTN__      A10A     A10      A10      A10      A10      A10      A10
CD * A124   ANTONOV AN-124    ANTONOV      B732__      AN4R     A124     A124     A124     A124     A124     A124
CD - A306   A300B4-600        AIRBUS       A306__      A306     A306     A306     A306     A306     A306     A306
CD - A30B   A300B4-200        AIRBUS       A30B__      EA30     A300     A30B     A30B     A30B     A30B     A30B
CD - A310   A310              AIRBUS       A310__      EA31     A310     A310     A310     A310     A310     A310
CD * A318   A318              AIRBUS       A319__      A318     A318     A318     A318     A318     A318     A318
CD - A319   A319              AIRBUS       A319__      A319     A319     A319     A319     A319     A319     A319
CD - A320   A320              AIRBUS       A320__      EA32     A320     A320     A320     A320     A320     A320
CD - A321   A321              AIRBUS       A321__      A321     A321     A321     A321     A321     A321     A321
CD - A332   A330-200          AIRBUS       A332__      A332     A332     A332     A332     A332     A332     A332
CD - A333   A330-300          AIRBUS       A333__      EA33     EA33     EA33     A330     A333     A333     A333
CD * A342   A340-200          AIRBUS       A343__      A342     A342     A342     A342     A342     A342     A342
CD - A343   A340-300          AIRBUS       A343__      EA34     EA34     EA34     A340     A343     A343     A343
CD * A345   A340-500          AIRBUS       A343__      A345     A345     A345     A345     A345     A345     A345
CD * A346   A340-600          AIRBUS       A343__      A346     A346     A346     A346     A346     A346     A346
```

There are three types of lines in the SYNONYM_ALL.LST file with the line type identified by the first two characters in the line. These line types with their associated two leading characters are listed below.

CC comment line

CD data line

FI end-of-file line

The data is organised into a two blocks separated by a comment line consisting of equal signs "=":

- file identification block
- aircraft list block

Each of these blocks is described in the subsections below.

6.3.7 File Identification Block

The file identification block provides information on the file name, creation and modification date. The block consists of 11 comment lines as shown below.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC SYNONYM_ALL.LST CCCCCCCCCCCCCCC/
CC                                                                    /
CC                BADA SYNONYM_ALL FILE                               /
CC                                                                    /
CC                                                                    /
CC      File_name: SYNONYM.NEW                                        /
CC                                                                    /
CC      Creation_date: May 22 2003                                    /
CC                                                                    /
CC      Modification_date: May 22 2003                                /
CC                                                                    /
```

The comment lines specify the file name along with the creation and last modification date. The creation date indicates the date when the file was created for the first time. The modification date indicates when the contents of the file were last modified.

6.3.2.2 Aircraft Listing Block

The aircraft listing block consists of 7 comment lines and at least one data line for each aircraft supported by the BADA Revision. Some aircraft have more than one data line, see under (f). A partial listing of this block is shown below.

```
* A10    THUNDERBOLT II    FAIRCHILD    FGTN__      A10A     A10      A10      A10      A10      A10      A10
* A124   ANTONOV AN-124    ANTONOV      B732__      AN4R     A124     A124     A124     A124     A124     A124
- A306   A300B4-600        AIRBUS       A306__      A306     A306     A306     A306     A306     A306     A306
- A30B   A300B4-200        AIRBUS       A30B__      EA30     A300     A30B     A30B     A30B     A30B     A30B
```

Each data line consists of 5 fields describing the aircraft type and number of additional fields providing the history of ICAO aircraft types designators. Detailed description is given below:

(a) Support Type Field

This field is one character in length being one of the following two values:

"-" to indicate an aircraft type directly supported, and,
"*" to indicate an aircraft type supported by equivalence with another directly supported aircraft

(b) Aircraft Code Field

This field identifies the aircraft type. It consists of a three or four-character ICAO code.

(c) Manufacturer Field

This field identifies the manufacturer of the aircraft. Examples are Boeing, Airbus or Fokker.

(d) Name or Model Field

This field identifies the name or model for the aircraft type. Examples are the 747-400 series or Learjet 35.

(e) File Field

This field indicates the name of the OPF, APF or PTF file, which contains the parameters for the aircraft type (minus the file extension).

For an aircraft type which is directly supported this file name will be the same as the ICAO code with an additional two or more underscore characters to form a string of six characters in length. For example, the file name corresponding to the A333 will be A333__. This indicates an OPF file A333__.OPF, an APF file A333__.APF and a PTF file A333__.PTF. For the Fokker F-27 with an ICAO code of F27, the file names include three underscore characters, that is, F27___.OPF, F27___.APF and F27___.PTF.

For an aircraft type which is supported through an equivalence the file name will indicate the file for the equivalent aircraft type which should be used. As an example, the Antonov 12 (AN12) is equivalent to the Lockheed C-130 Hercules (C130). Thus the files C130__.OPF, C130__.APF and C130__.PTF should be used.

(f) Old Code fields

The old code fields give the name of the aircraft that refers to the formerly known aircraft designator as published in one of the previous editions (versions, i.e. V24 to V31) of the ICAO document 8643 [RD10]. This allows the BADA 3.6 user to continue to use the old ICAO standard and to establish a link between the old and the new aircraft designators, as well as the corresponding BADA aircraft file name.

6.4 OPF File Format

The Operations Performance File (OPF) is an ASCII file, which for a particular aircraft type specifies the operations performance parameters described in Section 3. An example of an OPF file for the A306 (Airbus 300B4-600) aircraft is shown below.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC A306__.OPF CCCCCCCCCCCCCC/
CC                                                                       /
CC                AIRCRAFT PERFORMANCE OPERATIONAL FILE                  /
CC                                                                       /
CC                                                                       /
CC      File_name: A306__.OPF                                            /
CC                                                                       /
CC      Creation_date: Mar 26 2002                                       /
CC                                                                       /
CC      Modification_date: Mar 26 2002                                  /
CC                                                                       /
CD                                                                       /
CC====== Actype ========================================================/
CD   A306__         2 engines    Jet                        H            /
CC   Airbus A300-B4-622 with PW4158  engines               wake          /
CC                                                                       /
CC====== Mass (t) ======================================================/
CC    reference      minimum      maximum     max payload  mass grad    /
CD     .14000E+03   .87000E+02   .17170E+03   .39000E+02   .14100E+00 /
CC====== Flight envelope ===============================================/
CC     VMO(KCAS)        MMO        Max.Alt       Hmax        temp grad   /
CD     .33500E+03   .82000E+00   .41000E+05   .31600E+05  -.67000E+02 /
CC====== Aerodynamics ==================================================/
CC Wing Area and Buffet coefficients (SIM)                               /
CCndrst Surf(m2)     Clbo(M=0)       k           CM16                   /
CD 5   .26000E+03   .15300E+01   .10290E+01   .00000E+00               /
CC   Configuration characteristics                                       /
CC n Phase  Name    Vstall(KCAS)    CD0          CD2        unused       /
CD 1 CR   Clean     .15100E+03   .19000E-01   .53000E-01   .00000E+00 /
CD 2 IC   S15F00    .11700E+03   .33057E-01   .45362E-01   .00000E+00 /
CD 3 TO   S15F00    .11700E+03   .33057E-01   .45362E-01   .00000E+00 /
CD 4 AP   S15F15    .10900E+03   .38031E-01   .44932E-01   .00000E+00 /
CD 5 LD   S30F40    .97000E+02   .78935E-01   .44822E-01   .00000E+00 /
CC   Spoiler                                                             /
CD 1      RET                                                            /
CD 2      EXT                                  .00000E+00   .00000E+00 /
CC   Gear                                                                /
CD 1      UP                                                             /
CD 2      DOWN                    .22500E-01   .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     .30400E+06   .44800E+05   .11600E-09   .67500E+01   .42600E-02 /
CC      Desc(low)    Desc(high)   Desc level   Desc(app)    Desc(ld)    /
CD     .73000E-02   .20600E-01   .80000E+04   .12000E+00   .36000E+00 /
CC      Desc CAS     Desc Mach    unused       unused       unused      /
CD     .28000E+03   .79000E+00   .00000E+00   .00000E+00   .00000E+00 /
CC====== Fuel Consumption ==============================================/
CC   Thrust Specific Fuel Consumption Coefficients                       /
CD     .88100E+00   .16900E+05                                          /
CC   Descent Fuel Flow Coefficients                                      /
CD     .26805E+02   .45700E+05                                          /
CC   Cruise Corr.    unused       unused       unused       unused      /
CD     .10380E+01   .00000E+00   .00000E+00   .00000E+00   .00000E+00 /
CC====== Ground ========================================================/
CC        TOL          LDL        span         length       unused      /
CD     .23620E+04   .15550E+04   .44840E+02   .54080E+02   .00000E+00 /
CC======================================================================/
FI                                                                       /
```

There are three types of lines in the OPF file with the line type identified by the first two characters in the line. These line types with their associated two leading characters are listed below.

CC comment line

CD data line

FI end-of-file line

The comment lines are provided solely for the purpose of improving the readability of the file. All coefficients are contained within the CD lines in a fixed format. The end-of-file line is included as the last line in the file in order to facilitate the reading of the file in certain computing environments.

The data is organised into a total of eight blocks with each block separated by a comment line containing the block name and equal signs "=". These blocks are listed below and are described in further detail in the subsections below.

- file identification block
- aircraft type block
- mass block
- flight envelope block
- aerodynamics block
- engine thrust block,
- fuel consumption block
- ground movements block

6.4.1 File Identification Block

The file identification block provides information on the file name, creation date and modification date. The block consists of 11 comment lines. An example of the file identification block for the A306__.OPF file is shown below.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC A306__.OPF CCCCCCCCCCCCCC/
CC                                                                    /
CC                AIRCRAFT PERFORMANCE OPERATIONAL FILE               /
CC                                                                    /
CC                                                                    /
CC       File_name: A306__.OPF                                        /
CC                                                                    /
CC       Creation_date: Mar 26 2002                                   /
CC                                                                    /
CC       Modification_date: Mar 26 2002                              /
CC                                                                    /
```

The comment lines specify the file name along with the creation date and last modification date. The creation date indicates the date when the file was created for the first time. The modification date indicates when the contents of the file were last modified.

6.4.2 Aircraft Type Block

The OPF aircraft type block consists of 1 data line with 3 comment lines for a total of 4 lines. An example of the aircraft type block is given below.

```
        CC====== Actype ======================================================/
  1 ->  CD   A306__         2 engines    Jet                      H           /
        CC   Airbus A300-B4-622 with PW4158  engines             wake         /
        CC                                                                    /
```

The data line specifies the following aircraft type parameters:

- ICAO aircraft code (followed by 2 or more underscore characters as required to form a six character string),
- number of engines, n_{eng} ,
- engine type, and,
- 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).

The four values are specified in the following fixed format (Fortran notation)

'CD', 2X, A6, 10X, I1, 12X, A9, 17X , A1

The comment lines typically indicate the engine manufacturer's designation and the source of the performance coefficients.

6.4.3 Mass Block

The OPF mass block consists of 1 data line with 2 comment lines for a total of 3 lines.
An example of the mass block is given below.

```
        CC====== Mass (t) ====================================================/
        CC    reference      minimum      maximum     max payload  mass grad  /
  1 ->  CD     .14000E+03   .87000E+02   .17170E+03   .39000E+02   .14100E+00 /
```

The data line specifies the following BADA mass model parameters (in tonnes):

m_{ref} m_{min} m_{max} m_{pyld} G_W

These parameters are specified in the following fixed format (Fortran notation)

'CD', 2X, 5(3X, E10.5)

6.4.4 Flight Envelope Block

The OPF flight envelope block consists of 1 data line with 2 comment lines for a total of 3 lines. An example of the flight envelope block is given below.

```
        CC====== Flight envelope =============================================/
```

```
          CC      VMO(KCAS)       MMO        Max.Alt       Hmax       temp grad  /
  1 ->    CD     .33500E+03   .82000E+00   .41000E+05   .31600E+05  -.67000E+02 /
```

The date line specifies the following BADA speed envelope parameters:

V_{MO} M_{MO} h_{MO} h_{max} G_t

Note that all altitudes are expressed in feet.

These parameters are specified in the following fixed format (Fortran notation):

'CD' , 2X, 5(3X, E10.5)

6.4.5 Aerodynamics Block

The OPF aerodynamics block consists of 12 data lines and 8 comment lines for a total of 20 lines. An example of the aerodynamics block is given below.

```
          CC====== Aerodynamics ================================================/
          CC Wing Area and Buffet coefficients (SIM)                            /
          CCndrst Surf(m2)     Clbo(M=0)       k           CM16                 /
  1 ->    CD 5   .26000E+03   .15300E+01   .10290E+01   .00000E+00              /
          CC   Configuration characteristics                                    /
          CC n Phase  Name    Vstall(KCAS)     CD0          CD2        unused   /
  2 ->    CD 1 CR   Clean     .15100E+03   .19000E-01   .53000E-01   .00000E+00 /
  3 ->    CD 2 IC   S15F00    .11700E+03   .33057E-01   .45362E-01   .00000E+00 /
  4 ->    CD 3 TO   S15F00    .11700E+03   .33057E-01   .45362E-01   .00000E+00 /
  5 ->    CD 4 AP   S15F15    .10900E+03   .38031E-01   .44932E-01   .00000E+00 /
  6 ->    CD 5 LD   S30F40    .97000E+02   .78935E-01   .44822E-01   .00000E+00 /
          CC   Spoiler                                                          /
  7 ->    CD 1      RET                                                         /
  8 ->    CD 2      EXT                                 .00000E+00   .00000E+00 /
          CC   Gear                                                             /
  9 ->    CD 1      UP                                                          /
  10 ->   CD 2      DOWN                     .2250E-01   .00000E+00   .00000E+00 /
          CC   Brakes                                                           /
  12 ->   CD 1      OFF                                                         /
  13 ->   CD 2      ON                                    .00000E+00   .00000E+00 /
```

The first data line specifies the following BADA aerodynamic model parameters:

S Clbo(M=0) k C_{M16}

These parameters are specified in the following fixed format (Fortran notation):

'CD', 2X, 4 (3X, E10.5)

Note that the "5" under the header "ndrst" stands for the five drag settings. Currently this is not used but is left in for compatibility requirements.

The next line holds besides the stall speed and flap setting for cruise as well as the values for the two drag coefficients for this configuration:

$(V_{stall})_{CR}$ C_{D0} C_{D2}

These parameters are specified in the following fixed format (Fortran notation):

'CD', 15X, 3 (3X, E10.5)

The next four data lines have the same format and correspond to the other configurations. The configurations are specified in the following order, corresponding to a semi-monotonically decreasing stall speed:

IC initial climb
TO take-off
AP approach
LD landing

The stall speed, $(V_{stall})_i$, is specified for each configuration and C_{D0} and C_{D2} are given if available in the following fixed format (Fortran notation): C_{D0} and C_{D2}

'CD', 15X, 3 (3X, E10.5)

In case the IC configuration is equal to the CR configuration, the values for C_{D0} and C_{D2} are mentioned only in the CR dataline.

The data lines 7 through 9 are not used but are included for the reason of compatibility with previous versions.

Dataline 10 holds the drag increment for landing gear down:

$C_{D0\ \Delta LDG}$

The format of this line is:

'CD', 32X, E10.5

Datalines 11 and 12 are not used but are included for the reason of compatibility with previous versions.

6.4.6 Engine Thrust Block

The OPF engine thrust block consists of 3 data lines with 4 comment lines for a total of 7 lines. An example of the engine thrust block is given below.

```
       CC====== Engine Thrust ===============================================/
       CC          Max climb thrust coefficients (SIM)                        /
1 ->   CD      .30400E+06   .44800E+05   .11600E-09   .67500E+01   .42600E-02 /
       CC       Desc(low)    Desc(high)   Desc level   Desc(app)    Desc(ld)  /
2 ->   CD      .73000E-02   .20600E-01   .80000E+04   .12000E+00   .36000E+00 /
       CC       Desc CAS     Desc Mach    unused       unused       unused    /
3 ->   CD      .28000E+03   .79000E+00   .00000E+00   .00000E+00   .00000E+00 /
```

The first data line specifies the following BADA parameters used to calculate the maximum climb thrust, that is:

$C_{Tc,1}$ $C_{Tc,2}$ $C_{Tc,3}$ $C_{Tc,4}$ $C_{Tc,5}$

These parameters are specified in the following fixed format (Fortran notation):

'CD', 2X, 5 (3X, E10.5)

The second data line specifies the following BADA parameters used to calculate cruise and descent thrust, that is:

$C_{Tdes,low}$ $C_{Tdes,high}$ h_{des} $C_{Tdes,app}$ $C_{Tdes,ld}$

These parameters are specified in the following fixed format (Fortran notation):

'CD', 2X, 5 (3X, E10.5)

The third data line specifies the reference speed during descent, that is:

$V_{des,ref}$ $M_{des,ref}$

These parameters are specified in the following fixed format (Fortran notation):

'CD', 2X, 2 (3X, E10.5)

Note that these two coefficients are no longer used in BADA 3.4. For the moment they are left in place until it is clear if they will be of use for the new descent thrust algorithm, to be developed for a future release of BADA.

The zero values in the data lines are not used but are included in the file due to compatibility requirements with previous versions.

6.4.7 Fuel Consumption Block

The OPF fuel consumption block consists of 3 data lines with 4 comment lines for a total of 7 lines. An example of a fuel consumption block is shown below.

```
       CC====== Fuel Consumption ============================================/
       CC   Thrust Specific Fuel Consumption Coefficients                    /
1 ->   CD     .88100E+00   .16900E+05                                        /
       CC   Descent Fuel Flow Coefficients                                   /
2 ->   CD     .26805E+02   .45700E+05                                        /
       CC   Cruise Corr.    unused       unused       unused       unused    /
3 ->   CD     .10380E+01   .00000E+00   .00000E+00   .00000E+00   .00000E+00 /
```

The first data line specifies the following BADA parameters for thrust specific fuel consumption.

C_{f1} C_{f2}

These parameters are specified in the following fixed format (Fortran notation):

'CD', 2X, 2 (3X , E10.5)

The second data line specifies the following BADA parameters for descent fuel flow.

C_{f3} C_{f4}

These parameters are specified in the following fixed format (Fortran notation):

'CD', 2X, 2 (3X, E10.5)

The third data line specifies the cruise fuel flow correction factor.

C_{fcr}

The parameter is specified in the following fixed format (Fortran notation):

'CD', 5X, E10.5

6.4.8 Ground Movement Block

The OPF ground movement block consists of 1 data line with 3 comment lines for a total of 4 lines. An example of a ground movement block is shown below. The ground movement block is the last block in the OPF file and is thus followed by the end-of-file line as shown below.

```
        CC====== Ground ======================================================/
        CC        TOL          LDL         span         length       unused    /
1 ->    CD     .23620E+04   .15550E+04   .44840E+02   .54080E+02   .00000E+00 /
        CC====================================================================/
        FI                                                                     /
```

The data line specifies the following BADA parameters for ground movements:

TOL LDL span length

These parameters are specified in the following fixed format (Fortran notation):

'CD', 2X, 4 (3X, E10.5)

6.5 APF File Format

The Airlines Procedures File (APF) is an ASCII file which, for a particular aircraft type, specifies recommended speed procedures for climb, cruise, and descent conditions. An example of an APF file for the Airbus A306 aircraft is shown below.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC A306__.APF CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC/
CC                                                                                                  /
CC                AIRLINES PROCEDURES FILE                                                          /
CC                                                                                                  /
CC      File_name: A306__.APF                                                                       /
CC                                                                                                  /
CC      Creation_date: Mar 26 2002                                                                  /
CC                                                                                                  /
CC      Modification_date: Mar 26 2002                                                              /
CC                                                                                                  /
CD                                                                                                  /
CC                                                                                                  /
CC   LO= 087.00 to ---.--  /  AV= ---.-- to ---.--  /  HI= ---.-- to 171.70                         /
CC                                                                                                  /
CC==================================================================================================/
CC  COM CO    Company name ------climb-------  --cruise--  -----descent------  --approach-  model- /
CC                    mass  lo  hi              lo  hi         hi  lo           (unused)          /
CC    version engines  ma  cas cas mc xxxx xx  cas cas mc  mc cas cas xxxx xx  xxx xxx xxx  opf___ /
CC===:=======:=======::==::===:===:==:====:==::===:===:==::==:===:===:====:==::===:===:===::======:/
CD  *** **    Default Company                                                                      /
CD    B4_622  PW4158   LO  250 300 79          250 310 79  79 280 250            0   0   0  A306__ /
CD    B4_622  PW4158   AV  250 300 79          250 310 79  79 280 250            0   0   0  A306__ /
CD    B4_622  PW4158C  HI  250 300 79          250 310 79  79 280 250            0   0   0  A306__ /
CC===:=======:=======::==::===:===:==:====:==::===:===:==::==:===:===:====:==::===:===:===::======:/
CC///////////////////////////////////  THE END   ////////////////////////////////////////////////////
```

There are two types of lines in the APF file with the line type identified by the first two characters in the line. These line types with their associated two leading characters are listed below:

CC - comment line
CD - data line

The last line in the file, as shown above, is also a comment line.

The comment lines are provided solely for the purpose of improving the readability of the file. All coefficients are contained within the CD lines in a fixed format.

The data is organised into 2 blocks separated by a comment line containing a string of equal signs, "=":

- file identification block
- speed procedures block

Each of the two blocks is described further in the subsections below.

6.5.1 File Identification Block

The file identification block provides information on the file name, revision number and modification date. The block consists of 1 data line with 12 comment lines for a total of 13 lines. An example of a file identification block is shown below.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC A306__.APF CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC/
CC                                                                                                  /
CC               AIRLINES PROCEDURES FILE                                                           /
CC                                                                                                  /
CC      File_name: A306__.APF                                                                       /
CC                                                                                                  /
CC      Creation_date: Mar 26 2002                                                                  /
CC                                                                                                  /
CC      Modification_date: Mar 26 2002                                                              /
CC                                                                                                  /
CD                                                                                                  /
CC                                                                                                  /
CC   LO= 087.00 to ---.--  /  AV= ---.-- to ---.--  /  HI= ---.-- to 171.70                         /
CC                                                                                                  /
```

The comment lines provide background information on the file contents. In addition, the comment lines specify the file name along with the creation and last modification date. The creation date indicates the date when the file was created for the first time. The modification date indicates when the contents of the file were last modified.

The second last comment line in the identification block specifies three mass ranges for the aircraft in tons. That is, a low range (LO), average range (AV) and high range (HI). The definition of these ranges is used for interpreting the information presented below in the procedures specification block. In the example given above, all three ranges are assumed equivalent.

6.5.2 Procedures Specification Block

The APF procedures specification block consists of 4 data lines with 7 comment lines for a total of 11 lines. An example of a procedures specification block is shown below.

```
       CC==================================================================================================/
       CC  COM CO    Company name ------climb-------  --cruise--  -----descent------  --approach-  model- /
       CC                   mass  lo  hi              lo  hi         hi  lo           (unused)          /
       CC    version engines  ma  cas cas mc xxxx xx  cas cas mc  mc cas cas xxxx xx  xxx xxx xxx  opf___ /
       CC===:=======:=======::==::===:===:==:====:==::===:===:==::==:===:===:====:==::===:===:===::======:/
1 ->   CD  *** **    Default Company                                                                    /
2 ->   CD    B4_622  PW4158   LO  250 300 79          250 310 79  79 280 250             0   0   0  A306__ /
3 ->   CD    B4_622  PW4158   AV  250 300 79          250 310 79  79 280 250             0   0   0  A306__ /
4 ->   CD    B4_622  PW4158C  HI  250 300 79          250 310 79  79 280 250             0   0   0  A306__ /
       CC===:=======:=======::==::===:===:==:====:==::===:===:==::==:===:===:====:==::===:===:===::======:/
       CC/////////////////////////////////  THE END   ///////////////////////////////////////////////////
```

The first data line specifies the company name for which the next three datalines are valid. The company can be identified by its 3 and 2 letter code plus the company name. The dataline fomat is:

'CD', 2X, 3A, 1X, 2A, 4X, 15A

As it is, within BADA 3.3 all APF files specify procedures for only one "default" company.

The next three data lines specify the following parameters corresponding to climb, cruise and descent

$V_{cl,1}$ $V_{cl,2}$ M_{cl} $V_{cr,1}$ $V_{cr,2}$ M_{cr} M_{des} $V_{des,1}$ $V_{des,2}$

Note that all Mach number values are also multiplied by a value of 100. For example, the 78 indicated for M_{cl} above corresponds to a Mach number of 0.78.

The three lines specify parameters for mass ranges of Low (LO), Average (AV) and High (HI) respectively. These parameters are specified in the following fixed format (Fortran notation):

'CD', 25X, 2(I3, 1X), I2, 10X, 2(I3, 1X), I2, 2X, I2, 2(1X, I3)

Note that approach values are set to zero. These values are not used but are included in the file due to compatibility requirements with previous versions.

Also, each line specifies an aircraft version number, engine, and operational model. The operational model is always the same as the file name. The version number may provide some additional information on the aircraft version covered by the file while the engine states which engine is used by the aircraft.

The file format is designed such that the four data lines can be repeated for the different companies which operate the aircraft and which may have different standard procedures. If data were to be provided for more than one company then the version, engine and operational model fields may be useful since different companies could operate different versions of the aircraft with different engines and thus different associated operational models.

6.6 PTF File Format

The Performance Table File (PTF) is an ASCII file, which for a particular aircraft type specifies cruise, climb and descent performance at different flight levels. An example of a PTF file for the Airbus A306 aircraft is shown below.

```
                              BADA PERFORMANCE FILE         Apr 23 2002

AC/Type: A306__
                               Source OPF File:               Mar 26 2002
                               Source APF file:               Mar 26 2002

 Speeds:   CAS(LO/HI)  Mach   Mass Levels [kg]         Temperature:   ISA
 climb   - 250/300     0.79   low     - 104400
 cruise  - 250/310     0.79   nominal - 140000         Max Alt. [ft]:  41000
 descent - 250/280     0.79   high    - 171700
======================================================================================
 FL |          CRUISE           |            CLIMB                 |       DESCENT
    |  TAS          fuel        |  TAS        ROCD         fuel    |  TAS  ROCD    fuel
    | [kts]       [kg/min]      | [kts]       [fpm]      [kg/min]  | [kts] [fpm] [kg/min]
    |          lo   nom    hi   |          lo  nom   hi    nom     |        nom    nom
======================================================================================
  0 |                           |  157   2210 1990 1620   270.3    |  131   760    97.2
    |                           |                                  |
  5 |                           |  158   2190 1970 1600   267.3    |  132   780    96.1
    |                           |                                  |
 10 |                           |  159   2170 1950 1570   264.3    |  138   800    95.0
    |                           |                                  |
 15 |                           |  166   2290 2030 1650   261.5    |  149   850    94.0
    |                           |                                  |
 20 |                           |  167   2270 2010 1620   258.5    |  181  1020    31.0
    |                           |                                  |
 30 |  230    61.2  81.4 104.3  |  190   2750 2360 1920   253.0    |  230  1360    25.0
    |                           |                                  |
 40 |  233    61.2  81.4 104.4  |  225   3350 2780 2270   247.7    |  233  1380    24.5
    |                           |                                  |
 60 |  272    65.9  81.7  99.6  |  272   4210 3070 2370   236.8    |  240  1410    23.3
    |                           |                                  |
 80 |  280    65.8  81.7  99.7  |  280   4040 2930 2230   225.7    |  280  1550    22.1
    |                           |                                  |
100 |  289    65.8  81.7  99.8  |  289   3860 2780 2090   214.8    |  289  1590    20.9
    |                           |                                  |
120 |  297    65.7  81.7  99.8  |  356   3820 2800 2170   204.8    |  332  1880    19.8
    |                           |                                  |
140 |  306    65.6  81.7  99.9  |  366   3590 2610 2000   194.3    |  342  1920    18.6
    |                           |                                  |
160 |  389    82.4  93.1 105.3  |  377   3360 2410 1820   184.1    |  353  1960    17.4
    |                           |                                  |
180 |  401    82.1  92.9 105.1  |  388   3120 2220 1650   174.2    |  363  2000    16.2
    |                           |                                  |
200 |  413    81.7  92.6 104.9  |  400   2880 2020 1470   164.5    |  375  2040    15.1
    |                           |                                  |
220 |  425    81.3  92.3 104.7  |  412   2630 1810 1290   155.0    |  386  2080    13.9
    |                           |                                  |
240 |  438    80.9  91.9 104.5  |  425   2380 1610 1100   145.8    |  398  2120    12.7
    |                           |                                  |
260 |  452    80.4  91.6 104.3  |  438   2130 1400  920   136.9    |  411  2160    11.6
    |                           |                                  |
280 |  466    79.9  91.2 104.1  |  452   1880 1200  730   128.1    |  424  2200    10.4
    |                           |                                  |
290 |  468    78.4  90.1 103.4  |  459   1760 1090  640   123.9    |  431  2220     9.8
    |                           |                                  |
310 |  464    74.3  87.0 101.5  |  464   2200 1290  660   115.4    |  444  2250     8.6
    |                           |                                  |
330 |  459    70.6  84.7 100.6  |  459   1950 1050  420   107.2    |  459  2290     7.4
    |                           |                                  |
350 |  455    67.6  83.0  97.9  |  455   1700  810  170    99.2    |  455  3150     6.3
    |                           |                                  |
370 |  453    65.1  82.0  90.3  |  453   1320  510    0    91.6    |  453  2850     5.1
    |                           |                                  |
390 |  453    63.2  81.9  83.0  |  453   1080  260    0    84.1    |  453  2850     3.9
    |                           |                                  |
410 |  453    61.9  75.9  75.9  |  453    830   10    0    77.0    |  453  2880     2.8
=====================================================================================
```

The OPF and APF files are generated as a result of a modelling process using Excel spreadsheets [RD6]. Once these two files are generated, the PTF can be automatically generated. A brief summary of the format of these files is given below.

The header of each PTF file contains information as described below.

file creation date: This is in the first line, at the top-right corner

aircraft type: This is in the third line.

source file dates: The last modification dates of the OPF and APF files which were used to create the PTF file are given in the 4th and 5th lines respectively.

speeds: The speed laws for climb, cruise and descent are specified in lines 8, 9 and 10, that is:

climb	$V_{cl,1}$ / $V_{cl,2}$	M_{cl}
cruise	$V_{cr.1}$ / $V_{cr.2}$	M_{cr}
descent	$V_{des,1}$ / $V_{des.2}$	M_{des}

mass Levels: The performance tables provide data for three different mass levels in lines 8, 9 and 10 that is:

low	1.2 $m_{min.}$
nominal	m_{ref}
high	m_{max}

Note that the low mass is not the Minimum Mass but 1.2 time the minimum mass.

temperature data: The temperature is mentioned in line 7. All PTF files currently only provide for ISA conditions.

maximum altitude: The maximum altitude as specified in the OPF file, h_{MO} , is given in line 9.

The table of performance data within the file consists of 13 columns. Each of these columns is described below:

Column 1	FL
Column 2	cruise TAS (nominal mass) in knots
Column 3	cruise fuel consumption (low mass) in kg/min
Column 4	cruise fuel consumption (nominal mass) in kg/min
Column 5	cruise fuel consumption (high mass) in kg/min
Column 6	climb TAS (nominal mass) in knots
Column 7	rate of climb with reduced power (low mass) in fpm
Column 8	rate of climb with reduced power (nominal mass) in fpm
Column 9	rate of climb with reduced power (high mass) in fpm
Column 10	climb fuel consumption in kg/min
Column 11	descent TAS (nominal mass) in knots
Column 12	rate of descent (nominal mass) in fpm
Column 13	descent fuel (nominal mass) consumption in fpm

The format for data presented in each line of the table is as follows (Fortran notation)

I3, 4X, I3, 2X, 3(2X, F4.1), 5X, I3, 2X, 3(1X,I4), 4X, F4.1, 5X, I3, 2X, I4, 4X, F4.1

Further explanatory notes on the data presented in the performance tables are given below:

(a) Cruise data is only specified for flight levels greater than or equal to 30.

(b) Performance data is specified up to a maximum flight level of 510 or to highest level for which a positive rate of climb can be achieved at the low mass.

(c) True Air Speed for climb, cruise and descent is determined based on the speed schedules specified in Sections 4.1, 4.2 and 4.3 respectively.

(d) Rates of climb are calculated at each flight level assuming the energy share factors associated with constant CAS or constant Mach speed laws and using the reduced power correction as given in Section 3.8.

(e) The fuel consumption in climb is independent of the aircraft mass and thus only one value is given. There are three different climb rates however corresponding to low, nominal and high mass conditions.

(f) The rate of descent and fuel consumption in descent is calculated assuming the nominal mass. Values for other mass conditions are not given.

(g) Discontinuities in climb rate can occur for the following reasons:

- change in speed between flight levels (e.g. removal of 250 knot restriction above FL100)
- transition from constant CAS to constant Mach (typically around FL300)
- transition through the tropopause (FL360 for ISA)

(h) Discontinuities in descent rate can occur for the following reasons:

- transition through tropopause (FL360 for ISA)
- transition from constant Mach to constant CAS
- change in assumed descent thrust (specified by the BADA h_{des} parameter)
- change in speed between flight levels (e.g. application of 250 knot limit below FL100)

(i) The PTF files are made with "non clean" configuration data for approach and landing when data is available.

Note that all PTF files are available in document form in [RD9].

6.7 BADA.GPF File Format

The BADA.GPF file is an ASCII file which specifies the values of the global aircraft parameters (see Section 5). The complete BADA.GPF file is shown below:

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC BADA.GPF CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC/
CC                                                                                  /
CC                GLOBAL PARAMETERS FILE                                            /
CC                                                                                  /
CC      File_name: BADA.GPF                                                         /
CC                                                                                  /
CC      Creation_date: Mar 26 2002                                                  /
CC                                                                                  /
CC      Modificatio_date: Mar 26 2002                                               /
CC                                                                                  /
CD                                                                                  /
CC======== Class ===================================================================/
CC                                                                                  /
CC Flight = civ,mil                                                                 /
CC Engine = jet,turbo,piston                                                        /
CC Phase  = to,ic,cl,cr,des,hold,app,lnd,gnd                                        /
CC                                                                                  /
CC======== Parameters List =========================================================/
CC                                                                                  /
CC Name             Unit                                                            /
CC Parameter       Flight  Engine           Phase                       Value       /
CC                                                                                  /
CC max. long. acc.  [fps2]                                                          /
CD acc_long_max    civ     jet,turbo,piston to,ic,cl,cr,des,hold,app,lnd  .20000E+01 /
CC max. norm. acc.  [fps2]                                                          /
CD acc_norm_max    civ     jet,turbo,piston to,ic,cl,cr,des,hold,app,lnd  .50000E+01 /
CC nom. bank angle  [deg]                                                           /
CD ang_bank_nom    civ     jet,turbo,piston to,lnd                        .15000E+02 /
CC nom. bank angle  [deg]                                                           /
CD ang_bank_nom    civ     jet,turbo,piston ic,cl,cr,des,hold,app         .35000E+02 /
CC nom. bank angle  [deg]                                                           /
CD ang_bank_nom    mil     jet,turbo,piston to,ic,cl,cr,des,hold,app,lnd  .50000E+02 /
CC max. bank angle  [deg]                                                           /
CD ang_bank_max    civ     jet,turbo,piston to,lnd                        .25000E+02 /
CC max. bank angle  [deg]                                                           /
CD ang_bank_max    civ     jet,turbo,piston hold                          .35000E+02 /
CC max. bank angle  [deg]                                                           /
CD ang_bank_max    civ     jet,turbo,piston ic,cl,cr,des,app              .45000E+02 /
CC max. bank angle  [deg]                                                           /
CD ang_bank_max    mil     jet,turbo,piston to,ic,cl,cr,des,hold,app,lnd  .70000E+02 /
CC exp. desc. fact. [-]                                                             /
CD C_des_exp       civ,mil jet,turbo,piston des                           .16000E+01 /
CC to thrust factor [-]                                                             /
CD C_th_to         mil,civ jet,turbo,piston to                            .12000E+01 /
CC cr thrust factor [-]                                                             /
CD C_th_cr         mil,civ jet,turbo,piston cr                            .95000E+00 /
CC max alt for to  [ft]                                                             /
CD H_max_to        mil,civ jet,turbo,piston to                            .40000E+03 /
CC max alt for ic  [ft]                                                             /
CD H_max_ic        mil,civ jet,turbo,piston ic                            .20000E+04 /
CC max alt for app  [ft]                                                            /
CD H_max_app       mil,civ jet,turbo,piston app                           .80000E+04 /
CC max alt for ld  [ft]                                                             /
CD H_max_ld        mil,civ jet,turbo,piston lnd                           .30000E+04 /
CC min speed coef.  [-]                                                             /
CD C_v_min         mil,civ jet,turbo,piston cr,ic,cl,des,hold,app,lnd     .13000E+01 /
CC min speed coef.  [-]                                                             /
CD C_v_min_to      mil,civ jet,turbo,piston to                            .12000E+01 /
CC spd incr FL < 15 [KCAS]                                                          /
CD V_cl_1          mil,civ jet              cl                            .50000E+01 /
CC spd incr FL < 30 [KCAS]                                                          /
CD V_cl_2          mil,civ jet              cl                            .10000E+02 /
CC spd incr FL < 40 [KCAS]                                                          /
CD V_cl_3          mil,civ jet              cl                            .30000E+02 /
CC spd incr FL < 50 [KCAS]                                                          /
CD V_cl_4          mil,civ jet              cl                            .60000E+02 /
CC spd incr FL < 60 [KCAS]                                                          /
CD V_cl_5          mil,civ jet              cl                            .80000E+02 /
```

(BADA.GPF continued)

```
CC spd incr FL < 5  [KCAS]                                                               /
CD V_cl_6          mil,civ turbo,piston     cl                               .20000E+02 /
CC spd incr FL < 10 [KCAS]                                                               /
CD V_cl_7          mil,civ turbo,piston     cl                               .30000E+02 /
CC spd incr FL < 15 [KCAS]                                                               /
CD V_cl_8          mil,civ turbo,piston     cl                               .35000E+02 /
CC spd incr FL < 10 [KCAS]                                                               /
CD V_des_1         mil,civ jet,turbo        des                              .50000E+01 /
CC spd incr FL < 15 [KCAS]                                                               /
CD V_des_2         mil,civ jet,turbo        des                              .10000E+02 /
CC spd incr FL < 20 [KCAS]                                                               /
CD V_des_3         mil,civ jet,turbo        des                              .20000E+02 /
CC spd incr FL < 30 [KCAS]                                                               /
CD V_des_4         mil,civ jet,turbo        des                              .50000E+02 /
CC spd incr FL < 5  [KCAS]                                                               /
CD V_des_5         mil,civ piston           des                              .50000E+01 /
CC spd incr FL < 10 [KCAS]                                                               /
CD V_des_6         mil,civ piston           des                              .10000E+02 /
CC spd incr FL < 15 [KCAS]                                                               /
CD V_des_7         mil,civ piston           des                              .20000E+02 /
CC hold. spd FL < 140 [KCAS]                                                             /
CD V_hold_1        mil,civ jet,turbo,piston hold                             .23000E+03 /
CC hold. spd FL < 200 [KCAS]                                                             /
CD V_hold_2        mil,civ jet,turbo,piston hold                             .24000E+03 /
CC hold. spd FL < 340 [KCAS]                                                             /
CD V_hold_3        mil,civ jet,turbo,piston hold                             .26500E+03 /
CC hold. spd FL > 340 [M]                                                                /
CD V_hold_4        mil,civ jet,turbo,piston hold                             .83000E+00 /
CC backtrack spd    [KCAS]                                                               /
CD V_backtrack     mil,civ jet,turbo,piston gnd                              .35000E+02 /
CC taxi spd         [KCAS]                                                               /
CD V_taxi          mil,civ jet,turbo,piston gnd                              .15000E+02 /
CC apron spd        [KCAS]                                                               /
CD V_apron         mil,civ jet,turbo,piston gnd                              .10000E+02 /
CC gate spd         [KCAS]                                                               /
CD V_gate          mil,civ jet,turbo,piston gnd                              .50000E+01 /
CC Piston pow. red. [-]                                                                  /
CD C_red_piston    mil,civ piston           ic,cl                            .000000+00 /
CC Turbo pow. red.  [-]                                                                  /
CD C_red_turbo     mil,civ turbo            ic,cl                            .250000+00 /
CC Jet power red.   [-]                                                                  /
CD C_red_jet       mil,civ jet              ic,cl                            .150000+00 /
FI======================================================================================/
CC////////////////////////////////  THE END  ///////////////////////////////////////////
```

There are three types of lines in the BADA.GPF file with the line type identified by the first two characters in the line. These line types with their associated two leading characters are listed below.

CC comment line

CD data line

FI end-of-file line

The data is organised into three blocks separated by a comment line consisting of equal signs "=":

- file identification block
- class block
- parameter block

Each of these blocks is described in the subsections below.

6.7.1 File Identification Block

The file identification block provides information on the file name, creation and modification date. The block consists of 9 comment lines and one data line.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC BADA.GPF CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC/
CC                                                                                   /
CC                  GLOBAL PARAMETERS FILE                                           /
CC                                                                                   /
CC       File_name: BADA.GPF                                                         /
CC                                                                                   /
CC       Creation_date: Mar 26 2002                                                  /
CC                                                                                   /
CC       Modificatio_date: Mar 26 2002                                               /
```

The comment lines specify the file name along with the RCS current revision and last modification date. The creation date indicates the date when the file was created for the first time. The modification date indicates when the contents of the file were last modified.

6.7.2 Class Block

The class block consists of 6 comment lines and defines the three classes (Flight, Engine and Phase) and their instances that are used in the BADA.GPF file.

```
CC======== Class ===================================================================/
CC                                                                                 /
CC Flight = civ,mil                                                                /
CC Engine = jet,turbo,piston                                                       /
CC Phase  = to,ic,cl,cr,des,hold,app,lnd,gnd                                       /
CC                                                                                 /
```

With:

With:	civ	=	civil flight
	mil	=	military flight
	jet	=	jet engine
	turbo	=	turboprop engine
	piston	=	piston engine
	to	=	take off
	ic	=	initial climb
	cl	=	climb
	cr	=	cruise
	des	=	descent
	hold	=	holding
	app	=	approach
	lnd	=	landing
	gnd	=	ground

6.7.3 Parameter Block

The parameter block contains the values of the global aircraft parameters. This block has 5 comment lines plus a comment line and a dataline for each parameter.

```
CC======== Parameters List =========================================================/
CC                                                                                 /
CC Name             Unit                                                           /
CC Parameter       Flight  Engine           Phase                          Value   /
CC                                                                                 /
```

```
       CC max. long. acc.  [fps2]                                                        /
1 ->   CD acc_long_max    civ     jet,turbo,piston to,ic,cl,cr,des,hold,app,lnd  .20000E+01 /
       CC max. norm. acc.  [fps2]                                                        /
2 ->   CD acc_norm_max    civ     jet,turbo,piston to,ic,cl,cr,des,hold,app,lnd  .50000E+01 /
       CC nom. bank angle  [deg]                                                         /
3 ->   CD ang_bank_nom    civ     jet,turbo,piston to,lnd                        .15000E+02 /
```

The parameter comment line contains the parameter name and its unit.

The parameter data line contains five fields:

(a) Parameter Field: This field identifies the parameter.

(b) Flight Field: This field identifies whether the parameter is valid for a civil flight, a military flight or both.

(c) Engine Field: This field identifies the engine type (jet, turboprop or piston) for which the parameter is valid.

(d) Phase Field: This field identifies for which flight phase the parameter is valid. 8 different flight phases are currently defined

(e) Value Field: The value field gives the value of the parameter.

The fields above are specified in the following fixed format (Fortran notation):

'CD', 1X, A15, 1X, A7, 1X, A16, 1X, A29, 1X, E10.5

The parameter list continues until 'FI' (end of file) is reached.

7 REMOTE FILE ACCESS

All files associated with BADA Revision 3.6 are placed within a compressed tar file located on the EEC computing facilities.

These files can be only accessed by those within Eurocontrol. Other users, provided that they have been granted the rights to use BADA, are furnished with the BADA files by a means of electronic mail.

Inside the EEC:

from UNIX:

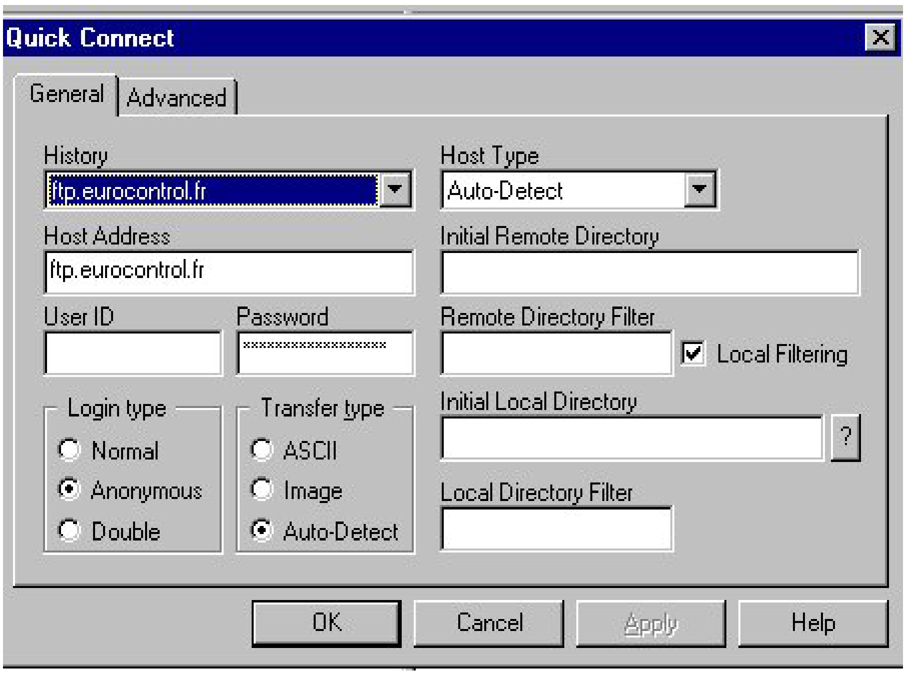
(a) Initiate an **ftp** session to the Internet address: **ftp.eurocontrol.fr** using the **anonymous** account. No password is needed for this account, however, to allow for tracing of access to the account it is requested that your E-mail address is used as the password, that is:

name@eurocontrol.fr

From here onwards you may follow the same procedure as for external users.

from PC:

(a) Start an ftp session. Fill in:
Remote Host Name: **ftp.eurocontrol.fr**
User Name: **anonymous**
Password: ***your own e-mail address***



From here onwards you may follow the same procedure as for external users.

(b) Via intranet home page: go to the “BADA – Aircraft Performance Database” under “Projects”.

Note that any enquiries can be addressed to the following addresses:

E-mail: ftp@eurocontrol.fr
bada@eurocontrol.fr

Fax: + 33 1 69 88 73 33

BADA web page: http://www.eurocontrol.fr/projects/bada/

APPENDIX A

BADA 3.6 – RELEASE SUMMARY FILE

BADA Release Summary File

```
==============================================================================
File Name    Version  ReleaseID          Release Date
==============================================================================
A306__.APF      3      bada3.4         Mon Jun 17 17:23:48 2002
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A306__.PTF      2      bada3.4         Mon Jun 17 17:23:52 2002
A30B__.APF      3      bada3.6         Tue May 25 15:01:58 2004
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A30B__.PTF      3      bada3.6         Tue May 25 15:01:59 2004
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A310__.OPF      3      bada3.6         Tue May 25 15:01:59 2004
A310__.PTF      3      bada3.6         Tue May 25 15:02:00 2004
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A319__.OPF      3      bada3.6         Tue May 25 15:02:00 2004
A319__.PTF      3      bada3.6         Tue May 25 15:02:00 2004
A320__.APF      3      bada3.6         Tue May 25 15:02:00 2004
A320__.OPF      3      bada3.6         Tue May 25 15:02:01 2004
A320__.PTF      3      bada3.6         Tue May 25 15:02:01 2004
A321__.APF      3      bada3.6         Tue May 25 15:02:01 2004
A321__.OPF      3      bada3.6         Tue May 25 15:02:01 2004
A321__.PTF      3      bada3.6         Tue May 25 15:02:01 2004
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A333__.APF      3      bada3.6         Tue May 25 15:02:02 2004
A333__.OPF      3      bada3.6         Tue May 25 15:02:02 2004
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A343__.APF      3      bada3.6         Tue May 25 15:02:03 2004
A343__.OPF      3      bada3.6         Tue May 25 15:02:03 2004
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AT43__.OPF      2      bada3.4         Mon Jun 17 17:23:49 2002
AT43__.PTF      2      bada3.4         Mon Jun 17 17:23:52 2002
AT45__.APF      3      bada3.6         Tue May 25 15:02:03 2004
AT45__.OPF      3      bada3.6         Tue May 25 15:02:03 2004
AT45__.PTF      3      bada3.6         Tue May 25 15:02:04 2004
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AT72__.OPF      2      bada3.4         Mon Jun 17 17:23:49 2002
AT72__.PTF      3      bada3.4         Mon Jun 17 17:23:52 2002
ATP___.APF      2      bada3.4         Mon Jun 17 17:23:41 2002
ATP___.OPF      2      bada3.4         Mon Jun 17 17:23:41 2002
ATP___.PTF      2      bada3.4         Mon Jun 17 17:23:52 2002
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B462__.OPF      1      bada3.6         Tue May 25 15:02:04 2004
B462__.PTF      1      bada3.6         Tue May 25 15:02:04 2004
B703__.APF      2      bada3.4         Mon Jun 17 17:23:49 2002
B703__.OPF      3      bada3.5         Fri May 23 14:46:58 2003
B703__.PTF      2      bada3.4         Mon Jun 17 17:23:52 2002
B712__.APF      1      bada3.5         Fri May 23 14:46:59 2003
B712__.OPF      1      bada3.5         Fri May 23 14:46:59 2003
B712__.PTF      1      bada3.5         Fri May 23 14:46:59 2003
B722__.APF      2      bada3.4         Mon Jun 17 17:23:49 2002
B722__.OPF      2      bada3.4         Mon Jun 17 17:23:49 2002
B722__.PTF      2      bada3.4         Mon Jun 17 17:23:52 2002
B732__.APF      3      bada3.6         Tue May 25 15:02:05 2004
B732__.OPF      3      bada3.6         Tue May 25 15:02:05 2004
B732__.PTF      3      bada3.6         Tue May 25 15:02:05 2004
B733__.APF      3      bada3.6         Tue May 25 15:02:05 2004
B733__.OPF      3      bada3.6         Tue May 25 15:02:06 2004
B733__.PTF      3      bada3.6         Tue May 25 15:02:06 2004
B734__.APF      4      bada3.5         Fri May 23 14:46:58 2003
B734__.OPF      4      bada3.5         Fri May 23 14:46:58 2003
```

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B735__.OPF	4	bada3.5	Fri May 23 14:46:58 2003
B735__.PTF	3	bada3.5	Fri May 23 14:46:58 2003
B736__.APF	1	bada3.5	Fri May 23 14:46:59 2003
B736__.OPF	1	bada3.5	Fri May 23 14:46:59 2003
B736__.PTF	1	bada3.5	Fri May 23 14:46:59 2003
B737__.APF	4	bada3.5	Fri May 23 14:46:58 2003
B737__.OPF	4	bada3.5	Fri May 23 14:46:58 2003
B737__.PTF	3	bada3.5	Fri May 23 14:46:58 2003
B738__.APF	3	bada3.5	Fri May 23 14:46:58 2003
B738__.OPF	4	bada3.5	Fri May 23 14:46:58 2003
B738__.PTF	4	bada3.5	Fri May 23 14:46:58 2003
B742__.APF	3	bada3.6	Tue May 25 15:02:06 2004
B742__.OPF	3	bada3.6	Tue May 25 15:02:06 2004
B742__.PTF	3	bada3.6	Tue May 25 15:02:06 2004
B743__.APF	4	bada3.5	Fri May 23 14:46:58 2003
B743__.OPF	4	bada3.5	Fri May 23 14:46:58 2003
B743__.PTF	3	bada3.5	Fri May 23 14:46:58 2003
B744__.APF	3	bada3.6	Tue May 25 15:02:07 2004
B744__.OPF	3	bada3.6	Tue May 25 15:02:07 2004
B744__.PTF	3	bada3.6	Tue May 25 15:02:07 2004
B752__.APF	3	bada3.6	Tue May 25 15:02:07 2004
B752__.OPF	3	bada3.6	Tue May 25 15:02:08 2004
B752__.PTF	3	bada3.6	Tue May 25 15:02:08 2004
B753__.APF	1	bada3.5	Fri May 23 14:46:59 2003
B753__.OPF	1	bada3.5	Fri May 23 14:46:59 2003
B753__.PTF	1	bada3.5	Fri May 23 14:46:59 2003
B762__.APF	4	bada3.5	Fri May 23 14:46:58 2003
B762__.OPF	4	bada3.5	Fri May 23 14:46:58 2003
B762__.PTF	3	bada3.5	Fri May 23 14:46:58 2003
B763__.APF	2	bada3.4	Mon Jun 17 17:23:50 2002
B763__.OPF	3	bada3.5	Fri May 23 14:46:58 2003
B763__.PTF	3	bada3.5	Fri May 23 14:46:59 2003
B764__.APF	1	bada3.6	Tue May 25 15:02:08 2004
B764__.OPF	1	bada3.6	Tue May 25 15:02:09 2004
B764__.PTF	1	bada3.6	Tue May 25 15:02:09 2004
B772__.APF	4	bada3.6	Tue May 25 15:02:09 2004
B772__.OPF	3.1.1	bada3.6	Tue May 25 15:02:09 2004
B772__.PTF	4	bada3.6	Tue May 25 15:02:09 2004
B773__.APF	1	bada3.6	Tue May 25 15:02:10 2004
B773__.OPF	1	bada3.6	Tue May 25 15:02:10 2004
B773__.PTF	1	bada3.6	Tue May 25 15:02:10 2004
BA11__.APF	2	bada3.4	Mon Jun 17 17:23:02 2002
BA11__.OPF	2	bada3.4	Mon Jun 17 17:23:02 2002
BA11__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
BADA.GPF	3	bada3.4	Mon Jun 17 17:23:33 2002
BE20__.APF	2	bada3.4	Mon Jun 17 17:23:03 2002
BE20__.OPF	2	bada3.4	Mon Jun 17 17:23:03 2002
BE20__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
BE99__.APF	2	bada3.4	Mon Jun 17 17:23:03 2002
BE99__.OPF	2	bada3.4	Mon Jun 17 17:23:04 2002
BE99__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
BE9L__.APF	2	bada3.4	Mon Jun 17 17:23:41 2002
BE9L__.OPF	2	bada3.4	Mon Jun 17 17:23:41 2002
BE9L__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
C130__.APF	2	bada3.4	Mon Jun 17 17:23:04 2002
C130__.OPF	2	bada3.4	Mon Jun 17 17:23:04 2002
C130__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
C160__.APF	2	bada3.4	Mon Jun 17 17:23:41 2002
C160__.OPF	2	bada3.4	Mon Jun 17 17:23:41 2002
C160__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
C421__.APF	2	bada3.4	Mon Jun 17 17:23:33 2002
C421__.OPF	2	bada3.4	Mon Jun 17 17:23:33 2002

C421__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
C550__.APF	2	bada3.4	Mon Jun 17 17:23:05 2002
C550__.OPF	2	bada3.4	Mon Jun 17 17:23:05 2002
C550__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
C560__.APF	2	bada3.4	Mon Jun 17 17:23:05 2002
C560__.OPF	2	bada3.4	Mon Jun 17 17:23:05 2002
C560__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
C750__.APF	1	bada3.5	Fri May 23 14:46:59 2003
C750__.OPF	1	bada3.5	Fri May 23 14:46:59 2003
C750__.PTF	1	bada3.5	Fri May 23 14:46:59 2003
CL60__.APF	2	bada3.4	Mon Jun 17 17:23:30 2002
CL60__.OPF	2	bada3.4	Mon Jun 17 17:23:30 2002
CL60__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
CRJ1__.APF	2	bada3.4	Mon Jun 17 17:23:50 2002
CRJ1__.OPF	2	bada3.4	Mon Jun 17 17:23:50 2002
CRJ1__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
D228__.APF	3	bada3.4	Mon Jun 17 17:23:06 2002
D228__.OPF	2	bada3.4	Mon Jun 17 17:23:06 2002
D228__.PTF	3	bada3.4	Mon Jun 17 17:23:53 2002
D328__.APF	2	bada3.4	Mon Jun 17 17:23:30 2002
D328__.OPF	2	bada3.4	Mon Jun 17 17:23:31 2002
D328__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
DC10__.APF	2	bada3.4	Mon Jun 17 17:23:06 2002
DC10__.OPF	2	bada3.4	Mon Jun 17 17:23:07 2002
DC10__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
DC87__.APF	2	bada3.4	Mon Jun 17 17:23:51 2002
DC87__.OPF	2	bada3.4	Mon Jun 17 17:23:51 2002
DC87__.PTF	2	bada3.4	Mon Jun 17 17:23:53 2002
DC94__.APF	3	bada3.4	Mon Jun 17 17:23:56 2002
DC94__.OPF	3	bada3.4	Mon Jun 17 17:23:56 2002
DC94__.PTF	3	bada3.4	Mon Jun 17 17:23:56 2002
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DH8A__.OPF	1	bada3.6	Tue May 25 15:02:11 2004
DH8A__.PTF	1	bada3.6	Tue May 25 15:02:11 2004
DH8C__.APF	2	bada3.4	Mon Jun 17 17:23:51 2002
DH8C__.OPF	2	bada3.4	Mon Jun 17 17:23:51 2002
DH8C__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
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E120__.OPF	2	bada3.4	Mon Jun 17 17:23:08 2002
E120__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
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E145__.OPF	2	bada3.4	Mon Jun 17 17:23:56 2002
E145__.PTF	2	bada3.4	Mon Jun 17 17:23:56 2002
F100__.APF	2	bada3.4	Mon Jun 17 17:23:41 2002
F100__.OPF	2	bada3.4	Mon Jun 17 17:23:42 2002
F100__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
F27___.APF	2	bada3.4	Mon Jun 17 17:23:42 2002
F27___.OPF	2	bada3.4	Mon Jun 17 17:23:42 2002
F27___.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
F28___.APF	2	bada3.4	Mon Jun 17 17:23:42 2002
F28___.OPF	2	bada3.4	Mon Jun 17 17:23:42 2002
F28___.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
F50___.APF	2	bada3.4	Mon Jun 17 17:23:42 2002
F50___.OPF	2	bada3.4	Mon Jun 17 17:23:42 2002
F50___.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
F70___.APF	2	bada3.4	Mon Jun 17 17:23:42 2002
F70___.OPF	2	bada3.4	Mon Jun 17 17:23:42 2002
F70___.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
F900__.APF	2	bada3.4	Mon Jun 17 17:23:42 2002
F900__.OPF	2	bada3.4	Mon Jun 17 17:23:43 2002
F900__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
FA10__.APF	2	bada3.4	Mon Jun 17 17:23:43 2002
FA10__.OPF	2	bada3.4	Mon Jun 17 17:23:43 2002
FA10__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002

FA20__.APF	2	bada3.4	Mon Jun 17 17:23:43 2002
FA20__.OPF	2	bada3.4	Mon Jun 17 17:23:43 2002
FA20__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
FA50__.APF	2	bada3.4	Mon Jun 17 17:23:43 2002
FA50__.OPF	2	bada3.4	Mon Jun 17 17:23:43 2002
FA50__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
FGTH__.APF	2	bada3.4	Mon Jun 17 17:23:56 2002
FGTH__.OPF	2	bada3.4	Mon Jun 17 17:23:56 2002
FGTH__.PTF	2	bada3.4	Mon Jun 17 17:23:56 2002
FGTL__.APF	2	bada3.4	Mon Jun 17 17:23:56 2002
FGTL__.OPF	2	bada3.4	Mon Jun 17 17:23:56 2002
FGTL__.PTF	2	bada3.4	Mon Jun 17 17:23:56 2002
FGTN__.APF	2	bada3.4	Mon Jun 17 17:23:56 2002
FGTN__.OPF	2	bada3.4	Mon Jun 17 17:23:56 2002
FGTN__.PTF	2	bada3.4	Mon Jun 17 17:23:56 2002
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H25B__.OPF	2	bada3.4	Mon Jun 17 17:23:43 2002
H25B__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
JS31__.APF	2	bada3.4	Mon Jun 17 17:23:51 2002
JS31__.OPF	2	bada3.4	Mon Jun 17 17:23:51 2002
JS31__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
JS41__.APF	2	bada3.4	Mon Jun 17 17:23:51 2002
JS41__.OPF	3	bada3.5	Fri May 23 14:46:58 2003
JS41__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
L101__.APF	2	bada3.4	Mon Jun 17 17:23:08 2002
L101__.OPF	2	bada3.4	Mon Jun 17 17:23:09 2002
L101__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
LJ35__.APF	2	bada3.4	Mon Jun 17 17:23:44 2002
LJ35__.OPF	2	bada3.4	Mon Jun 17 17:23:44 2002
LJ35__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
LJ45__.APF	2	bada3.5	Fri May 23 14:46:59 2003
LJ45__.OPF	1	bada3.5	Fri May 23 14:46:59 2003
LJ45__.PTF	1	bada3.5	Fri May 23 14:46:59 2003
MD11__.APF	2	bada3.4	Mon Jun 17 17:23:31 2002
MD11__.OPF	2	bada3.4	Mon Jun 17 17:23:31 2002
MD11__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
MD82__.APF	1	bada3.6	Tue May 25 15:02:11 2004
MD82__.OPF	1	bada3.6	Tue May 25 15:02:11 2004
MD82__.PTF	1	bada3.6	Tue May 25 15:02:11 2004
MD83__.APF	2	bada3.4	Mon Jun 17 17:23:56 2002
MD83__.OPF	2	bada3.4	Mon Jun 17 17:23:56 2002
MD83__.PTF	2	bada3.4	Mon Jun 17 17:23:56 2002
MU2___.APF	2	bada3.4	Mon Jun 17 17:23:10 2002
MU2___.OPF	2	bada3.4	Mon Jun 17 17:23:10 2002
MU2___.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
P28A__.APF	2	bada3.4	Mon Jun 17 17:23:51 2002
P28A__.OPF	2	bada3.4	Mon Jun 17 17:23:51 2002
P28A__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
PA27__.APF	2	bada3.4	Mon Jun 17 17:23:44 2002
PA27__.OPF	2	bada3.4	Mon Jun 17 17:23:44 2002
PA27__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
PA31__.APF	2	bada3.4	Mon Jun 17 17:23:10 2002
PA31__.OPF	2	bada3.4	Mon Jun 17 17:23:11 2002
PA31__.PTF	2	bada3.4	Mon Jun 17 17:23:54 2002
PA34__.APF	3	bada3.4	Mon Jun 17 17:23:11 2002
PA34__.OPF	3	bada3.4	Mon Jun 17 17:23:12 2002
PA34__.PTF	3	bada3.4	Mon Jun 17 17:23:55 2002
PAY2__.APF	2	bada3.4	Mon Jun 17 17:23:51 2002
PAY2__.OPF	2	bada3.4	Mon Jun 17 17:23:51 2002
PAY2__.PTF	2	bada3.4	Mon Jun 17 17:23:55 2002
PAY3__.APF	2	bada3.4	Mon Jun 17 17:23:51 2002
PAY3__.OPF	2	bada3.4	Mon Jun 17 17:23:51 2002
PAY3__.PTF	2	bada3.4	Mon Jun 17 17:23:55 2002
RJ85__.APF	1	bada3.5	Fri May 23 14:46:59 2003

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RJ85__.OPF       1       bada3.5        Fri May 23 14:46:59 2003
RJ85__.PTF       1       bada3.5        Fri May 23 14:46:59 2003
SB20__.APF       2       bada3.4        Mon Jun 17 17:23:44 2002
SB20__.OPF       2       bada3.4        Mon Jun 17 17:23:44 2002
SB20__.PTF       2       bada3.4        Mon Jun 17 17:23:55 2002
SF34__.APF       2       bada3.4        Mon Jun 17 17:23:12 2002
SF34__.OPF       2       bada3.4        Mon Jun 17 17:23:12 2002
SF34__.PTF       2       bada3.4        Mon Jun 17 17:23:55 2002
SH36__.APF       3       bada3.4        Mon Jun 17 17:23:32 2002
SH36__.OPF       2       bada3.4        Mon Jun 17 17:23:32 2002
SH36__.PTF       3       bada3.4        Mon Jun 17 17:23:55 2002
SW3___.APF       2       bada3.4        Mon Jun 17 17:23:13 2002
SW3___.OPF       2       bada3.4        Mon Jun 17 17:23:13 2002
SW3___.PTF       2       bada3.4        Mon Jun 17 17:23:55 2002
SYNONYM.LST      5       bada3.6        Tue May 25 15:02:12 2004
SYNONYM.NEW      4.1.1   bada3.6        Tue May 25 15:02:12 2004
SYNONYM_ALL.LST  2       bada3.6        Tue May 25 15:02:12 2004
T134__.APF       2       bada3.4        Mon Jun 17 17:23:44 2002
T134__.OPF       2       bada3.4        Mon Jun 17 17:23:44 2002
T134__.PTF       2       bada3.4        Mon Jun 17 17:23:55 2002
T154__.APF       2       bada3.4        Mon Jun 17 17:23:44 2002
T154__.OPF       2       bada3.4        Mon Jun 17 17:23:45 2002
T154__.PTF       2       bada3.4        Mon Jun 17 17:23:55 2002
TRIN__.APF       2       bada3.4        Mon Jun 17 17:23:45 2002
TRIN__.OPF       2       bada3.4        Mon Jun 17 17:23:45 2002
TRIN__.PTF       2       bada3.4        Mon Jun 17 17:23:55 2002
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APPENDIX B

BADA 3.6 – LIST OF AVAILABLE AIRCRAFT MODELS

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List of Aircraft Types Supported by BADA 3.6

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
A10	equiv.	Fairchild Thunderbolt II	FGTN	50000	50000	M
A124	equiv.	Antonov AN-4	B732	37000	34500	M
A306	direct	Airbus A300B4-600		41000	31600	H
A30B	direct	Airbus A300B4-200		39000	34000	H
A310	direct	Airbus A310		41000	36400	H
A318	equiv.	Airbus A318	A319	39000	37600	M
A319	direct	Airbus A319		39000	37600	M
A320	direct	Airbus A320		39100	36500	M
A321	direct	Airbus A321		39100	36400	M
A332	direct	Airbus A330-200		41000	36600	H
A333	direct	Airbus A330-300		41000	38500	H
A342	equiv.	Airbus A340-200	A343	41000	35000	H
A343	direct	Airbus A340-300		41000	35000	H
A345	equiv.	Airbus A340-500	A343	41000	35000	H
A346	equiv.	Airbus A340-600	A343	41000	35000	H
A3ST	equiv.	Airbus A-300ST Beluga	B732	37000	34500	M
A4	equiv.	McDonnell-Douglas Skyhawk	FGTN	50000	50000	M
A6	equiv.	Grumman Intruder	FGTN	50000	50000	M
A7	equiv.	A7	FGTN	50000	50000	M
A748	equiv.	BAE 748	AT72	25000	21300	M
AA5	equiv.	American AA5	P28A	12000	12000	L
AC80	equiv.	Rockwell Turbo Commander	BE20	32000	32000	L
AC90	equiv.	Rockwell Turbo Commander	BE20	32000	32000	L
AC95	equiv.	Rockwell Turbo Commander	BE20	32000	32000	L
AEST	equiv.	Dassault Alpha Jet	FGTN	50000	50000	M
AJET	equiv.	Embraer AMX	FGTN	50000	50000	M
AMX	equiv.	Antonov AN-12	C130	40000	17500	M
AN12	equiv.	Antonov AN-124	F27	25000	21000	M
AN24	equiv.	Antonov AN-26	F27	25000	21000	M
AN26	equiv.	Antonov AN-26	F27	25000	21000	M

List of Aircraft Types Supported by BADA 3.6 (cont'd)

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
AN72	equiv.	Antonov AN-72	F28	35000	31000	M
ASTR	equiv.	IAI 1125 Astra	LJ45	51000	43000	M
AT43	direct	ATR 42-300		25000	24500	M
AT44	equiv.	ATR 42-400	AT43	25000	24500	M
AT45	direct	ATR 42-500		25000	23700	M
AT72	direct	ATR 72		25000	21300	M
ATLA	equiv.	Dassault Atlantic	C130	40000	17500	M
ATP	direct	BAE Advanced Turboprop		25000	21000	M
B1	equiv.	Rockwell B1 Lancer	FGTL	41000	33000	H
B190	equiv.	Beech1900	JS31	25000	25000	L
B350	equiv.	BeechB300	BE20	32000	32000	L
B461	equiv.	BAE 146-100/RJ	B462	31000	31000	M
B462	direct	BAE 146-200/RJ		31000	31000	M
B463	equiv.	BAE 146-300/RJ	B461	31000	31000	M
B52	equiv.	B-52 Stratofortress	FGTL	41000	33000	H
B701	equiv.	Boeing 707-100	B703	42000	35000	H
B703	direct	Boeing 707-300		42000	35000	H
B712	direct	Boeing 717-200		38000	37000	M
B720	equiv.	Boeing B720B	B703	42000	35000	M
B721	equiv.	Boeing 727-100	B722	37000	31200	M
B722	direct	Boeing 727-200		37000	31200	M
B731	equiv.	Boeing 737-100	B732	37000	34500	M
B732	direct	Boeing 737-228		37000	34500	M
B733	direct	Boeing 737-300		37000	34300	M
B734	direct	Boeing 737-400		37000	33980	M
B735	direct	Boeing 737-500		37000	34800	M
B736	direct	Boeing 737-600		41000	39600	M
B737	direct	Boeing 737-700		41000	37700	M
B738	direct	Boeing 737-800		41000	35600	M
B739	equiv.	Boeing 737-900	B738	41000	39000	M

List of Aircraft Types Supported by BADA 3.6 (cont'd)

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
B741	equiv.	Boeing 747-100	B742	45000	32000	H
B742	direct	Boeing 747-200		45000	32000	H
B743	direct	Boeing 747-300		45000	32200	H
B744	direct	Boeing 747-400		45000	35400	H
B74D	equiv.	Boeing 747-400 Domestic	B744	45000	35400	H
B74S	equiv.	Boeing 747-SP	B744	45000	35400	H
B752	direct	Boeing 757-200		42000	35700	M
B753	direct	Boeing 757-300		43000	33900	M
B762	direct	Boeing 767-200		43000	36100	H
B763	direct	Boeing 767-300		43000	33800	H
B764	direct	Boeing 767-400		43000	33800	H
B772	direct	Boeing 777-200		43100	35000	H
B773	direct	Boeing 777-300		43100	35000	H
BA11	direct	BAE 111, All Series		35000	29750	M
BDOG	equiv.	BAE SA-3 Bulldog	P28A	12000	12000	L
BE10	equiv.	Beechcraft King Air 100	BE20	32000	32000	L
BE20	direct	Beech Super King Air 200/HURON		32000	32000	L
BE30	equiv.	Beech Super King Air 300	BE20	32000	32000	L
BE33	equiv.	Beech Bonanza 33	PA34	15000	15000	L
BE36	equiv.	Beech Bonanza 36	PA34	15000	15000	L
BE40	equiv.	Beech BJ40/T1	FA10	45000	38400	M
BE55	equiv.	Beech 55	D228	28000	24000	L
BE58	equiv.	Beech Baron 58	PA27	20000	20000	L
BE60	equiv.	Beech Duke 60	C421	23500	23500	L
BE76	equiv.	Beech Duchesse	PA27	20000	20000	L
BE95	equiv.	Beech Travelair 95	PA31	23000	23000	L
BE99	direct	Beech Airliner C99		15000	15000	L
BE9L	direct	Beech King Air 90		31000	31000	L
BER4	equiv.	Beriev Albatros	B722	37000	31200	M
BN2P	equiv.	Pilatus Islander BN2-A/B	PA31	23000	23000	L

List of Aircraft Types Supported by BADA 3.6 (cont'd)

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
C130	direct	Lockheed Hercules		40000	17500	M
C135	equiv.	Boeing Stratolifter 717	B703	42000	35000	M
C141	equiv.	Lockheed Stratolifter	DC87	42000	34000	H
C160	direct	Transall C160		30000	25500	M
C17	equiv.	McDonnell-Douglas Globe-Master	A320	39100	36500	M
C170	equiv.	Cessna 170	PA34	15000	15000	L
C172	equiv.	Cessna Skyhawk 172	P28A	12000	12000	L
C177	equiv.	Cessna Cardinal 177	P28A	12000	12000	L
C182	equiv.	Cessna Cardinal 182	P28A	12000	12000	L
C208	equiv.	Cessna 208 Caravan	PA27	20000	20000	L
C210	equiv.	Cessna Centurion	PA31	23000	23000	L
C212	equiv.	Casa C-212 AVIOCAR	D228	28000	24000	L
C303	equiv.	Cessna Crusader 303	PA31	23000	23000	L
C30J	equiv.	Lockheed Martin C130 J	C130	40000	17500	M
C310	equiv.	Cessna	PA31	23000	23000	L
C337	equiv.	Cessna C-337 Super Sky Master	PA34	15000	15000	L
C340	equiv.	CessnaC-340/340A	PA31	23000	23000	L
C402	equiv.	Cessna402	PA31	23000	23000	L
C414	equiv.	Cessna Chancellor 414	C421	23500	23500	L
C421	direct	Cessna Golden Eagle 421		23500	23500	L
C425	equiv.	Cessna Corsair/Conquest	PAY2	29000	29000	L
C441	equiv.	Cessna 441 Conquest	C421	23500	23500	L
C5	equiv.	Lockheed GALAXY	B742	45000	32000	H
C500	equiv.	Cessna Citation	C550	43000	41000	L
C501	equiv.	Cessna Citation	C550	43000	41000	L
C525	equiv.	Cessna CitationJET	C550	43000	41000	L
C526	equiv.	Cessna CitationJET	C550	43000	41000	L
C550	direct	Cessna Citation II-S2		43000	41000	L
C551	equiv.	Cessna Citation 2SP	C550	43000	41000	L
C560	direct	Cessna Citation V		45000	45000	M

List of Aircraft Types Supported by BADA 3.6 (cont'd)

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
C56X	equiv.	Cessna Citation X	FA10	45000	38400	M
C650	equiv.	Cessna Citation III	LJ35	43000	37000	M
C72R	equiv.	Cessna Skyhawk 172	P28A	12000	12000	L
C750	direct	Cessna Citation X		51000	43000	M
C77R	equiv.	Cessna Cardinal 177	P28A	12000	12000	L
C82R	equiv.	Cessna Skylane 182	P28A	12000	12000	L
CL60	direct	Canadair Challenger 600/601		41000	38000	M
CN35	equiv.	Airtech CN-235	AT43	25000	24500	M
CONC	equiv.	BAE-Aerospatiale Concorde	FGTN	50000	50000	M
CRJ1	direct	Canadair Regional Jet		41000	36500	M
CRJ2	equiv.	Canadair Regional Jet	CRJ1	41000	36500	M
CRJ7	equiv.	Canadair Regional Jet	CRJ1	41000	36500	M
CVLT	equiv.	Convair 540/580/600/640	AT43	25000	24500	M
D228	direct	Dornier DO 228-100/200		28000	24000	L
D28D	equiv.	Dornier DO 28	PA31	23000	23000	L
D328	direct	Dornier 328		32800	30000	M
DC10	direct	McDonnell-Douglas DC-10		39000	32000	H
DC3	equiv.	Douglas DC3	DH8C	25000	25000	M
DC85	equiv.	McDonnell-Douglas DC-85	DC87	42000	34000	H
DC86	equiv.	McDonnell-Douglas DC-86	DC87	42000	34000	H
DC87	direct	McDonnell-Douglas DC-87		42000	34000	H
DC91	equiv.	McDonnell-Douglas DC-9 /10	DC94	35000	33500	M
DC92	equiv.	McDonnell-Douglas DC-9 /20	DC94	35000	33500	M
DC93	equiv.	McDonnell-Douglas DC-9 /30	DC94	35000	33500	M
DC94	direct	McDonnell-Douglas DC-9 /40		35000	33500	M
DC95	equiv.	McDonnell-Douglas DC-9 /50	DC94	35000	33500	M
DH8A	direct	De Havilland Dash 8 –100		25000	25000	M
DH8B	equiv.	De Havilland Dash 8 –200	DH8C	25000	25000	M
DH8C	direct	De Havilland Dash 8 –300		25000	25000	M
DH8D	equiv.	De Havilland Dash 8 –400	DH8C	25000	25000	M

List of Aircraft Types Supported by BADA 3.6 (cont'd)

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
E110	equiv.	Embraer Bandeirante	D228	28000	24000	L
E120	direct	Embraer 120/HH/RT		32000	31000	M
E135	equiv.	Embraer RJ 135	FA50	45000	36550	M
E145	direct	Embraer 145		37000	37000	M
E3CF	equiv.	Boeing E-3 Sentry	B703	42000	35000	M
E3TF	equiv.	Boeing E-3 Sentry	B703	42000	35000	M
EC35	equiv.	Eurocopter EC35	P28A	12000	12000	L
ETAR	equiv.	DASSAULT Etendard 4	FGTN	50000	50000	M
EUFI	equiv.	Eurofighter	FGTN	50000	50000	M
F1	equiv.	Dassault-Breguet Mirage F1	FGTN	50000	50000	M
F100	direct	Fokker100		35000	33000	M
F104	equiv.	Lockheed F104	FGTN	50000	50000	M
F117	equiv.	Lockheed F-117 Nighthawk	FGTN	50000	50000	M
F14	equiv.	Grumman Tomcat	FGTN	50000	50000	M
F15	equiv.	McDonnell-Douglas F15 Eagle	FGTN	50000	50000	M
F16	equiv.	General Dynamics Fighting Falcon	FGTN	50000	50000	M
F18	equiv.	McDonnell-Douglas F18 Hornet	FGTN	50000	50000	M
F27	direct	Fokker Friendship		25000	21000	M
F28	direct	Fokker Followship		35000	31000	M
F2TH	equiv.	Dassault FALCON 2000	F900	49000	38200	M
F4	equiv.	McDonnell-Douglas F4 PHANTOM	FGTN	50000	50000	M
F5	equiv.	NORTHROP F-5	FGTN	50000	50000	M
F50	direct	Fokker50		25000	24000	M
F70	direct	Fokker 70		37000	37000	M
F900	direct	Dassault- Bregeut Falcon 900		49000	38200	M
FA10	direct	Dassault- Bregeut Falcon 10		45000	38400	M
FA20	direct	Dassault- Bregeut Falcon 20		42000	38000	M
FA50	direct	Dassault- Bregeut Falcon 10		45000	36550	M
FGTH	direct	Generic Military Fighter High		50000	50000	M

List of Aircraft Types Supported by BADA 3.6 (cont'd)

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
FGTL	direct	Generic Military Fighter Low		41000	33000	H
FGTN	direct	Generic Military Fighter Normal		50000	50000	M
G222	equiv.	Fiat/ Aeritalia C27 Spartan	ATP	25000	21000	M
GALX	equiv.	IAI 1126	LJ45	51000	43000	M
GLAS	equiv.	Stoddard-Hamilton Glasair	P28A	12000	12000	L
GLEX	equiv.	Bombardier BD-700 Global Express	B744	45000	35400	M
GLF2	equiv.	Gulfstream II	CL60	41000	38000	M
GLF3	equiv.	Gulfstream III	CL60	41000	38000	M
GLF4	equiv.	Gulfstream IV	CL60	41000	38000	M
GLF5	equiv.	Gulfstream V	CL60	41000	38000	M
H25A	equiv.	BAE 125-400/600	H25B	41000	38000	M
H25B	direct	BAE 125-700/800		41000	38000	M
H25C	equiv.	BAE 125-1000	H25B	41000	38000	M
HAR	equiv.	BAE HARRIER	FGTN	50000	50000	M
HAWK	equiv.	BAE FIGHTER	FGTN	50000	50000	M
HELI	equiv.	Generic Helicopter	P28A	12000	12000	L
IL18	equiv.	Ilyushin IL-18	C130	40000	17500	M
IL62	equiv.	Ilyushin IL-62 /-62M / MK	B703	42000	35000	M
IL76	equiv.	Ilyushin IL-76	A30B	39000	34000	H
IL86	equiv.	Ilyushin IL-86	DC87	42000	34000	H
IL96	equiv.	Ilyushin IL-96 BETTER –86	DC87	42000	34000	H
J328	equiv.	Fairchild Dornier 328 Jet Envoy 3	F28	35000	31000	M
J728	equiv.	Fairchild Dornier 328 Jet	B738	41000	35600	M
JAGR	equiv.	Dassault-Breguet Jaguar	FGTN	50000	50000	M
JS1	equiv.	BAE Jetstream	JS31	25000	25000	L
JS20	equiv.	BAE Jetstream	JS31	25000	25000	L
JS3	equiv.	BAE Jetstream	JS31	25000	25000	L
JS31	direct	BAE Jetstream 31		25000	25000	L
JS32	equiv.	BAE Jetstream 31	JS31	25000	25000	L
JS41	direct	BAE Jetstream 41		26000	22100	M

List of Aircraft Types Supported by BADA 3.6 (cont'd)

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
K35A	equiv.	Boeing Stratotanker KC135A	B703	42000	35000	M
K35E	equiv.	Boeing Stratotanker KC135D/E	B703	42000	35000	M
K35R	equiv.	Boeing Stratotanker K35R	B703	42000	35000	M
L101	direct	Lockheed Tristar L101		42000	33000	H
L159	equiv.	AERO (2) L-159	FGTN	50000	50000	M
L188	equiv.	Lockheed Electra/ Orion	C130	40000	17500	M
L29A	equiv.	Lockheed Jetstar	CL60	41000	38000	M
L29B	equiv.	Lockheed Jetstar	CL60	41000	38000	M
L410	equiv.	Let410	D228	28000	24000	L
LJ24	equiv.	Bombardier Learjet 24	FA10	45000	38400	M
LJ25	equiv.	Bombardier Learjet 25	LJ35	43000	37000	M
LJ31	equiv.	Bombardier Learjet 31	LJ35	43000	37000	M
LJ35	direct	Bombardier Learjet 35		43000	37000	M
LJ45	direct	Bombardier Learjet 45		51000	43000	M
LJ55	equiv.	Bombardier Learjet 55	LJ35	43000	37000	M
LJ60	equiv.	Bombardier Learjet 60	LJ45	51000	43000	M
M20P	equiv.	Mooney Mark 20	TRIN	12000	12000	L
M20T	equiv.	Mooney Mark 20	TRIN	12000	12000	L
MD11	direct	McDonnell-Douglas MD-11		43000	32500	H
MD81	equiv.	McDonnell-Douglas MD-80/ 81/	MD83	37000	34000	M
MD82	equiv.	McDonnell-Douglas MD-80/ 82/	MD83	37000	34000	M
MD83	direct	McDonnell-Douglas MD-80/ 83/		37000	34000	M
MD87	equiv.	McDonnell-Douglas MD-80/ 87/	MD83	37000	34000	M
MD88	equiv.	McDonnell-Douglas MD-80/ 88/	MD83	37000	34000	M
MD90	equiv.	McDonnell-Douglas MD-90	MD83	37000	34000	M
MG21	equiv.	Mikoyan MIG-21	FGTN	50000	50000	M
MG23	equiv.	Mikoyan MIG-23	FGTN	50000	50000	M
MG25	equiv.	Mikoyan MIG-25	FGTN	50000	50000	M
MG29	equiv.	Mikoyan MIG-29	FGTN	50000	50000	M
MIR2	equiv.	Dassault-Bregeut Mirage 2000	FGTN	50000	50000	M

List of Aircraft Types Supported by BADA 3.6 (cont'd)

A/C Code	Model Type	Aircraft Name	Equiv. A/C	h_{MO} [ft] (max operational)	h_{max} [ft] (at MTOW)	Wake Cat.
MIR4	equiv.	Dassault- Bregeut Mirage IV	FGTN	50000	50000	M
MRF1	equiv.	Dassault- Bregeut Mirage F1	FGTN	50000	50000	M
MU2	direct	Mitsubishi Marquise/ Solitaire		28500	28500	L
MU30	equiv.	Mitsubishi MU-300	C550	43000	41000	L
N262	equiv.	Aerospatiale Nord 262	JS41	26000	22100	L
NIM	equiv.	Hawker Siddeley Nimrod	B703	42000	35000	M
P180	equiv.	PIAGGIO P-180 Avanti	F70	37000	37000	L
P28A	direct	Piper PA-28-140 ARCHER		12000	12000	L
P28B	equiv.	Piper PA-28-201T235/236	P28A	12000	12000	L
P28R	equiv.	Piper PA-28R-180/200/201	TRIN	12000	12000	L
P28T	equiv.	Piper PA-28RT ARROW 4	TRIN	12000	12000	L
P3	equiv.	Lockheed ORION	C130	40000	17500	M
P32R	equiv.	Piper Cherokee	PA34	15000	15000	L
P68	equiv.	Partentavia P-68	PA31	23000	23000	L
PA18	equiv.	Piper Super Club	P28A	12000	12000	L
PA23	equiv.	Piper Apache	PA27	20000	20000	L
PA27	direct	Piper PA23 Aztec		20000	20000	L
PA31	direct	Piper PA31		23000	23000	L
PA32	equiv.	Piper PA-32 Cherokee Six	PA34	15000	15000	L
PA34	direct	Piper PA34-200T Seneca-III		15000	15000	L
PA44	equiv.	Piper PA-44 Seminole	PA27	20000	20000	L
PAY1	equiv.	Piper Cheyenne II	PA31	23000	23000	L
PAY2	direct	Piper PA42		33000	33000	L
PAY3	direct	Piper PAY3		33000	33000	L
PAY4	equiv.	Piper PAY4	PAY3	33000	33000	L
PC12	equiv.	Pilatus PC12	PAY3	33000	33000	L
R135	equiv.	Boeing RC135	B703	42000	35000	H
RJ1H	equiv.	Avroliner RJ1H	F28	35000	31000	M
RJ70	equiv.	Avroliner RJ70	B462	31000	31000	M
RJ85	direct	Avroliner RJ85		35000	33000	M

List of Aircraft Types Supported by BADA 3.6 (cont'd)

S601	equiv.	Aerospatiale SB 601 Corvette	C550	43000	41000	L
S76	equiv.	Sikorsky S-76	P28A	12000	12000	L
SB05	equiv.	SAAB 105	C550	43000	41000	L
SB20	direct	SAAB 2000		31000	31000	M
SB32	equiv.	SAAB Lansen	FGTN	50000	50000	M
SB35	equiv.	SAAB Draken	FGTN	50000	50000	M
SB37	equiv.	SAAB Viggen	FGTN	50000	50000	M
SB39	equiv.	SAAB Gripen	FGTN	50000	50000	M
SBR1	equiv.	Rockwell Saberliner	FA20	42000	38000	M
SF34	direct	SAAB-Scania SF 340		31000	26350	M
SH33	equiv.	Shorts SH3-330	SH36	20000	20000	M
SH36	direct	Shorts SH3-360		20000	20000	M
SW2	equiv.	Fairchild Merlin IIA/B	SW3	31000	27000	L
SW3	direct	Fairchild Merlin IVC, METRO III		31000	27000	L
SW4	equiv.	Fairchild Merlin IIA/	SW3	31000	27000	L
T134	direct	Tupolev 134,134A/B		39000	37300	M
T154	direct	Tupolev 154,154A/B/B2/C/M		41000	36000	M
T204	equiv.	Tupolev 204 204-200 204-220	B752	42000	35700	M
TBM7	equiv.	TBM 700	PAY3	33000	33000	L
TOBA	equiv.	Aerospatiale Tobago TB-10	P28A	12000	12000	L
TOR	equiv.	Panavia Tornado	FGTN	50000	50000	M
TRIN	direct	Aerospatiale Trinidad TB-20		12000	12000	L
VC10	equiv.	BAE VC10-1100	B703	42000	35000	M
WW24	equiv.	IAI 1124 Westwind	H25B	41000	38000	M
YK40	equiv.	Yakolev YAK-40	DH8C	25000	25000	M
YK42	equiv.	Yakolev YAK-42	B461	31000	31000	M

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APPENDIX C

BADA 3.6 - SOLUTIONS FOR BUFFETING LIMIT ALGORITHM

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A general solution for finding the roots of a cubic expression $\left(X^3 + a_1 \cdot X^2 + a_2 \cdot X + a_3 = 0 \right)$ can be found in Ref. 1. If we take expression 3.6-6, we can rewrite it to:

$$M^3 - \frac{C_{Lbo(M=0)}}{k} \cdot M^2 + \frac{\frac{W}{S}}{0.583 \cdot P \cdot k} = 0$$

Therefore:

$$a_1 = \frac{C_{Lbo(M=0)}}{k}$$

$$a_2 = 0 \qquad a_3 = \frac{\frac{W}{S}}{0.583 \cdot P \cdot k}$$

Now let: $Q = \frac{\left(3 \cdot a_2 - a_1^{\ 2}\right)}{9}$ and $R = \frac{\left(9 \cdot a_1 \cdot a_2 - 27 \cdot a_3 - 2 \cdot a_1^{\ 3}\right)}{54}$

The discriminant D is equal to: $Q^3 + R^2$. In our case D is always < 0 that means that all roots are unequal and real. A simplified computation method with the help of trigonometry is given below:

$$X_1 = 2 \cdot \sqrt{-Q} \cdot \cos\left(\frac{\theta}{3}\right) - \frac{a_1}{3}$$

$$X_2 = 2 \cdot \sqrt{-Q} \cdot \cos\left(\frac{\theta}{3} + 120^0\right) - \frac{a_1}{3}$$

$$X_3 = 2 \cdot \sqrt{-Q} \cdot \cos\left(\frac{\theta}{3} + 240^0\right) - \frac{a_1}{3}$$

With: $\cos\theta = \frac{R}{\sqrt{-Q^3}}$

The solutions x1, x2 and x3 now give the possible values of M. One solution (in our case usually x1) is always negative. The others are positive with the lower one (usually x2) being the low speed buffeting limit we are looking for.

Ref. 1 Mathematical Handbook; M.R. Spiegel; 1968; McGraw-Hill book company