



GHANA
CIVIL AVIATION AUTHORITY

ADVISORY CIRCULAR AC 14-007

AERONAUTICAL STUDY AND RISK ASSESSMENT

GENERAL

Ghana Civil Aviation Authority (GCAA) Advisory Circulars from Aerodrome Safety and Standards (ASAS) contain information about standards, practices and procedures that the Authority has found to be an Acceptable Means of Compliance (AMC) with the associated Directives.

An AMC is not intended to be the only means of compliance with a Directive, and consideration will be given to other methods of compliance that may be presented to the Authority.

PURPOSE

This Advisory Circular (AC) provides information and guidance to aerodrome operators on the conduct of Aeronautical Study and risk assessment where the aerodrome is unable to meet requirements and need to identify alternative means to achieve an equivalent level of safety.

REFERENCE

GCAD Part 24, – Aerodrome Certification
GCAD Part 25, – Aerodrome Registration
Aerodrome Manual of Standards (MOS)
Procedure for accepting non-compliances at aerodrome.
ICAO Annex 14, Volume I; Aerodrome Design and Operations
ICAO Doc 9774 (Manual on the Aerodrome Certification)
ICAO Doc 9859 (Safety Management Manual)

STATUS OF THIS AC

This is the first AC to be issued on this subject.

FOREWARD

This document provides guidance to Aerodrome Operators on the processes to petition GCAA for an exemption from any requirement of GCAD Part 24.

□

APPROVAL


Issue No : 01	<p>Approved by:</p>  _____ Director-General	<p>2015</p> <hr/>
---------------	---	-------------------



TABLE OF CONTENTS

Table of Contents

1.1. INTRODUCTION	4
1.2. AERONAUTICAL SAFETY	4
1.3. TRIGGER FACTORS	5
2. OVERVIEW	6
2.1. AERONAUTICAL STUDY	6
3. THE CONCEPT OF RISK	7
3.2. ACCEPTABLE RISK	8
3.3. THE CONCEPT OF RISK	9
3.4. ACCEPTABLE RISK	9
3.5. RISK MANAGEMENT PROCESS	10
3.6. SUMMARY OF THE SEVEN STEP SYSTEM RISK PROCESS	11
3.7. AN EXAMPLE OF AN AERONAUTICAL STUDY METHODOLOGY	12
(i) Initiation: Step 1	12
(iii) Risk Estimation: Steps 3 & 4.	12
(iv) Risk Evaluation: Step 5	12
(v) Risk Control: Step 6	12
(vi) Action/Monitoring	13
4. PROCESS	13
4.1. THE STUDY CONTENT	13
4.2. COLLISION RISK MODEL	13
4.3. AERODROME COMPLEXITY MODEL	14
4.4. Consultation	15
APPENDIX 1	16
Scenario:	16

AERONAUTICAL STUDIES FOR AERODROME OPERATORS

1.1. INTRODUCTION

- 1.1.1. The Ghana Civil Aviation Directives (GCAD) Part 27 contains basic provisions on the use of Aeronautical Studies as a means to identify alternative means to achieve an equivalent level of safety by means other than full compliance with a specific requirement.
- 1.1.2. It is acknowledged that there could be some other cases where full compliance with requirements cannot be achieved, and for which a deviation from a regulatory requirement will have to be sought. A safety case based on the same principles as an Aeronautical Study should accompany any application for a deviation.

1.2. AERONAUTICAL SAFETY

- 1.2.1. An aeronautical study is a tool used to review aerodrome and airspace processes and procedures to ensure that safety criteria in place are appropriate. The study can be undertaken in a variety of ways using various analytical methods appropriate to the aeronautical study requirements.
- 1.2.2. An aeronautical study should include the use of;
 - current state review (baseline position)
 - quantifiable data analysis
 - stakeholder interviews
 - safety/risk matrix
- 1.2.3. In general an aeronautical study should be viewed as providing an overarching document giving a holistic view of an aerodrome's operational environment. An aeronautical study may contain many elements; however risk assessment, risk mitigation and risk elimination are key components. Additionally there may be aviation system constraints.
- 1.2.4. The goal of risk management in an aeronautical study is to identify risks, and take appropriate action to minimize risk as much as is reasonably practicable. Decisions made in respect of risks must balance the technical aspects of risk with the social and moral considerations that often accompany such issues.
- 1.2.5. These decisions may have significant impact on an aerodrome's operation and for an effective outcome there should be a level of consensus as to their acceptability among the key stakeholders.
- 1.2.6. While this Advisory Circular focuses on the safety outcomes, there may also be non-safety consequences, such as financial loss and operational loss of the aircraft, increased insurance costs and damage to reputation. This

Advisory Circular discusses the concept of risk and goes on to describe the trigger factors that may lead to an aeronautical study, the conduct of the study and the types of activities that should be included in the study.

- 1.2.7. The aeronautical study should be seen as a framework for effective decision- making, rather than as a guaranteed process to come up with the correct outcomes. This framework for conducting aeronautical studies proposes a systematic method, and some tools, for analyzing complex risk issues so as to help the decision-maker to make decisions with confidence and, if necessary, to articulate these decisions.
- 1.2.8. Aerodrome operators should also undertake aeronautical studies when the aerodrome operating environment changes. These changes are normally precipitated by a trigger event such as a change, or a proposed change in; airspace design, aircraft operations, aerodrome infrastructure or the provision of an air traffic service.
- 1.2.9. It is the aeronautical study process that determines the site-specific need for services, and identifies and recommends a course of action, or presents options for decision makers to act upon. In all cases the aeronautical study should document and demonstrate the site-specific need and rationale for the level of service, procedure design or operational requirements.

1.3. TRIGGER FACTORS

- 1.3.1. The aeronautical study is a tool for the aerodrome management to use as part of its operations and strategic planning and is an integral part of the aerodrome's Quality Assurance and Safety Management Systems.
- 1.3.2. One of the purposes of the aeronautical study is to determine levels of operational safety, service or procedures that should apply at a particular location. The decision to undertake this type of study may be triggered by any one or more of a wide range of factors.
- 1.3.3. These may include changes to:
 - the number of movements
 - the peak traffic periods
 - the ratio of IFR to VFR traffic
 - the type of operations - scheduled, General Aviation (GA), training, etc
 - the types, and variety of types, of aircraft using the aerodrome (jet, turbo-prop, rotary, etc)
 - aerodrome layout
 - aerodrome management structure
 - runway or taxiway and associated manoeuvring areas
 - operations of a neighbouring aerodrome or adjacent airspace.

-
- 1.3.4. Feedback about any changes should be sought from aviation stakeholders including pilots, individuals and other representative groups as part of the study.
- 1.3.5. The Director-General (DG) of the Ghana Civil Aviation Authority (GCAA), an aerodrome operator or other interested party, such as an air traffic service provider or air operators, may initiate an aeronautical study.
- 1.3.6. The DG can assist in identifying whether an aeronautical study is required and the appropriate methodology for the aeronautical study and in reviewing the aeronautical study.

2. OVERVIEW

2.1. AERONAUTICAL STUDY

- 2.1.1. An aeronautical study can be undertaken at anytime. It is constructed to consider all relevant factors, including traffic volume, mix and distribution, weather, aerodrome role, aerodrome and airspace configuration, surface activity and the efficiency requirements of operators using the service. The scope of studies can range from minor adjustments to aerodrome configuration, e.g. from the widening of a taxiway to a complete review of aerodrome airspace with the introduction of a new runway.
- 2.1.2. The scope of an aeronautical study usually reflects one of three situations:
- the existing operation, e.g. the aerodrome, airspace or ATS (or sometimes just a particular part of the operation)
 - a change to the existing operation
 - a new operation.
- 2.1.3. Where the aeronautical study is used to consider a change to existing operations or a new operation, it may not initially be possible to provide all the safety assessment and evidence required.
- 2.1.4. An aeronautical study can identify and evaluate aerodrome service options, including service increases or decreases or the introduction or termination of services (such as the introduction of a rapid exit taxiway or removal of a grass runway). The initial baseline study will be followed by a review of operational issues; this will typically involve an in-depth safety analysis based on quantifiable data and extensive consultation with customers and stakeholders using various interview and data gathering processes. This may identify any changes that are required to ensure the safe, orderly and efficient operation of the aerodrome.
- 2.1.5. Larger projects may have distinct phases such as requirements definition,

design evaluation, introduction to service and routine operation. The aeronautical study can be presented in parts corresponding to these phases as information becomes available; this is illustrated in the flow chart below.

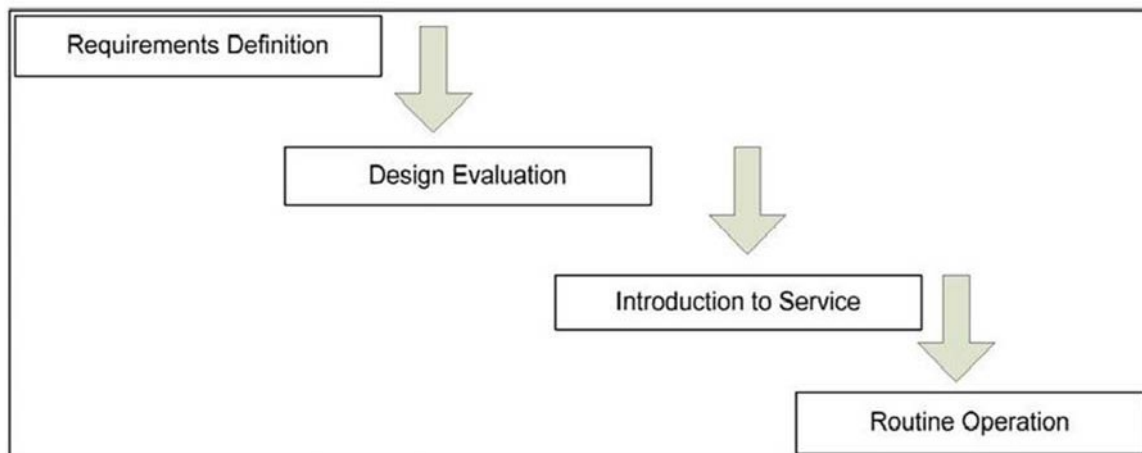


Figure 1: Source UKCAA CAP 728 Chapter 3

2.1.6. An Aeronautical Study Process is provided in Appendix 1. Aerodrome operators should assess the type of process or model to be used as outlined in section 5.0 of this Advisory Circular.

3. THE CONCEPT OF RISK

3.1.1. Risk assessment is a key area in an aeronautical study.

3.1.2. A risk scenario is a sequence of events with an associated frequency of occurrence and consequence. This sequence of events may be summarized as “hazard – threats – controls – key event – mitigations – consequences”. The hazard is what ultimately generates the loss; it may present a number of threats, each of which, without controls, will lead to the “key event”. The key event is the point at which control of the hazard is lost. Once this point has been reached, mitigations may still avoid or reduce undesirable consequences. Controls are proactive defenses, while mitigations may be proactive or reactive.

3.1.3. For example, a rainstorm (the hazard) may result in sheet water on runways (a threat) and reduced braking performance (another threat). The key event in this case is loss of control of the aircraft on the runway; this may result in damage or injury (the consequences). Controls might include tyre design and anti-skid braking systems, while mitigations could include runway end safety areas. The consequences are the damages and injuries that may result.

3.1.4. The risk is the likelihood (or probability) of the damage or injury resulting from the loss of control of the aircraft; it therefore includes the probability of

loss of control and the probability of damage or injury. A study scenario example is attached in Appendix 1.

3.2. ACCEPTABLE RISK

3.2.1. “Acceptable risk” is based on the concept that no activity is without some risk, however small. The level of risk that is acceptable varies with the type of activity and according to the consequences; in general, the acceptable level of risk for adventure activities is higher than that for normal day-to-day activities, and higher for single fatality accidents than for those with multiple fatalities.

3.2.2. If the risk does not meet the pre-determined acceptability criteria, an attempt must always be made to reduce it to a level that is acceptable using appropriate mitigation procedures. If the risk cannot be reduced to or below the acceptable level, it may be regarded as tolerable if:

- the risk is below the pre-determined intolerable level; and
- the risk has been reduced to a level that is as low as reasonably practicable (ALARP); and
- the benefits of the proposed system or changes are sufficient to justify accepting the risk.

3.2.3. “Acceptable risk” is based on the concept that no activity is without some risk, however small. The level of risk that is acceptable varies with the type of activity and according to the consequences; in general, the acceptable level of risk for adventure activities is higher than that for normal day-to-day activities, and higher for single fatality accidents than for those with multiple fatalities.

3.2.4. Perceptions of risk can be divided into three broad categories:

- risks that are so high that they are intolerable;
- risks that are low enough to be acceptable; and
- risks between these two categories, these need to be reduced/mitigated to an acceptable level.

3.2.5. If the risk does not meet the pre-determined acceptability criteria, an attempt must always be made to reduce it to a level that is acceptable, using appropriate mitigation procedures. If the risk cannot be reduced to or below the acceptable level, it may be regarded as tolerable if:

- the risk is below the pre-determined intolerable level; and
- the risk has been reduced to a level that is as low as reasonably practicable (ALARP); and
- the benefits of the proposed system or changes are sufficient to justify accepting the risk.

3.3. THE CONCEPT OF RISK

- 3.3.1. Risk assessment is a key area in an aeronautical study.
- 3.3.2. A risk scenario is a sequence of events with an associated frequency of occurrence and consequence. This sequence of events may be summarized as “hazard – threats – controls – key event – mitigations – consequences”. The hazard is what ultimately generates the loss; it may present a number of threats, each of which, without controls, will lead to the “key event”. The key event is the point at which control of the hazard is lost. Once this point has been reached, mitigations may still avoid or reduce undesirable consequences. Controls are proactive defenses, while mitigations may be proactive or reactive.
- 3.3.3. For example, a rainstorm (the hazard) may result in sheet water on runways (a threat) and reduced braking performance (another threat). The key event in this case is loss of control of the aircraft on the runway; this may result in damage or injury (the consequences). Controls might include tyre design and anti-skid braking systems, while mitigations could include runway end safety areas. The consequences are the damages and injuries that may result.
- 3.3.4. The risk is the likelihood (or probability) of the damage or injury resulting from the loss of control of the aircraft; it therefore includes the probability of loss of control and the probability of damage or injury. A study scenario example is attached in Appendix 1.

3.4. ACCEPTABLE RISK

- 3.4.1. “Acceptable risk” is based on the concept that no activity is without some risk, however small. The level of risk that is acceptable varies with the type of activity and according to the consequences; in general, the acceptable level of risk for adventure activities is higher than that for normal day-to-day activities, and higher for single fatality accidents than for those with multiple fatalities.
- 3.4.2. Perceptions of risk can be divided into three broad categories:
- risks that are so high that they are intolerable;
 - risks that are low enough to be acceptable; and
 - risks between these two categories, these need to be reduced/mitigated to an acceptable level.
- 3.4.3. If the risk does not meet the pre-determined acceptability criteria, an attempt must always be made to reduce it to a level that is acceptable, using appropriate mitigation procedures. If the risk cannot be reduced to or below

acceptable level, it may be regarded as tolerable if:

- the risk is below the pre-determined intolerable level; and
- the risk has been reduced to a level that is as low as reasonably practicable (ALARP); and
- the benefits of the proposed system or changes are sufficient to justify accepting the risk.

3.5. RISK MANAGEMENT PROCESS

3.5.1. Risk mitigation measures may work through reducing the probability of occurrence, or the severity of the consequences, or both. Achieving the desired level of risk reduction may require the implementation of more than one mitigation measure.

3.5.2. The process becomes one of iteration following the steps below,

1. Systematically identify possible hazards.
2. Evaluate the seriousness of the consequences of the key event occurring.
3. Consider the chances of it happening.
4. Determine whether the consequent risk is tolerable and within the organization's acceptable safety performance criteria. If not, take action to reduce the risk to a tolerable level by reducing the severity of the consequences or the probability of them arising.

3.5.3. Risk mitigation strategies can include:

- revision of the system design;
- modification of operational procedures;
- changes to staffing arrangements;
- training of personnel to deal with the hazard;
- development of emergency and/or contingency arrangements and plans;
- ultimately, ceasing operation.

3.6. SUMMARY OF THE SEVEN STEP SYSTEM RISK PROCESS

3.6.1. Risk assessment and mitigation requires a systematic approach. The complete process can be divided into seven steps and may be iterative. These are illustrated in the flow chart below:

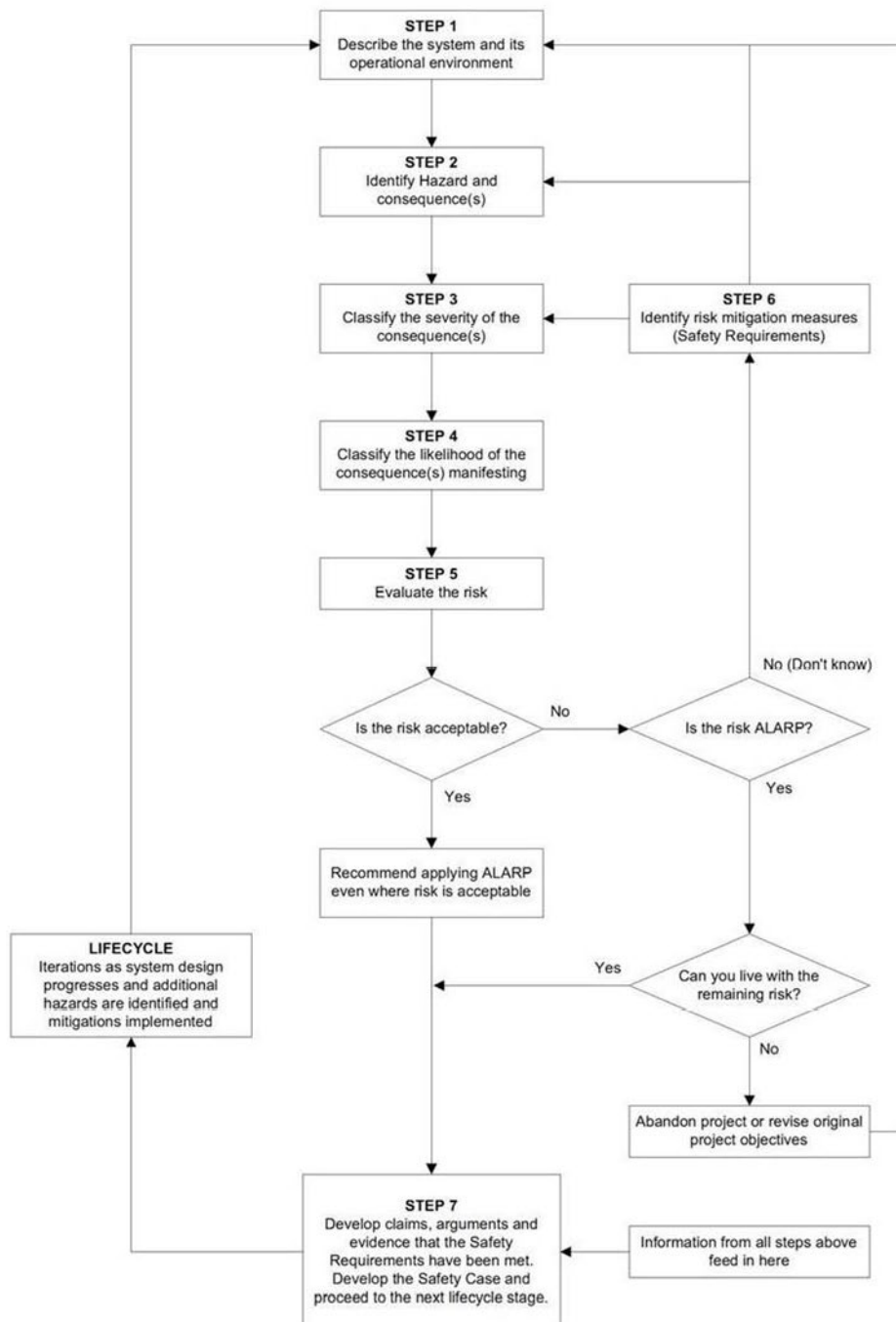


Figure 2: The Seven-Step Approach (CAP 760 Chapter 2)

3.7. AN EXAMPLE OF AN AERONAUTICAL STUDY METHODOLOGY

3.7.1. By way of explanation a generic model of an Aeronautical Study methodology consists of initiation, preliminary analysis, risk estimation, risk evaluation, risk control and action/monitoring and is related to the flow diagram above.

(i) Initiation: Step 1

This step consists of defining the opportunity or problem and the associated risk issues; setting up the risk management team; and beginning to identify potential users who may be affected by any change.

(ii) Preliminary Analysis: Step 2.

The second step consists of defining the basic dimensions of the risk problem and undertaking an initial identification, analysis and evaluation of potential risks. This preliminary evaluation will help determine:

- whether a situation exists that requires immediate action;
- whether the matter requires further study prior to any action being taken; or,
- whether the analysis should be ended as the risk problem is determined not to be an issue.

(iii) Risk Estimation: Steps 3 & 4.

These steps estimate the degree of risk. Step 3 estimates the severity of the consequences and step 4 estimates the probability of their occurrence.

Note: Safety Risk Probability Table, Safety Risk Severity Table and Safety Risk Index Matrix are given in appendix 2 of procedure for accepting non-compliances at aerodrome.

(iv) Risk Evaluation: Step 5

The benefits and operational costs of the activity are integrated into the analysis and the risk is evaluated in terms of the safety implications of the activity and of the needs, issues, and concerns of affected users.

(v) Risk Control: Step 6

This step identifies feasible risk controls and mitigations which will act to reduce either the probability of the event or the consequence of the event should it occur.

(vi) **Action/Monitoring**

(vii) **Step 7.**

This step entails implementing the chosen risk control options, evaluating the effectiveness of the risk management decision process, and implementing an ongoing monitoring program.

4. PROCESS

4.1. THE STUDY CONTENT

- 4.1.1. There will be a number of hazards in any aerodrome environment; these must be identified so that the risks that each bears can be determined. It can be very useful to start the process by identifying a number of key events and then deciding what hazards and threats can lead to those events and their possible consequences.
- 4.1.2. The class of airspace or type of air traffic service required is primarily determined by the level of risk at the aerodrome and in its immediate airspace.
- 4.1.3. The next stage is to assess the risk levels. The relative risk levels can then be used to identify the threats that have the highest risk, after which it will be possible to determine what, if any, controls can be put in place to reduce the risks.
- 4.1.4. While this type of study is aimed at determining the appropriate airspace environment at and around an aerodrome, these tools may highlight other risk areas.
- 4.1.5. There are several tools that can be used in this type of risk assessment; two of them, the Collision Risk Model and the Aerodrome Complexity Model, are discussed later.

4.2. COLLISION RISK MODEL

- 4.2.1. A widely used tool for this type of study is the collision risk model (CRM). Airspace designers, air navigation service providers or specialist consultants normally use this tool.
- 4.2.2. The basic output of the CRM is the relative risk of collision between two aircraft (or an aircraft and a parachute) whose intended tracks would bring them into a collision zone. Such pairs are referred to as “conflict pairs”. The relative risk is affected by the environment (type of airspace, service, aircraft)

but not by the number of movements. Multiplying the relative risk of collision by the annual number of conflict pairs gives an annual collision risk, which can then be compared to some measure of acceptable risk.

- 4.2.3. The CRM estimates the risk of collision from failure to take considered action (failure of the control) and failure to take evasive action (failure of the mitigation). As its name suggests, the pilot has some time to initiate a considered action, which is generally the result of information received by radio. A problem close to the collision zone is generally detected visually and requires evasive action. An action initiated within a few seconds of the collision zone is typically too late to alter the flight path sufficiently, so whether a collision takes place or not is a matter of chance.
- 4.2.4. The model considers the various factors that can lead to the need for considered action and to evasive action, and arranges them in a tree leading to the collision zone. The linking of the branches of the tree is by arithmetical 'AND' and 'OR' operators. Thus to reach the collision zone, both considered action and evasive action must fail. If one aircraft has no radio or is on the wrong frequency, then radio communication fails.
- 4.2.5. A numerical risk is assigned to each contributory factor, and thus the risk of reaching the collision zone can be calculated. Whether the aircraft will actually collide in the collision zone depends on the collision geometry and a collision geometry factor is applied to allow for this.
- 4.2.6. For a collision to take place, the two aircraft must initially be on a collision course, at least to the extent that, uncorrected, they will occupy the collision zone at the same time. These pairs are termed "conflict pairs". The total number of pairs that may become conflict pairs can be calculated from traffic data.

4.3. AERODROME COMPLEXITY MODEL

- 4.3.1. Another tool to estimate risk is an aerodrome complexity model. This type of model assumes that the complexity of operating at, and in the environment of, an aerodrome bears a relationship to pilot workload and hence to the risk of accident. The model therefore identifies a number of complexity factors and scores these according to the relative influence that they are deemed to have. The number of movements and the VFR/IFR mix are then taken into account and an overall complexity score calculated.
- 4.3.2. Typical complexity factors include the number and disposition of runways and taxiways, the types of operation, the topography and extreme weather conditions that may be expected.
- 4.3.3. This type of tool allows an aerodrome operator, for example, not only to determine a score that may be compared against some criterion, but also

interactively to identify those areas of aerodrome planning where complexity may be reduced.

4.4. Consultation

4.4.1. It is essential that, in conducting the aeronautical study, there is consultation with as wide a range of aerodrome users and other stakeholders as possible. Different users have different views of hazards and the corresponding threats, controls, mitigations and consequences. The following should be included in the consultation:

- Aerodrome operators (including adjacent affected aerodrome operators).
- Aerodrome users.
- Airspace user groups.
- Aircraft operators and operator groups.
- Pilot organisations.
- Air traffic service providers.

4.4.2. Experience has shown that consultation undertaken in open meetings, where ideas can be exchanged and debated, generally results in consensus being achieved. Individual consultation, on the other hand, tends to result in dissatisfaction for those whose proposals or viewpoints are not eventually accommodated

APPENDIX 1

Sample Aeronautical Study Considerations

A basic aerodrome aeronautical study would consider matters like, but not limited to, the elements below;

Scenario:

An operator of a commercial flight training flying organization is considering a start-up or expanded operation on an aerodrome.

The aerodrome operator considers as part of its review of the impact on this possible new operation that it should conduct an aerodrome airspace review.

Aeronautical Study elements may include the following elements:

- Modeling a number of levels of aircraft operations covering a range of options for the fleet size from the initial startup fleet size to the expected “final/optimum” size of the fleet.
- Modeling a number of local aerodrome operational factors, including:
 - Runway/taxiway design; note the taxiway design has a major influence of the runway and hence airspace capacity.
 - Location of the flight line apron in relation to the runways and taxiways and other facilities e.g. fuel, maintenance, etc.;
 - Location of navigational aids in the adjacent and regional airspace required for IFR training e.g. VOR, ILS, NDB;
 - Location of controlled airspace both locally and in the region;
 - Location of suitable areas of airspace for general handling (VFR) training;
 - Location of other aerodromes in the region suitable for cross country operations;
 - Local and regional meteorological conditions and seasonal patterns;
 - Location of suitable aircraft maintenance support services;
 - The current level (baseline) of aerodrome operations, e.g. airline and local operations;
 - Aerodrome air traffic density, e.g. circuit training, etc. Various modeling tools are available;
 - Aerodrome air traffic complexity, e.g. Crosswind runway, IFR approaches, etc.;