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FOR THE SAFETY OF AIR NAVIGATION



**EUROCONTROL EXPERIMENTAL CENTRE**

**BASE OF AIRCRAFT DATA (BADA) PRODUCT MANAGEMENT DOCUMENT**

**EEC Technical/Scientific Report No. 2009-008**

Project BADA

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<b>Abstract:</b> <p>This document is the Base of Aircraft Data (BADA) Product Management document. BADA is an Aircraft Performance designed for use in aircraft trajectory simulation and prediction algorithms within the domain of Air Traffic Management.</p> <p>The present document refers to the BADA family 3 and is applicable for the BADA release 3.7 onwards. It describes three main features of the BADA Product: (1) the BADA Aircraft Performance Model (APM), (2) Support Tools and (3) Support Services. It details information on the BADA APM management related processes. This includes definition of actors, roles and responsibilities, procedures for reporting, registering and evaluating the user requests; forms and tools; decision making process for corrective and evolutionary measures; BADA release cycles and available communication means.</p>						

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## EXECUTIVE SUMMARY

This document is the Base of Aircraft Data (BADA) Product Management document. BADA is an Aircraft Performance designed for use in aircraft trajectory simulation and prediction algorithms within the domain of Air Traffic Management.

The present document refers to the BADA family 3 and is applicable for the BADA release 3.7 onwards. It describes three main features of the BADA Product: (1) the BADA Aircraft Performance Model (APM), (2) Support Tools and (3) Support Services. It details information on the BADA APM management related processes. This includes definition of actors, roles and responsibilities, procedures for reporting, registering and evaluating the user requests; forms and tools; decision making process for corrective and evolutionary measures; BADA release cycles and available communication means.

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## 1. INTRODUCTION

### 1.1. IDENTIFICATION

This document is the Base of Aircraft Data (BADA) Product Management document. BADA is an Aircraft Performance Model managed by EUROCONTROL Validation Infrastructure Centre of Expertise located at EUROCONTROL Experimental Centre at Brétigny-sur-Orge, France. BADA is designed for use in aircraft trajectory simulation and prediction algorithms within the domain of Air Traffic Management. The present document refers to the BADA family 3 and is applicable for the BADA release 3.7 onwards.

### 1.2. PURPOSE

This document addresses the BADA product management. It describes each of its main features: (1) the BADA Aircraft Performance Model (APM), (2) Support Tools and (3) Support Services and provides information on change and configuration management processes. This includes definition of actors, roles and responsibilities, procedures for reporting, registering and evaluating the user requests; forms and tools; decision making process for corrective and evolutionary measures; BADA release cycles and communication means.

### 1.3. DOCUMENT ORGANISATION

This document consists of five sections including:

- Section 1:** Introduction, provides list of referenced documents along with definitions and a glossary of acronyms.
- Section 2:** BADA Product, defines the BADA Product and describes its components.
- Section 3:** Licence Agreement, provides information on conditions for BADA use and the way the licence agreement process is managed.
- Section 4:** Actors, Roles and Responsibilities, provides list of actors and corresponding roles and responsibilities.
- Section 5:** BADA APM management, addresses services and processes associated with maintenance, support, change and configuration management of the BADA APM.
- Section 6:** BADA Support Tools Managements, briefly describes conditions for support service provision.
- Section 7:** Support Services Management, explains the ways support service is managed.
- Section 8:** Communication means, provides information on information exchange means.

There are several appendices to this document:

- Appendix A:** Provides detailed description of the BADA documents.
- Appendix B:** Licence Agreement terms and conditions
- Appendix C:** Guidelines for validation of BADA implementation in simulation tools
- Appendix D:** Supporting data for problem analysis

#### 1.4. REFERENCED DOCUMENTS

Ref.	Document
[1]	User Manual for BADA
[2]	Revision Summary Document for BADA
[3]	Aircraft Performance Summary Tables for BADA
[4]	Synonym Aircraft Report for BADA
[5]	BADA Aircraft Modelling and Accuracy Reports
[6]	Model Accuracy Summary Report for BADA
[7]	Coverage of European Air Traffic for the BADA
[8]	BADA Aircraft Performance Modelling Manual
[9]	User Guide for BADA Support Application

#### 1.5. DEFINITIONS

Change Request – CR	Part of user request
Clarification Inquiry - CI	Part of user request
Problem Report – PR	Part of user request
Technical Support Request – TSR	Part of user request
User Request – UR	Includes Change Request, Clarification Inquiry, Problem Report, Technical Support

**1.6. ACRONYMS**

<b>ANSP</b>	<b>Air Navigation Service Provider</b>
<b>APF</b>	<b>Airline Procedure File</b>
<b>APM:</b>	<b>Aircraft Performance Model</b>
<b>APC</b>	<b>Aircraft Performance Calculation</b>
<b>ATC</b>	<b>Air Traffic Control</b>
<b>ATM</b>	<b>Air Traffic Management</b>
<b>BADA:</b>	<b>Base of Aircraft Data (BADA)</b>
<b>BSA</b>	<b>BADA Support Application</b>
<b>CCB:</b>	<b>Change Control Board</b>
<b>CFMU</b>	<b>Central Flow Management Unit</b>
<b>CI</b>	<b>Clarification Inquiry</b>
<b>CM</b>	<b>Change Management Synergy</b>
<b>CR</b>	<b>Change Request</b>
<b>DCM</b>	<b>Distributed Change Management</b>
<b>ECAC</b>	<b>European Civil Aviation Conference</b>
<b>EEC</b>	<b>EUROCONTROL Experimental Centre</b>
<b>FDPS</b>	<b>Flight Data Processing System</b>
<b>ICAO</b>	<b>International Civil Aviation Organization</b>
<b>KPI</b>	<b>Key Performance Indicators</b>
<b>LAB</b>	<b>Licence Agreement Board</b>
<b>LAC</b>	<b>Licence Agreement Coordinator</b>
<b>MET</b>	<b>Meteorological Data</b>
<b>MTOW</b>	<b>Maximum Take Off Weight</b>
<b>PM</b>	<b>Project Manager</b>
<b>PR</b>	<b>Problem Report</b>
<b>RDAP</b>	<b>Radar Data Processing and Analysis Tool</b>
<b>RSD</b>	<b>Revision Summary Document</b>
<b>TO</b>	<b>Technical Officer</b>
<b>TP</b>	<b>Trajectory Prediction</b>
<b>TSR</b>	<b>Technical Support Request</b>
<b>UCG</b>	<b>User Consultation Group</b>
<b>UFP</b>	<b>User Focal Point</b>
<b>UM</b>	<b>User Manual</b>
<b>UR</b>	<b>User Request</b>

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## 2. BADA PRODUCT COMPONENTS

The BADA product combines three main features that will be detailed in the following sub-sections: (1) BADA Aircraft Performance Model, (2) Support Tools and (3) Support services.

### 2.1. BADA AIRCRAFT PERFORMANCE MODEL (APM)

The BADA APM refers to a set of documents and data files that provide complete information on the theoretical aircraft performance model and aircraft model performance parameters for a number of different aircraft types. The following set of files and documents are referred to as a BADA release.

**Table 1: BADA APM Release Documents**

<b>BADA APM Release Documents</b>	User Manual for BADA
	Revision Summary Document for BADA
	Aircraft Performance Summary Tables for BADA
	Synonym Aircraft Report for BADA
	Model Accuracy Summary Report for BADA

More information on the contents of the documents is provided in the Appendix A.

**Table 2: BADA APM Release Data Files**

<b>BADA APM Release Data Files</b>	Files provided per aircraft model: AC_ID.OPF AC_ID.APF AC_ID.PTF AC_ID.PTD
	Generic file applicable to all aircraft model: BADA.GPF
	Synonym aircraft related files: SYNONYM.NEW SYNONYM.ALL SYNONYM.LST

Information on the contents, format and use of the above listed data files is provided in the User Manual for BADA [1].

The BADA release is known as the core BADA product delivered to Users and governed by change and configuration process for maintenance and evolutions. This process will be further elaborated in the Section 5 in this document.

Moreover, within the scope of the BADA APM, several documents and data sets are developed and maintained to provide description on BADA APM development, validation, accuracy, scope of use, coverage of European traffic, as well as information on change and configuration management.

**Table 3: Other BADA APM Documents**

<b>Other BADA APM documents</b>	BADA APM Development Manual
	BADA product management document (present document)
	BADA Aircraft Modelling Reports (internal EEC document as it may contain confidential data)
	Coverage of European Air Traffic for BADA

**Table 4: Other BADA Data Files**

<b>Other data files</b>	Assurance data: aircraft performance reference data and operational radar data available for consultation at EEC premises only – for audit (if requested by users).
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The use of the BADA APM is stipulated in the Licence Agreement [Appendix B]. The process for obtaining access rights is detailed in Section 3.

## 2.2. BADA SUPPORT TOOLS

The BADA support tools have been developed in order to facilitate the implementation, validation and use of the BADA APM. They comprise the BADA Calculation Tool and the Radar Data Analysis and Processing (RDAP) tool. The way in which the use of support tools is managed is described in Section 6.

### 2.2.1. BADA Calculation Tool

The BADA Calculation Tool is a web based application. The primary function of the BADA Calculation Tool is called Aircraft Performance Calculation (APC) session which allows the calculation of aircraft performances based on the BADA APM for all flight phases (including flight envelope) under various conditions. The input parameters are chosen by the user. The calculation results are made available to the users in two ways: displayed on the screen and provided in text file which can be downloaded for further use. In addition to the APC function, there are other functionalities such as:

- speed conversions;
- transition altitude calculation between predefined CAS and Mach;
- atmospheric conditions.

The tool also provides a “synonym search” function to assist the user to identify an aircraft model in BADA which meets the user selected criteria in terms of aircraft performance characteristics.

### **2.2.2. Radar data analysis and processing tool (RDAP)**

RDAP tool is used for the import, storage, processing and analysis of aircraft operational data (radar tracks with corresponding flight plan and meteorological (MET) data).

Assuming availability of aircraft operational data, the tool features provide means to:

- perform studies on aircraft operational factors such as airline specific procedures, ATC constraints and procedures, etc.;
- verify conformance of BADA APM with real aircraft performances;
- manipulate, process and use aircraft operational data for aircraft performance modelling or synonym aircraft identification purposes;
- support development and validation of new modelling algorithms.

The user of the tool is responsible for population of the aircraft operational data in the RDAP database, as well as acquisition of the SAS system software that is required for use of RDAP.

### **2.3. SUPPORT SERVICES**

The purpose of the support service activity is to cater for user customised needs that are outside of the scope of the BADA core product management (BADA APM). The support services could refer to:

- technical support request (TSR) for expert assistance in the BADA APM related domain,
- provision of training on BADA APM,
- assistance in installation and configuration of the BADA Support Tools,
- modelling study definition and execution,
- new tools developments,
- etc.

The way in which the support services are managed is described in Section 7.

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### 3. LICENCE AGREEMENT

The use of BADA is regulated through the licence agreement which stipulates terms of conditions of use based on the contractual constraints EUROCONTROL is committed to with its data source providers.

#### 3.1. TERMS AND CONDITIONS OF USE

Terms and conditions of the BADA licence agreement (provided in Appendix B) prohibit the use of BADA:

- for all safety critical decisions and
- for uses destined for a commercial nature.

The BADA User takes full responsibility to design and use any system or application relying on BADA in a way ensuring that BADA can under no circumstances be used as the sole means for any safety critical decisions.

User in an end system/application is subject to demonstration of compliance, by the user, with applicable regulatory requirements. This includes the demonstration that the implementation of any system or application relying on BADA can be undertaken within tolerable safety levels, as well as the provision to National Supervisory Authority (as per the SES Regulations), of the technical files deemed required as a result of implementing a system or application relying on BADA.

In the context of BADA's use within FDPS, ANSPs remain solely responsible for the safe use of BADA in their system, applications and local environment, in a manner fully compliant with applicable regulatory requirements and taking into account all relevant elements as provided in the BADA licence agreement.

BADA (data and information) are made available on an AS IS, WHERE IS basis and manufacturers having provided the source data to BADA make no warranty whatsoever, and specifically disclaims any warranty of merchantability or fitness for a particular use.

A copy of the BADA Licence agreement terms and conditions is provided in Appendix B. It can be also found on the BADA web site: <http://badaext.eurocontrol.fr/licence37/licence.php>

#### 3.2. LICENCE AGREEMENT MANAGEMENT

The BADA licence agreement management is web based and the corresponding process is explained in this sub-section.

All new BADA requestors are invited and guided to fill and submit the on-line registration form at the following address: <http://badaext.eurocontrol.fr/licence37/licence.php>

. The requestor is prompted to register in 2 steps:

1. Read and accept the terms and conditions (licence agreement) as stipulated for the determined uses for BADA.
2. Complete the on-line user registration form in order to self register.

Through the use of the user request form the requesters are obliged to fill mandatory data thus providing valuable data regarding the nature of the requester (e.g. ANSP, Research organisms, University etc.) and detailed information on the intended use of BADA. In the case of educational establishments only requests which have been formally submitted on behalf of the educational establishments or university project supervisor's are accepted for review.

It is not EUROCONTROL's policy to process requests submitted on the behalf of individuals.

Access to the BADA Calculation Tool (<http://yquem.eurocontrol.fr/bada/>) and the BADA User Support Application (BSA) (<https://remedyweb.eurocontrol.fr/arsys/shared/login.jsp>) is also regulated through the use of the on-line BADA licence agreement. It is provided as an option in the user request form.

## 4. ACTORS, ROLES AND RESPONSIBILITIES

The management of BADA Product is a shared responsibility between:

- BADA User,
- BADA User Consultation Group (UCG),
- BADA Licence Agreement Coordinator (LAC) and Licence Agreement Board (LAB),
- BADA Project Manager (PM),
- BADA Technical Officer (TO),
- BADA Change Control Board (CCB).

### 4.1. BADA USER

A User is an organisation who holds the BADA Licence Agreement. Each organisation shall attribute a focal point who will act as principal interface between the User organisation and the BADA project team at EUROCONTROL. The User organisation may appoint different contact persons to liaise with the BADA team on technical level via communication means explained further on in this document.

### 4.2. BADA USER CONSULTATION GROUP

The BADA User Consultation Group (UCG) is formed of the BADA User focal points (or delegated contact persons) who wish to actively participate in the BADA product and strategy development.

The USG is an advisory body to EUROCONTROL, while EUROCONTROL keeps design authority for BADA developments. The UCG meets once a year with the aim to discuss, define and prioritize requirements to be proposed for implementation in the new BADA releases.

### 4.3. BADA LICENCE AGREEMENT COORDINATOR AND LICENCE AGREEMENT BOARD

The BADA Licence Agreement Coordinator (LAC) is responsible for management and administration of licence requests and is a member of the BADA Licence Agreement Board (LAB). The LAB is an internal EUROCONTROL body who has the responsibility to examine requests for BADA in order to decide if the access to BADA shall be granted or not.

This process comprises following tasks with LAC being the main interface with the requestor:

- User requests record keeping;
- Contacts with requesters with a view to further understand and confirm their intended use of BADA and explain the terms and conditions of the Licence Agreement;
- Assessment of the requestor's requirements against the BADA restrictions in use and terms and conditions and decision making to grant a licence or not;
- In case of positive opinion, LAC will provide a Logon and Password by email directly to the requestor.

#### 4.4. BADA PROJECT MANAGER

The BADA PM is the person in charge of BADA project who is responsible for supervision and coordination of activities between TO, LAC, UCG, CCB. BADA PM chairs the UCG and CCB meetings. The PM coordinates any changes to the Licence Agreement relying on legal and regulatory advice from within EUROCONTROL.

#### 4.5. BADA TECHNICAL OFFICER

The TO is the primary person responsible for maintenance and development of the BADA APM and management of the supporting tools.

In particular, the BADA TO is responsible for the following tasks:

- liaising with users;
- user requests and resulting actions record keeping;
- analysis and evaluation of User requests;
- definition and execution of corrective measures;
- development of aircraft performance models;
- updates of BADA documentation;
- configuration management of BADA data files and documents at EUROCONTROL;
- provision of technical support to the users;
- preparation of agendas and minutes for meetings,
- etc.

#### 4.6. BADA CHANGE CONTROL BOARD (CCB)

The CCB is a EUROCONTROL internal body. The members of the CCB can vary, but will always include the BADA PM, TO and representatives from other EUROCONTROL sections/ divisions who have interest in the BADA applications and development.

The role of the CCB is to provide a central control mechanism to ensure that user requests are properly considered, coordinated and prioritized. The CCB takes under consideration the advices from the UCG and makes decisions related to the BADA development strategy. EUROCONTROL is the only sponsor and development is funded through a budgetary envelope. Priorities will have to be decided in order to fit within the limits of this envelope.

The CCB attendees must guarantee their ability to understand the completeness of requirements and to be empowered to come to an agreement on BADA prioritisation of changes. The CCB formally meets twice a year. Between the formal meetings of the CCB, members may still be called periodically in case of urgent need.

## 5. BADA APM MANAGEMENT

This section describes different aspects of the BADA APM management. It defines the scope of maintenance and support by detailing provided services and defining corresponding processes. The way user requests are dealt with together with supporting tools for change and configuration management are mentioned. The BADA release management and corresponding lifecycles are also presented.

### 5.1. MAINTENANCE AND SUPPORT

Maintenance refers to corrective and evolutionary change management of the BADA APM components (ranging from the BADA model algorithms to the aircraft models and corresponding parameters). The support refers to the provision of the first level support to the BADA users in implementing and using the BADA APM.

To enable efficient communication and support management of various user requests (UR) by ensuring traceability and transparency, the BADA user support application (BSA) is being used. The BSA also provides a protected data/ documents repository and exchange environment. A brief information on how to access the BSA is given in the section 8.2, while more details on the functions that it provides are presented in [9].

More details on different categories of URs with corresponding lifecycles are given in the following paragraphs.

#### 5.1.1. User Request Management

There are two main categories of User Requests with respect to the BADA APM maintenance. Namely, corrective maintenance which accounts for problem reports (PR) and evolutionary maintenance which caters for User Requests for changes (CR).

##### **Problem Report (PR)**

In the context of the BADA APM, a PR can be considered in the following cases:

- Problem with existing aircraft model;
- Problem with existing synonym model;
- Missing aircraft or synonym model;
- Generic problem report.

For all the above listed cases, the User Focal Point (UFP) submits a UR via the BSA. At the time of creation, the UFP chooses among the proposed request categories and provides information as requested in the BSA templates. The UFP is requested to provide evidence and supporting data for problem analysis (as described in Appendix C and D).

The TO analyses the request and clarifies unclear issues with the UFP. Once the TO has all the relevant information and data it deals with the PR.

In case of a reported problem with an existing model aircraft, the problem analysis is focused on the BADA model and its coefficients. This analysis can lead to the discovery of errors in the coefficient determination due to, for example, using inappropriate information from the aircraft performance reference data. If such errors are detected then the model can be regenerated and the problem resolved.

In some cases it may be verified that the BADA model correctly matches the reference information, but reference information is specific to an aircraft model or version of the aircraft type which is different from the aircraft versions in actual use. A corrective action in this case is more difficult. If the current model is based on an older version that is no longer widely used, then it is recommended practice to re-generate the model based on a more modern widely-used version.

The problem resolution may require the availability of additional aircraft performance reference data, aircraft manufacturer's or operational data. The TO should try to acquire the data through contacts with the aircraft manufacturers and operating airlines. The UFP through its organisation may also assist in the process of finding the contacts and obtaining the required data. In case the aircraft operational data (i.e. radar data) is required, then the UFP shall ensure access to this information to the BADA TO.

A generic problem report can be related to an inherent limitation in the BADA models and algorithms. In these cases there may be no immediate corrections that can be defined. Instead, longer term studies over a period of several weeks or months may be required to identify the best way to upgrade the model and then implement the upgrades for all aircraft types. This kind of problem report is then reclassified to CR.

It may also be that the reported problem is due to a misinterpretation by users, wrong use of aircraft parameters or due to a known/unknown error in another piece of software such as the on-line trajectory prediction or trajectory generation software. For cases like these the PR for BADA is rejected with the recommendation that it has to be assigned to another component without any corrective action taken in BADA.

In a case where TO resolves the problem, a correction patch is sent to the UFP for validation and feedback. The approval process shall be based on data and facts to avoid conflicting and dead end situations. This is an aspect that shall be further elaborated and discussed in the BADA workshops and UCG meetings. However, to avoid having requests staying indefinitely in the status 'Under approval', either the system or a BADA team member may accept the correction in place of the user.

Once the modification is approved by the user, an intermediate BADA version is released and provided on the BSA.

All the problem requests which have been registered since the last CCB meeting are presented at the CCB meeting. The TO explains the reported problems and corrective actions that were taken. In collaboration with the members of the CCB, a decision is made whether these modifications will be incorporated in the future BADA baseline release.

The PR related workflow is depicted in the Figure 5-1 below and implemented in the BSA.

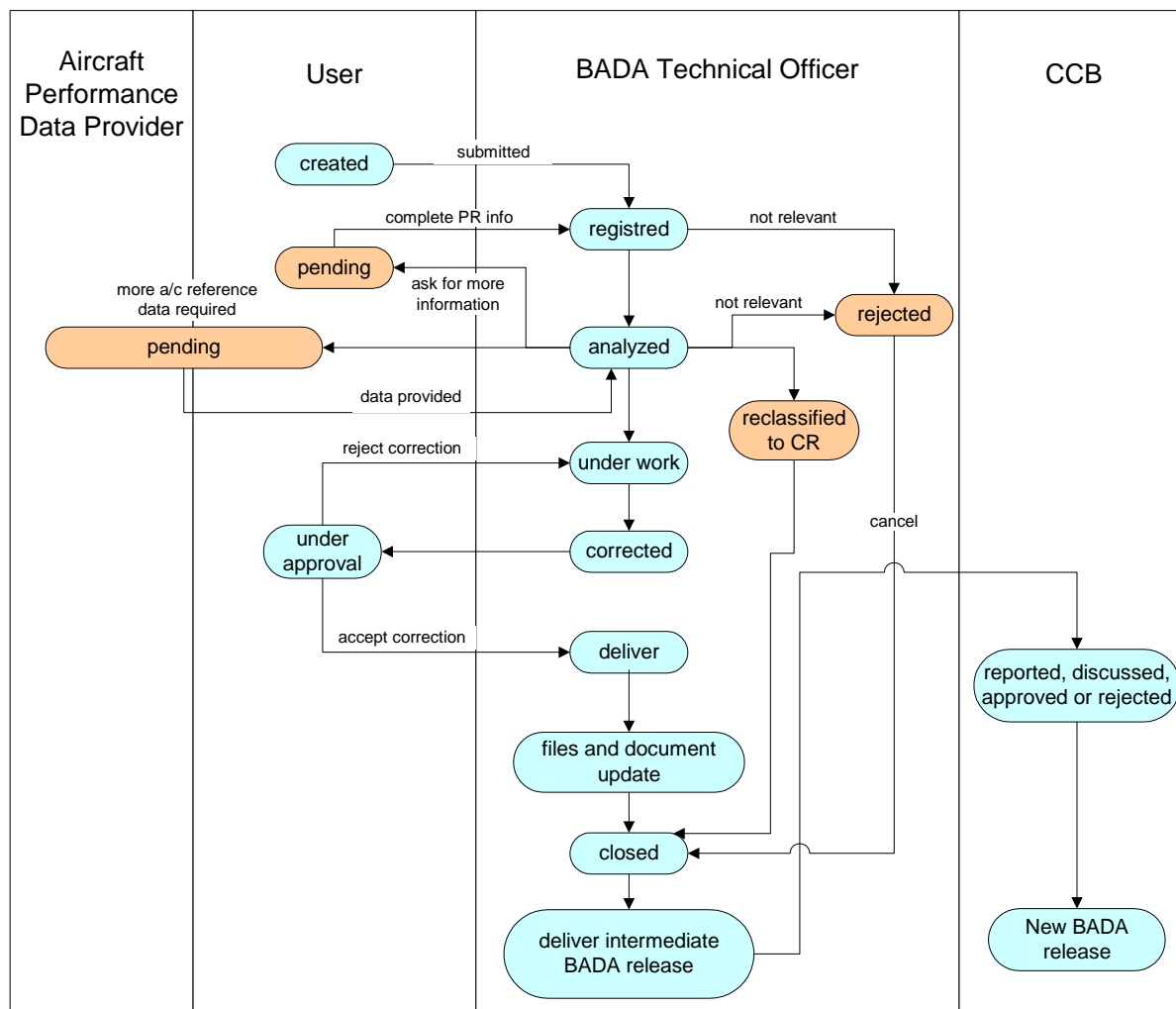


Figure 5-1: PR Workflow

### Change Request (CR)

In the context of the BADA APM, a CR can be considered in cases where change in the model algorithms, format of the release files or data in global aircraft parameters is requested.

Similar to the PR, the User Focal Point submits a CR via the BSA. At the time of creation, the UFP chooses the CR category and provides information as requested in the BSA templates. The UFP is requested to provide as much information and supporting data for to enable analysis of the request. The TO analysis the request and clarifies unclear issues with the UFP until obtaining all the relevant information that would enable identification of required actions.

Most of the times, a prerequisite for analysing, validating and implementing the change is due to availability of the aircraft performance reference data, aircraft manufactures or operational data.

The BADA TO may also propose changes that are deemed beneficial to improvement of the model.

All the change requests are discussed at the UCG and CCB meeting. The TO explains the results of the analysis and identifies required resources (data and staff). In function of that and expressed user needs, the CCB decides on prioritisation and definition of the actions.

After development the changes are implemented in one of the future BADA releases based on the release cycle (section 5.3.2) and BADA development roadmap.

The CR related workflow is depicted in Figure 5-2 below and implemented in the BSA.

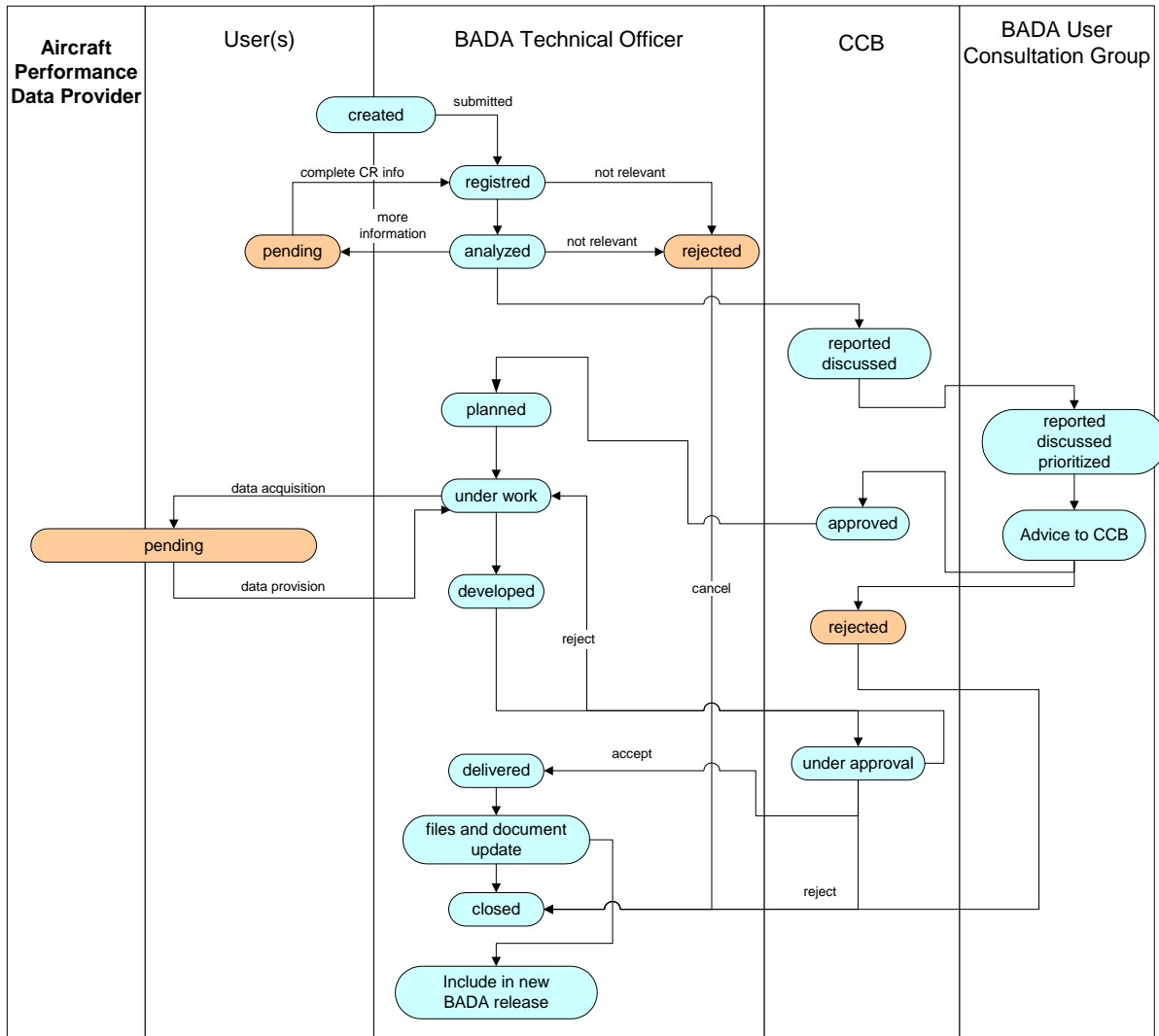
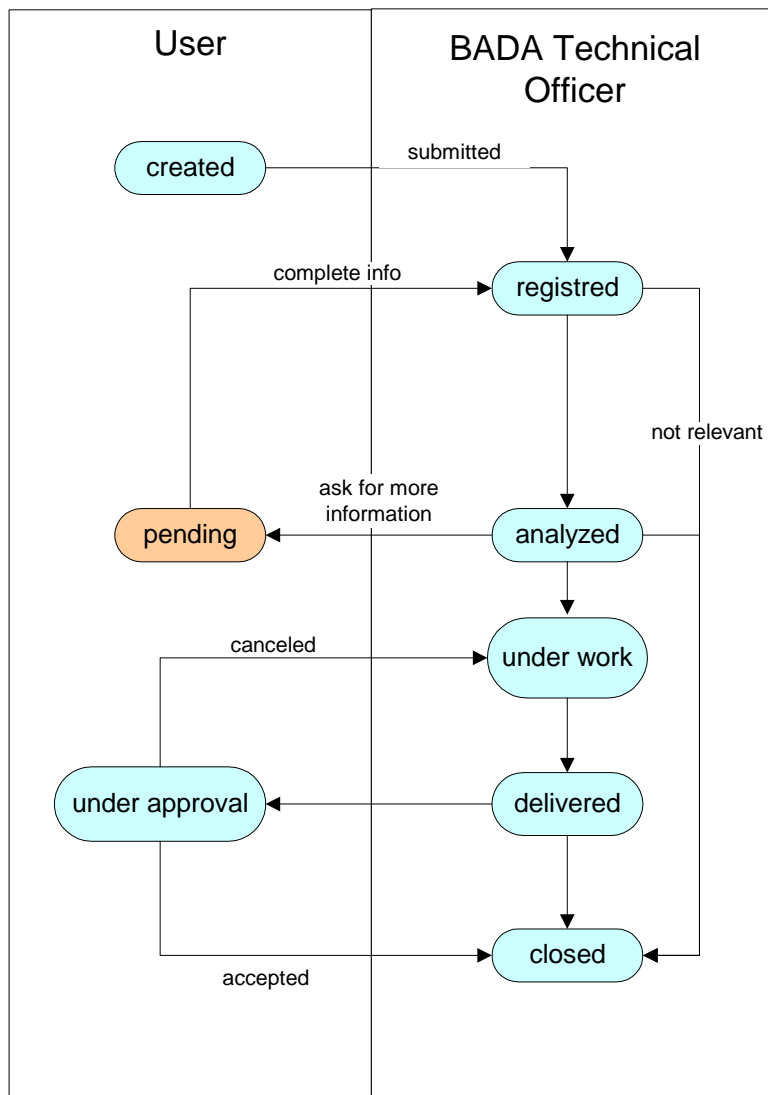


Figure 5-2: CR Workflow

### 5.1.2. User Support

Within the scope of the BADA APM maintenance, the BADA User Support refers in principle to the provision of the answers to clarification inquiries (CI) and some hotline support provided by telephone. This category of the UR refers to questions related to different aspects of the BADA model, from its theoretical foundations to implementation and application.

The process is similar to those previously described. The UFP submits a CI using the BADA BSA, the TO analyses the request and responds to the user. The CI related workflow is depicted in the **Figure 5-3** below and implemented.



**Figure 5-3: CI Workflow**

### 5.1.3. Responsiveness

Responsiveness is defined as the response time within which a User Request is being dealt with and a response (not necessarily a solution) is provided back to the requestor.

Considering the nature of BADA APM related URs (described in the previous chapters), there is a strong dependency on the availability of the required data (aircraft performance or operational data) and resolution of the problem or implementation of a change. It is therefore impossible to precisely predict or define the total response time.

While an acknowledgement and diagnosis period with feedback to the User on the estimated delay of resolution can in principle better be controlled, when taking into account the limited resources available to the BADA TO, EUROCONTROL cannot commit to a fixed period for response.

EUROCONTROL shall, however, endeavour to keep such period as short as possible.

## 5.2. CHANGE AND CONFIGURATION MANAGEMENT

Change and configuration management is related to the version management of the BADA APM data files and documents.

The Change Management Synergy (CM Synergy) tool at EUROCONTROL is used for this purpose. The CM Synergy provides a complete change management environment in which development and management of the files and documents is 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 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.

Within the CM Synergy, different methodologies in the way the files are managed are used. For BADA APM 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 following BADA APM release files are placed in the CM Synergy database:

- the three Synonym Files,
- the GPF file,
- all APF, OPF, PTF and PTD files.

All BADA documents and written records are maintained by the CM Synergy.

### 5.3. RELEASE MANAGEMENT

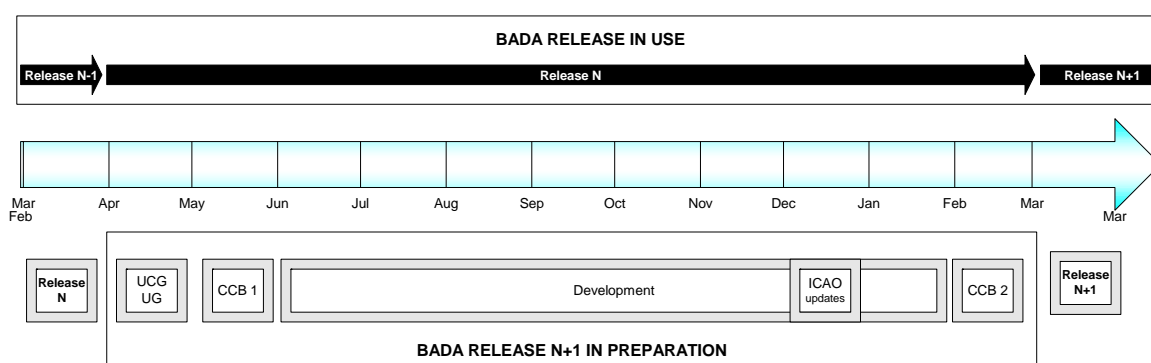
#### 5.3.1. Release content

There are two main inputs to definition of the BADA APM release contents:

1. Updates to the BADA files and documentation following the user problem reports and change requests.
2. Update of ICAO aircraft designators in accordance with ICAO 8643 document.

#### 5.3.2. Release Cycle

The BADA APM baseline (major) release cycle is depicted in the Figure 5-4 below.



**Figure 5-4: BADA APM baseline release**

As shown on the figure, the BADA release takes place in the month of March. It is followed by the UCG (who meets once a year) with agenda generally covering the following items:

- information on the current BADA release (N) content;
- review of the actions since the last meetings;
- status report of the PR/ CRs since the last meeting;
- presentation of the KPI (Key Performance Indicators) in managing the User Requests;
- discussion about new user requirements and recommendation for content of the new release (N+1);
- future actions definition.

The CCB(1) is held in the month following the UCG with main objective to finalise definition of the BADA N+1 release. This is done taking into account the result of following activities:

- review of PRs/ CRs registered since the last CCB meeting;
- review of recommendations from the UCG;
- prioritization of changes and definition of tasks and actions for development of the new release (N+1).
- discussion about the studies of general interest to improve the BADA model with recommendation for its execution.

After the CCB(1)1 the development work on release N+1 starts,

The CCB(2) takes place after the development work has been completed with main objectives to approve the BADA release N+1 and to start discussing the requirements for the following release in preparation for the next UCG meeting.

#### **5.4. MAINTENANCE SERVICE APPLICABILITY**

As stipulated in the BADA licence agreement [Appendix B], different maintenance and support levels will apply to different BADA licensees in function of the availability of the appropriate expert resources.

EUROCONTROL Member States or Air Navigation Service Providers of Member States will have priority while dealing with the user requests.

Corrective maintenance and support shall be applied to the latest BADA release identified as the one which is in use. Exceptionally, the corrective maintenance could be provided for the release N-1 provided that justification is made by the user for a need to keep the same release during the whole study life.

In order to benefit from the maintenance and support service, user is obliged to use the latest BADA release and related intermediate release.

## **6. SUPPORT TOOLS MANAGEMENT**

The tools described in Section 2.2 are provided on user request only and are not subject to BADA product maintenance and support services.

These are auxiliary tools and their uses by BADA users are optional.

However, with aim to ensure consistency in information management and exchange among the BADA user community and the BADA technical team, their use is recommended.

The way to request access to these tools is described in Section 3 of this document.

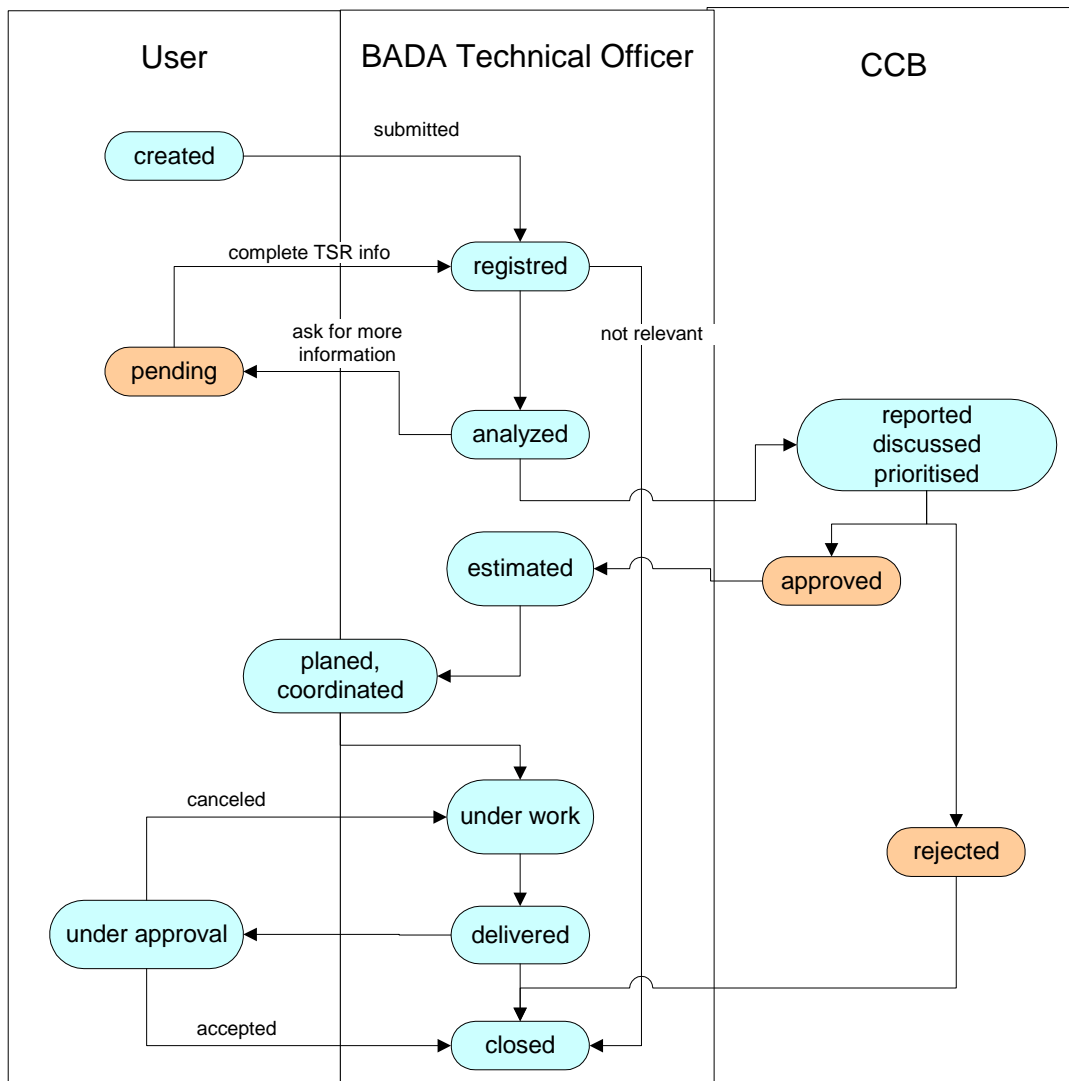
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## 7. SUPPORT SERVICE MANAGEMENT

Provision of the support services introduced in the Section 2.3 depends on the nature of request and the cost/ effort incurred. This section provides information on how the support service request is managed within the BADA product.

The BADA UFP submits the Technical Support Request (TSR) using the BSA. The TO registers and analyses the request. He/she reports the request to CCB who discusses and decides on its feasibility and priority. In case of a positive opinion, the TO prepares technical specifications and estimates the cost. This is used for coordination and planning with the request originator in order to plan schedules and agree on technical and contractual details.

The Figure 7-1 below depicts the process flow.



**Figure 7-1: Support Service process flow**

It is worth considering that the maximum effort for this activity is limited to the availability of the aircraft performance expert resources at EUROCONTROL. The User is likely to be asked to participate financially, while contractual and execution aspects shall be discussed and defined on case to case basis.

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## **8. COMMUNICATION MEANS**

### **8.1. BADA WEB PAGE**

A Web Page for BADA is created on the EUROCONTROL website [http://www.eurocontrol.int/eec/public/standard\\_page/proj\\_BADA.html](http://www.eurocontrol.int/eec/public/standard_page/proj_BADA.html). This is a publicly available web page with purpose to provide information and an easy access to BADA public documents to all interested parties or future users.

### **8.2. BADA USER SUPPORT APPLICATION**

The BSA is a principal communication media between the BADA licensed users and the BADA product management team at EUROCONTROL.

The BSA is a web based application developed with the BMC/ Remedy Action Request System©. The BSA can be directly accessed by using following URL: <https://remedyweb.eurocontrol.fr/arsys/shared/login.jsp>.

More details on how to use the BSA is provided in the [9].

### **8.3. BADA ONESKY TEAM**

Through the use of its extranet OneSky Online, EUROCONTROL has provided for its different projects collaborative exchange environments know as OneSky Teams.

The intention behind the BADA OneSky online domain is to provide an interactive means for BADA users to share documents and feed-back with fellow BADA users, to ask questions, make comments and suggestions. Its also acts as a repository for the EEC BADA team providing a means to disseminate documents (e.g. conference publications and workshop presentations) to a restricted community.

This domain is reserved for pre-licensed BADA users. To access this portal, the user is required to register at the following address <https://extranet.eurocontrol.int/http://onesky1.eurocontrol.int>

The BADA Licence Agreement Coordinator (LAC) will in turn assess the request and provide the necessary access level required.

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## **APPENDICES**

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## Appendix A: Content summary of BADA documents

### A.1 User Manual for BADA

The BADA provides a set of ASCII files containing performance and operating procedure coefficients for different aircraft types. The coefficients include those related to general, operating and aircraft configurations characteristics and those used to calculate thrust, drag, fuel flow, flight envelope and altitude capability. Information on speed schedules that specify nominal cruise, climb and descent operations are also provided.

The BADA User Manual (UM) [1] describes the mathematical models on which the data is based, provides definitions of each of the coefficients, specifies the format of the files which contain the data.

The UM consists of several sections covering the following aspects:

- **Operation Performance Models:** defines the set of equations and coefficients used by the BADA operations performance model. This includes models for *Actions* (*aerodynamic* - drag and lift, *propulsive* – thrust and related *fuel consumption*, *gravitational* – weight), *Motion* (*Total Energy Model*), *Operations* (provides the features that are needed to bring actions and motion together thereby closing the mathematical problem to compute the resulting aircraft trajectory), *Limitations* (restrict the aircraft behaviour in order to keep it between certain limits to safeguard the safe operation of the aircraft) and *Aircraft Characteristics* (each aircraft is described with a set of coefficients which represent characteristics that are intrinsic to the aircraft), ground movements (number of values are specified that can be of use when simulating ground movements). Standard atmosphere (ISA) equations are also provided.
- **Airline Procedure Models:** defines the set of parameters which are used to characterize a default standard airline speed procedures for climb, cruise, and descent as provided in the aircraft manufacturers' documentation.
- **Global Aircraft Parameters:** defines the set of global aircraft parameters that are valid for all, or a group of, aircraft.
- **File Structure:** describes the files in which the BADA aircraft parameters are maintained.

The TO is responsible for the update of the UM which is done for each release of a new BADA release.

### A.2 Revision Summary Document for BADA

This Revision Summary Document (RSD) [2] describes all the changes made to BADA files with respect to the previous release. Change and configuration management procedures for BADA trace all changes and the RSD thus presents a list of all changes implemented for a specific BADA release along with a description for each change.

For each implemented change a description of the change, motivation for the change and a specification of the affected files is provided. Additional information might be provided to enable users' evaluation of the impact of a new release on their end system (software/ files; major/minor changes).

### A.3 BADA Aircraft Modelling and Accuracy Reports

Each time a new aircraft model is generated, an Aircraft Modelling and Accuracy Report [5] is prepared. This purpose of this report is to:

- specify the reference sources used for model generation;
- document any assumptions made during model generation; and,
- summarise the results of the model generation, in particular the errors between trajectories calculated using BADA model coefficients and the reference trajectories (accuracy summary report).

The Aircraft Modelling Reports are prepared using Microsoft Word and are based on results obtained through the BADA modelling process.

Aircraft Model Reports are internal EUROCONTROL document as they contain confidential information on reference aircraft performances.

### A.4 Model Accuracy Summary Report for BADA

This document [6] is an extraction of the Aircraft Model Report that gives an overview of the accuracy of the BADA aircraft models. It is intended to provide the User with information of the trajectory and fuel consumption accuracy that can be expected from a particular model under the given conditions. The accuracy and range of the model validity is given in relation to the reference data that was used to identify the model.

Modelling Accuracy Summary report is provided to Users.

### A.5 Synonym Aircraft Report for BADA

BADA provides a set of ASCII files containing performance and operating procedure coefficients for different aircraft types, based on data provided by aircraft manufacturers. These are the so-called directly supported models. To deal with aircraft for which no manufacturers' data were made available to EUROCONTROL, BADA provides additional models, that were assessed to be relatively equivalent to one of the directly supported models.

This document [4] presents an evaluation of aircraft equivalences by providing the summary results on comparison between the attributes of the equivalence and reference aircraft, that is:

- Wake Vortex Category;
- type of engines;
- maximum take-off weight (MTOW);
- Maximum Operational Altitude;
- maximum operating speed;
- normal operating speed in cruise

It provides information of the source of reference data information and documents all the assumptions made. It also describes the criteria and average errors that are used for evaluating and selecting an aircraft for each individual attribute and a global evaluation. The aircraft models are identified through the use of their ICAO designators.

## **A.6 Aircraft Performance Summary Tables for BADA**

This document [3] is a collection of the aircraft performance table files for each aircraft type provided in the corresponding BADA Release. The performance tables specify the true air speed, rate of climb/descent and fuel flow for conditions of climb, cruise and descent at various flight levels and aircraft mass. The performance figures contained within the tables are calculated based on a total-energy model and the BADA aircraft model performance coefficients.

The motivation for providing the performance summary tables is that many ATM applications prefer the use of table-based performance data over TEM coefficients for determining aircraft performances.

## **A.7 Coverage of European Air Traffic for BADA**

The air traffic statistics obtained from the CFMU for the ECAC airspace are used to determine the mix of European air traffic aircraft types. The BADA Coverage report [7] then permits a statistical comparison of the available BADA models against that of the current representation of European traffic. This annual coverage report allows to high-light the new aircraft models that would then be needed to achieve the annual BADA target of a 90% traffic coverage. In parallel, the coverage of the BADA synonym aircraft types is also shown.

## **A.8 BADA Aircraft Performance Modelling Manual**

The purpose of this document [8] is to provide information on the BADA aircraft performance modelling environment to the BADA end users. The document is intended for both, the beginner trying to obtain a general view of the modelling environment and the experienced user interested in understanding underlying assumptions.

The document includes information on the high level design of the BADA modelling environment, description on its components (tools, databases), data exchange format and the information flow.

It describes the data preparation, the identification and the validation process. The data preparation includes aircraft performance reference data acquisition, data processing and the determination procedure in which parameter selection for the identification is defined. In the identification process the BADA Enhanced Approach to Modelling concept was introduced as the new identification concept and the identification process itself is described in details. The validation process includes checking the behaviour of developed models in respect to input performance data, checking the syntax of release files, cross validation of the BADA baseline implementation and validation of developed models in respect to real data. The results consist of documentation and release files that contain all needed parameters.

## **A.9 BADA Product Management Document**

(Present document)

This document is valid for the management of the BADA APM family 3, from BADA release 3.7 onwards. It is updated whenever there is a change in the forms and documentation, procedures, computing environment or utilities. When a new BADA Revision is released, it does not automatically mean that this document needs to be updated.

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## Appendix B: BADA Licence Agreement terms and conditions

### LICENCE AGREEMENT FOR THE EUROCONTROL BASE OF AIRCRAFT DATA

**BEFORE YOU CLICK ON THE "SUBMIT" BUTTON AT THE END OF THIS LICENCE AGREEMENT, CAREFULLY READ THE TERMS AND CONDITIONS BELOW. BY CLICKING ON THE "SUBMIT" BUTTON YOU ARE CONSENTING TO BE BOUND BY AND ARE REQUESTING TO BECOME THE LICENSEE OF THE EUROCONTROL BASE OF AIRCRAFT DATA ("BADA"). IF YOU DO NOT AGREE TO ALL OF THE TERMS OF THIS LICENCE, CLICK THE "DO NOT ACCEPT" BUTTON.**

When you ("LICENSEE") "click" the "SUBMIT" button the European Organisation for the Safety of Air Navigation ("EUROCONTROL") will examine your request to be granted a licence for the use of BADA. EUROCONTROL will, if necessary, then contact you with a view to further understand your intended use of BADA data and explain these terms and conditions, as well as other relevant information, EUROCONTROL will notify you electronically of its decision to grant you a licence or not, of your access rights and of the procedure to obtain a copy of BADA, including its documentation.

CONSIDERING that BADA consists of algorithms, mathematical models, data and documentation and that BADA can therefore not be considered:

- as a *system* or a *constituent* as per EC Regulation 550/2004 (SES Interoperability Regulation).
- to be subject to EUROCONTROL Safety Regulatory Requirements, ESARR 6 "Software in ATM system", nor to any equivalent regulation promulgated at Community or national level;

EMPHASISING that where LICENSEE is an air navigation service provider, it shall remain solely responsible for the safe use of BADA in its system, applications and local environment, and will take all necessary measures to ensure this use is in compliance with applicable regulatory requirements.

HAVING REGARD to the fact that BADA contains technical data and information:

- made available by aircraft manufacturers and that his data and information is made available on a strictly "AS IS" basis and these aircraft manufacturers make no warranty whatsoever, and specifically disclaim any warranty of merchantability or fitness for a particular use.
- extracted from aircraft flight manuals and related data and information are made available on a strictly "AS IS" basis.

EUROCONTROL disclaims any warranty of merchantability or fitness for a particular use.

1. BADA, to be provided under this Agreement, includes, per release:

**BADA Files:**

- Files provided per aircraft model:
  - AC\_ID.OPF
  - AC\_ID.APF
  - AC\_ID.PTF
  - AC\_ID.PTD
- Generic file:
  - BADA.GPF

- Synonym aircraft related files:
  - SYNONYM.LST
  - SYNONYM.NEW
  - SYNONYM\_ALL.LST

**BADA documentation**

- User Manual for the Base of Aircraft Data (BADA)
- Revision Summary Document for the Base of Aircraft Data (BADA)
- Aircraft Performance Summary Tables for the Base of Aircraft Data (BADA)
- Model Accuracy Summary Report for the Base of Aircraft Data (BADA)
- Synonym Aircraft Report for the Base of Aircraft Data (BADA)

Other documents published periodically:

- BADA Product Management Document
- BADA Aircraft Performance Modelling Manual
- Coverage of European Air Traffic for the Base of Aircraft Data (BADA)

2. EUROCONTROL may provide support tools and services in relation to the use of BADA. Such support tools and services are optional and described in Section 12 below.
3. Upon favourable examination of LICENSEE's request, LICENSEE will be granted a non-exclusive, non-transferable licence for BADA. The licence permits LICENSEE to use BADA as detailed in Section 1 above in accordance with the terms contained in this Agreement.
4. In this Agreement "Use" shall mean and include the utilisation of BADA by copying, transmitting or loading BADA into the permanent memory (e.g. hard disk, CD-ROM or other storage device) of a system for the processing of system instructions or statements contained in BADA; and copying BADA which is in a machine-readable form for Use by LICENSEE on the system for the purposes only of understanding the contents of such machine-readable material.
5. BADA is made available free of charge.
6. **Obligations of LICENSEE**

Upon acceptance of the terms of this Agreement and upon receipt of BADA, LICENSEE shall:

- (a) maintain accurate and up-to-date records of the number and location of all copies of BADA that LICENSEE is entitled to make under this Agreement;
- (b) ensure that LICENSEE's employees and agents who will use BADA are notified of the terms of this Agreement and will comply with them prior to such employee, and/or agent using the same;
- (c) ensure that LICENSEE's employees and agents who will use BADA are notified of the latest release of the set documents BADA provides for by default, as described under Section 1 above, and shall comply with them prior to such employee and/or agent using the same;
- (d) design and use any system or application relying on BADA in a way ensuring that BADA can under no circumstances be used as the sole means/tool for any safety critical decisions and to be able demonstrate this to any certifying and/or supervising authority;
- (e) supervise and control the Use of BADA in accordance with the terms of this Agreement;
- (f) not use BADA beyond the limitations outlined under Section 7 below and beyond any additional limitations and conditions described in "User Manual for the Base of Aircraft Data (BADA)" (see Section 1 above);

- (g) ensure that the BADA modelling algorithms and corresponding data are correctly implemented and be able to demonstrate this by providing an assurance report;
- (h) not modify BADA files unless otherwise foreseen and authorised in “User Manual for the Base of Aircraft Data (BADA)” (see Section 1 above), as such modifications may impact the validity of the data provided in the “Model Accuracy Summary Report for the Base of Aircraft Data (BADA)” (see Section 1 above);
- (i) ensure that the BADA default parameters (see APF file in Section 1 above) are modified in a way compliant with “User Manual for the Base of Aircraft Data (BADA)” (see Section 1 above) and taking into account information provided in the BADA Accuracy report (see Section 1 above) and that the changes are traceable, documented and reported to EUROCONTROL;
- (j) provide EUROCONTROL with all data, reports and documents produced and/or developed with BADA which will enable EUROCONTROL to further improve the aircraft models, including as a minimum the results of the local validation activities;
- (k) upon request, support EUROCONTROL in validating new aircraft models and new model features;
- (l) make available to EUROCONTROL for its internal purposes and the overall improvement of aircraft models, any anomaly deemed attributable to BADA together with supporting data;
- (m) report any other feed back and suggestions on the use of BADA to: [bada@eurocontrol.int](mailto:bada@eurocontrol.int) ;
- (n) reproduce and include the copyright notice of EUROCONTROL as it appears in or on BADA on all copies made in accordance with this Agreement;
- (o) reference BADA, EUROCONTROL and aircraft manufacturers in all and any reports produced by LICENSEE with the use of BADA;
- (p) not copy BADA other than for normal operation and one (1) copy of BADA may be made for back-up and one (1) copy for disaster recovery provided they contain the same copyright information as the original.
- (q) not translate BADA and or any documents related thereto;
- (r) not disassemble, decompile or reverse engineer BADA by any manner (or to attempt to perform such actions or to have such actions performed by third parties);
- (s) not sub-licence, provide or otherwise make available BADA to any person other than LICENSEE's employees and agents herein without prior explicit written consent from EUROCONTROL;
- (t) not display BADA on any public bulletin board, ftp site, worldwide web site, chat room or by any other unauthorised means;
- (u) not use any part of BADA for the purpose of creating any rival/competitive product to BADA;
- (v) not use BADA for immoral, illegal or for any other purpose which may be determined threatening, abusive or harmful including but not limited to the creation or transmission of any virus, worms, Trojan horse, cancelbot or any other destructive or contaminating programme;
- (w) not sell and/or use BADA for commercial purposes without the explicit and prior agreement from EUROCONTROL;
- (x) destroy, within fourteen (14) calendar days after the date of termination or discontinuance of this Agreement for whatever reason, BADA and all upgrades or copies and confirm in writing to EUROCONTROL that such has been done.

## 7. RESTRICTIONS ON USE

- (A) BADA SHALL ONLY BE USED FOR MODELLING AND STRATEGIC PLANNING IN OPERATIONAL GROUND AIR TRAFFIC MANAGEMENT OPERATIONS.
- (B) BADA SHALL UNDER NO CIRCUMSTANCES BE USED AS THE SOLE MEANS/TOOL FOR ANY SAFETY CRITICAL DECISIONS.

## 8. LIMITATION OF LIABILITY

- (A) BADA IS PROVIDED ON A STRICTLY "AS IS" BASIS, WITHOUT ANY WARRANTY OF ANY KIND EITHER EXPRESS OR IMPLIED INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE AND NON-INFRINGEMENT.
- (B) EUROCONTROL NOR ANY THIRD PARTY (IN PARTICULAR AIRCRAFT MANUFACTURERS) DO NOT WARRANT THAT BADA WILL BE ERROR-FREE OR THAT SUCH ERRORS WILL BE CORRECTED AND YOU ARE SOLELY RESPONSIBLE FOR ALL COSTS AND EXPENSES ASSOCIATED WITH RECTIFICATION, REPAIR OR DAMAGE CAUSED BY SUCH ERRORS.
- (C) NEITHER EUROCONTROL OR ANY THIRD PARTY (IN PARTICULAR AIRCRAFT MANUFACTURERS) SHALL BE LIABLE TO LICENSEE OR TO ANY OTHER PARTY FOR ANY LOSS OR DAMAGE WHATSOEVER OR HOWSOEVER CAUSED ARISING DIRECTLY OR INDIRECTLY IN CONNECTION WITH THIS AGREEMENT, BADA, ITS USE OR OTHERWISE EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

## 9. Intellectual Property Rights

All copyright, trade marks and other intellectual property rights subsisting in or used in connection with BADA (including but not limited to all images, animations, audio and other identifiable material relating to BADA) are and remain the sole property of EUROCONTROL and other third parties (mentioned herein and/or known to EUROCONTROL), as may be the case.

## 10. Communications

- (a) Any public communication on BADA and/or its performance shall be coordinated with EUROCONTROL **in advance** and shall require the prior approval of EUROCONTROL.
- (b) Upon approval make due reference to EUROCONTROL and its data suppliers (where so requested by EUROCONTROL) and the database right of EUROCONTROL and be assorted by a statement along the following lines: "© 2009 The European Organisation for the Safety of Air Navigation. All rights reserved."

## 11. BADA Maintenance and Support

- (a) EUROCONTROL may provide limited support and maintenance services relating to LICENSEE as per "BADA Product Management Document" (see Section 1 above). The provision of such services will depend on the availability of the appropriate resources.
- (b) Different maintenance and support levels may apply to LICENSEES being EUROCONTROL Member States or Air Navigation Service Providers of Member States as per "BADA Product Management Document" (see Section 1 above)
- (c) All User Requests shall be registered through the BADA Support Application (BSA) only as per "BADA Product Management Document" (see Section 1 above);
- (d) EUROCONTROL will analyse problem reports received from LICENSEE as per "BADA Product Management Document" (see Section 1 above) with a view to resolving related issues and proposing appropriated corrective actions;

- (e) EUROCONTROL will analyse change request received from LICENSEE as per “BADA Product Management Document” (see Section 1 above) with a view to incorporating them if they are judged by EUROCONTROL to be beneficial for BADA improvement and usable for wider user community;
- (f) EUROCONTROL may, at its entire discretion, develop new models or re-model existing ones if aircraft performance reference data of better quality is made/ becomes available;
- (g) As a result of changes under (a) (b) or (c) above, EUROCONTROL may create new versions of BADA ("Releases") as described in Section 1 above, and inform LICENSEES according to the procedure describe in “BADA Product Management Document” (see Section 1 above). Information and notification of such Releases will also be available at: [www.eurocontrol.int/projects/bada/](http://www.eurocontrol.int/projects/bada/) ;
- (h) LICENSEE may have to re-register from time to time especially when major Releases are produced. While EUROCONTROL will attempt to ensure compatibility between the current Release and future Releases, EUROCONTROL does not guarantee that this will be the case. EUROCONTROL will provide advanced notification to LICENSEE of appropriate changes.

## 12. BADA Support Tools and Services

- (a) EUROCONTROL shall not be under any obligation to provide any support services or tools relating to BADA, beyond those forming part of BADA as defined under Section 1 above and/or maintenance support as described under Section 11 above.
- (b) EUROCONTROL may, upon request, provide support tools and corresponding documentation, in order to support the validation of the BADA model implementation, identification of local aircraft and airline operational factors/parameters and synonym aircraft types:
  - (i) BADA calculation web application (including synonym aircraft search function),
  - (ii) RDAP – Radar data analysis and processing tool.

The provision of these tools may form the subject of specific licensing arrangements.

- (c) EUROCONTROL may, at its own discretion, deliver training sessions, including exercises based on real life examples.
- (d) EUROCONTROL may, upon request, provide expert assistance in the analysis of local anomalies, with a view to confirming the causes of the problem. Provision of such support may be subject to charges.
- (e) EUROCONTROL will facilitate a BADA Users Group meetings with the objective of collecting user requirements, engineering an intelligence sharing among BADA users and identifying the need for further modelling studies.
- (f) EUROCONTROL may conduct and share the results of any studies initiated with a view to further improving BADA models (such as proposing use of common methodologies and tools amongst the users).

**13. Focal Points**

LICENSEES Focal point shall be identified on the on-line registration form.

**14. Termination**

- a) LICENSEE may terminate this Agreement at any time by destroying all copies of BADA and any documentation related thereto and by notifying EUROCONTROL in writing that LICENSEE has done so.
- b) EUROCONTROL may terminate this Agreement by written notice to LICENSEE at any time if LICENSEE is found in breach of any of the terms of this Agreement. In such case LICENSEE shall cease immediately, upon receipt of written notice of termination, the use of the BADA and shall destroy all copies of BADA and any documentation related thereto and confirm top EUROCONTROL in writing that LICENSEE has done so.
- c) Burkhardt to add the last one about termination

**15. Dispute Settlement and Law Applicable**

Any dispute, controversy or claim arising under, out of or relating to this Agreement and any subsequent amendments to this Agreement, including without limitation, its formation, validity, binding effect, interpretation, performance, breach or termination, as well as non-contractual claims, shall be referred to and finally determined by arbitration in accordance with the WIPO<sup>1</sup> Arbitration Rules. The arbitral tribunal shall consist of three arbitrators. The place of arbitration shall be Brussels (Belgium). The language to be used in the arbitral proceedings shall be English. The dispute, controversy or claim shall be decided according to the laws of Belgium.

**SUBMIT**

**Then registration form**

**DO NOT  
ACCEPT**

**end**

<sup>1</sup> World Intellectual Property Organization

## **Appendix C: Guidelines for validation of BADA implementation**

### **C.1 Introduction and scope**

There are two common ways in which the BADA APM is used in the simulation tools:

1. Full implementation of the BADA TEM using APF and OPF files.
2. Use of the tabular aircraft performance data from the BADA PTF/ PTD files.

Regardless of the way the BADA data is used in a simulation application, there is first a need to ensure that the aircraft performance model algorithms, parameters and data are used correctly. Only then will it be possible to troubleshoot and analyse a reported problem related to a BADA APM.

Therefore, such a validation activity is considered to be a pre-requisite for provision of maintenance and support to the users of BADA.

### **C.2 Baseline implementation**

The software implementation of the BADA APM algorithms within the BADA Modelling environment developed in MatLab by EUROCONTROL, described in [8], is considered to be the baseline for the purpose of this validation. The BADA PTF and PTD files are obtained using the flight profile calculator function of this implementation. The correctness of this application is cross-checked and validated against other existing implementations of BADA at the EUROCONTROL, such as BADA web calculation application, and both air and ground components of the ESCAPE simulator.

### **C.3 Validation objectives**

The main objectives of the validation activity are to ensure that:

- BADA APM algorithms are correctly implemented.
- BADA coefficients and data parameters are correctly read from the BADA ASCII files (APF, OPF, PTF and PTD).
- calculation results of aircraft performance parameters under different conditions are identical to those obtained with the BADA baseline implementation.

### **C.4 Validation enablers and process**

Each BADA user (owner of simulation tool) is responsible for the preparation and provision of a text file, produced by using his simulator application specific tools (so called flight profile generator or similar), that contains recordings of the flight profile parameters across several scenarios. The parameters to record, the basic principles to apply and the step-by-step process to follow are described hereafter.

### C.4.1 Required parameters

Table 5 presents the list of parameters that shall be recorded by the user to provide sufficient level of details to perform an analysis of the implementation.

**Table 5: Parameters required to validate an implementation of BADA**

Description	Type	Units
Aircraft Type	Text	-
Sequence Number or Time stamp	Number	hh:mm:ss
Altitude	Number	ft
Air Temperature	Number	Degree Kelvin
Density	Number	kg/m <sup>3</sup>
Pressure	Number	Pa
Configuration (take off, climb, cruise, descent, approach, landing, initial climb)	Text	-
Speed Domain (CAS or Mach)	Text	-
CAS	Number	kt
MACH	Number	-
TAS	Number	kt
Aircraft Mass	Number	kg
Max Climb Thrust	Number	N
Available Thrust (CRZ or DESC)	Number	N
Lift Coefficient	Number	-
Drag coefficient	Number	-
Drag	Number	N
Available Power	Number	W
Power Coefficient	Number	-
ESF	Number	-
Rate of Climb or Descent	Number	ft/min
Flight Path Angle	Number	degree
Fuel Flow	Number	kg/min
Acceleration	Number	m/s <sup>2</sup>

### C.4.2 Basic principles

The profile preparation process shall be based on the following principles:

- Use of a set of different aircraft types to cover all engine types, with a minimum of 3 aircraft models per type of engine, covering if possible different sizes and technologies
- Use of 'point type' calculation for aircraft performance parameters, that is without performing integration over time:
  - o aircraft weight is constant and does not account for consumed fuel
  - o speed changes take place immediately and do not account for acceleration

This principle allows legitimate comparisons between implementations, without relying on particular integration algorithms.

- Use of aircraft default speed schedules as provided in the BADA APF file and explained in Section 4 (Airline Procedure Model) of the BADA User Manual [2]
- Flight profiles in climb, cruise and descent without imposing any constraint
- Take-off and landing occur at sea level
- Use of ISA+0 and ISA+20 and no wind weather conditions
- Calculation step shall be defined in terms of pressure altitude. Altitude step should not be greater than 1000 ft.

### C.4.3 Step-by-step process

Taking into account above listed principles, the following steps shall be performed:

1. Generate climb profiles at 3 different aircraft masses: BADA low, nominal and high (as provided in the BADA PTF file)
2. Generate descent profile at BADA nominal mass
3. Generate cruise profile at BADA nominal mass at several FLs to account for different types of speed (CAS or Mach)
4. Print results of the calculations for following parameters: FL, T [K], p [Pa], rho [kg/m<sup>3</sup>], a [m/s<sup>2</sup>], TAS [kt], CAS [kt], M, mass [kg], Thrust [N], Drag [N], Fuel flow [kg/min], ESF, Rate of Climb or Descent [fpm], PWC (power reduction coefficient)
5. Compare obtained results per aircraft parameter type with the figures provided in the BADA PTD file
6. Present results of comparison in the most suitable form (numerical comparison with reporting of the error per parameter, graphically presented results, etc)
7. Report findings to the BADA team

Note: Reference data are not provided for ISA+20 conditions in the PTF/PTD files. The data for off-ISA conditions are intended for release in the next BADA revisions, and are available on request until then.

## C.5 Analysis of the results

If differences in aircraft performance parameters appear, then the source of the problem shall be troubleshoot. Here a “top-down’ approach can be taken using the most used formulation of the TEM:

$$ROCD = \left[ \frac{(T - D) \cdot V_{TAS} \cdot C_{pow,red}}{m \cdot g} \right] \cdot ESF$$

If the ROCD is incorrect, then one has to go deeper and analyse the underlying parameters. If for example Drag is not correct then an error may lie in incorrect speed, drag coefficient, lift coefficient,  $V_{TAS}$ , air density, etc.

The error can be caused by use of a wrong coefficient (possible format problem), different interpretations of the BADA algorithms or errors in implementation.

In any case, this validation shall become one of the important means of validating and cross-checking different implementations of the BADA, hence improving its use and reducing risk of misuse. Furthermore, the established recording and reporting means will be used in the future for dealing with the problem reports.

## Appendix D: Supporting data for problem analysis

For the purpose of analysis and evaluation of the Problem Reports the User is invited to provide supporting information and data. The type of data is related to the nature of the problem, but as minimum the User has to provide:

- Report and assurance data proving that the BADA APM is implemented and used in correct way;
- Copies of locally used BADA files (APF, OPF, PTF, SYNONYM.LST, BADA.GPF);
- Information on any modification in BADA files and reason for changing it
- Any other supporting data as requested by BADA TO which is required to timely and efficiently troubleshoot the problem.