

FINAL REPORT

DEVELOPMENT OF STANDARDS AND PRACTICES FOR THE MANAGEMENT OF AERODROME AIRSPACE RISK

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Report to:



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TABLE OF CONTENTS

Executive Summary	1
1. Introduction	3
1.1 <i>Background</i>	3
1.1.1 <i>Need for the Study</i>	3
1.2 <i>Scope & Objectives of the Study</i>	4
1.3 <i>Study Team Details</i>	4
1.4 <i>Summary of Study Activities</i>	5
1.4.1 <i>Initial Briefing of Civil Aviation Authority</i>	5
1.4.2 <i>The Project Plan.....</i>	5
2. International Practice.....	6
2.1 <i>International Civil Aviation Organisation (ICAO)</i>	6
2.1.1 <i>Annex 11 – Air Traffic Services</i>	7
2.1.2 <i>Document 9426: Air Traffic Services Planning Manual.....</i>	7
2.1.3 <i>Document 9689 – Manual on Airspace Planning Methodology for the Determination of Separation Minima</i>	8
2.1.4 <i>Document 4444 – Procedures for Air Navigation Services – Air Traffic Management</i>	8
2.1.5 <i>Summary of ICAO Characteristics.....</i>	9
2.1.6 <i>Target Levels of Safety</i>	9
2.2 <i>International Good Practice</i>	10
3. New Zealand Legislation	11
3.1 <i>The Act, the Rules and International Agreements</i>	11
3.1.1 <i>Rule Part 139.....</i>	11
3.1.2 <i>Provision of Air Traffic Services.....</i>	13
3.1.3 <i>Rule Part 71.....</i>	13
3.1.4 <i>International and Other Agreements</i>	13
3.2 <i>Policy Framework.....</i>	14
3.3 <i>Who Should Conduct an Aeronautical Study?.....</i>	15
4. Development of the Risk Model	16
4.1 <i>Approach Taken in the Study of Risk</i>	16
4.2 <i>Relative Risk</i>	16
4.3 <i>Consultation</i>	17
4.3.1 <i>Consultation undertaken during the model development.....</i>	17
4.4 <i>Description of the Risk Model Developed</i>	17
4.5 <i>Risk factors identified</i>	18
4.6 <i>Threat Barriers Identified.....</i>	18
4.6.1 <i>Evaluating Effectiveness of Threat Barriers.....</i>	18
4.7 <i>Generic Model.....</i>	18
4.7.1 <i>Media.....</i>	19
4.7.2 <i>Limitations of the Model</i>	19

5. Application of the Risk Model	19
5.1 <i>The Aerodrome Airspace Change Process</i>	20
5.2 <i>Service Options.....</i>	21
5.3 <i>Structures to Manage Aerodrome Risk.....</i>	21
5.4 <i>Monitoring of Aerodrome Airspace Risk</i>	23
5.5 <i>Base lining of Aerodrome Airspace Risk.....</i>	24
5.6 <i>Development of Documentation on the Preparation of Aeronautical Studies.....</i>	25
5.7 <i>Training</i>	25
5.8 <i>Location Specific Aerodrome Airspace Management</i>	25
6. The Canadian Model.....	25
7. Proposed New Zealand Model.....	26
7.1 <i>Step 1: Initiation</i>	26
7.2 <i>Step 2: Analysis & Risk Evaluation</i>	27
7.3 <i>Step 3 Action & Monitoring</i>	27
7.4 <i>Initiation of an Aeronautical Study</i>	28
7.5 <i>Consultation Process: Stakeholders to be Included.....</i>	28
7.6 <i>Using the Risk Model</i>	29
7.6.1 <i>Data Requirements and Sources</i>	29
7.6.2 <i>Expert Judgement Panels</i>	29
7.6.3 <i>Data Inputs to the Model.....</i>	29
7.6.4 <i>Data outputs from the model.....</i>	30
7.6.5 <i>Preliminary findings.....</i>	30
7.6.6 <i>Consultation with Stakeholders</i>	31
7.6.7 <i>Implementation.....</i>	31
7.6.8 <i>Regulatory Impact Statement.....</i>	31
7.6.9 <i>The Regulatory Decision.....</i>	31
7.7 <i>Users Guide</i>	32
7.8 <i>Case Study Review</i>	32
7.8.1 <i>Gisborne</i>	32
7.8.2 <i>Timaru.....</i>	33
8. Implementation and Transition	33
9. Conclusion and Recommendations	33
9.1 <i>Legislation and Policy</i>	34
9.2 <i>Initiation and Conduct of an Aeronautical Study</i>	35
9.3 <i>The Next Steps</i>	36
Appendix 1: References	
Appendix 2: Aerodrome Airspace Project Plan	
Appendix 3: Review of International Practice	
Appendix 4: Aerodrome Airspace Model	
Appendix 5: Criteria	
Appendix 6: Final Presentation Attendance	
Appendix 7: Process Diagrams	

EXECUTIVE SUMMARY

The Civil Aviation Authority of New Zealand (CAA) issued a Request for Proposal to develop and propose standards and practices for the management of aerodrome airspace risk on the 26th of February 2007.

The Ambidji Group Pty. Ltd. responded to the Request for Proposal and was selected as the successful tenderer. Ambidji assembled a team consisting of a Project Manager (Ambidji), specialist risk advisers (R2A Pty Ltd) and New Zealand based aviation consultants (Astral Ltd) to perform the work. The work was divided into five deliverables:

Deliverable 1

This consisted of the project plan as prepared by Ambidji and accepted by the CAA on [date]. The project plan was developed from initial meetings with the CAA and other stakeholders 15-16 May 2007. The plan is attached at Appendix 2.

Deliverable 2

It was agreed that a review of overseas good practice in aerodrome airspace risk would be developed as part of the contract, and this became deliverable 2. This review examines practices used by the International Civil Aviation Organisation (ICAO) as the body which sets international standards and five leading aviation States - The European Union (Eurocontrol), the United Kingdom, Canada, Australia and the United States of America. It then briefly reviews policy implications for New Zealand and makes initial recommendations which are further developed in this final project report. Deliverable 2 (attached at Appendix 3) was accepted by the CAA on 21 June 2007.

Deliverable 3

Deliverable 3 consists of a preliminary aerodrome airspace risk model. Deliverable 3 was accepted by the CAA on 20 July 2007 and is attached at Appendix 4. It was developed by R2A and is based on the concept of relative risk. The model was refined during a two day workshop session at Gisborne Airport on 6-7 June 2007. Extensive input and consultation occurred with stakeholders and local Gisborne operators in this phase of the project.

Deliverable 4

Deliverable 4 consists of a draft aeronautical study and generic aerodrome airspace risk model, the latter being a refinement and extension of deliverable 3. This deliverable further developed the Gisborne model through a second workshop examining Timaru airport. This "desk study" took place at the CAA offices in Wellington on 28 June 2007. This deliverable was accepted by CAA on or about the 28 July 2007 and is attached at Appendix 4.

Deliverable 5

This report constitutes deliverable 5. It summarises the project, discusses possible changes to the Rules then develops options for the institutional arrangements that will be required to support the effective operation of the aerodrome airspace risk model. It then discusses the model at a summary level, develops recommendations which CAA may wish to consider and proposes a possible implementation strategy.

Consultation

Overseas and New Zealand experience has shown that an open and transparent process involving extensive consultation with stakeholders is essential in airspace matters. This project has consulted extensively both with national industry bodies and local aviation communities. Formal briefing sessions have been held to ensure that stakeholders have an overall

understanding of the model and its concepts. Workshops have also been undertaken to trial the model in real world situations.

Findings and Recommendations

At the strategic level, some rule changes are recommended to clarify the powers of the Director in the regulation of aerodrome airspace. Important institutional arrangements are also recommended to:

- Initially rank aerodromes;
- Provide processes to monitor aerodrome airspace for changes in aviation activity and risk;
- Appropriate triggers to alert stakeholders to the need to consider undertaking an aeronautical study;
- Provide processes to manage an aeronautical study; and
- Support the implementation of recommendations from an aeronautical study.

Possible policy changes are also discussed. These consider the role of the CAA and aerodrome operators in the conduct of a study, the criteria for the study and the range of control measures that may be implemented.

The aerodrome airspace risk model developed during this project forms the core of an aeronautical study. It is an estimative risk model that demonstrates the change in risk for the addition or removal of different control options. It is designed to determine the change in risk for the various control options both at the loss of control points and in terms of an annualised estimate of persons at risk.

The costs of the controls will be determined by others at a later date. The decision to implement or remove controls would be made as a result of a cost/benefit analysis of any proposal. This would have to take

both safety and business case aspects into consideration.

Recommendations are made in the following areas:

- Changes to Rules 139 and 12;
- Updating of the CAA Policy Paper;
- Target levels of safety;
- A graduated response to management of aerodrome airspace risk;
- Development of guidance material;
- Management of ongoing monitoring of aerodrome airspace risk and triggers for action;
- Collection of movement statistics;
- Use of a Terms of Reference document in the management of aeronautical studies; and
- Establishment of aerodrome airspace safety committees.

1. INTRODUCTION

The management of risk in aerodrome airspace is a contentious issue as it affects a wide range of stakeholders at each location and can directly impact on commercial viability. The safety regulator has an overarching responsibility to provide a safe aviation environment, especially for the fare paying passenger. The Aerodrome Airspace Risk Project addresses this issue through; a due diligence based risk model, institutional arrangements to identify aerodrome airspace at risk, processes to trigger then manage aeronautical studies and legislative and policy amendments to provide the necessary authority.

1.1 Background

The Civil Aviation Authority of New Zealand (CAA) issued a Request for Proposal to develop and propose standards and practices for the management of aerodrome airspace risk on the 26th of February 2007. The Ambidji Group Pty. Ltd. responded to the Request for Proposal and was selected as the successful tenderer.

The management of aerodrome airspace risk is part of the wider issue of regulation of the aviation industry. Stakeholders in the industry have sometimes differing expectations of the regulator. In Australia and New Zealand the travelling public, media and Parliament have a low tolerance to aircraft accidents and fatalities. The aviation industry, while safety focussed, needs a regulatory regime which also allows it to grow and remain profitable. Such conflicting demands provide challenges to the regulator and make robust, transparent policy even more important.

1.1.1 Need for the Study

The Civil Aviation Act 1990 ("the Act") establishes a general CAA function of promoting civil aviation safety and tasks the Director with conducting reviews of the civil aviation system. The CAA however has no explicit regulatory framework or established methodology for the assessment and management of risk in aerodrome airspace. It also holds no reliable information on the level of risk that exists at specific aerodromes in NZ. In addition, should the CAA become aware that an unacceptable risk exists at a particular aerodrome; the power of the Director to mitigate that risk by requiring the provision of an Air Traffic Service (ATS) or other risk mitigators at the aerodrome is limited. The CAA policy for 'The Provision of Air Traffic Services at Aerodromes' (dated Aug 2005) goes some way to rectify the problem by setting out the policy to be incorporated into a regulatory framework for the provision of Air Traffic Services at aerodromes. The policy deals primarily with the provision of ATS at aerodromes as a means of reducing risk in aerodrome airspace, however it recognises that there may be other options.

1.2 Scope & Objectives of the Study

The project scope as defined in the CAA Request for Proposal is as follows:

- Development of a detailed project plan
- Review of current policy for the provision of ATS at aerodromes and amendments as necessary to reflect the project objective
- Determination of acceptable levels of aerodrome airspace safety
- Determination of aeronautical study methodology
- Development of aeronautical study “triggers and/or filtering tools or models”, and
- Validation of the proposed process through the conduct of an aeronautical study.

1.3 Study Team Details

Brief details on the qualifications and experience of each of the team members is given below:

Mr Brian Jackson, Ambidji (Program Director)

Brian is the Ambidji executive responsible for the oversight of the Aerodrome Airspace Risk Project. He has an ATS background as well as considerable experience as a consultant in the management, planning and provision of aviation services and systems. His aviation management experience covers air transport sector reviews, aviation policy development and regulatory reform, institutional restructuring and capacity building, privatisation of aviation assets, design development of a range of airport, air traffic management and flight operations infrastructure, as well as ATS facility and airport management. Brian also holds an Australian pilots licence with current multi-engine instrument and night ratings.

Ambidji established a project team with a wide range of skills and experience:

Robin Graham, Ambidji (Project Manager)

Robin has extensive experience in managing aviation policy development, investigatory and rule making projects on behalf of Airservices Australia, the Civil Aviation Safety Authority of Australia, the Australian Air Transport Safety Bureau (as Director, Safety Investigation) and the Civil Aviation Authority of New Zealand. Robin was also the Deputy Project Manager for the implementation of Australia's modern ATC automation system (TAAATS). He is currently the Chairman of CASA's Industry Standards Consultative Committee, the peak body which considers all regulatory development proposals for the Australian aviation environment and has recently been appointed by the Minister for Transport and Regional Services to the Taskforce reviewing safety regulation in Australian aviation.

Dave Park, Astral (Deputy Project Manager)

Dave has substantial rule development experience primarily assisting the CAA with the update of New Zealand's Civil Aviation Rules. Significantly he has undertaken a number of aviation studies for airport authorities, as well as for the CAA in relation to rule development projects for aircraft collision avoidance equipment and other technical requirements. Dave has wide experience of aircraft operations and the New Zealand aviation environment.

Richard Robinson, R2A (Risk Engineer)

Richard will be the R2A director responsible for the project. Richard has previously been responsible for implementing major risk and reliability studies and technical due diligence reviews for large organizations including the risk review for Airservices Australia, South Port NZ, Silverfern Shipping NZ and the review of the performance of the Office of Gas Safety. Richard is the principal author of Risk & Liability Management, the post graduate distance education unit validated by Deakin University and the 7th edition of the R2A Text (2007) *Risk & Reliability – An Introductory Text*. He is also the presenter of the 2-day Risk Management short course for Engineering Education Australia.

Gaye Francis, R2A (Risk Analyst)

Gaye is the nominated R2A project manager. Gaye, also a R2A Director, has been involved in numerous risk and reliability assessments as well as technical due diligence reviews. She has been involved in projects including due diligence reviews for RailCorp, Connex Melbourne, VicRoads, South Port NZ and Port Phillip Sea Pilots. Modelling projects include high-level enterprise availability modelling for Melbourne Water and the Austin Hospital as well as black start modelling for Transpower NZ.

1.4 Summary of Study Activities

This section briefly summarises the major stages of the study and the tasks and outcomes associated with each stage.

1.4.1 Initial Briefing of Civil Aviation Authority

The CAA and the Ambidji team held an initial project meeting on 15 May 2007 to ensure that all parties had a common appreciation of the task in hand. CAA was briefed on the proposed risk assessment methodology and in particular the use of a due diligence approach. CAA then provided the project team with an overview of their role and operations.

1.4.2 The Project Plan

A project plan (Appendix 2) was developed. It defined the tasks to be undertaken and a schedule of deliverables. The deliverables were:

- *Deliverable 1 : Project Plan*

- *Deliverable 2 : Review of International Good Practice*

An extensive review of airspace management starting with the standards and recommended practices set by ICAO then an examination of models used by the European Union, the United Kingdom, Canada, Australia and the United States

- *Deliverable 3 : Development of a Preliminary Risk Model*

An aeronautical study workshop was conducted in Gisborne on 6-7 June 2007 to trial the initial concept. Interviews were held with a wide spectrum of stakeholders and a preliminary model was developed. This model was presented to the CAA and a programme of further development was agreed

- *Deliverable 4 : Development of the Generic Risk Model*

A further workshop was held on 28 June 2007, mainly with CAA staff, to further develop the model through a desktop study of the aerodrome airspace risk existing at Timaru airport. This input was then used to develop a generic model which could be applied to any location in New Zealand.

- *Deliverable 5 : The Final Project Report*

The final project report including details of the institutional initiatives and the final generic risk model.

2. INTERNATIONAL PRACTICE

As indicated above, an extensive review of airspace management practices being applied in some of the world's more advanced aviation environments was undertaken to identify those practices that may have beneficial application within the New Zealand aviation environment.

This review started with the analysis of the standards and recommended practices set by ICAO then an examination of models used by the European Union, the United Kingdom, Canada, Australia and the United States.

2.1 International Civil Aviation Organisation (ICAO)

ICAO, under the Chicago Convention, sets the framework and standards for international aviation through a series of Annexes and Documents. New Zealand, as a signatory to the Convention should comply with these standards or formally file a difference with ICAO.

The following is a summary of annexes and documents relevant to airspace design and management. A fuller discussion can be found in Appendix 3 of this report (*A Review of International Good Practice*).

2.1.1 Annex 11 – Air Traffic Services

Annex 11 at section 2.2 states that the objectives of ATS are to:

- a. Prevent collisions between aircraft and between aircraft on the ground and obstructions;
- b. Maintain an orderly and expeditious flow of air traffic;
- c. To provide aircraft with advice and information required for the safe and efficient conduct of flights; and
- d. To notify those involved with search and rescue of aircraft in need of this service and assist them in this task.

Section 2.4 discusses determination of the need for air traffic services and requires that the following be considered:

- a. The types of traffic involved;
- b. The density of the air traffic;
- c. The meteorological conditions; and
- d. Such other factors as may be relevant.

Section 2.4 goes on to state that due to the number of elements involved it has not been possible to develop specific data to determine the need for ATS in a given area or at a given location. For example:

- a. A mix of different types of air traffic with aircraft of varying speeds (conventional jets, etc) might necessitate the provision of ATS whereas a relatively greater density of traffic where only one type of operation is involved may not.
- b. Meteorological conditions might have considerable effect in areas where there is a constant flow of air traffic (e.g. scheduled traffic), whereas similar or worse meteorological might be relatively unimportant in an area where air traffic would be discontinued in such conditions (e.g. local VFR flights).

2.1.2 Document 9426: Air Traffic Services Planning Manual

Section 2 Chapter 1 of this document deals with the need for ATS. Section 2, at 1.1.7 summarises that [it would appear that] the need for ATS at and in the vicinity of specific aerodromes can, to a large extent, be determined on a local or national level and in consultation with the operators concerned up to the point when those services will have consequences on the en-route flow of air traffic over a wider area.

Section 2 at 1.5 describes the progressive development of ATS from aerodrome

flight information service (AFIS) to an aerodrome control service with varying levels of sophistication.

There is no methodology suggested for determining when AFIS is required other than the subjective assessment of “where traffic tends to congregate”. The suggested point of step up from AFIS to an aerodrome control service is also somewhat subjective.

2.1.3 Document 9689 – Manual on Airspace Planning Methodology for the Determination of Separation Minima

Chapter 5 of this document deals with ICAO’s recommended method for identifying the method of safety assessment for a proposed system.

Section 5.1 of the document states that the safety of a system depends on a number of characteristics of the airspace which need to be identified and quantified. It goes on to discuss the two basic methods for determining if the system is acceptably safe viz:

- a. Comparison with a reference system – requires selection of a suitable reference airspace. Chapter 6 of the document discusses this approach in more detail.
- b. Evaluation of system risk against a threshold – requires identification and quantification of all the safety-related characteristics of the system and development of an explicit relationship between the characteristics and collision risk. The estimated risk of the system is then compared against the maximum tolerable risk. Chapter 6 also describes the detail of this approach.

ICAO considers that, although the evaluation method is likely to be time consuming and complex, it is the only choice when a radical change is planned which has not previously been tried in other regions

Annex 9 (The Eurocontrol Hazard/Risk Analysis Methodology) describes Eurocontrol’s hazard/risk analysis methodology. It is more focused on en route/high level issues but is still conceptually useful for airport airspace.

Annex 10 (*Application Of Risk Analysis To Airspace Planning In Australia*) describes quantitative modelling undertaken in Australia in recent years. It provides a Target Level of Safety value of 1.5×10^{-8} fatal accidents due to collisions per system flight hour. It also acknowledges the need to demonstrate due diligence.

2.1.4 Document 4444 – Procedures for Air Navigation Services – Air Traffic Management

Chapter 2 of this document addresses ATS safety management. Section 2.1 requires States to ensure that the level of ATS and communications, navigation and surveillance, as well as the ATS procedures applicable to the airspace or

aerodrome concerned, are appropriate and adequate for maintaining an acceptable level of safety in the provision of the ATS. To ensure this the appropriate ATS authority shall implement formal and systematic safety management programmes for the ATS under its jurisdiction.

This appears to relate more to the requirement to ensure any ATS provided is suitably safe rather than whether an ATS is required at a particular location or area.

Section 2.3 requires, inter alia, a safety assessment in respect of the planned implementation of airspace re-organisations. This would apply, for example, to the implementation or withdrawal of controlled airspace around and aerodrome.

Section 2.6.2 of the document discusses safety significant factors which include:

- a. Types of aircraft and their performance characteristics, including aircraft navigation capability;
- b. Traffic densities and distribution;
- c. Airspace complexity;
- d. Aerodrome layout, including runway configurations, runway lengths and taxiway configuration;
- e. Types of air-ground communications;
- f. Types and capabilities of surveillance systems; and
- g. Local or regional weather characteristics.

Section 2.7 addresses safety-enhancing measures but only in very general terms requiring the ATS authority to implement safety-enhancing measures if it becomes apparent that the level of safety is not acceptable.

2.1.5 Summary of ICAO Characteristics

Many of the ICAO documents are relatively old, some from the mid 1980s. They offer a “reference system approach” as well as describing research undertaken by leading states. They do not have explicit target levels of safety or trigger points. However, the ICAO document suite does establish clear guiding principles upon which States may base airspace management.

2.1.6 Target Levels of Safety

Some administrations publish target levels of safety. They are usually generic to aviation safety rather than specific to aerodrome airspace risk. Appendix 6 provides indicative figures used in Australia. ICAO Annex 11 no longer provides a target level of safety for collision risk.

The European Union publish no explicit aerodrome airspace target level of safety but the over-riding European safety objective for the tolerable level of accidents in controlled airspace is set as 1.55×10^{-8} accidents per flight hour (or 2.31×10^{-8} per flight).

The Netherlands use a target level of safety of 10^{-8} collision risk in any airspace proposal.

There is some debate on the merits of target levels of safety. To be useful, they must be meaningful and achievable. The proposed model focuses on due diligence rather than a more abstract target level of safety.

2.2 International Good Practice

As part of this project, CAA NZ required the development of a paper discussing overseas experience in aerodrome airspace risk good practice. It examined practices used by ICAO as the body which sets international standards, and five leading aviation States - The European Union (Eurocontrol), the United Kingdom, Canada, Australia and the United States of America. It then briefly reviewed policy implications for New Zealand and made some initial recommendations which are developed in this report.

ICAO through Annex 11 and associated documents sets guidelines for airspace management. There is however no standard method of airspace administration although some common threads are evident. In most administrations airspace policy and regulatory functions are distinct and separate from safety regulatory functions. In Europe they are in separate organisations. The United Kingdom has both functions within CAA (UK) but segregated at Board level. Australia will have the airspace regulatory function within CASA but reporting directly to the CEO while Canada has both functions within Transport Canada. America has both safety and airspace regulatory functions within the same office of the Federal Aviation Administration and is the only State to also have the air traffic service provider within the same organisation.

There are formal processes in place in all administrations to manage changes to aerodrome airspace. They provide a policy and infrastructure framework within which qualitative and quantitative risk evaluation tools can be applied. Components of this framework include both national and local consultation programmes and ongoing risk review mechanisms such as Hazops Committees. Meaningful consultation is viewed by all as critical to the success of any airspace change process. All administrations have developed, or are in the process of developing, a "risk management toolbox" for use in aeronautical studies.

Some administrations (see Appendix 5) publish traffic criteria which trigger a review of service levels through an aeronautical study. This is a more sustainable approach than making changes to service levels solely on traffic volumes. An aeronautical study will for instance take into account a wide range of location specific criteria including the mix of aviation activities, terrain, weather and airspace complexity.

As discussed previously, some administrations publish Target Levels of Safety (TLS). These are usually generic rather than specific to aerodrome airspace risk but can provide useful guidance.

In the main, ATS providers or airline/airport operators are proponents for aeronautical studies. The role of the regulator is to review then approve the studies. In certain cases the regulator may undertake a study if they consider it necessary in the interest of safety. In such cases care must be taken to ensure that the study is reviewed and approved by an independent party.

The review identified the following practices that might be appropriate for New Zealand:

- Canada, the United Kingdom, the USA and Australia all have in place institutional arrangements to support and manage the risk assessment of aerodrome airspace;
- The Canadian model is well established and could form the core of a New Zealand institutional model;
- Both Australia and the United Kingdom have some policies, practices and procedures which could augment the Canadian model;
- All States see open, honest and effective communication as vital;
- Some states have trigger points which initiate an aeronautic study rather than the decision that ATS is needed; and
- Canada and Australia in particular have a menu of options to mitigate risk before the placement of formal ATS.

3. NEW ZEALAND LEGISLATION

Section 14 of the Civil Aviation Act requires the Minister to undertake functions in such a way as contributes to *“the aim of achieving an integrated, safe, responsive and sustainable transport system, and to ensure that New Zealand’s obligations under international civil aviation agreements are met”*.

3.1 The Act, the Rules and International Agreements

The Act and its associated Rules provide the authority under which the Director of Civil Aviation regulates New Zealand aviation.

Rules have been developed under the Act to give effect to its provisions. Rules define the minimum levels of safety to be achieved. They set a standard, so that everyone in aviation can have a shared understanding of the right way to operate.

3.1.1 Rule Part 139

Rule Part 139 prescribes the regulatory requirements relating to —

- the certification and operation of aerodromes;
- the security measures applicable to aerodromes;

- the use of aerodromes by aircraft operators;
- the provision of UNICOM and AWIB services.

Rule 139.5 provides the requirements for the holding of an aerodrome operator certificate:

(a) No person shall operate an aerodrome serving any aeroplane having a certified seating capacity of more than 30 passengers that is engaged in regular air transport operations except under the authority of, and in accordance with the provisions of, an aerodrome operating certificate issued for that aerodrome under this Part.

(b) An aerodrome operator who is not required under paragraph (a) to hold an aerodrome operating certificate may apply for an aerodrome operating certificate under this Part.

Further, 139.113, aerodrome aircraft traffic management requires that

“Each holder of an aerodrome operating certificate shall ensure the provision of an aerodrome flight information service or an aerodrome control service or both at their aerodrome when so required by the Director in the interest of safety”

Part 139.305, Use of aerodromes - air transport aeroplanes, requires that

“No person operating an aeroplane engaged on an air transport operation shall use any place for the purpose of landing at or taking off from unless —

(5) if the aeroplane has a certified seating capacity of more than 30 passengers and is engaged on a scheduled flight, the place is certificated as an aerodrome under this Part or licensed as an aerodrome under the Civil Aviation Regulations 1953; and

(6) if the place is not certificated under this Part, the aeroplane can be manoeuvred in the aerodrome traffic circuit clear of any obstructions, and not in conflict with the aerodrome traffic circuit or instrument approach procedure of any other aerodrome.

Rule Part 139 therefore limits on the authority of the Director to require the provision of levels of air traffic service at aerodromes which are certificated. If an aerodrome does not have air transport movements by aircraft with more than 30 seats it need only be certificated through the goodwill of the operator.

The Director may be able to impose some regulation on uncertificated aerodromes through the use of some “umbrella powers” elsewhere in the rules but such an action might be subject to challenge by judicial review. Many regional air transport operations are undertaken by aircraft of less than 30 seats.

In such cases, parties other than ultimately the CAA, do not have specific responsibilities for the management of aerodrome airspace. The operation of carriers in such airspace is regulated through other rule parts such as 125 and

135 and CAA does have some powers to impose special use airspace such as MBZs. The consequence of a mid-air collision in such circumstances would be significant.

3.1.2 Provision of Air Traffic Services

Air Traffic Services are provided by the Airways New Zealand, a State Owned Enterprise under the State Owned Enterprise Act 1986 in accordance with an MOU between the CAA and Airways for provision of ATS. There is no requirement under the MOU for a particular level of service at any aerodrome unless that aerodrome is certificated under Part 139, and then only in respect to aerodrome flight information services and air traffic control should the Director require such services to be provided in the interests of safety.

In addition to air traffic control services Airways provide aerodrome flight information at selected aerodromes to provide advice and information for aircraft on or in the vicinity of the aerodrome. Milford Sound is an example of such a service. They also provide area flight information which includes weather and other information useful for the safe conduct of flight in uncontrolled airspace in New Zealand. This service includes search and rescue alerting services for aircraft on a flight plan, the relaying of clearances on behalf of air traffic control and in predefined areas of uncontrolled airspace the provision of traffic information for pilots to determine their position in relation to each other to prevent collisions.

3.1.3 Rule Part 71

Part 71 prescribes the general rules for the designation and classification of airspace for aviation purposes and in the public interest. In particular, Part 71 empowers the Director to designate and classify airspace for aviation purposes in New Zealand's domestic airspace.

Part 71 also empowers the Director to restrict aviation activity by the designation of special use airspace. Airspace can be designated as either controlled airspace or special use airspace. Controlled airspace is designated where there is a need for an air traffic control service to be provided for the safety and efficiency of aircraft operations. Such designations include control areas and control zones. Special use airspace is designated where there is a need to impose limitations on the operation of aircraft for aviation safety and security, or national security, or for any other reason in the public interest. Special use airspace includes restricted areas, military operating areas, mandatory broadcast zones, volcanic hazard zones, danger areas, and low flying zones.

3.1.4 International and Other Agreements

The ICAO Asia and Pacific Regional Air Navigation Plan provides for full air

traffic control (ATC) at the three designated international aerodromes: Auckland, Wellington and Christchurch. It does not cover other aerodromes with international services. The CAA discharges its responsibility to provide these services via the MOU with the Airways Corporation.

In conclusion although CAA can designate controlled airspace, it does not have the power to require any person or organisation (except via the Airways MoU and to a very limited extent under Part 139.113) to actually provide a control or any other service.

3.2 Policy Framework

The New Zealand Government may choose to issue policy directives which provide guidance (and an obligation to comply) to the CAA.

Within CAA, policy does not have legal status per se. It derives its powers from the Act and the Rules and must therefore by definition, not exceed their boundaries or authority. A robust policy framework is nevertheless useful in effective safety regulation as it:

- Provides CAA staff with guidelines under which they can operated;
- Provides constraints with which CAA staff must comply;
- Allows stakeholders to understand CAA's strategic direction;
- Provides a baseline against which negotiations can take place;
- Provides a basis for discussions with the Government and the Ministry; and
- Provides a basis for the development of CAA Rules.

CAA produced a policy document on the Provision of Air Traffic Services at Aerodromes in August 2005. It identifies *the potential for operations to be conducted at some aerodromes where the level of collision risk is excessive by comparison with overseas benchmarks or there is at least uncertainty over the level of risk*. The policy document suggests several valid policy options, including the formalisation of an aeronautical study process, and provides a useful starting point for further policy development but it has some shortcomings:

- It addresses only ATS solutions to risk in aerodrome airspace (while noting that other solutions may be possible); and
- It suggests that the Rules should prescribe the level of ATS to be provided at aerodromes. It refers to an appendix which contains criteria based on traffic parameters – total aircraft movements, IFR movements and international passenger services. On its own, this is a rather narrow approach as it does not take into account types of operation at the location (such as training), operational complexity or location specific operational issues such as terrain and weather. That being said, such criteria can be useful as triggers for further examination where they are supported by other validated intelligence. Criteria used overseas are attached at Appendix 6 to this report.

Canada and Australia use annual location specific movement levels to trigger further study, while the FAA have benefit to cost ratio criteria for establishment and discontinuance of control towers. The most important factor in determining the need for an aeronautical study may however be significant changes to aviation activity at the location.

3.3 Who Should Conduct an Aeronautical Study?

A major policy issue is the responsibility for the initiation and conduct of an aeronautical study. This issue is discussed further in section 5.4 of this report so only the high level policy issues are addressed here.

If a system approach to safety is used, all parties (CAA, aerodrome operators and aircraft operators) have a responsibility for aerodrome airspace safety. However the day to day management of risk at a location most probably rests with the aerodrome. There is probably an obligation to continually monitor for changing or emerging risks whether the aerodrome is certified or not. Where a risk is identified, action should be taken to quantify and apply reasonable measures to mitigate it. CAA has an overarching responsibility to monitor the aviation system as a whole. It is however constrained as its direct powers relate only to certificated aerodromes.

An aeronautical study can be initiated by the aerodrome operator or by CAA. CAA, in some circumstances (such as certification) could require an aerodrome operator to undertake an aeronautical study. The study can be performed by the aerodrome operator itself, by specialists under contract or by the CAA.

A second policy issue is whether an aerodrome operator has a conflict of interest when conducting an aeronautical study. While Canada allows Nav Canada (a not for profit organisation) to undertake aeronautical studies, Australia is of the view that they should be undertaken by the regulator. There are policy and governance issues with both approaches. On one hand, if the proponent is the aerodrome operator it may have a conflict of interest as it may be perceived as attempting to minimise costs and interference to operations. On the other hand, if the regulator is the proponent and undertakes the study, who can then independently undertake a review and make a recommendation to the Director? For instance when terms of reference are being developed by CAA, it would be wise to provide them to key stake holders for comment. Overall, the best protection is probably the transparency of the proposed process through the participation and interaction of all stakeholders at the location.

As there is a due diligence aspect to undertaking an aeronautical study, it would be most unwise for a proponent to falsify evidence or skew the study for purely commercial reasons. The United Kingdom CAA in its Airspace Change Process document (DAP 724) is explicit in stating that should the airspace regulator have any concerns that the detail of a study is insufficient, a request for supplementary information will be submitted to the proponent. This caveat is discussed further in Section 5.1.

Another issue is the ability of an aerodrome operator to acquire or contract the appropriate skills to undertake a study. The question of appropriate skills can be substantially addressed through the adoption of terms of reference prior to the commencement of a study with a critical section being the nomination of individuals with the skills necessary to undertake the review. An aeronautical study may involve significant time and effort. A general policy position on funding should be developed.

As previously stated, the provision of ATS at aerodromes was reviewed in a CAA Policy Paper of August 2005. While other risk mitigation options in addition to ATS were addressed in passing, the overall thrust was towards an ATS solution. While it may well be true in general terms that ATS may be the optimal safety option, this may or may not be so at a particular location. There are intermediate options including (but not limited to) flight procedures, administrative agreements such as MOUs between operators, Unicom and locally staffed licensed flight information services which should be considered before moving to an ATS solution. This graduated approach has the advantage of tailoring the solution to the management of risk at the location and building confidence within the aviation community that CAA is focussed on efficiency of operations provided that the overarching safety obligation is met.

The CAA Policy Paper envisages most aeronautical studies being developed externally by the proponent of the change using a standard methodology. Such studies would then be reviewed by the Aeronautical Services Branch of the CAA. This is a robust model which segregates the development and review processes. As a regulator, CAA may occasionally face a situation where it wishes to undertake a study internally in response to safety concerns. In this case, the study would most probably be undertaken by the Aeronautical Services Branch as it has the required expertise. As previously discussed, this could cause a governance issue as a single area of the organisation would both develop then review the proposal. This could be minimised by having any study open to public scrutiny/submission as is already done for approvals to establish aerodromes or heliports under Rule 157.

4. DEVELOPMENT OF THE RISK MODEL

This section of the report provides a brief overview of the risk model itself. Definitive information on the model is contained in the R2A paper at Appendix 4 of this report. References to the appropriate section of the R2A paper are noted throughout this section.

4.1 Approach Taken in the Study of Risk

The method adopted for the CAA Aerodrome Airspace Risk Review is based on a common law safety case approach which is a documented demonstration by the organisation that all statutory, regulatory and common law requirements have been met. It consists of a number of arguments that demonstrate that all reasonable practicable precautions are in place. A common law safety case essentially ensures that due diligence is (seen to be) demonstrated, not that accidents / incidents won't happen. (R2A Paper 2.3)

4.2 Relative Risk

The aerodrome airspace risk model is a relative risk model that demonstrates the change in risk different control options make to an initial estimation of the risk at the time at the location. It is designed to determine the change in risk for the various control options both at the loss of control points and in terms of an annualised estimate of persons at risk.

The costs of the controls are to be determined by others at a later date. The decision to

implement or remove controls would be made as a result of a cost/ benefit analysis of any proposal. This would have to take both safety and business case aspects into consideration. This task is also the responsibility of others. (R2A Paper 4.0)

4.3 Consultation

Consultation is an integral part of both the overall aeronautical study process and the implementation of the aerodrome airspace risk model itself.

4.3.1 Consultation undertaken during the model development

The following meetings and workshops were convened to provide stakeholders with an overview of the model and to assist in development of the model

- Tuesday 15 May 2007 - Key CAA staff
- Wednesday 16 May 2007 - Aviation Industry Association (CEO)
- Wednesday 16 May 2007 - Airports Association
- Thursday 17 May 2007 - Ministry of Transport
- Tuesday 5 June 2007 - Industry stakeholders
- Wednesday 6 June 2007 - Gisborne Stakeholders
- Thursday 7 June 2007 - Gisborne Stakeholders
- Friday 8 June 2007 - Key CAA staff
- Thursday 28 June - CAA staff, industry representatives
- Thursday 2 August - Key CAA staff
- Friday 3 August - Industry representatives

Full details of the scope of the meetings and attendee lists can be found at R2A Paper 3.

4.4 Description of the Risk Model Developed

The aerodrome airspace movement collision risk model is an estimative risk model that demonstrates the change in risk for the addition or removal of different control options. It is designed to determine the change in risk for the various control options both at the loss of control points and in terms of an annualised estimate of persons at risk.

The costs of the controls are to be determined by others at a later date. The decision to implement or remove controls would be made as a result of a cost/ benefit analysis of any

proposal. This would have to take both safety and business case aspects into consideration. (R2A Paper 4.0)

4.5 Risk factors identified

Generic threats and complexity factors were identified. They are discussed in detail in the R2A Paper 4.1 through 4.4 however examples of key characteristics are:

- *Threats*
 - Change to action plan
 - Fatigue, inadequate skills etc
 - Considered action creates another conflict and
 - Sudden weather change
- *Complexity factors*
 - Terrain
 - Other aviation activities
 - Multi runway operations and
 - Speed differentials at aerodromes.

4.6 Threat Barriers Identified

For aerodrome airspace users there appear to be only three main barriers to mitigate the risk of a collision. They are; preparation and execution of a movement action plan, maintaining separation either by a 3rd party or by the actual user, and evasive action.

The various generic controls outlined in section 5.3 enhance these three main barriers. For example, the movement action plan can either be provided by a 3rd party including ATC or developed by the user. An aerodrome airspace user will use such tools as pre-flight information, airspace classification information and local rules to determine the appropriate action plan for a particular aerodrome.

Separation can either be provided by a 3rd party including ATC or by the airspace user. An MBZ, CFZ or TCAS display provides information to the user to achieve self-separation which enhances the base case of see-and-avoid.

Evasive action including a TCAS resolution advisory is the last barrier prior to the loss of control point (R2A paper 4.4.2).

4.6.1 Evaluating Effectiveness of Threat Barriers

The effectiveness of threat barriers is discussed in R2A Paper 4.4

4.7 Generic Model

The generic model provides a platform for location specific analysis of aerodrome airspace

risk. It contains base data and works via analytical techniques to establish levels of risk.

4.7.1 Media

The aerodrome airspace collision risk model has been developed as an excel workbook. The template model is made up of 12 sheets consisting of a summary page, a collision consequence page and one page for each of the 10 aerodrome airspace classes.

It is expected that for each of the aerodrome airspace classes at a particular aerodrome, one sheet will be completed. The sheet will initially be completed by users of that particular class and is then expected to be peer reviewed by each of the other aerodrome airspace class users at that aerodrome (and ATC, if present). Each sheet consists of two tables, the first for the main threat sequence of having to change their action plan due to a conflict craft and the second for the identified secondary threats. Data input requirements have been highlighted by the blue cells. All other cells in the model are calculated (R2A Paper 5.1/5.2).

4.7.2 Limitations of the Model

The model has some limitation as noted briefly below:

- The model is peculiar to time and place and the class of user. It represents a snap shot of the perceived risk at a particular aerodrome at a particular point in time by the collective stakeholders at the aerodrome;
- The model is silent on collision risks with terrain except in so far as terrain causes increased complexity by 'forcing' other craft in common traffic zones or patterns as estimated by the class users;
- The model does not consider special military operations. Military craft operating under civil aviation rules are expected to be covered by the aerodrome airspace user classes defined in R2A Paper 4.2; and
- ATC failure has not specifically been considered in the model. That is, the possibility that ATC could direct two aircraft to the same place at the same time creating a conflict (R2A Paper 6.4).

5. APPLICATION OF THE RISK MODEL

The generic risk model is an important part of an overall risk management system. It must however be supported by a range of institutional processes such as procedures to monitor for changes in aviation activity and advice to assist non specialists in use of the model.

5.1 The Aerodrome Airspace Change Process

The risk model is the core of the aeronautical study but for it to operate effectively; several other components must be in place. They include triggers which alert operators and regulators to the need for a study, a process to manage the study, data gathering, implementation and monitoring.

Discussions with CAA and other stakeholders confirmed that they not only need a robust and transparent risk model but also a process to identify emerging risks and mechanisms to initiate and manage an aeronautical study. The review of international good practice for the management of aerodrome airspace risk identified several options which are in use overseas. These models and practices form the basis of the model discussed below. In addition, CAA has published some guidance on the conduct of aeronautical studies in Rule 157.9. Also, if New Zealand moves to the use of safety management systems for aerodromes, the process discussed below may become part of that overall safety management system.

Canada and the United Kingdom both have sound aeronautical study models with Canada having significant experience (estimated at least to be 50 aeronautical studies) closely aligned to those which may be required in New Zealand. The aeronautical study of Cambell River (British Columbia) is a good example of this approach. The draft of Australia's CASR Part 71 (Manual of Standards) refers to an aeronautical study methodology published in Advisory Circular 71-1(0) which is similar to the Nav Canada model and is consistent with AS/NZS 4360.

The major States reviewed have multiuse processes in place which govern the conduct of aeronautical studies. The Canadian model (based on Risk Standard Q850) uses a six step process:

- Initiation;
- Preliminary analysis;
- Risk estimation;
- Risk evaluation;
- Risk control; and
- Action/monitoring.

Once the aeronautical study has been completed it may be reviewed by the regulator prior to implementation. In Canada, the Board of Nav Canada review aeronautical studies before they are passed to Transport Canada for a final review.

The UK approach has several useful additional checks and balances.

For instance, in the UK DAP 724, Appendix 2 states:

“Stage 5 - Regulatory Decision

16. *The Regulatory Decision stage is made up of two phases. Initially, Directorate staff*

would check documentation to ensure all the required elements specific to the Proposal are included in the submission to the Directorate. The Change Sponsor will be informed and asked to provide the outstanding documentation if necessary. The proposal will not progress to the second phase (the Case Study) until the Directorate has confirmed receipt of all outstanding proposal information.

17. Once the proposal has been assessed for completeness, it will progress to the Case Study, the purpose of which is to allow the Directorate the opportunity to satisfy itself that the proposal is justified and meets all the necessary requirements.

18. During this stage, the Directorate will scrutinise and assess the content of the proposal against the Proposal Requirements in detail. Should the detail within the proposal be considered insufficient, a request for supplementary information will be submitted to the Change Sponsor, stipulating the timescale in which a response must reach the Directorate so as to facilitate the earliest resumption of the Case Study. In such cases, this could result in delaying implementation of the proposed change. .

19. On completion of the Case Study, the Director, Airspace Policy, will reach a decision to accept or reject the proposal. The Directorate shall provide a regulatory decision within a total time of 16 weeks from the confirmation of the documentation check.

20. The Change Sponsor will be notified of the regulatory decision to approve or reject the airspace change proposal. The Directorate will publicise its regulatory decision in the form of a press release (ideally in conjunction with the Change Sponsor).”

The CAA may therefore need to consider a process whereby a regulatory decision can be made on the results of an aeronautical study. This may not be necessary in all cases but for example, any review which recommends a change to a category of airspace would need regulatory action. Processes, and examples of cases where a regulatory decision may be necessary, are discussed at section 7.6.9.

5.2 Service Options

Overseas administrations have several options available to them to address risk in aerodrome airspace as per Table 1. They are barriers which may be used in the model to address threats and risks.

The service options detailed in Table 1 are the barriers available to mitigate threats when using the aerodrome risk model.

5.3 Structures to Manage Aerodrome Risk

As previously discussed, all stakeholders have a part to play in managing aerodrome airspace risk. However the aerodrome operator plays a key role. If for example there is a change in aviation activity such as a new type of activity at an aerodrome which could affect the existing level of risk, the aerodrome operator should have processes in place to identify and quantify the change.

Table 1

International Comparison of Service Options for Aerodrome Airspace

State	EC/Eurocontrol (enroute entity only)	UK	Canada	Australia	United States of America
ATC Tower (Class C)	N/A	Y	Y	Y	Y
ATC Tower (Class D)	N/A	Not Found	Y	Y	Y
ATC Tower (Class E)	N/A	N	Y	Y	Y
AFIS (Licensed FIS)	N/A	Y	Y	Y	Y
CAGRS (Certified FIS)	N/A	N	N	Y	N
Unicom (3 rd Party no FIS)	N/A	N	Y	Y	Y
CTAF (Radio Required)	N/A	Y	Y	Y	Y
CTAF (Radio Optional)	N/A	N	Y	Y	Y
Procedures & local agreements	N/A	Y	Y	Y	Y
G Airspace IFR/IFR Traffic, known VFR traffic	N/A	N	Y	Y	?

The regulator has an ongoing responsibility for the safety of the aviation system as a whole. From the regulator's perspective, there are two distinct aspects. Firstly, there is the need for ongoing processes to monitor risk in the aviation system and secondly, arrangements for the management of an aeronautical study at a specific location after the need for such a study has been identified.

The responsibility may differ at aerodromes where ATS is provided as it is reasonable to assume the ATS service provider will play a large part in managing airspace risk. At large international airports the responsibility may rest almost entirely with the ATS service provider.

5.4 Monitoring of Aerodrome Airspace Risk

The management of aerodrome airspace risk requires ongoing monitoring to identify significant changes which may require further study or action. As a matter of due diligence an aerodrome operator, or the provider of air traffic services when they are present, should have processes place to:

- Establish the current risk level for operations in the aerodrome's airspace;
- Meet their due diligence obligations by evaluating options for reducing that risk (cost benefit);
- Have processes in place to monitor changes and emerging risks such as :
 - Growth in aviation activity;
 - Significant changes in the type of operation (such as the introduction of jet services);
 - Feedback from compliance audits;
 - Trends in aviation safety incidents; and
 - Analysing reports from concerned operators.

It is possible that aerodrome operators do not have access to all of the above data and it may be necessary to ensure data is made available to the operator. An approach already in use at some aerodromes is the formation of an operational safety committee, usually facilitated by the aerodrome operator, which includes all major operators at the aerodrome. This committee should meet regularly to identify emerging risks and possible solutions. They should provide the aerodrome operator with advice on safety trends which the aerodrome operator should act on.

The regulator also has the statutory responsibility to monitor the safety health of the aviation sector. It must have processes in place to monitor aerodrome airspace, identify potential risks areas and to provide infrastructure support: It should work cooperatively with aerodrome operators to address issues it identifies as potential safety threats through:

- Ongoing monitoring of aerodromes for changing or emerging risks :
 - Reviewing aviation activity level changes;
 - Using intelligence from compliance audits;
 - Aviation safety incident reports; and
 - Verified reports of safety concerns from concerned parties in the aviation industry
- Development, and propagation of documents defining the processes to be followed in the management and assessment of aerodrome airspace risk;
- Training of CAA staff and industry members in the preparation of aeronautical studies;
- Establishment of CAA/industry consultative forums such as Hazops committees. These might take the form of local operator safety forums. Models which may be appropriate are in place at locations such as Ardmore, Queenstown and Taupo. CAA Field Advisors could be used as ex-officio members of the committees to provided guidance and support.

A diagram depicting a possible process to monitor specific locations is attached at Appendix 7.

5.5 Base lining of Aerodrome Airspace Risk

An estimation of the current airspace risk at New Zealand aerodromes may be useful in identifying those that need urgent examination. When this has been completed, there will be a need for an ongoing monitoring programme using appropriate triggers to identify any changes to the risk levels

The CAA has developed an aerodrome complexity evaluator (“ACE”) which could be used to produce an initial priority table of aerodromes which may require an aeronautical study. The Aerodrome Complexity Evaluator attempts to quantify, for individual aerodromes, the complexity of the environment for a pilot. The underlying assumption is that there is a direct correlation between complexity, pilot workload, and ultimately, the need for services that assist the pilot. The system considers a number of key factors contributing to complexity, such as traffic density, airspace and traffic diversity, and grades each according to the conditions prevailing at the aerodrome. The resulting indices take into account how the various factors may differ for VFR and IFR operations, and also allows the effect of air traffic services to be assessed.

ACE may also be a tool for ongoing monitoring.

The assessment of aerodrome airspace risk at New Zealand aerodromes should be a three step process:

- a. Agree in consultation with Airways Corporation those aerodromes where it can reasonably be assumed Airways take prime (but not sole) responsibility for managing airspace risk. In the view of the study team this should include all aerodromes where Airways provide an ATS.
- b. Identify those aerodromes where regular air transport aircraft operations do not occur. These aerodromes do not carry a significant public risk and, in the view of the study team, can be excluded unless the public risk materially changes.
- c. Prioritise the remaining aerodromes in order of perceived level of concern. This could be done by:
 - Surveying users and other stakeholders;
 - Applying ACE;
 - Reviewing incident reports and audit findings; and
 - Determining if certain activities known to present a higher level of airspace risk exist at the aerodrome, e.g. parachute dropping, extensive NORDDO operations.

A diagram depicting a possible process to prioritise locations is attached at Appendix 7.

5.6 Development of Documentation on the Preparation of Aeronautical Studies

It will be essential for CAA to develop acceptable means of compliance and/or guidance material on how to conduct, prepare and present aeronautical studies relating to aerodrome airspace risk. This would include a detailed explanation of the relative risk model. This documentation, best provided in the form of an Advisory Circular, should be sufficiently comprehensive that the manager of a small aerodrome can, together with a risk adviser, prepare a robust study which can be reviewed by the CAA without the need for extensive changes.

Similar AC material exists for the preparation of aerodrome expositions and obstruction surveys although in the case of aerodrome airspace risk more technical data on risk may be necessary.

This AC could most readily be developed as part of the first application of the model through documentation of the process from the selection of the initial aerodrome to the completion of the aeronautical study.

5.7 Training

It may not be necessary for individual aerodrome managers to be trained in the preparation of aeronautical studies as this is not a task any one manager would be performing regularly. An appreciation of the purpose, scope, preparation and content of a study would be worthwhile but it is probably sufficient to provide this in the guidance material.

CAA staff will need training and again this could best be provided by “hands on” involvement in the preparation of the initial study or studies. Although the primary responsibility to prepare a study rests with the aerodrome operator it is envisaged that a participative and open approach would be taken that would include CAA. Longer term CAA participation in the preparation of a study may be normally via the local Flight Safety Adviser, but initially could include Aeronautical Services staff.

5.8 Location Specific Aerodrome Airspace Management

When it is decided that an aeronautical study is needed at an aerodrome the first question is, who does it? A study and the associated risk modelling require a reasonable level of familiarity with the evaluation system and a good understanding of airspace management. Some aerodromes may have this expertise and may wish, with the assistance of guidance material such as an Advisory Circular, to undertake the exercise themselves. Others may wish to manage the process but contract risk professionals to undertake the technical aspects. Some however may feel that they do not have the necessary background and may ask CAA to do the study on their behalf. Given the transparency of the model if the process is followed, all of these options are feasible.

6. THE CANADIAN MODEL

Aeronautical studies are conducted in accordance with Canadian Risk Standard Q850.

They begin with the issuance of formal terms of reference (see Review of Air Navigation Services Mackenzie River and Liard River Areas of the Northwest Territories) then follow a standard process:

Consideration of all relevant factors, including traffic volume, mix and distribution, weather, airport role, airport and airspace configuration, surface activity and the efficiency requirements of operators using the service. The scope of studies can range from minor adjustments to airspace boundaries to an examination of the impacts of replacing an airport control service with another form of service, introducing a new service, or terminating a service completely.

The above is a comprehensive framework that involves full consultation with those affected by changes to air navigation services so that all potential effects of a proposed change on those who use the services can be fully understood.

Consultation with stakeholders formally occurs following the preliminary analysis phase when issues and impacts of a proposed service change are reviewed. However stakeholders may share their views and concerns at any time during a study. Consultation helps confirm or disprove assumptions made during the preliminary analysis and validates customer issues.

The aeronautical study process provides a systematic methodology for analysing complex issues using a risk management approach. Risk analysis includes the identification of exposures to risk, and the identification and evaluation of alternative strategies for reducing or eliminating losses. Perception and communications issues that affect risk decisions are also fully assessed.

Once an aeronautical study is completed, it is forwarded to Nav Canada's senior management and the Board of Directors for approval. The Ministry of Transport reviews Nav Canada's aeronautical studies as per section 806.02 (2) of the Canadian Aviation Regulations, to assess "whether the risk to aviation safety would be unacceptably increased by a proposed termination or reduction in the level of air navigation service".

An aeronautical study consists of a six-step process: initiation, preliminary analysis, risk estimation, risk evaluation, risk control and action/monitoring. How this could apply in the New Zealand context is described below.

7. PROPOSED NEW ZEALAND MODEL

7.1 Step 1: Initiation

Given that a concern such as a significant change in aviation activity has been identified through the ongoing monitoring processes, an aeronautical study will be initiated.

The initial step is based on the of the initiation phase in the Canadian model:

- The proponent¹ develops a Terms of Reference for the aeronautical study;
- Discusses and agrees the Terms of Reference with the CAA; and
- CAA agrees with the proponent on a point of contact for the aeronautical study.

7.2 Step 2: Analysis & Risk Evaluation

Actioning of the aeronautical study. This is the equivalent to steps 2 through 5 in the Canadian model:

- The core of this process is the application of the risk model;
- Undertaking a cost benefit analysis using the output of the risk model and an independent estimates of the costs involved; and
- Production of a report with recommendations.

7.3 Step 3 Action & Monitoring

Actioning of the recommendations. Equivalent of step 6 of the Canadian model:

- Report reviewed by CAA technical experts. The review should concentrate on compliance with the published process and the adequacy of the evidence used;
- The CAA requests any evidence, clarifications or further analysis it considers necessary;
- The CAA meets with the proponent and any other interested parties to discuss the draft recommendations. The proponent and/or other interested parties could make any dissenting view known;
- If any changes are necessary to the certification of the aerodrome, the Director makes a decision based on the above evidence. The Director may wish to put conditions (such as annual reviews) in any such approval; and
- Ongoing monitoring of the location.

A diagram depicting a possible aeronautical study process is attached at Appendix 7.

¹ *The proponent is the party initiating the study. Normally this would be the aerodrome operator, but it could be the ATS provider or the CAA itself*

7.4 Initiation of an Aeronautical Study

When an aerodrome has been identified as requiring an aeronautical study, formal terms of reference will be developed by the proponent. The terms of reference should address the following:

- Purpose, description of the objectives of the study;
- Scope, what will be studied and outputs to be produced;
- Methodology;
- Human Resources, resources required including description of skills and experience;
- Work Plan, may be developed at the initial team meeting;
- Aeronautical study team members, nomination of individuals to undertake the project, skills and experience should match requirements of Item 5 above;
- Consultation, list of stakeholders to be consulted; and
- Who will make the decision on implementation of any recommendations arising from the study?

The terms of reference will then be passed to the CAA for agreement. When agreed, the proponent will initiate the next step of the aeronautical study process.

CAA will nominate an officer as the primary contact point for the study. If the study is complex, a CAA team may be required to oversee the study.

7.5 Consultation Process: Stakeholders to be Included

All overseas administrations studied in this review placed great importance on consultation with industry stakeholders. Many found consultation with the broad spectrum of general aviation interests challenging. Consultation takes place at both national and local levels and is seen as vital to the acceptance of the outcome.

New Zealand has several peak aviation bodies with which it can consult (AIA, AOPA and the Aerodrome Association). Such bodies will be involved in consultation over the aeronautical study methodology and may wish to keep a watching brief over individual studies on behalf of their members. However, they may not need to be formally involved in the detail of each implementation.

The methodology under development by this project stresses the importance of consultation at national and local levels. The terms of reference document will identify stakeholders to be consulted prior to the commencement of the study.

It is essential to both the validity of the aeronautical study and the acceptance of its findings that consultation be as wide as reasonably possible. It is not envisaged that

consultation would involve the general public but would certainly involve:

- Regular air transport operators at the aerodrome;
- Local commercial fixed base operators such as helicopter operators, flying schools, aircraft maintenance organisations, parachute operators;
- Recreational operators such as aero clubs, private owners and gliders;
- Aerodrome owner(s) if distinct from the operator;
- The CAA, probably via the local Flight Safety Adviser;
- Airways Corporation, if providing or likely to provide an ATS at the aerodrome or if controlled airspace is in close vicinity to the aerodrome;
- The New Zealand Airline Pilots Association.

7.6 Using the Risk Model

With the terms of reference in place, the preliminary work of gathering data for the risk model can commence.

7.6.1 Data Requirements and Sources

Several data sets will be developed for use in the risk modelling. They will be derived from several sources, in particular, key stakeholders as discussed below.

7.6.2 Expert Judgement Panels

The aerodrome airspace collision risk model has been developed through consultation with the stakeholders and reflects their views regarding aerodrome airspace collision risk. It assumes a generative approach with aerodrome airspace class users as, to be successful, it requires the constructive and robust input from users (R2A Paper 6.0). If aerodrome safety committees are established, they may form a nucleus of expertise which can be drawn upon.

In this context “a generative approach” is one where the experts or facilitators do not impose their views on the local operators but rather help them come to an agreed position on the actual threats at the location.

7.6.3 Data Inputs to the Model

The following section summaries the key data inputs for the model. An explanation of all inputs is included on the Jet sheet (page 3) in the template

model as attached in R2A Paper Appendix E.

Each of the aerodrome airspace classes is required to enter the number of entry, exit and transit movements per year at the aerodrome under consideration. A success probability for each of the barriers (barrier effectiveness) relevant to that particular class is then determined for each of the aerodrome airspace entry, exit and transit movements. It is noted that if ATC is not present then the success probability is zero (default value).

The aerodrome airspace operational loss of control is then determined by summing the contribution of all the threat scenarios and barriers. This is an estimate by the aerodrome airspace classes of the likelihood (per annum) that two craft will be in a conflict situation that requires one craft to take evasive action.

The collision envelope loss of control is then calculated by multiplying the aerodrome airspace loss of control point total by the evasion barrier failure probability. This is an estimate by the aerodrome airspace classes of the likelihood (per annum) that the collision envelope of one craft will touch another craft.

Based on previous risk work in the aviation industry the ratio of misses to collisions for jets is between 99 and 999 to 1. Taking this chance (or luck) barrier into consideration, the likelihood of a collision can then be determined (R2A Paper 5.2).

The consequence of two craft colliding depends on the class of aircraft involved. For the collision, the model assumes that both craft are fully loaded with the maximum number of persons on board and all person on board are at risk. For example, if two jets collide with a maximum capacity of 145 then 290 persons are at risk. This calculation is completed on sheet 2 of the template workbook.

7.6.4 Data outputs from the model

The model estimates three key values; the aerodrome airspace loss of control point, the loss of control point of the collision envelope of one craft touching another craft and a value for persons at risk. The values from the calculation completed based on representative data for Timaru Aerodrome (see R2A Paper Appendix D) appears not inconsistent with other collision risk work by CAA (R2A Paper 5.3).

7.6.5 Preliminary findings

The model calibration using some Timaru data (see Appendix D of the R2A Report) suggests that the results are consistent with other CAA studies.

7.6.6 Consultation with Stakeholders

Detailed consultation at the location would be by way of generative interviews with individuals then workshops to the whole stakeholder group. The generic model would be used to assess baseline risk at the location under existing operations. After suitably calibration, the workshops would identify the change in risk brought about by the change in aeronautical activity. The effect of the introduction of appropriate threat barriers would then be estimated.

Full details of the interviews, views expressed and the debate at the workshop would be included in the completed aeronautical study.

7.6.7 Implementation

Section 8 of this report provides a possible implementation programme which CAA may wish to consider.

7.6.8 Regulatory Impact Statement

Some jurisdictions (including Australia) require a Regulatory Impact Statement (RIS) to be developed prior to a decision to introduce or amend regulations. A RIS discusses issues such as: current assessed risk levels, the shift in relative risk, stakeholder views as to whether there needs to be a risk response, if so what mitigation options are available and their likely impact (on airlines, charter operations, sports and recreation bodies, airport managers, the surrounding community, costs and benefits, implementation strategy, and compliance monitoring.

7.6.9 The Regulatory Decision

When the aeronautical study is complete, it may be necessary for the CAA to review it then make a regulatory decision on its implementation. This may be required in the following situations:

- CAA has specifically required a study to be conducted;
- the study has been initiated because some trigger level has been exceeded; or
- the study recommends a reduction in the current level of ATS provided;
- any change to the categorisation of airspace; and
- any proposal requiring a change to the AIP.

In such cases the proponent of the aeronautical study would provide CAA with the study for review. CAA would:

- assess the study against the terms of reference;
- assess the study against the published process;
- review the evidence presented for completeness; and
- request any additional evidence or information it considers relevant.

CAA would then provide the proponent with an assessment of the study, and allow the proponent and other interested parties to make submissions on the assessment.

The Director would then make a regulatory decision based on all the evidence available to him.

In other situations the proponent would forward the study to CAA for information prior to implementing the recommendations.

7.7 Users Guide

As previously discussed, it is recommended that an Advisory Circular be developed as a guide to users. It should explain both the institutional arrangements and the model itself. An explanation of all inputs is included on the Jet sheet (page 3) in the template model as attached in R2A Paper Appendix E.

7.8 Case Study Review

Two model development studies were undertaken. The first, Gisborne involved on-site interviews with stakeholders and developed the preliminary model. The second, a desk-top study of Timaru, was used to develop the generic model and test the concepts. A full on-site study at a suitable location is suggested prior to a full roll out of the aerodrome airspace risk assessment system.

7.8.1 Gisborne

With the assistance of local stakeholders, threat scenarios and threat barrier diagrams were developed. Possible barriers were then explored. A full description of the Gisborne study is at R2A Paper Appendix C.

The following outcomes were identified:

- Once the legal loss of control is reached and the collision envelopes of two aircraft touch, there are only two possible outcomes modelled. Either there is a near miss or a collision with fatalities expected;
- With the 10 user groups currently identified, up to 55 collision pair types are possible. With 5 user groups (an expected number for regional

airports) 15 collision pair types are expected; and

- In the first instance the fatalities per collision pair will be assessed on the maximum persons on board for the aircraft types. The ratio of the collision pair types will be initially determined by the ratios of the annualised movements of the types of aircraft and activities as reported by the airspace user groups (R2A Paper Appendix C 5.4).

7.8.2 Timaru

The Timaru model development review built on the Gisborne work and is described in the R2A Paper 3.4. Representative aerodrome airspace movements for aircraft user classes were used with relevant barrier success probabilities. The preliminary results are shown as Appendix D of the R2A Report. This enabled the completion of the generic model developed at Gisborne by R2A and provided a reality check on the utility of the results the model may provide. The feeling of that workshop was that the model seemed to 'make sense'.

8. IMPLEMENTATION AND TRANSITION

This project has developed a generic model for identifying aerodrome airspace relative risk. The model is the core of an aerodrome airspace aeronautical study and is given effect by carrying out a study. To implement the model several additional steps are required:

- Acceptance by CAA of the proposed aeronautical study process described in this report as well as the model itself;
- Development of an industry discussion paper outlining the proposed aeronautical study process and the risk model. In particular the paper should address potential areas of industry concern such as CAA review and the responsibilities of the proponent;
- Development of guidance material, through the preparation and issue an Advisory Circular;
- Training of key staff in CAA and industry; and
- Amendment of CAA Rules as discussed in section 9.1 below.

9. CONCLUSION AND RECOMMENDATIONS

The supporting processes and the aerodrome airspace risk model described in this report address the due diligence obligations of key stakeholders and propose a process which is both transparent and draws on the expertise of those operators with the most intimate knowledge of operations in the airspace in question. There will often be a debate over the practical needs of operators and the statutory requirements of the regulator. Such issues

are best resolved by open and constructive consultation.

While in most cases the aeronautical study would be undertaken or managed by the aerodrome operator, there may be occasions where the aerodrome operator may wish CAA to undertake the study on their behalf. CAA must also reserve the right to conduct a study or have the aerodrome operator conduct a study if they have valid safety concerns and Rule 139 may need amendment to address this.

There is a raft of options that may be used as barriers to counter threats in aerodrome airspace. They range from local procedures through to the introduction of air traffic control. The proposed model is based on the solution being commensurate with the risk.

9.1 Legislation and Policy

As discussed in the CAA Policy Paper (2005) and reviewed in Section 3 of this report, there are gaps in Rule Part 139 whereby the Director does not have authority over an aerodrome unless it is certificated. There are also no agreed trigger points or means of assessing risk. In the short term the approach proposed in this report, which relies extensively on consultation, should minimise the potential for disputes. However, amendments to Rule 139 should be considered as a means of formalising the situation.

Rule 139.113 is written in terms of the provision of an ATS. A more flexible approach which allows for other solutions that provide an appropriate response to the level of risk would be more practical.

Rule Parts 12 or 139 do not require an aerodrome operator to provide aerodrome movement data to the regulator. Such data is essential to effective regulatory oversight.

Rule Part 12 limits the requirement to report airspace incidents to a Part 172 certificate holder. There is no requirement for an aerodrome certificate holder to report any airspace incidents of which the operator may become aware. This places total reliance on pilots to report as aircraft incidents any aerodrome airspace incidents that they may be involved with at aerodromes where an ATS certificated under Part 172 is not provided.

It is suggested that CAA consider amending Rules and policies to reflect the following recommendations:

Recommendation 1

The CAA considers reviewing their Rule 139 and the supporting policy to make aerodrome operators the primary proponents of aeronautical studies. This may be by including it in the requirement for Safety Management Systems such that managing aerodrome airspace risk becomes part of an aerodrome SMS unless ATS is in place at the airport.

Recommendation 2

That the CAA consider amending Rule Part 139 to provide the Director with the authority to require any aerodrome operator to prepare an Aeronautical Study on the aerodrome's airspace risk if, in the opinion of the Director, there are factors or evidence that reasonably suggest operational risks exist at that aerodrome that require management by the aerodrome operator.

and

provide the Director of Civil Aviation with a reserve power to undertake or commission an aeronautical study if there are verified safety concerns for that aerodrome airspace.

Recommendation 3

The CAA considers reviewing the criteria in Appendix I of the CAA Policy paper to provide a broader method of establishing if an aeronautical study is required, and publishing these criteria in an Advisory Circular

Recommendation 4

If the CAA wishes to make use of target levels of safety in some situations, it considers adopting those used by overseas as discussed in Section 2.1.6.

Recommendation 5

That CAA considers adopting a graduated response to the management of aerodrome airspace risk. There should be an examination of the full range of options to address an identified risk with ATS implementation reserved for the higher risk areas.

Recommendation 6

That CAA considers developing and publishing guidance material for the conduct of an aeronautical study to assess the level of aerodrome airspace risk.

Recommendation 7

That if not already in place, the CAA considers establishing by means of ACE, user surveys, consultation with bodies such as NZALPA, review of occurrence data, assessment of known risk factors, or a combination of all, a shortlist of aerodromes where aerodrome airspace risk warrants the preparation of an Aeronautical Study. This would require the development of the list, consultation with the industry on the list, a process to review the list (including changes to it) at regular intervals and formal advice to the Director on emerging safety concerns.

Recommendation 8

The CAA considers amending the Rules to require aerodrome operators (whether certificated or not) to collect appropriate movement statistics and provide them to CAA.

9.2 Initiation and Conduct of an Aeronautical Study

Recommendation 9

The CAA considers making the use of Terms of Reference (similar to those used in Canada) an integral part of an aeronautical study.

Recommendation 10

The CAA considers requiring aerodrome operators to establish an aerodrome airspace safety committee (where one does not already exist) to assist in the identification of emerging risks and processes to manage such risks.

9.3 The Next Steps

This report provides the basis for the implementation of an aerodrome airspace risk model in New Zealand. It is suggested that the following steps should be undertaken (not necessarily in the order shown):

1. CAA reviews their aerodrome airspace policy and issue a discussion paper to industry. This paper will outline the updated policy and the overall methodology to be used to evaluate aerodrome airspace risk.
2. Conduct an initial aeronautical study to trial the process and model. This would probably be more effective and efficient if it is conducted at a location where there is no controversy. This exercise will also provide a training opportunity for CAA staff and industry representatives.
3. Building on the experience gained in Step 2 above, issue an Aeronautical Circular defining the process and providing guidance in its application.

APPENDIX 1

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APPENDIX 1: References

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APPENDIX 2

Aerodrome Airspace Project Plan

APPENDIX 2: Aerodrome Airspace Project Plan

***CIVIL AVIATION AUTHORITY OF NEW
ZEALAND***

***DEVELOPMENT AND PROPOSAL OF
STANDARDS AND PRACTICES FOR THE
MANAGEMENT OF AERODROME AIRSPACE
RISK***

Project Plan

16 May 2007



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Melbourne

Sydney

Malaysia

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1.0	Final – Project Plan	16/5/07	R. Graham	B. Jackson

CONTENTS

1 INTRODUCTION 1
2 BACKGROUND 1
3 INITIAL DISCUSSIONS AND CONTRACT FINALISATION 2
4 PROPOSED PROJECT PLAN 2
5 STAKEHOLDER CONSULTATION 4
6 CONSULTATION GROUP 4
7 SCHEDULE 5
8 FINAL REPORT 6

1 INTRODUCTION

The Civil Aviation Authority of New Zealand (CAA) issued a Request for Proposal to develop and propose standards and practices for the management of aerodrome airspace risk on the 26th of February 2007. The Ambidji Group Pty. Ltd. responded to the Request for Proposal and was selected as the successful tenderer.

2 BACKGROUND

The project scope as defined in the CAA Request for Proposal is as follows:

- Development of a detailed project plan
- Review of current policy for the provision of ATS at aerodromes and amendments as necessary to reflect the project objective
- Determination of acceptable levels of aerodrome airspace safety
- Determination of aeronautical study methodology
- Development of aeronautical study “triggers and/or filtering tools or models, and
- Validation of the proposed process through the conduct of an aeronautical study.

In their response to the CAA Request for Proposal, Ambidji proposed a five phase project with the following deliverables:

- Phase 1 (Research Phase)
 - Deliverable 1 Project Plan/Briefing Sheet on all findings and stakeholder issues
- Phase 2 (Comparative Analysis)
 - Deliverable 2 Briefing paper on existing models highlighting strengths and weaknesses of each model and its suitability for deployment within the New Zealand regulatory environment.
- Phase 3 (Development of Aeronautical Study Methodology)
 - Deliverable 3 Presentation of preliminary model for CAA review
- Phase 4 (Model Validation and stakeholder presentation)
 - Deliverable Draft aeronautical study
- Phase 5 (Final Review and Presentation)
 - Deliverable 5 Presentation of final review and agreed model.

3 INITIAL DISCUSSIONS AND CONTRACT FINALISATION

Following notification that they had been selected as the successful tenderer, preliminary discussions took place between CAA and Ambidji. As a result of these discussions it was agreed that:

- Ambidji would review its proposal to ensure that resources were focussed on extensive and meaningful consultation with stakeholders
- The project would kick off in Wellington on 15 May 2007 with an initial briefing of the process with CAA executives and legal representations. Follow up work will continue for the remainder of that week
- It was agreed that Government, the Ministry of Transport and the Authority are aware of the project and that a specific briefing was not required at this stage
- The primary direct consultation with stakeholders will take place in New Zealand during the week commencing 4 June 2007
- CAA will consider forming a small advisory Steering Group. This group will ensure ongoing visibility and provide industry comment on the effectiveness of the model.

At the initial meeting and subsequent contract finalisation meetings it was agreed that:

- The “due diligence” approach to aerodrome airspace risk management would be used
- Gisborne aerodrome would be used as a development site. It was suggested that Taupo aerodrome should also be examined as a validation site
- CAANZ will consider forming a small stakeholder consultation group
- The CAANZ project sponsor is Graeme Harris
- CAANZ staff Terry Curtis, Merv Falconer, Alan Roberts and Mike Haines will be involved in the project
- CAANZ will provide their complexity model and Gisborne specific data.

4 PROPOSED PROJECT PLAN

Based on the proposal request and response as well as the subsequent discussions between Ambidji and CAA, the following tasks are proposed in order to deliver the 5 phases outlined in section 2.0 above:

- Development of a briefing paper prior to the initial inception meeting (15 May 2007). This will outline the different aerodrome risk management process currently being used around the world. Based on this initial desktop review, the proposed process to

be adopted for the aerodrome airspace risk review for New Zealand will be outlined, highlighting how the Civil Aviation Authority can demonstrate diligence if it adopts such a process.

- The initial inception meeting between CAA and Ambidji in Wellington will continue for the remainder of the week to allow:
 - Briefing of CAA executives and legal representatives on the proposed review methodology including explanation of the appropriateness of threat barrier diagrams in demonstrating due diligence. It is essential that CAA understand and accept this approach
 - CAA to brief Ambidji on the history of aerodrome airspace risk management in NZ and their expectations of the project
 - Discussion on a graduated approach to airspace risk and identification of internationally recognised good practice control solutions. For instance alternatives such as procedures or MBZ could be considered as mitigators prior to consideration of ATS
 - Planning for consultation with industry and preparation of a draft list of interested parties
 - Discussion and determination of the location of the validation trial
 - Finalisation of the project schedule
 - Preparation of a generic list of aerodrome hazards and good practice aerodrome control options such as ATC, Flight Service, Certified Air Ground Radio Services, MBZs, unicoms and CTAFs.
 - Initial meetings with CAANZ staff, AIA and NZAA.
- During the week of 4 June, it is proposed that initial briefings be given to key stakeholders. Key stakeholders will be invited to a consultation meeting in Wellington. This briefing will give them an overview of the proposed strategy and an opportunity to make any comments they wish.
- The remainder of the week will take place at the selected trial location. It is suggested that the initial model should be developed for this location. This will be done in two parts :
 - The first will be a series of generative interviews with the various relevant stakeholders to collect information regarding the issues at the selected trial location and more importantly existing controls and possible additional controls that can be considered to mitigate the identified hazards. We would expect the relevant stakeholders for this part of the exercise to generally be location specific
 - Secondly, stakeholder input will be brought together and a preliminary model developed. This preliminary model will then be presented to stakeholders at the end of the week.
- R2a and other project staff are happy to work out of hours if this can make the consultation process more effective by capturing a wider group of stakeholders.

This process will provide a sound basis to further develop the model on a generic basis and allow an initial expert calibration of trials, barrier effectiveness and outcomes. It is then expected that the generic model will be presented to stakeholders.

In addition, a hazardous scenario completeness check will also be done to confirm that all

credible, critical hazards have been identified. Information will be collected from history, arrivals and departures mapping and generative interviews with key stakeholders.

Further consultation with local interests will be undertaken as per the requirements of the model.

5 STAKEHOLDER CONSULTATION

Stakeholder consultation is a critical aspect in the development of a successful aerodrome risk model. Stakeholder identification will be undertaken in close consultation with the CAA.

As the Client and major stakeholder, some time will be spend with the CAA assessing its degree of risk exposure, scope for developing policy solutions, its internal capability for performing aeronautical studies using the methodology developed and other relevant factors.

The Ministry of Transport, representing the Minister as “owner” of the CAA rules must also be kept abreast of progress and emerging issues. The CAA will advise the project team when it wishes any briefing to take place.

In addition to the CAA, key organizations (as discussed above) are expected to include the Aviation Industry Association, Airways Corporation of New Zealand, Aircraft Owners and Pilots Association, representative pilot organizations, airport representative organisations and individual airports which are of particular interest. They will be contacted directly for their comments relating to the identification of specific aerodrome airspace risks and other safety threats as well as possible controls and mitigations.

Of particular interest are smaller airports that lack an ATS such as Taupo, Wanaka, Milford Sound (which has Flight service), Timaru, Kaikoura, Paraparaumu, Ardmore and the users of those airports. These airports may present a significant risk and, subject to resource constraints, may be visited so that the team can observe and validate the perceived risks first hand and also discuss these risks with local airport operators and airspace users in more detail.

In addition to the briefings outlined above, interested parties will consulted where necessary through follow up meetings and discussions on the section of the final report summarising the consultative process and conclusions reached.

6 CONSULTATION GROUP

CAANZ will consider establishing a consultation group with representatives from AIA, ALPA, NZAA for ongoing industry consultation after the project is completed.

7 SCHEDULEWeek by Week Activity Schedule

Week 1 May 14 - May 18

15/16	Meetings and Briefings CAA Wellington Discussions AIA, NZAA List of generic controls	BJ/RG/RR/GF/DP RG/DP/GF RG/DP/GF
17	Follow up meetings CAA if required Plan development	RG/DP RG/DP
18	Closing meeting CAA	RG

Delivery of project Plan (deliverable 1)

Week 2 May 21 - May 25

21/25	Good Practice Briefing Paper (deliverable 2) Contact National and local stakeholders Consultation session (5/6) agenda & background information	DP GF	RG/GF
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Week 3 May 28 - June 1

	Preparation for development site	RG/DP/RR/GF
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Week 4 June 4 - June 8

4	Queens Birthday	
5	9am – 1pm National Consultation session (Wellington)	RG/GF/RR/DP
6	Gisborne Consultation & Generative interviews	RG/GF/RR/DP
7	Model development and Industry presentation (pm)	RG/GF/RR/DP
8	Briefing and feedback to CAA Wellington (am)	RG/GF/RR/DP

Week 5 June 11 - June 15

15	Deliverable 2 to CAA Good Practice Paper (International Comparative Analysis)	RG
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	Deliverable 3 to CAA Preliminary model	RG
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Week 6 & 7 June 18 - June 22, June 25 – June 29

Write up of Aeronautical Study & Generic Model RR/GF

Week 8 July 2 - July 6

Develop draft final report RG/DP

6 Deliverable 4 to CAA Draft Aeronautic Study & generic model

Week 9 July 9 - July 13

Consultation with CAA and stakeholders (Wellington) RG/DP/RR/GF

Week 10 July 16 - July 20

16-20 Finalise Report & delivery to CAA RG/DP

20 Deliverable 5 to CAA Final Report RG

8 FINAL REPORT

A final report will be produced to complete the project. It will include an appendix containing the final validated methodology.

APPENDIX 3

Aerodrome Airspace Review Of International Practice

Deliverable 2

REVIEW OF INTERNATIONAL GOOD PRACTICE AND METHODOLOGIES FOR THE ASSESSMENT OF AERDROME AIRSPACE RISK

(Civil Aviation Authority of New Zealand)

Copy: Original



15 June, 2007



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Melbourne, Australia

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Table of Contents

EXECUTIVE SUMMARY	1
1. INTRODUCTION	2
2. BACKGROUND	2
3. SCOPE	2
4. SUMMARY OF METHODOLOGIES USED BY OVERSEAS ADMINISTRATIONS	3
4.1. INTERNATIONAL CIVIL AVIATION ORGANISATION	3
4.1.1. <i>Annex 11</i>	3
4.1.2. <i>Document 9426: Air Traffic Services Planning Manual</i>	4
4.1.3. <i>Document 9689 – Manual on Airspace Planning Methodology for the Determination of Separation Minima</i>	5
4.1.4. <i>Document 4444 – Procedures for Air navigation Services – Air Traffic Management</i>	6
4.1.5. <i>Summary of ICAO Characteristics</i>	7
4.2. EUROPEAN UNION (EU), EASA AND EUROCONTROL	7
4.2.1. <i>Outline of Regulatory Structure</i>	7
4.2.2. <i>European Airspace Policy</i>	8
4.2.3. <i>Consultative Arrangements</i>	8
4.2.4. <i>Procedures and Design Process</i>	8
4.2.5. <i>Summary of Key Characteristics</i>	9
4.3. UNITED KINGDOM (UK).....	10
4.3.1. <i>Outline of Regulatory Structure</i>	10
4.3.2. <i>National Airspace Policy</i>	12
4.3.3. <i>Consultative Arrangements</i>	12
4.3.4. <i>Procedures and Design Process</i>	12
4.3.5. <i>Summary of Key Characteristics</i>	14
4.4. CANADA.....	15
4.4.1. <i>Outline of Regulatory Structure</i>	16
4.4.2. <i>National Airspace Policy</i>	16
4.4.3. <i>Consultative Arrangements</i>	17
4.4.4. <i>Procedures and Design Process</i>	17
4.4.5. <i>Aerodrome Services Available at Uncontrolled Airports:</i>	18
4.4.6. <i>Trigger Points under the Canadian System</i>	19
4.4.7. <i>Aeronautical Studies</i>	19
4.4.8. <i>Other Studies</i>	20
4.4.9. <i>Summary of Key Characteristics</i>	21

4.5.	AUSTRALIA	22
4.5.1.	<i>Outline of Regulatory Structure</i>	22
4.5.2.	<i>National Airspace Policy</i>	23
4.5.3.	<i>Consultative Arrangements</i>	25
4.5.4.	<i>Procedures and Design Process</i>	25
4.5.5.	<i>Summary of Key Characteristics</i>	27
4.6.	UNITED STATES OF AMERICA – FEDERAL AVIATION ADMINISTRATION (FAA)	28
4.6.1.	<i>Outline of Regulatory Structure</i>	29
4.6.2.	<i>National Airspace Policy</i>	29
4.6.3.	<i>Consultative Arrangements</i>	30
4.6.4.	<i>Procedures and Design Process</i>	30
4.6.5.	<i>Airspace Management Handbook</i>	30
4.6.6.	<i>APO-90-7 Establishment and Discontinuance Criteria for Airport Air Traffic Control Towers</i>	31
4.6.7.	<i>Summary of Key Characteristics</i>	31
5.	PRINCIPLE FINDINGS & RECOMMENDATIONS.....	32
5.1.	AIRSPACE POLICY AND REGULATORY STRUCTURES	32
5.2.	AIRSPACE RISK MANAGEMENT POLICY IN NEW ZEALAND	33
5.2.1.	<i>Consultative Arrangements</i>	34
5.3.	PROCEDURES AND DESIGN PROCESS	34
5.3.1.	<i>Trigger Points, Criteria & Target Levels of Safety</i>	35
5.4.	OTHER ISSUES ARISING FROM CAA POLICY PAPER AUGUST 2005.....	35
6.	SUMMARY	37
APPENDIX A: References		
APPENDIX B: Australian Criteria		
APPENDIX C: Eurocontrol Hazard/Risk Analysis Methodology		
APPENDIX D: Australian Airspace Risk Analysis Methodology		
APPENDIX E: Canadian Aeronautical Study Terms of Reference		
APPENDIX F: Campbell River (Canada) Aeronautical Study		

EXECUTIVE SUMMARY

The Civil Aviation Authority of New Zealand (CAA) issued a Request for Proposal to develop and propose standards and practices for the management of aerodrome airspace risk on the 26 February 2007. The Ambidji Group Pty. Ltd. responded to the Request for Proposal and was selected as the successful tenderer. It was agreed that a review of overseas good practice in aerodrome airspace risk would be developed as part of the contract. This review examines practices used by the International Civil Aviation Organisation, as the body that sets international standards, and five leading aviation States - The European Union (Eurocontrol), the United Kingdom, Canada, Australia and the United States of America. It then briefly reviews policy implications for New Zealand and makes some initial recommendations, which will be further developed in the final project report.

The International Civil Aviation Organisation (ICAO) through Annex 11 and associated documents sets guidelines for airspace management. There is, however, no standard method of airspace administration although some common threads are evident. In most administrations, airspace policy and regulatory functions are distinct and separate from safety regulatory functions. In Europe they are in separate organisations. The United Kingdom has both functions within the CAA (UK) but segregated at Board level. Australia will shortly have the airspace regulatory function residing within CASA but reporting directly to the CEO, while Canada has both functions within Transport Canada. America has both safety and airspace regulatory functions within the same office of the Federal Aviation Administration and is the only State to also have the air traffic service provider within the same organisation.

There are formal processes in place in all administrations to manage changes to aerodrome airspace. They provide a policy and infrastructure framework within which qualitative and quantitative risk evaluation tools can be applied. Components of this framework include both national and local consultation programmes and ongoing risk review mechanisms such as Hazops Committees. Meaningful consultation is viewed by all as critical to the success of any airspace change process. All administrations have developed, or are in the process of developing, a “risk management toolbox” for use in aeronautical studies.

Some administrations publish traffic criteria that trigger a review of service levels through an aeronautical study. This is a more sustainable approach than making changes to service levels solely on traffic volumes. An aeronautical study will, for instance, take into account a wide range of location specific criteria including the mix of aviation activities, terrain, weather and airspace complexity.

Several administrations publish Target Levels of Safety (TLS). These are usually generic, rather than specific, to aerodrome airspace risk but can still provide useful guidance. The summary table in Section 6 of this review provides a comparison of trigger points and target levels of safety.

In the main, ATS providers or airline/airport operators are usually the proponents for aeronautical studies. The role of the regulator is to review, then approve, the studies. In certain cases, the regulator may undertake a study if they consider it necessary in the interest of safety, with some taking steps to ensure that the study is reviewed and approved by an independent party.

1. INTRODUCTION

Professor James Reason, writing on aviation accident investigation, devotes a chapter to a discussion of the role of the regulator. He observes that *“the regulator’s lot is not a happy one”*. He then considers the environment in which an aviation regulator exists and the conflicting expectations which act upon a regulatory administration.

This review of international good practice in aerodrome airspace risk management will examine the various risk management techniques and paradigms in use by leading aviation administrations and will also discuss how overseas experience may be relevant to New Zealand. It will also highlight the importance of sound policy and institutional frameworks in achieving effective aviation safety administration.

2. BACKGROUND

The Civil Aviation Authority of New Zealand (CAA) issued a Request for Proposal to develop and propose standards and practices for the management of aerodrome airspace risk on the 26 February 2007. The Ambidji Group Pty. Ltd. responded to the Request for Proposal and was selected as the successful tenderer.

The project scope as defined in the CAA Request for Proposal is as follows:

- Development of a detailed project plan;
- Review of current policy for the provision of ATS at aerodromes and amendments as necessary to reflect the project objective;
- Determination of acceptable levels of aerodrome airspace safety;
- Determination of aeronautical study methodology;
- Development of aeronautical study “triggers and/or filtering tools or models; and
- Validation of the proposed process through the conduct of an aeronautical study.

3. SCOPE

Aviation policy does not exist in a vacuum; it operates within the confines of the statutes and addresses “real world” issues such as the dichotomy between public and government safety expectations and the need for an efficient and profitable aviation industry.

This review will address aerodrome airspace risk practices in the context of an overarching policy framework. It examines practices in several major aviation States then discusses their strengths, weakness and applicability to New Zealand.

It should be noted that this review is based on data and literature that can be readily accessed through the public domain. The project did not hold discussions with the aviation regulators mentioned in the paper. In an area evolving as rapidly as airspace risk management, it is quite possible that administrations have “*moved on*” through the development of in-house solutions or tools that are not yet published, and may not be published due to intellectual property concerns. The findings of this review should, therefore, be used carefully. CAA NZ, as a regulator may have better access to confidential data and should cross check any issues that they consider critical to their decision making.

4. SUMMARY OF METHODOLOGIES USED BY OVERSEAS ADMINISTRATIONS

The management of aerodrome airspace risk around the world must be discussed in context. States differ in geography, culture, regard for and value of human life and the maturity of their aviation systems.

This section therefore, examines, the International Civil Aviation Organisation (ICAO) as the global body that sets (minimum) standards, a union of independent States (the European Union), as well as a number of individual States (USA, Canada, the UK and Australia) that have comparable cultures, values and aviation system maturity to that of New Zealand. A summary of the key characteristics of each administration and a comparative table is then developed.

4.1. International Civil Aviation Organisation

The International Civil Aviation Organisation (ICAO), under the Chicago Convention, sets the framework and standards for international aviation through a series of Annexes and Documents. New Zealand, as a signatory to the Convention, should comply with these standards or formally file a difference with ICAO. The following Annex and Documents are relevant to airspace design and management.

4.1.1. Annex 11

Section 2.2 states that the objectives of ATS are to:

- (a) Prevent collisions between aircraft and between aircraft on the ground and obstructions;
- (b) Maintain an orderly and expeditious flow of air traffic;
- (c) To provide aircraft with advice and information required for the safe and

efficient conduct of flights;

- (d) To notify those involved with search and rescue of aircraft in need of this service and assist them in this task.

Section 2.4 discusses determination of the need for air traffic services and requires that the following be considered:

- (a) The types of traffic involved;
- (b) The density of the air traffic;
- (c) The meteorological conditions; and
- (d) Such other factors as may be relevant.

Section 2.4 goes on to state that due to the number of elements involved it has not been possible to develop specific data to determine the need for ATS in a given area or at a given location. For example:

- (a) A mix of different types of air traffic, with aircraft of varying speeds (conventional jets, etc), might necessitate the provision of ATS whereas a relatively greater density of traffic, where only one type of operation is involved, would not.
- (b) Meteorological conditions might have considerable effect in areas where there is a constant flow of air traffic (e.g. scheduled traffic), whereas similar or worse meteorological might be relatively unimportant in an area where air traffic would be discontinued in such conditions (e.g. local VFR flights).

4.1.2. Document 9426: Air Traffic Services Planning Manual

Section 2 Chapter 1 of this document deals with the need for ATS. Section 2, at 1.1.7 summarises that *“[it would appear that] the need for ATS at and in the vicinity of specific aerodromes can, to a large extent, be determined on a local or national level and in consultation with the operators concerned up to the point when those services will have consequences on the en-route flow of air traffic over a wider area”*.

Section 2 at 1.5 describes the progressive development of ATS from aerodrome flight information service (AFIS) to an aerodrome control service with varying levels of sophistication. The document states that *“at those aerodromes where traffic tends to concentrate, it would [then] seem appropriate to establish an AFIS which, in addition to alerting service and normal FIS, will provide aircraft with detailed information regarding other traffic operating in the vicinity of the aerodrome so as to permit pilots to arrange their flights so that safe and expeditious flow of air traffic results”*.

There is no methodology suggested for determining when AFIS is required other than the subjective assessment of “where traffic tends to congregate”. The suggested point of step up from AFIS to an aerodrome control service is also somewhat subjective, 1.5.2 stating *“In most cases, fairly early in the development of traffic at specific aerodromes, the point will be reached where the responsibility of the arrangement of such a safe and expeditious flow of traffic can no longer be left to the discretion of individual pilots. This applies particularly when IFR operations of a commercial nature are conducted at such aerodromes. However, experience has shown that, if the traffic at a specific aerodrome is composed largely of pilots who are thoroughly familiar with the local conditions and their operations consist primarily of VFR flights, the decision to establish an aerodrome control may not need to be taken as early as would otherwise have been needed”*.

4.1.3. Document 9689 – Manual on Airspace Planning Methodology for the Determination of Separation Minima

Chapter 5 of this document deals with ICAO’s recommended method for identifying the method of safety assessment for a proposed system.

Section 5.1 of the document states that the safety of a system depends on a number of characteristics of the airspace, which need to be identified and quantified. It goes on to discuss the two basic methods for determining if the system is acceptably safe viz:

- (a) Comparison with a reference system – requires selection of a suitable reference airspace. Chapter 6 of the document discusses this approach in more detail.
- (b) Evaluation of system risk against a threshold – requires identification and quantification of all the safety-related characteristics of the system and development of an explicit relationship between the characteristics and collision risk. The estimated risk of the system is then compared against the maximum tolerable risk. Chapter 6 also describes the detail of this approach.

ICAO considers that, although the evaluation method is likely to be time consuming and complex, it is the only choice when a radical change is planned, which has not previously been tried in other regions. It also has the advantage that once the model is built, it is possible to adjust the parameters to determine the most appropriate method of achieving the required improvements in airspace.

ICAO provides a flow diagram to assist in determining which method is most appropriate for the circumstances.

These approaches have been developed in the context of higher level ATM issues such as reduced lateral and vertical separation, implementation of radar airspace etc., but the principles could be applied to aerodrome airspace

risk assessment.

Annex 9 (*The Eurocontrol Hazard/Risk Analysis Methodology*) describes Eurocontrol's hazard/risk analysis methodology. It is more focused on en route/high level issues but is still conceptually useful for airport airspace. This document is discussed more fully in Section 4.2.4, while the complete document is available at Appendix C.

Annex 10 (*Application Of Risk Analysis To Airspace Planning In Australia*) describes quantitative modelling undertaken in Australia in recent years. It provides a Target Level of Safety value of 1.5×10^{-8} fatal accidents due to collisions per system flight hour. It also acknowledges the need to demonstrate due diligence. This document is discussed more fully in Section 4.5.4, while the full document is available at Appendix D.

4.1.4. Document 4444 – Procedures for Air navigation Services – Air Traffic Management

Chapter 2 of this document addresses ATS safety management. Section 2.1 requires States to ensure that the level of ATS and communications, navigation and surveillance, as well as the ATS procedures applicable to the airspace or aerodrome concerned, are appropriate and adequate for maintaining an acceptable level of safety in the provision of the ATS. To ensure this, the appropriate ATS authority shall implement formal and systematic safety management programmes for the ATS under its jurisdiction.

This appears to relate more to the requirement to ensure any ATS provided is suitably safe, rather than whether an ATS is required at a particular location or area.

Section 2.3 requires, inter alia, a safety assessment in respect of the planned implementation of airspace re-organisations. This would apply, for example, to the implementation or withdrawal of controlled airspace around an aerodrome.

Section 2.6.2 of the document discusses safety significant factors which include:

- (a) Types of aircraft and their performance characteristics, including aircraft navigation capability;
- (b) Traffic densities and distribution;
- (c) Airspace complexity;
- (d) Aerodrome layout, including runway configurations, runway lengths and taxiway configuration;
- (e) Types of air-ground communications;

- (f) Types and capabilities of surveillance systems; and
- (g) Local or regional weather characteristics.

Section 2.7 addresses safety-enhancing measures, but only in very general terms requiring the ATS authority to implement safety-enhancing measures if it becomes apparent that the level of safety is not acceptable.

4.1.5. Summary of ICAO Characteristics

Many of the ICAO documents are relatively old, some from the mid 1980s. They offer a “*reference system approach*” as well as describing research undertaken by leading States. They do not have explicit target levels of safety or trigger points. However, the ICAO document suite does establish clear guiding principles upon which States may base airspace management.

4.2. European Union (EU), EASA and Eurocontrol

Eurocontrol is the agency tasked with the provision of air traffic services for member states of the European Union. Eurocontrol is not an aviation regulator; the regulatory function has recently been ceded by member States to the European Aviation Safety Authority (EASA).

Europe and Eurocontrol are less relevant than the other States discussed in this paper as they generally manage only upper airspace. However, Europe is discussed in some detail as it is becoming one of the two largest aviation administrations in world aviation, and has recently released some significant documentation on the risk assessment of airspace.

EASA is the centrepiece of the European Union’s strategy for aviation safety. Its mission is to promote the highest common standards of safety and environmental protection in civil aviation. National authorities continue to carry out the majority of operational tasks such as certification of individual aircraft and the licensing of pilots. The Agency will continue to develop common safety and environmental rules at the European level. EASA monitors the implementation of standards through inspections of Member States and provides technical expertise, training and research. It is also responsible for type-certification, i.e. the certification of specific models of aircraft, engines or parts approved for operation in the European Union. The Agency expects to take over additional regulatory tasks by 2008. In the long-term, it is also likely to play a key role in the safety regulation of airports and air traffic management systems.

4.2.1. Outline of Regulatory Structure

EASA became operational in 2003 through a European Parliament and Council Regulation (1592/2002). As an independent EU body under

European law, it is accountable to the Member States and the EU institutions.

A Management Board with representatives from the Member States and the European Commission (EC) manages the Agency's budget and work programme. The aviation industry is actively involved in the Agency's work through a number of consultative and advisory committees. There is also an independent Board of Appeal. The EC has established a high level Air Traffic Management Unit (ATMU) which, to some extent, develops airspace management policy.

European legislation requires each State to establish a National Supervisory Authority, usually the Ministry of Transport or the regulator within that State. This Authority ensures compliance with EC requirements, including the issuance of certificates to Air Navigation Service Providers (ANSP) on the basis of common standards. When certified, an ANSP can provide services in any State and can cross subsidise between tower and enroute services. At present, certification applies only to upper airspace.

Eurocontrol is the aviation advisor to the EC. The EC has given Eurocontrol a mandate to advise on airspace design. The initiatives discussed below derive from this mandate. Eurocontrol cannot enforce any regulation.

4.2.2. European Airspace Policy

The major EC policy initiative is the Single European Sky (SES) concept, which is under development by the Air Traffic Management Unit.

4.2.3. Consultative Arrangements

Eurocontrol has formal consultative arrangements with civil and military ANSPs. There are a number of observer groups that include industry groups, the FAA and some individual airlines. General Aviation (GA) is represented through the Aircraft Owners' and Pilots' Association (AOPA) but it has been observed that the influence of GA is reducing in Europe due to the capacity demands of public transport.

The EC has two consultative forums, the SES Committee (Member States only) and a second industry wide group including IATA and IFATCA. It is also developing an MoU with the USA. Formation of an independently chaired industry consultative body including CANSO, IATA, AEA (Association of European Airports) and IFACTA is under consideration.

4.2.4. Procedures and Design Process

The Eurocontrol Hazard/Risk Analysis Methodology (which has been incorporated into ICAO documentation) describes Eurocontrol's hazard/risk analysis methodology. The methodology focuses on enroute rather than

aerodrome airspace. There is a formal hazard identification process involving searches of incident and accident databases, as well as the use of hazard identification workshops. After analysis, the results are compared to pre-defined target levels of safety.

As part of a process to develop and manage traffic growth in Europe, several reviews and working parties have been established.

A 2004 review collected and evaluated techniques and methods capable of supporting the guidelines of the EATMP Safety Assessment Methodology (SAM). It identified over 500 techniques being used in nine different industries. Of the 500 identified, 19 techniques believed to be able to support the SAM immediately, or in the short term, were selected for further evaluation including:

- Bow tie analysis (threat barrier analysis);
- Common cause analysis (CCA) or zonal analysis;
- Event tree analysis (ETA);
- External event analysis;
- Failure modes effects and criticality analysis (FMECA);
- Fault tree analysis (FTA);
- Hazard and operability analysis (HazOp);
- Human error assessment and reduction technique (HEART);
- Reliability Centred Maintenance (RCM); and
- Use of expert judgement.

This shortlist is consistent with techniques used in Australia and proposed for New Zealand.

4.2.5. Summary of Key Characteristics

Policy, Regulatory and Service Delivery Structures:

Safety Regulator	-	EASA
Airspace Regulator	-	EC/ATMU
Service Delivery	-	Eurocontrol
Airspace Policy	-	EC (European Transport Commissioner)

Airspace Change Process

ICAO sanctioned methodology.

Aerodrome airspace change processes are through the individual State's administrations. A toolbox of techniques was developed in 2004.

Decision Criteria

No triggers found. No explicit aerodrome airspace target levels of safety published but the over-riding European safety objective for the tolerable level of accidents in controlled airspace is set as 1.55×10^{-8} accidents per flight hour (or 2.31×10^{-8} per flight).

Aerodrome Airspace Service Options

Upper airspace only eg. Airways, Permanent Upper Air Routes (UAR), Conditional Routes (CDRs), Advisory Routes.

Pending Changes/ Improvements

The main change issues surround capacity enhancement, harmonisation and the Single European Sky programme.

Strengths & Weaknesses

Given that the European environment operates under a significantly different political structure than State administrations:

Strengths

Segregation of airspace and safety regulatory functions
Single arbiter of airspace policy
Hazard/risk assessment methodology
Toolbox of techniques (qualitative and quantitative).

Weaknesses

Segregation of airspace policy and management between EC and Member States
Separation of functions between EC and national administrations.

4.3. United Kingdom (UK)

As a member of the European Union, the United Kingdom is in a period of transition to regulation by the European Aviation Safety Authority (EASA). This adds a level of complexity to safety regulation in the UK, as it is also moving towards Europe's "Single European Sky" objective and the integration of UK airspace with Eurocontrol.

UK legislation is subservient to the EC regulations.

4.3.1. Outline of Regulatory Structure

The Civil Aviation Authority (UK), a public corporation, was established by

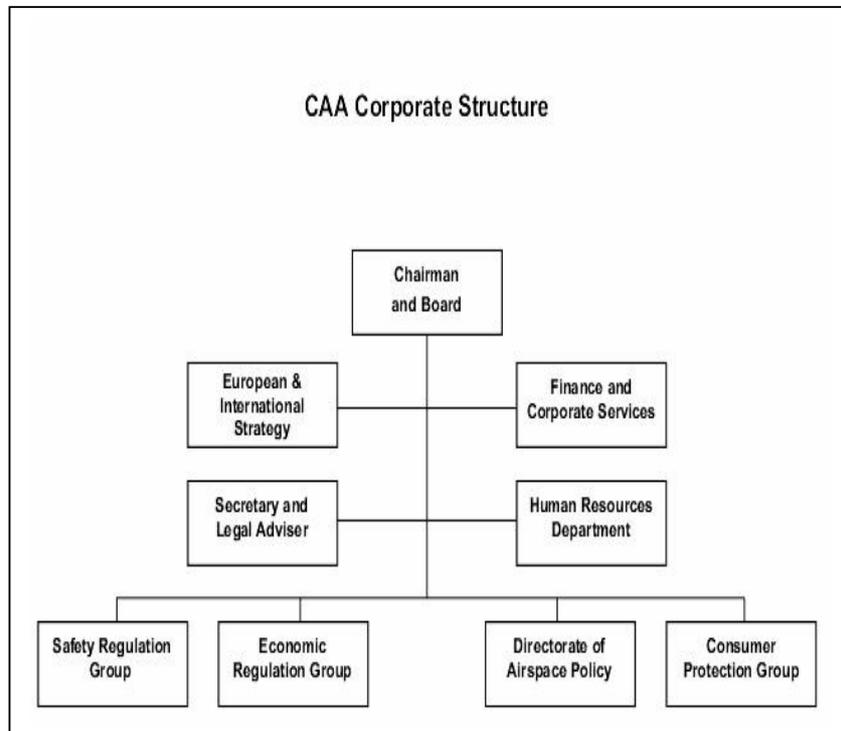
Parliament in 1972 as an independent specialist aviation regulator and provider of air traffic services. The CAA Board reports through the Ministry of Transport.

In 2001, there was a separation of the National Air Traffic Services (NATS) from the CAA. This left the CAA as the UK's independent aviation regulator, with all civil aviation regulatory functions (economic regulation, airspace policy, safety regulation and consumer protection) integrated within a single specialist body. The Economic Regulation Group within the CAA is influential in EC policy making and in ensuring that CAA regulations have the transparency required by the EC.

The UK Government requires that the CAA's costs are met entirely from its charges on those whom it regulates. There is no direct Government funding of the CAA's work. The Transport Act 2000 allows the Secretaries of Transport and Defence to make joint directives to CAA.

The UK NATS is a private sector company 49% owned by the government. It provides air traffic services within the UK.

Within the constraints discussed above, safety regulation in the UK is still undertaken by the Safety Regulation Group of the Civil Aviation Safety Authority. As shown below, there is an autonomous Directorate of Airspace Policy.



4.3.2. National Airspace Policy

The Directorate of Airspace Policy (DAP) is an independent entity within the CAA. The Director of the DAP is a CAA Board member and can be issued with government policy objectives and directives. He has some latitude in deciding how these can be achieved and has considerable independence in that he cannot be over-ruled by fellow board members on airspace matters. SRG staff are not seconded to DAP but do participate in DAP working groups. Most airspace change proposals either come from NATS, jointly from NATS and the Ministry of Defence, or from airport owners or operators such as the British Airports Authority and local councils. DAP reviews submissions and determines whether they meet its published criteria. It takes into account both safety and economic factors.

4.3.3. Consultative Arrangements

At the national level, the United Kingdom has a peak consultative body, the National ATM Advisory Committee, which comprises fifty to sixty people and organisations.

During an aeronautical study, extensive consultation is built into the change process described below.

4.3.4. Procedures and Design Process

Airspace within the UK is owned by the State and is regarded as a national asset. Change proposals address both safety and economic efficiency and must take environmental considerations into account.

DAP does not monitor facilities or levels of service (some safety monitoring is carried out by the SRG) – they see the onus being on NATS, aerodrome owners and operators.

Procedures specified by the DAP for the airspace change process and the establishment of aerodrome traffic zones are contained in CAP 724 *Airspace Charter*¹ and its associated Appendix 1.

The party proposing the change must conform to the standard published process and convince the Director Airspace Policy, of the need for, and merits of, the proposed change. The seven stage process is outlined below:

- Framework Briefing
- Proposal Development
- Preparing for Consultation

¹ Link to CAP 724 *Airspace Charter* (<http://www.caa.co.uk/docs/33/CAP724.PDF>)

- Consultation and Formal Proposal Submission
- Regulatory Decision
- Implementation
- Operational Review.

The UK Civil Aviation Authority has issued CAP 760 *Guidance on the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases*² to assist the industry in applying hazard identification and in developing safety cases. It describes an additional seven step process for the detailed analysis of risk:

- System description
- Hazard and consequence identification
- Estimation of the severity of the consequences of the hazard occurring
- Estimation/assessment of the likelihood of the hazardous consequences occurring
- Evaluation of the risk
- Risk mitigation and safety requirements
- Claims, arguments and evidence that safety requirements have been met and documented in a safety case.

It also includes guidelines on an institutional framework in which the risk model functions, including the establishment of consultative bodies, forming of hazops committees and the use of a hazard log to assist in the ongoing management of risk.

Under the UK model, Class G airspace is all that airspace that is neither classified as controlled or advisory airspace (i.e. all airspace outside of classes A-F). There are only 2 types of uncontrolled airports within the UK; those with an associated Air Traffic Zone (ATZ) and those without.

In order to provide an Air Traffic Service (ATC/AFIS) or an Aerodrome Air/Ground Radio Service, the aerodrome must have a published ATZ associated with it. The dimensions of an ATZ are typically a 10 nm radius of the candidate aerodrome up to 2,000 ft agl.

In a significant departure from international practice, the UK does not necessarily implement controlled zones/areas in all portions of airspace to support the delivery of air traffic control services within an ATZ; hence there are a number of G airspace aerodromes that offer ATC services even though they are considered to be uncontrolled airports.

In these instances, although the controller issues direct (ATC-type) instructions to the pilot, the pilots understand that they are flying in an uncontrolled environment and that the associated controller instructions are treated as advisory in nature; however the pilot is expected to follow ATC instructions wherever possible.

² Link to CAP 760 *Guidance on the Conduct of Hazard Identification, Risk Assessment and the Production of Safety Cases* (<http://www.caa.co.uk/docs/33/CAP760.PDF>)

An example of aerodrome airspace is where ATZs as defined by Article 129 of the Air Navigation Order 2000 are established at certain aerodromes to afford protection to aircraft operating in the visual circuit and in the vicinity of the aerodrome. Licensed aerodromes where flying training takes place will normally have an ATZ. The qualifying criteria and the provisions for the establishment of ATZ are contained in Rule 39 of the Rules of the Air Regulations 1996. CAP 428 *Safety Standards at Unlicensed Aerodromes*³ describes safety standards that should be met or established at unlicensed aerodromes.

DAP may visit an aerodrome which has applied for the creation of the ATZ and any other aerodrome or aviation activity site that might be affected by the change. Information gathered may include levels of activity, movement data together with any co-ordination procedures and other factors relevant to their decision such as gliding, parachuting or microliter operations. They will also, if necessary, act as a mediator to resolve conflicting interests.

When a manned ATZ facility is closed, the associated tower/AFIS frequency becomes the published broadcast frequency for all aircraft operating into/out of the relevant aerodrome (ATZ).

For those aerodromes that do not have a published ATZ, the national broadcast frequency (known as "SafetyCom") is 135.475 MHz.

Another CAA document (CAP 728) defines safety management systems for organisations. In addition to discussing risk management in terms of likelihood and consequence, it sets out a table of criticality. These measures are qualitative rather than quantitative.

As far as can be established, DAP do not have firm triggers for an aeronautical study. This is left to the judgement of SRG (from safety monitoring), NATS, owners or operators. The SRG do in some circumstances, mandate levels of service but do not have prescribed public standards or criteria. They rely on "intelligence" which includes audit reports, traffic growth and formal reviews undertaken during the licensing process.

4.3.5. Summary of Key Characteristics

Policy, Regulatory and Service Delivery Structures:

Safety Regulator	-	CAA UK Safety Regulation Group
Airspace Regulator	-	CAA UK Directorate of Airspace Policy
Service Delivery	-	National Air Traffic Services

³ Link to CAP 428 *Safety Standards at Unlicensed Aerodromes* (<http://www.caa.co.uk/docs/33/CAP428.PDF>)

Airspace Policy - Department of Transport, CAA UK Directorate of Airspace Policy

Airspace Change Process:

The proponents of change (usually NATS) develop an aeronautical study for DAP review and approval. EC policies impact on UK airspace (upper airspace at present). Procedures and methodologies for change process are well established under CAP 724, CAP 728 and CAP 760.

Decision Criteria:

No triggers found, monitoring and industry intelligence used. European target levels of safety are used as guidance.

Aerodrome Airspace Service Options:

The type of route or structure:

Control Zones
Aerodrome Traffic Zones
SafetyCom areas.

Pending Changes/ Improvements:

As far as can be established, no changes to the present methodologies are under consideration. Airspace changes will, in the near term, be driven by EC requirements.

Strengths & Weaknesses:

Strengths

Segregation of airspace and safety regulatory functions
Single arbiter of airspace policy
Well defined methodology to conduct aeronautical studies.
Well documented risk evaluation tools.

Weaknesses

Identification of risk locations mainly through NATS and local operators, little direct DAP surveillance
Few options for risk management at aerodromes.

4.4. Canada

Canada is a progressive and respected aviation State with considerable influence within ICAO and other international forums. Its systems are, through necessity,

closely aligned with those of the United States, but its size and relatively sparse population provide it with challenges that in many ways mirror Australia and New Zealand.

4.4.1. Outline of Regulatory Structure

Transport Canada is the Ministry of the Transport portfolio for Canada. It is also the regulator and oversees NAV CANADA, the commercial air navigation service provider. NAV CANADA was established by statute in 1996 as a private, non-share capital (and not for profit) organisation that owns and operates Canada's civil air navigation service. It provides air traffic control, flight information, weather briefings, aeronautical information, airport advisory services and electronic aids to navigation.

NAV CANADA is regulated by Transport Canada in the same way as an airline and is, therefore, subject to oversight and audit. Level of service changes are processed via a NAV CANADA business and safety case mechanism that goes through the NAV CANADA Board prior to being sent to the regulator for approval. NAV CANADA is required by statute (the Commercialisation Act) to ensure appropriate levels of safety, which are further defined in regulation (Canadian Aviation Regulations – Part VIII Air Navigation Services Subpart 6 – Levels of Service)⁴. These are phrased in terms of acceptable risk rather than hard figures. Levels of service are however under constant review.

The real estate of major airports is owned by the Canadian Government with airport operators paying land rent to the Government. Regional airports are owned by local municipalities. Transport Canada also regulates a number of private towers (currently operated by Serco) as well as a range of small ANSPs such as navaid maintenance companies.

4.4.2. National Airspace Policy

Transport Canada is the safety and airspace regulatory authority; it is also the airspace policy maker.

The Chief of Standards in Transport Canada has the authority to make changes to airspace classifications, and NAV CANADA can make changes to route structures (such as SIDs, STARs or VFR routes) as long as they are consistent with established design criteria. The Minister of Transport can also direct NAV CANADA to undertake an aeronautical study, this has occurred following submissions from airspace users. The current regulations are based on the facility providing the service and are limited to those service providers who operate Air Traffic Control Units and Flight Service Stations.

⁴ Link to Canadian Level of Service policy document
(http://www.navcanada.ca/contentdefinitionfiles/Services/ANSPrograms/LevelOfService/ANS_Policy_en.pdf)

4.4.3. Consultative Arrangements

Canada has formal industry consultation processes in place. At the highest level five members of the NAV CANADA Board are appointed by airlines, business and general aviation, while two are appointed by unions. Extensive consultation occurs at both national and local levels during any aeronautical study. The formal terms of reference for an aeronautical study (refer Appendix E) nominate organisations and individuals who must be consulted.

4.4.4. Procedures and Design Process

The Canadian Standard for Risk Assessment (Q850) forms the basis of the risk model used to assess changes in airspace classification by way of an aeronautical study.

It appears that some assessment of an appropriate level of service is made when reviewing an aerodrome licence, or when changing an airline AOC to include new ports of operation for RPT aircraft. There are no target levels of safety other than the principles in Q850 and as far as could be determined, there are no hard movement figures used by Transport Canada for the establishment or disestablishment of airspace. NAV CANADA, however does have threshold criteria that prompt closer examination of the level of service; for example, if movement rates fall below 60,000 movements per annum, or vary between 20,000 and 40,000 movements per annum, an aeronautical study may be undertaken. However, these trigger points are not absolute and there is no apparent public document or legislation giving them any head of power.

Canada operates the full range of ICAO-approved airspace classifications (i.e. A, B, C, D, E, F and G). Controlled airspace classifications and operations are similar to those of Australia or New Zealand. Uncontrolled airspace includes classifications F and G. F airspace (frequency 126.7 MHz) is normally deployed for advisory areas and for any operations within Special Use Airspace (i.e. Danger or Restricted Areas).

In G airspace, uncontrolled aerodromes are all allocated an aerodrome traffic frequency (ATF) whereby aircraft can communicate with each other for traffic separation purposes, or with authorised ground vehicles to ascertain the status of maintenance works or runway availability. The ATF will normally be the frequency of the Unicom where one exists or the general broadcast frequency of 123.2 MHz for those aerodromes that don't have a Unicom service. An ATF (different frequency) can also exist outside of manned hours at those airports that normally operate a control tower or FSS during the day. This concept of operation is very similar to Australia's current CTAF procedures.

The designation of an ATF is not limited to aerodromes only. An ATF may also be designated for use in certain areas other than the area immediately surrounding an aerodrome, where VFR traffic activity is high, and there is a

safety benefit in ensuring that all traffic monitors the same frequency. For example, an ATF area could be established along a frequently flown corridor between two uncontrolled aerodromes. All aircraft operating within the area, below a certain altitude, would be requested to monitor and report intentions on one frequency. When such an area is designated, it will be specified either in an Aviation Notice, or in the Canadian Flight Supplement (CFS).

At the busier and more complex airports, a mandatory frequency area (MF) is established with a discrete published frequency. An MF area typically encompasses an area of 5nm radius of the airport up to 3,000ft agl and traffic information may be exchanged by communicating with either an FSS (local or remote), a CARS (Community Aerodrome Radio Station), Unicom operator, vehicle operator, or by simply a broadcast transmission. For the aerodromes with an MF, the specific frequency, distance and altitude within which MF procedures apply will be published in the CFS.

4.4.5. Aerodrome Services Available at Uncontrolled Airports:

Flight Service Stations (FSS):

Flight Service Stations provide site specific resources for flight planning, access to briefings on weather and other pre-flight information, aeronautical information, en-route and airport advisory services, vehicle control services, monitoring of nav aids, VHF/DF assistance and alerting of Search and Rescue centres for overdue aircraft.

Flight Information Centres (FICs):

FICs centralize the provision of those flight information services that are not location dependent, providing pilots with efficient, seamless flight planning, en-route services and better access to flight information services. They are a one-stop shop for flight planning and in-depth interpretive weather briefings provided by qualified specialists, using the latest computer and communications technology. Services are offered pre-flight and en route. NAV CANADA has 7 FICs.

Remote Communications Outlets (RCOs) and Remote Aerodrome Advisory Services (RAAS):

RCOs are remote transmitters/receivers set up to extend the communications capabilities of FSS stations. They allow Flight Service Specialists to provide some flight information services to remote areas and aerodromes without a staffed NAV CANADA facility. When an RCO is used to provide airport advisory services at a remote aerodrome, the service is referred to as a Remote Aerodrome Advisory Service (RAAS).

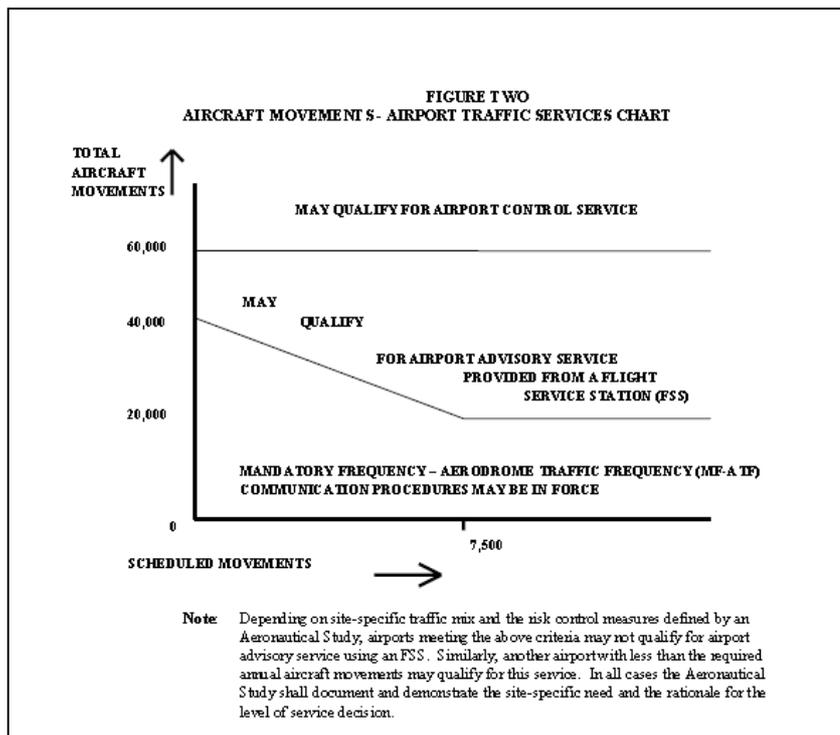
Community Aerodrome Radio Stations (CARS):

CARS provide aviation weather and communications services at designated

sites in the Yukon, Northwest Territories, Nunavut and Northern Québec. CARS are operated by observers/communicators who are usually recruited locally. Each CARS is assigned to a designated Flight Service Station which provides operational support assistance. A Unicom is similar to CARS but without the formal link to a parent FSS.

4.4.6. Trigger Points under the Canadian System

Canada uses 20,000 annual movements as the first benchmark for establishment of an Aerodrome Flight Information Service (AFIS) unit and 60,000 annual movements as the benchmark for the establishment of an aerodrome control service. In general, the decision to implement AFIS would be at around 40,000 movements with some complexity. Remote Advisory Airport Services (RAAS) and Community Aerodrome Radio Stations (similar to Unicom) are used to manage safety issues at remote locations. The diagram below summarises the criteria used.



4.4.7. Aeronautical Studies

Aeronautical studies are conducted in accordance with Q850. They begin with the issuance of formal terms of reference (see *Review of Air Navigation Services Mackenzie River and Liard River Areas of the Northwest Territories* at Appendix E) then follow a standard process:

Consideration of all relevant factors, including traffic volume, mix and distribution, weather, airport role, airport and airspace configuration, surface activity and the efficiency requirements of operators using the service. The scope of studies can range from minor adjustments to airspace boundaries to an examination of the impacts of replacing an airport control service with another form of service, introducing a new service, or terminating a service completely.”

The above is a comprehensive framework that involves full consultation with those affected by changes to air navigation services so that all potential effects of a proposed change on those who use the services can be fully understood.

Consultation with stakeholders formally occurs following the preliminary analysis phase when issues and impacts of a proposed service change are reviewed. However stakeholders may share their views and concerns at any time during a study. Consultation helps confirm or disprove assumptions made during the preliminary analysis and validates customer issues. The service proposal can then be altered if warranted.

The Aeronautical Study process provides a systematic methodology for analysing complex issues using a risk management approach. Risk analysis includes the identification of exposures to risk, and the identification and evaluation of alternative strategies for reducing or eliminating losses. Perception and communications issues that affect risk decisions are also fully assessed.

Once an Aeronautical Study is completed, it is forwarded to NAV CANADA's senior management and the Board of Directors for approval. The Ministry of Transport reviews NAV CANADA's Aeronautical Studies as per section 806.02 (2) of the Canadian Aviation Regulations, to assess *"whether the risk to aviation safety would be unacceptably increased by a proposed termination or reduction in the level of air navigation service"*.

An Aeronautical Study consists of a six-step process: initiation, preliminary analysis, risk estimation, risk evaluation, risk control and action/monitoring. An example of a completed Canadian Aeronautical Study for Campbell River, British Columbia is located at Appendix F.

4.4.8. Other Studies

A CAANZ paper (November 2005) provides a detailed review of the Canadian system. In summary:

“Canada has conducted many aeronautical studies and has a wealth of knowledge in the area. Aeronautical studies in Canada are mainly conducted by NAV CANADA; Transport Canada has conducted studies but has come to the view that these should be completed by the service

provider.

Canadian aeronautical studies focus heavily on qualitative identification of risk by discussions with stakeholders and establishment of a risk register approach – Hazard Identification and Risk Analysis (HIRA). Studies are conducted in accordance with the standards contained in Q850. A guiding principle is that the size (complexity) of the study should be commensurate with the feature being addresses. TAAM modelling is available as are other forms of simulation; however the literature refers to their use for airspace design and capacity analysis rather than aerodrome risk modelling.

Control zones are established at aerodromes with scheduled IFR movements, irrespective of whether there is a control service provided or not. The objective is to amend the pilot's VMC to that of controlled airspace requiring a greater distance from cloud and any IFR aircraft. Special use airspace is treated as class F, Canada's equivalent to an MBZ is a Mandatory Frequency area (MF). Class E control zones are used in Canada and Class E airspace is used extensively for lower controlled airspace, training or gliding activity areas within controlled airspace and for unattended control zones.

There is an opinion that education along with a very structured environment can achieve similar results to ATS in suitable operational environments, presumably environments without undue complexity."

4.4.9. Summary of Key Characteristics

Policy, Regulatory and Service Delivery Structures:

- Safety Regulator - Transport Canada
- Airspace Regulator - Transport Canada (studies by NAV CANADA)
- Service Delivery - NAV CANADA
- Airspace Policy - Transport Canada

Airspace Change Process:

Well defined process consistent with risk standard Q850. Process includes an initial terms of reference and comprehensive guidance on consultation. Mainly qualitative models used.

Decision Criteria:

Threshold criteria for establishment of ATS services, monitoring and industry intelligence used in conjunction with criteria. No target levels of safety found.

Aerodrome Airspace Service Options:

Control Zones (Class E Zones also used), Flight Information, Mandatory Frequency Areas, Airport Advisory Areas, Remote Advisory Airport Services, Community Aerodrome Radio Stations (Unicom).

Pending Changes/ Improvements:

Changes mainly in areas of overall route structure efficiency and introduction of new ATS technology. Harmonisation with USA.

Strengths & Weaknesses:

Strengths

Single arbiter of airspace policy
Well defined methodology to conduct studies
Has undertaken many aeronautical studies
Extensive options for airspace risk management at aerodromes.

Weaknesses

Safety and Airspace regulatory functions both within Transport Canada
No quantitative risk tools found
Identification of risk locations mainly through NAV CANADA and local operators
All service providers below ATC/FIS level, including Community Aerodrome Radio Stations (CARS) and Approach Unicom (AU), are currently unregulated.

4.5. Australia

Airspace has been a contentious stakeholder issue in Australia for many years. To ameliorate stakeholder concerns, collision risk modelling was introduced, which attempted to bring some precision and rigor to the review of airspace requirements. This has been successful to some extent, but there has still been significant disagreement amongst stakeholders over assumptions, methodologies and conclusions.

4.5.1. Outline of Regulatory Structure

Civil aviation administration has evolved continuously, from the 1970s when there was an autonomous Department of Civil Aviation (DCA), through a period under the multi-modal Department of Transport, to a Civil Aviation Authority of Australia (1988). All of the above organisations had many, and at times conflicting, functions such as safety regulation, economic regulation,

administration and ownership of airports and provision of air traffic services. In 1995, the regulatory functions were devolved to a regulator (the Civil Aviation Safety Authority CASA). The commercial service provider, Airservices Australia, remained the airspace regulator.

Airspace administration and reform have had a troubled history since that time. There have been several abortive attempts at major airspace change. There has been ongoing debate on the risks involved where general aviation and sports aviation interface with passenger carrying activities. There has been significant lobbying of the government and the Minister has become involved in several instances.

The current structure has the Department of Transport and Regional Services as the portfolio agency. In addition to providing advice to the Minister it is also the economic and aviation security regulator. Airservices Australia is the air traffic services provider and airspace regulator. The Department of Defence is also involved in airspace regulatory issues. CASA performs all other safety regulatory functions.

A specialist unit within Airservices Australia (AERU) retains the responsibility for the design, declaration and management of airspace. CASA retains the responsibility for setting the minimum standards for safe operation within each class of airspace. CASA is able to propose the upgrading of particular airspace on safety grounds.

On 1 July 2007 all airspace regulatory functions will pass to the Office of Airspace Regulation (OAR) within CASA. The Office is segregated to an extent from the routine CASA safety regulatory function as it reports directly to the CEO.

4.5.2. National Airspace Policy

In May 2007, the Federal Minister of Transport and Regional Services released a draft airspace policy paper for consultation⁵. This paper sets out the Government's vision for airspace administration then provides five key principles which CASA must consider:

- Safety of passenger transport operations is the most important consideration;
- Efficient use of airspace is a benefit to the aviation sector and the Australian economy;
- Protection of the environment is of concern to all Australians;
- Access to airspace will be open to all users unless there are justifiable reasons to deny access in terms of safety, efficiency, environmental

⁵ Go to: http://www.dotars.gov.au/aviation/airspace_reform/pdf/AAPS_PublicRelease24May07.pdf

protection or national security; and

- Airspace administration will take into account national security.

The paper commits Australia to the ICAO airspace model with minor modifications and sets out the role of CASA in the airspace change process, including a requirement to undertake regular airspace reviews. It then outlines an airspace change process:

- Risk management analysis consistent with the CASA Risk Management System and the Common Risk Management Framework;
- An assessment of the potential costs and benefits of the proposed change;
- Inclusive consultation with stakeholders; and
- Ensuring consistency with Government policy as expressed in this Policy Statement.

Airspace design principles are stated, including a requirement to conform to the AS/NSZ 4360 Standard and to apply the ALARP (As Low As Reasonably Practicable) concept. Government airspace change priorities are then provided.

The future direction of airspace risk management in Australia is outlined in another draft consultation paper, issued in February 2007, by the Department of Transport and Regional Development, the Department of Defence, the Civil Aviation Safety Authority and Airservices Australia – the “*Common Risk Management Framework for New and Changed Operational Requirements within Aviation*”⁶. The joint nature of this document recognises that all agencies have an input and responsibility for aviation management and that a common, rational, analytical and co-operative approach is essential.

For the overall system to function effectively, it is important that the work of all agencies is complementary and based on a shared sense of understanding and purpose. Past experience has demonstrated that “*without a common apprehension of approaches to risk assessment and evaluation, the potential for misunderstanding and conflict within the industry can increase which is unproductive and time consuming.*” The document presents an agreed set of processes and structures that are directed at rationalising potential opportunities within Australian aviation, whilst managing adverse consequences. The Common Framework is summarised below.

The paper proposes the following key principles:

- The safety of air navigation is the most important consideration;

⁶ Go to: http://www.dotars.gov.au/aviation/airspace_reform/pdf/Common_Risk_Framework.pdf

- Air transport passengers should not be exposed to an increased level of risk unless the costs of this are more than offset by the benefits to society in other areas;
- National security considerations may over-ride all other interests; and
- Performance levels are likely to reduce during transition from one system state to another.

In Australia, there is a demand for airspace architectures that allow safe and efficient operations, but also equity of access to a national resource.

4.5.3. Consultative Arrangements

Extensive consultative arrangements are in place. At a strategic level a stakeholder group (ASTRA) has developed a national ATM strategic plan. The AERU unit has a consultation process in place and the CASA regulatory development Standards Consultative Committee (SCC) monitors airspace issues through a subcommittee.

During the planning and implementation of any airspace initiative extensive national and local consultation takes place through project teams, as well as established forums.

4.5.4. Procedures and Design Process

In the 1990's, an Airspace Risk Model (ARM) was developed by Airservices Australia to analyse the risks of various airspace classifications, in particular those in isolated areas. The critical event under this model is the "near miss" where two or more aircraft come within one nautical mile of 500 feet without being aware of the other's presence. A cause/consequence model is centred on this critical event. Since that time, both qualitative and quantitative tools have been used to evaluate airspace risk.

Under the proposed "Common Risk Model", all risk management systems will be in conformance with the Australian/New Zealand Standard (AS/NZS 4360:2004). All risk management systems will be premised on the concept of "As Low As Reasonably Practicable" (ALARP). This acknowledges that there are practical limits to which the aviation industry can go in managing risks. ICAO has published details of this modelling in Appendix 10 to Doc. 9689 (Appendix D). It provides a Target Level of Safety value of 1.5×10^{-8} fatal accidents due to collisions per system flight hour. It also acknowledges the need to demonstrate due diligence.

Risk Assessment and Evaluation:

Under the evolving Common Risk Framework, a "toolbox" of techniques will be available for the identification and analysis of risks. Tools will include:

- The Bow-Tie
- Collision Risk Modelling
- Failure Modes and Effects Criticality Analysis
- Fault Tree Analysis
- Human Factor Analysis
- Use of Expert Judgement

Agencies will ensure that facilitators and practitioners are skilled, and that as broad a range of stakeholders as practicable are asked to assist in the process. Additional tools will be developed jointly, viz:

- The first will be the Airspace Safety Levels, Assessment and Monitoring (ASLAM) model which will be used in mid-air collision risk assessments;
- Criteria for the evaluation of risk levels will be endorsed then published. When qualitative criteria are used in a consequence-likelihood matrix, they must be premised on the basis of the effect on aircrew and the travelling public;
- Agencies will use economic values published by the Bureau of Transport and Regional Economics (BTRE) in relation to the value of statistical life; and
- Large scale assessments will embrace formal cost benefit analysis.

To ensure that practices are, and remain, consistent with industry best practice a joint evaluation by an external stakeholder panel will take place every year. CASA is in the process of establishing a panel of contractors to provide specialist support in airspace risk management.

Modelling Criteria and Collision Pair Probabilities

Data on modelling criteria and collision pair probabilities are at Appendix B.

Trigger Points under the Australian System

A draft of CASR Part 71 contains trigger points as follows:

Annual Movements	CTAF	MBZ	CAGRO	ATC (D)	ATC
Total Movements	10,000 or	20,000 or	40,000 or	See Aerodrome Control Service	60,000
IFR Movements	3,000	>3,000	7,500		

Note 1. This table does not state the need for an assessment for aerodromes with operations of scheduled commercial aircraft of more than 30 seats capacity.

Notes 2. The above table does not reflect the differing requirements that may be revealed by the results of an aeronautical study taken on a site-specific basis.

Aerodrome Control Service.

The provision of an aerodrome control service at an uncontrolled aerodrome must be assessed by an aeronautical study where total annual aircraft movements:

- (a) exceed 15,000 IFR or
- (b) exceed 60,000 of which at least 15% are IFR or
- (c) otherwise exceed 100,000.

4.5.5. Summary of Key Characteristics

Policy, Regulatory and Service Delivery Structures:

Safety Regulator	-	CASA
Airspace Regulator-		Airservices Australia (CASA Office of Airspace Regulation from 1 July 2007)
Service Delivery	-	Airservices Australia
Airspace Policy -		Department of Transport and Regional Services (DOTARS)/OAR

Airspace Change Process:

Airservices Australia (AERU) have developed but not published an airspace change methodology, which may be modified by the incoming OAR. A Common Risk Management Framework is under development.

Decision Criteria:

Triggers as per draft CASR Part 71, monitoring and industry intelligence also used. Notional Target Level of Safety of 1×10^{-8} .

Aerodrome Airspace Service Options:

Approach Control
Control Zones (C,D,E airspace)
FIS in G airspace.
Certified Air/Ground Radio Service (CA/GRS)
CTAF(R), CTAF
Unicom

Pending Changes/ Improvements:

Airspace regulation is moving to an autonomous Office within CASA. A common Risk Framework is under development. A panel of risk consultants is being constituted. Draft airspace policy released by Minister for consultation. A CASR Part 71 is under development.

Strengths & Weaknesses:

Strengths

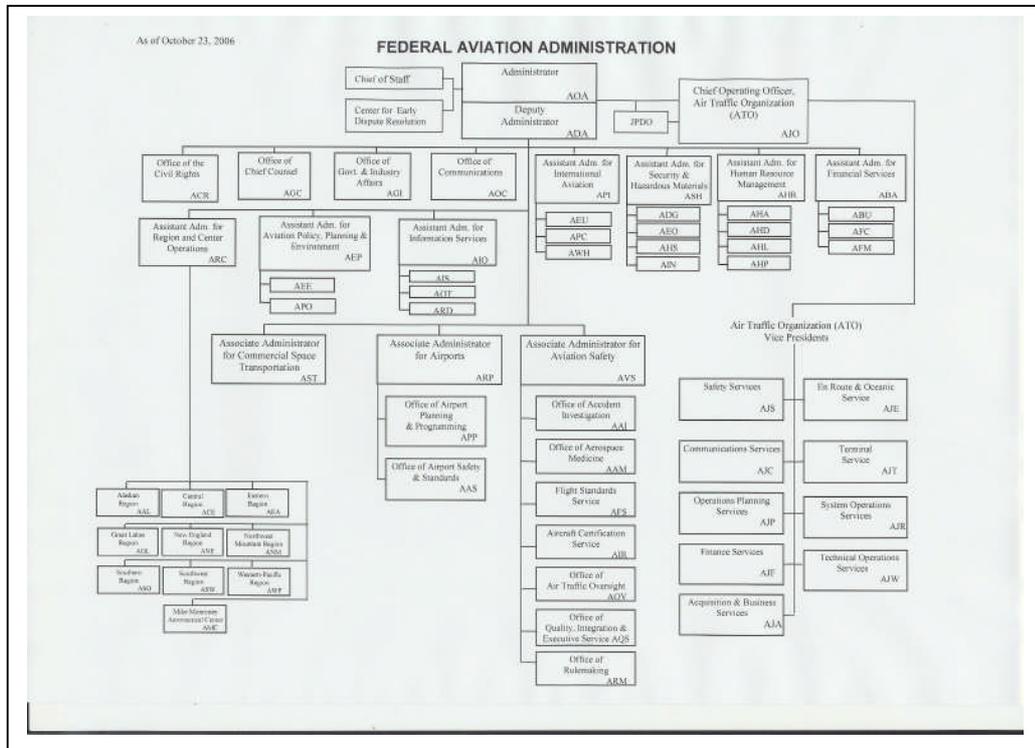
- Segregation of airspace and safety regulatory functions within CASA
- Single arbiter of airspace policy
- Wide range of risk treatment service options
- Well developed qualitative/quantitative risk tools

Weaknesses

- Highly political airspace management environment
- CASR Part 71 not yet made
- History of failed airspace change initiatives.

4.6. United States of America – Federal Aviation Administration (FAA)

The United States has a single aviation body, the FAA. It undertakes both safety regulation and service provision.



The major issue for the FAA is airspace capacity. They acknowledge that given the size of the organisation (Head Office alone has over 5,000 staff) and the complexity of managing their statutory requirements and stakeholders, change will take time and present some substantial challenges.

4.6.1. Outline of Regulatory Structure

The Air Traffic Organisation (ATO) is a relatively recent initiative within the FAA. It is consolidating many specialist functions including airspace management into five domains and five service units. The ATO still receives funding from Congress.

The Current FAA structure is shown on the previous page:

4.6.2. National Airspace Policy

Airspace policy in the USA places all airspace into two categories:

- Regulatory (Class A,B,C,D and E, restricted and prohibited areas); and
- Non Regulatory (Class G plus military, warning, alert and controlled firing areas.

Within these categories are four types:

- Controlled
- Uncontrolled
- Special Use and
- Other.

Decisions on categorisation are based on

- Complexity or density of operations
- The nature of operations within the airspace
- The level of safety required and
- The national and public interest.

A code of federal regulations covers the design of airspace segments and issues such as dimensions, exceptions, areas covered, exclusions, transponder and other equipment requirements as well as flight operations. There is a trend to the centralisation of airspace decision making in a division of the ATO that will provide national oversight for the development of airspace policy, establishment of guidelines for airspace architecture and structural changes and analysis of current and proposed operations.

4.6.3. Consultative Arrangements

The FAA tries to remain responsive to the needs of its stakeholders by adopting an airspace consultation strategy based on safety (the critical factor), security and efficiency. There are well established processes for consultation at national and local levels and through the rule development process. In addition, the FAA have a formal order (7400.2E) which prescribes procedures to be followed for all informal airspace meetings held in advance of airspace rulemaking actions.

4.6.4. Procedures and Design Process

The FAA has recently published an Airspace Management Handbook which documents process and tools for use in airspace management and risk analysis.

4.6.5. Airspace Management Handbook

The document and its associated Appendix D appear to lean heavily towards the classical risk assessment process. They outline an 8-step process for Airspace Management:

- Characterise the problem
- Perform an initial evaluation of the problem
- Initiate an appropriate airspace study for the identified problem
- Conduct an airspace study for the identified problem
- Summarise and present the results
- Select the required airspace changes
- Plan the implementation of the changes at a field facility
- Evaluate the changes after implementation.

The FAA website indicates that categories and types of airspace are dictated by:

- The complexity or density of aircraft movements
- The nature of operations conducted in the airspace
- The level of safety required and
- The national and public interest.

The FAA now has in place a selection of qualitative and quantitative tools to evaluate airspace risk. In addition, FAA document APO-90-7 provides a detailed mathematical modelling framework with criteria for the establishment and discontinuance of control towers. The criteria are given in terms of benefit/cost ratios rather than movement numbers.

4.6.6. APO-90-7 Establishment and Discontinuance Criteria for Airport Air Traffic Control Towers

This document presents the classic cost-benefit analysis applied to air traffic control towers. This involves:

- Identifying the costs of setting up and running a tower facility;
- The cost savings resulting from having the tower facility, not all of which are safety related. For example cost savings due to reduce flight delays are included; and
- Estimating the probability of the cost savings occurring, for example the number of accidents and associated fatalities and serious injuries avoided.

This appears to be a very similar approach to that taken for safety improvements in other transport modes (e.g. highways improvements) and airlines (e.g. assessing the benefit of incorporating safety enhancements on aircraft).

4.6.7. Summary of Key Characteristics

Policy, Regulatory and Service Delivery Structures:

Safety Regulator	-	FAA
Airspace Regulator	-	FAA
Service Delivery	-	FAA
Airspace Policy	-	FAA

Airspace Change Process:

The Airspace Management Handbook provides an eight step airspace change process.

Decision Criteria:

No triggers found per se but benefit/cost ratios available, monitoring and industry intelligence also used. No target levels of safety published. Airspace Handbook provides guidance on process and available tools.

Aerodrome Airspace Service Options:

Control Zones in B, C or D airspace
E airspace – no tower, amended weather minimums
FIS

CTAF
Unicom
Special Use Airspace.

Pending Changes/ Improvements:

Extensive work underway to improve overall efficiency of all airspace, capacity enhancement.

Strengths & Weaknesses:

Strengths

Single arbiter of airspace and safety policy (although still in Air Traffic Organisation of FAA)
Well defined methodology to conduct studies.

Weaknesses

Quantitative tools are complex (benefit/cost ratios)
Identification of risk locations mainly through local operators
Few options for risk management at aerodromes
Service provision and regulation are in the same operational area.

5. PRINCIPLE FINDINGS & RECOMMENDATIONS

This section of the review takes the data gathered in Section 4 (the structures, policies and methodologies used by a selection of major aviation States) as a basis for an analysis of overseas options and their applicability to New Zealand. It then discusses policy options which CAANZ may wish to consider. The caveat discussed in Section 3 of this report must be kept in mind when considering comments on overseas administrations. Where recommendations are developed, they will be carried through to the final project report.

If an analysis is to be meaningful, it should consider a regulatory approach in the context of the environment that exists in that country. For example, when considering Eurocontrol we must acknowledge that it provides only upper airspace management of congested airspace within the EU framework.

5.1. Airspace Policy and Regulatory Structures

Airspace regulatory structures vary. In all cases except the USA, service provision is segregated from regulatory functions. The UK, USA and Canada have the airspace and safety regulatory functions within the same organisation, Australia will adopt this model from 1 July 2007 following the establishment of the OAR within CASA. However, there are significant differences of approach among administrations to the segregation of airspace and safety regulatory functions.

In the UK for instance, the safety regulatory function operates at arms length from DAP. Nonetheless, DAP have a clear mandate to consider safety along with efficiency and the environment. In Canada, the safety and airspace regulatory functions exist side by side. Australia is moving to an arms length arrangement from 1 July 2007. The European Union is still in the formative stages of building airspace regulatory structures with low level and airport related aeronautical studies undertaken by individual State administrations. The main organisational design issue appears to be non-technical; it is partly historic, the way the organisations have evolved and partly political, how can it best be structured to achieve the safety/efficiency and environmental goals while retaining the trust of the industry.

Airspace change proposals (usually aeronautical studies) generally address safety, economic and environmental issues. In Australia, equity of access is also a major issue. Equity of access policy addresses the availability of airspace to general aviation and recreational aviation given the overarching safety priority of protecting the fare paying passenger.

5.2. Airspace Risk Management Policy in New Zealand

Under Section 14A of the Civil Aviation Act, the Minister is responsible for New Zealand's participation in the Convention on International Civil Aviation. Annex 11 of the Convention requires States to determine those portions of airspace and aerodromes where air traffic services are provided.

The provision of ATS at aerodromes was reviewed in a CAA Policy Paper of August 2005. While other risk mitigation options in addition to ATS are addressed in passing, the overall impression is that of an ATS solution. While it may well be true, in general terms, that ATS is the optimal safety option, this may or may not be so at a particular location. There are several intermediate options including procedures, administrative agreements, Unicoms and locally staffed licensed flight information services which should be considered before moving to an ATS solution. This graduated approach has the advantage of tailoring the solution to the management of risk at the location and building confidence within the aviation community that CAA is focussed on efficiency of operations provided that the overarching safety obligation is met.

Recommendation 1

That CAA New Zealand considers adopting a graduated response to the management of aerodrome airspace risk.

The CAA Policy Paper envisages most aeronautical studies being developed externally by the proponent of the change using a standard methodology. Such studies would then be reviewed by the Aeronautical Services Branch of the CAA. This is a robust model which segregates the development and review processes. As a regulator, CAA may occasionally face a situation where it wishes to undertake a study internally in response to safety concerns. In this case, the study would most probably be undertaken by the Aeronautical Services Branch as it has the required

expertise. This could cause a governance issue as a single area of the organisation would both develop, then review, the proposal.

Recommendation 2

That CAA New Zealand considers the development of aeronautical studies by external agencies (as envisaged by the 2005 Policy Paper) for review by the Aeronautical Services Branch prior to a recommendation for approval being made to the Director. Where, in response to safety concerns, the Branch undertakes the study, the Director may wish to have the study reviewed by an external and independent body before making a regulatory decision.

5.2.1. Consultative Arrangements

All overseas administrations studied in this review placed great importance on consultation with industry stakeholders. Many found consultation with the broad spectrum of general aviation interests challenging. Consultation takes place at both national and local levels and is seen as vital to the acceptance of the outcome.

New Zealand has an advantage in that it has a peak aviation body with which it can consult; other administrations have had to set up broad consultative councils to achieve this result.

The methodology under development by this project stresses the importance of consultation at national and local levels.

Recommendation 3

To assist in the management of aeronautical studies and, in particular consultation, CAA New Zealand may wish to consider requiring proponents to submit a Terms of Reference document (as in the Canadian model) for approval before the study commences. A list of organisations and individuals to be consulted would be an integral part of this document.

5.3. Procedures and Design Process

Overseas aeronautical studies vary from those of New Zealand. Many are qualitative rather than quantitative; processes to estimate costs and benefits also vary. Canadian economic analysis, for instance, is done through a business case. Others have quite complex mathematical tool sets available. Australia for example, is developing a Common Risk Framework which uses a selection of quantitative and qualitative techniques, while the FAA has recently published an Airspace Management Handbook that offers both types of tools.

5.3.1. Trigger Points, Criteria & Target Levels of Safety

Some administrations have target levels of safety in place. These are documented in the summary table and are in the order of magnitude of 10^{-8} for collision risk.

Canada and Australia have annual location specific movement levels, which trigger further action, while the FAA has benefit cost ratio criteria for establishment and discontinuance of control towers.

The CAA Policy Paper and its Appendix 1, provide criteria for different types of ATS. They are based on traffic parameters – total aircraft movements, IFR movements and international passenger services. On its own, this is a rather narrow approach as it does not take into account the type of operation (such as training), operational complexity or location specific operational issues such as terrain and weather. Canada also uses similar criteria (Section 4.4.4 above). That being said, such criteria can be useful triggers for further examination, as long as they are supported by the use of other types of intelligence.

Recommendation 4

That CAA New Zealand considers reviewing the criteria in Appendix I of the CAA Policy paper to ensure they reflect their use as triggers for further studies. Other factors that may affect aerodrome airspace safety may also be relevant when evaluating the need for an aeronautical study at a location. If CAA wishes to make use of target levels of safety in some situations, it considers adopting those used by overseas regulators.

Recommendation 5

If not already in place, CAA New Zealand considers establishing a shortlist of marginal locations to be monitored. This would require the development of the list, a process to review the list (including changes to it) at regular intervals, as well as formal advice to the Director on emerging safety concerns.

5.4. Other Issues Arising From CAA Policy Paper August 2005

The CAA Policy Paper 2005 raised several specific policy issues. They are discussed briefly below. It is suggested however that they be reviewed in terms of a graduated response to the management of risk in aerodrome airspace.

Also, thresholds may need to be reassessed as points at which further examination through an aeronautical study should be undertaken:

- Thresholds for provision of ATS:

Discussed above, levels where further evaluation should take place.

- The aerodrome operator to be responsible for ensuring that the provision of ATS is in accordance with the established thresholds:

This is generally in accordance with overseas practice; however wording may need to be changed to reflect the initiation of an aeronautical study.

- The approval specifications for an aerodrome shall specify the arrangements for the provision of the required level of ATS and its ongoing monitoring:

Placing the onus on operators through formal documents is in line with overseas practice. There may be other options rather than ATS which may be as or more effective.

- Air operators shall be prohibited from using aerodromes where ATS is required, but for whatever reason is not being provided:

Generally in line with overseas practice but there may be occasions where such use may be necessary. There should be a provision to handle such exceptions.

- Where an aerodrome is not already certified, it shall be required to be certified (or take other measures) if movements at that aerodrome reach the threshold for provision of any level of ATS:

As above, should be read that a point has been reached where an aeronautical study should be undertaken to establish whether the aerodrome should be certified. CAA may need to make a policy decision on the updating of Rules to provide the necessary powers.

- Aerodrome operators shall have the option of initiating an aeronautical study to determine the levels of risk at that aerodrome and identify possible alternatives to the provision of ATS:

Such a process should become the norm, not the option.

- The Director shall have the option of conducting a study if he considers ATS to be necessary even though the threshold may not have been reached:

By all stakeholders taking a wider view of the criteria, the need for the Director to take such action could be reduced.

- The methodology for aeronautical studies is to be published in an Advisory Circular:

It is essential that the methodology is readily available, transparent and understood by all stakeholders.

- All aerodromes with movements above a defined threshold, or when otherwise required by the Director, are to maintain data on aircraft movements at that aerodrome and supply the data to the Director

A CAA policy initiative.

6. SUMMARY

Overseas aviation administrations have differing organisational models for the management of aerodrome airspace risk, the aeronautical study is the tool most administrations use to evaluate and manage this risk. Qualitative risk tools are generally available but some administrations prefer to use quantitative methods. The table below summarises overseas practices.

International Comparison – Aerodrome Airspace

State	EC/Eurocontrol (enroute entity only)	UK	Canada	Australia	United States of America
Safety Regulator	EASA	CAA/ SRG	Transport Canada	CASA	FAA
Airspace Regulator	ECATMU	CAA/ DAP	Transport Canada	CASA	FAA
Service Delivery	Eurocontrol	NATS	Nav Canada	Airservices Australia	FAA
Airspace Policy	EC	UK DoT CAA/DAP	Transport Canada	DOTARS/ OAR	FAA
Decision Criteria	Not Published	Not Published	Not Published	See Criteria Table	See Twr cost/ benefit ratios
Aerodrome Airspace Service Options	Upper Airspace Only	Upper/Lower Airspace	Upper/Lower Airspace	Upper/Lower Airspace	Upper/Lower Airspace
ATC Tower (Class C)	N/A	Y	Y	Y	Y
ATC Tower (Class D)	N/A	Not Found	Y	Y	Y
ATC Tower (Class E)	N/A	N	Y	Y	Y
AFIS (Licensed FIS)	N/A	Y	Y	Y	?
CAGRS (Certified FIS)	N/A	N	N	Y	N
Unicom (3 rd Party no FIS)	N/A	N	Y	Y	Y
CTAF (Radio Required)	N/A	Y	Y	Y	Y
CTAF (Radio Optional)	N/A	N	Y	Y	Y
G Airspace IFR/IFR Traffic, known VFR traffic	N/A	N	Y	Y	?
Trigger Points	Not Published	Not Published	60K, 40K, 20K	As per Draft Part 71	Not Published
Target Levels of Safety	1.55x 10 ⁻⁸	1.55x 10 ⁻⁸	Not Found	1.5x 10 ⁻⁸	Not Found

APPENDIX A

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Appendix A: References

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APPENDIX B

Australian Criteria

Appendix B: Australian Criteria

Quantitative Criteria and References

<u>Parameter</u>	<u>Quantitative Criteria</u>
Safety	Det Norske Veritas (DNV) Control Limits ¹ 10 ⁻³ per annum for pilots (workers) and 10 ⁻⁴ for passengers (public) probability of fatality ² . In certain circumstances ICAO may publish a target level of safety which must be satisfied before an activity can be implemented eg RVSM.
Value of Life	Bureau of Transport and Regional Economics
Capacity	Number of aircraft able to access services/facilities (eg runway/airspace)
Cost	Quantified costs of service/flow on costs to passenger/user/industry
Efficiency	Capacity delivered over user demand
Environment	Carbon Dioxide emissions, Oxides of Nitrogen and Sulphur, Particulate Matter, Hazardous Particles, Noise.

¹ These limits are currently (February 2007) endorsed by the Airservices Board as the intolerable.

² This is an interim (as at February 2007) criterion until a report from an independent consultant is received.

Collision Pair Collision Probabilities

Collision Pair	VFR/VFR	IFR1/VFR	IFR2/VFR	IFR1/IFR1	IFR1/IFR2	IFR2/IFR2
Configuration						
Unalerted	7.84 E-5	1.61 E-4	7.07 E-5	2.76 E-4	2.34 E-4	6.28 E-5
CTAF 70%	3.31 E-5	2.93 E-5	1.27 E-5			
CTAF 80%	2.32 E-5	1.96 E-5	8.24 E-6			
CTAF 90%	1.43 E-5	1.15 E-5	4.67 E-6			
MBZ	4.93 E-5	3.85 E-6	1.29 E-6			
IMC No ATS				1.10 E-5	3.80 E-6	6.59 E-7
IMC ATS				7.12 E-6	1.80 E-6	4.55 E-7
VMC No ATS				1.19 E-6	2.02 E-7	1.69 E-8
VMC ATS				7.92 E-7	1.00 E-7	1.23 E-8

APPENDIX C

Eurocontrol Hazard/Risk Analysis Methodology

Appendix 9

THE EUROCONTROL HAZARD/RISK ANALYSIS METHODOLOGY

1. BACKGROUND

1.1 In future, RNP 1 routes will become available allowing, in principal, a reduction in spacing from the present 16 NM between centre lines to something approaching 6-8 NM. The navigation performance of RNP-1 is defined as having a 95 per cent containment value of 1 NM. However, this value defines only the achieved track-keeping performance of the navigation system. ATC system loop errors (blunders) and navigation system failures outside of this core are potentially very much larger. Hence, the route spacing achievable without considering controller intervention and based solely on collision risk modelling may be little better than that for present day ATS routes.

1.2 Collision risk modelling, taking into account the track-keeping performance, traffic density and the target levels of safety, without ATC ability to intervene, has been applied to route spacing for North Atlantic operations. European airspace, for which route-spacing standards were developed prior to the establishment of collision risk modelling techniques, includes radar surveillance for deviation monitoring and direct pilot/controller VHF voice communications, thus permitting ATC intervention to avoid potential losses of separation.

1.3 An initial study, sponsored by EUROCONTROL, examined the feasibility of using hazard analysis as an input into the development of minimum spacing between RNP-1 ATS routes. This study showed that hazard/risk analysis is a promising technique and that further work in developing a complete collision risk model, including the reduction in risk associated with the availability of surveillance and direct voice communication, would be desirable.

1.4 A follow-up study has been commissioned and is currently under way.

2. AIMS OF THE HAZARD ANALYSIS PROGRAMME

2.1 Hazard analysis originated in the development of automatic landing systems but has been developed substantially as a result of its application in high-technology industries, e.g. off-shore drilling, nuclear energy, for the assessment of the risks associated with the role of the human in the control loop.

2.2 This study aims to integrate the more conventional collision risk modelling (statistical analysis) with a detailed knowledge of the types, mechanisms and frequency of occurrences of deviations caused by ATC system loop errors located throughout the air traffic system. In addition, the programme takes account of the ability to use radar surveillance and VHF voice communications to eliminate perceived deviations and reduce risk.

2.3 The eventual aim of this programme is the development of RNP-1 lateral route spacing standards for application in continental European airspace. The methodology used in the study is adaptable, and could be used in applications in other regions or States, as appropriate.

3. METHODOLOGY

3.1 The overall methodology for the application of hazard analysis to the problem of collision risk in the presence of an ATC capability is shown schematically in Figure A-9-1 below.

3.2 Elements of the collision risk model

3.2.1 The main elements of the collision risk model include the following:

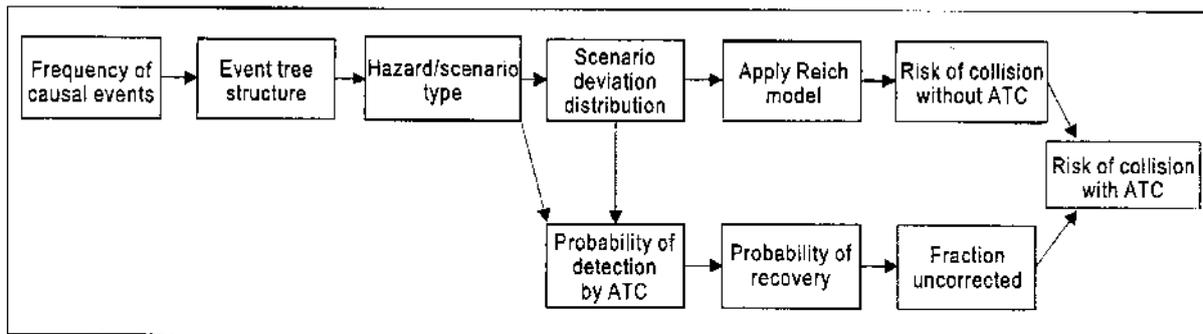


Figure A-9-1. Collision risk model structure

- a) the identification of scenarios which may lead to a loss of separation or a possible collision between two aircraft;
- b) the identification of specific hazards and the frequency with which they occur. Each hazard leads individually, or in combination with other circumstances, to a deviation scenario with an attendant deviation distribution;
- c) the calculation of the probable collision risk arising from the above scenarios assuming that the deviations are permitted to continue uncorrected (Reich model);
- d) the calculation of the probability of deviation detection and correction by either the pilot or ATC. The different modes of ATC intervention, i.e. conflict avoidance or deviation correction modes, will affect the time dependence of different hazard types and their detection and recovery strategies; and
- e) the deduction of the resultant overall probability of collision despite the surveillance capability. The probability of collision (in the absence of corrective action) is factored by the probability of non-detection and recovery before the collision occurs.

3.3 Notes on methodology

3.3.1 In the formulation of the model particular care has been taken to correctly represent the behaviour of both common mode failures (CMF), i.e. where a single hazard can cause the simultaneous malfunction or failure of several system elements, as well as events which might cause localized peaks in the tails of the deviation distributions of consequent importance when assessing the interaction/

convolution of the distributions. The current model takes account only of aircraft in level flight.

3.4 Model capability and output

3.4.1 The model will be capable of calculating the risk under given conditions and for various track spacings. The comparison between those risks and the applied TLS will help to determine the minimum track spacing. In addition, the model will determine the risk sensitivity to the various hazards and provide useful feedback with respect to the relationships between causal hazards and resultant risk. Finally, the model will predict other tangible events, which may be used for validation.

4. SCENARIOS

4.1 A number of scenarios are being examined and are shown below. These do not represent a complete set of possible scenarios but represent the types of resultant deviations induced by the identified hazards.

4.2 It should be noted that Figure A-9-2 could also represent a gentle wandering about the track centre line rather than a single drift off course. Also, the deviation may start, not from the centre line, but from an already offset track parallel to the centre line.

5. IDENTIFICATION OF HAZARDS AND DETERMINING THEIR FREQUENCY

5.1 Thus far, only hazards leading to lateral deviations have been considered.

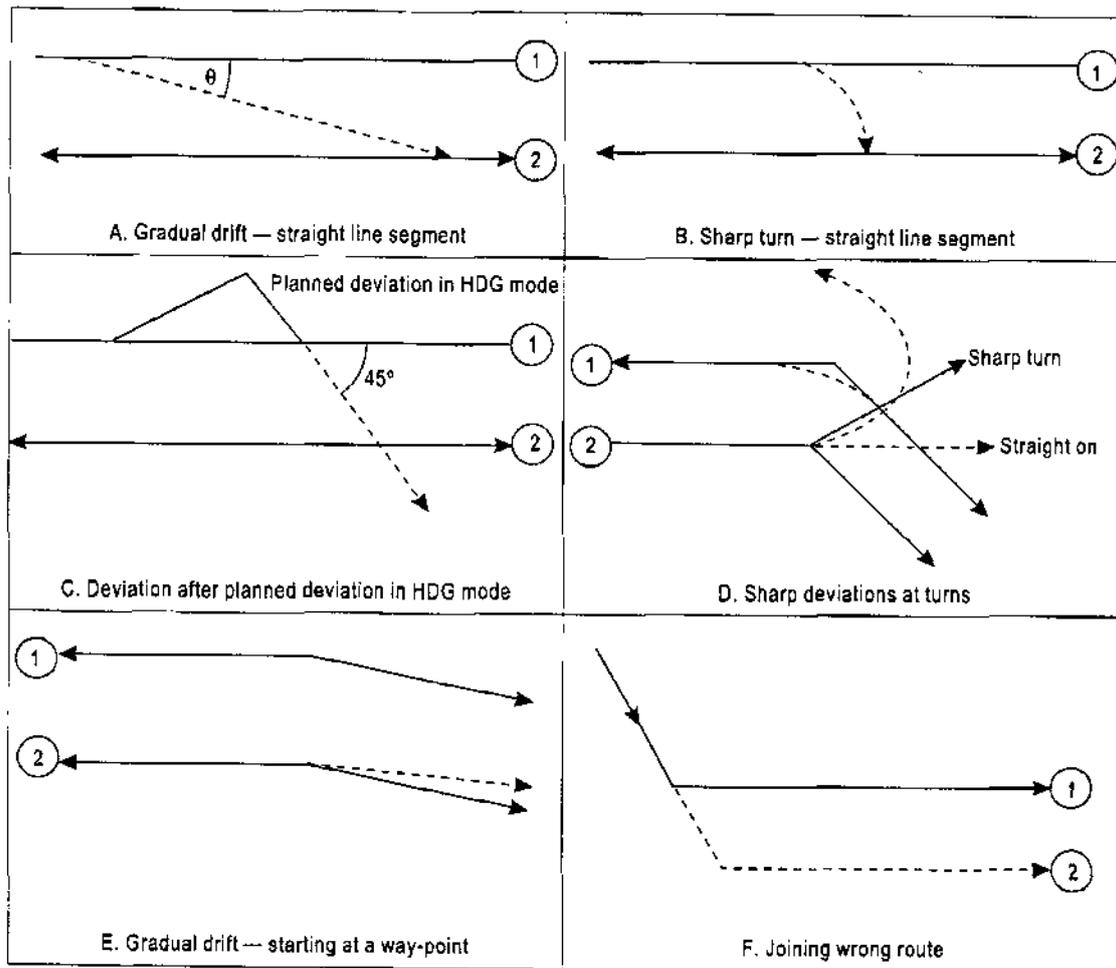


Figure A-9-2. Deviation scenarios

5.2 Hazard identification

5.2.1 Examples of the types of errors that are known to cause lateral deviations include the following:

- general navigation capability and variability including navaid quality, database errors and the carriage of navigation equipment inadequate for RNP-1 routes;
- flight crew error including incorrect data entry, way-point entry, cycling failure and general distraction;
- ATC error including incorrect sector handover and controller distraction;

- miscommunication between ATC and pilot, including call-sign confusion and the wrong aircraft responding to ATC instructions; and
- administrative and system errors, including flight plan errors, misleading NOTAMs, aircraft equipment failures and software errors.

5.2.2 Even when these errors are noticed during a flight, many are considered to be of no consequence and are not reported. Ad hoc cockpit/control room measures tend to be unofficially developed for minor problems that are encountered on a regular basis. However, it is often not an individual fault that causes a problem, but when two or more occur in tandem with other minor problems, a significant deviation can result. Relatively minor problems will potentially become more important with the application of RNP-1.

5.2.3 The hazards were identified by a combination of the following techniques:

- a) searches of incident reports, databases, etc.; and
- b) formal hazard identification and analysis sessions.

5.3 Searches of incident reports and incident databases

5.3.1 Many hazards have been extracted from the statutory reporting schemes and studies compiled by national or international authorities.

5.3.2 Among other sources, the EUROCONTROL study has relied heavily on information from operators in the European region. This data includes events reported voluntarily by flight crews, operators and ATS providers (controllers) in addition to the mandatory event reports by the same groups.

5.3.3 Lower-risk events can also be significant, but considerable amounts of data must be available to provide a representative sample of statistics. The problem associated with data gathering systems has been that normally only significant events have been recorded, which produces too small a sample of data to produce meaningful statistics. This study has been particularly interested in the potential hazards noted in the interaction between the flight crew and the controllers.

5.4 Formal hazard identification and analysis sessions (HAZOP)

5.4.1 HAZOP is a technique used to determine the likely hazards and consequences within a high-technology environment in which humans form a major link in the decision processes. A team of four or five experienced personnel draft a checklist on which the hazard identification sessions themselves are based. Each session is attended by some ten specialist personnel representing flight crews, controllers, and equipment manufacturers who are guided through the checklist of potential risk-inducing situations. The specialists are then invited to offer their opinions on:

- a) likely causes;
- b) possible safeguards; and
- c) possible consequences.

5.4.2 At the hazard identification sessions no attempt is made to quantify the risks associated with the hazards or the frequency with which the initiating hazards occur.

5.5 Hazard frequency and ranking

5.5.1 The relative importance of the various initiating hazards is determined by estimating the frequency of occurrence and the potential resultant risk.

5.5.2 Hazard frequency estimation is carried out by consideration of the various data sources with additional information being derived from other sources (radar recordings, etc.) where available. Finally, a panel of experts is convened to judge the validity of these estimates. Views expressed at the hazard frequency estimation session are incorporated into a questionnaire concerning specific hazards, their consequences, detection and correction. This is then sent to a wider selection of cooperating pilots and controllers.

5.5.3 During the course of estimating the frequency, and potential resultant risk, some hazards stand out as being major sources of risk in terms of both likelihood and severity. It is necessary to rank these key hazards in order of their importance and to try to estimate their frequency of occurrence with greater accuracy, since they have a relatively large effect on the final system risk.

6. EVENTS, DETECTION AND RECOVERY

6.1 It is evident from Figure A-9-1 that a combination of hazards interact to cause a particular type of deviation. The consequences of this deviation, and the possibility of it developing into an incident, is determined by a similar set of interactions, which are most easily assessed as a detection and recovery tree.

6.2 Important factors in detection

6.2.1 Factors that are integral to the detection of a deviation include the following:

- a) deviation type, traffic levels, ATC and pilot workload;
- b) whether the deviation occurs when a turn is expected;
- c) whether the deviation occurs during a sector handover; and

- d) the surveillance capability, including radar separation minima, basic radar accuracy, filtering and resolution.

6.2.2 The availability of alerting systems, the nature of the displays, the communication system, etc., all contribute to the variation in detection time.

6.3 Important factors in recovery

6.3.1 The following are important factors in the recovery from a deviation:

- a) delays due to misidentification of aircraft;
- b) misdirected corrective instruction or poor corrective manoeuvre; and
- c) the time remaining in which to take corrective action.

6.4 Simple deviation and recovery model

6.4.1 A simple model has been developed to simulate an aircraft deviating within the scenarios described in section 4. The possibility of flight crew and ATC detection, the correction reaction times and eventual recovery to the appropriate separation minimum have been included. The aim is to determine the probability of the deviating aircraft infringing on the adjoining track.

6.5 Conflict detection and resolution for a given scenario

6.5.1 Event trees associated with each deviation scenario have been determined and parameters (probabilities and time-scales) applied to:

- a) the detection of a deviating aircraft by ATC;
- b) the ability to communicate that fact to the deviating aircraft; and
- c) the ability of that aircraft to successfully complete a corrective (avoiding) manoeuvre.

6.5.2 The resultant structures are extremely complicated, and not all of the potential breakdowns of the tree can be readily analysed. However, the complexity has been reduced by assuming a more limited set of corrective time-scales, and deducing the likelihood of correction

before the application of short term conflict alert or reaching the closest point of approach, as shown in Figure A-9-3.

6.5.3 The capability of ATC to detect deviations is dependent on a number of circumstances described previously but particular attention should be paid to the likelihood of a CMF occurring.

6.6 Overall system collision risk under ATC

6.6.1 Figure A-9-4 is a further expansion of the structure of Figure A-9-3 but accumulated over N possible scenarios. The probability of a collision arising from a given scenario (in the absence of ATC) is given by P_N , but with ATC surveillance the deviation may be detected and corrected with varying probability right up to the time of collision. If the cumulative probability of this corrective action being applied successfully is PC_N per cent then the resultant probability of the collision occurring will be $P_N * (100 - PC_N)$ per cent. The overall probability of a collision arising will now be the sum over all of the scenarios.

6.7 Future factors affecting hazard detection and correction

6.7.1 Other factors, which have not been included at this stage, but which may be increasingly important in future, are those automated features, which enable the ATS system to predict and detect specific hazards and to suggest optimum corrective strategies. These include:

- a) on-board equipment that can detect drift from track or potential collision risk, (e.g. receiver autonomous integrity monitoring (RAIM), aircraft autonomous integrity monitoring (AAIM), traffic collision alert and avoidance system (TCAS)); and
- b) automated ATC capabilities including automatic intruder alerts, which can highlight poor handovers and monitor manoeuvres close to a boundary.

7. MODEL SENSITIVITY

7.1 Part of the hazard/risk analysis study carries out a sensitivity analysis to assess the effect of various estimated values and model simplifications on the calculated system risk. It is important that key factors/parameters are determined at an early stage to ensure that accurate assessments

	Deviation conflict detected	Conflict detected at STCA	Conflict resolved before CPA	Outcome	Probability	
Deviation on collision course	Early		Yes	No collision	A %	
			No	Collision		
	Later		Yes	No collision	B %	
			No	Collision		
	Very late		Yes	No collision	C %	
			No	Collision		
		Very late	Yes	Yes	No collision	D %
			No	No	Collision	

Figure A-9-3. Detection and correction tree

	Deviation on collision course	Probability of collision (if uncorrected)	Detected and corrected	With cumulative percentage of probability	Outcome	Remaining probability of collision
Set of initiating hazards	Scenario 1	P_1	Yes	PC_1	No collision	$P_1 * (100 - PC_1)$
			No		Collision	
	Scenario 2	P_2	Yes	PC_2	No collision	$P_2 * (100 - PC_2)$
			No		Collision	
	Scenario N	P_N	Yes	PC_N	No collision	$P_N * (100 - PC_N)$
			No		Collision	

Figure A-9-4. Collision risk with ATC detection and correction

are made of those parameters having a major influence on the result. The assessment methodology will also allow an evaluation of the impact of different environments on the TLS.

8. VALIDATION

8.1 Various practical data analyses have been carried out in the past, but it is very difficult to identify deviation statistics arising from specific causes. Those carried out by ICAO (1976) and EUROCONTROL (1982-84) give some results in relatively simple scenarios where attempts have been made to isolate any effects of ATC intervention. Even in these cases the tails of the deviation distributions are open to speculation.

8.2 In this case, the methodology predicts the distributions arising from specific combinations of hazards, different operating areas with different traffic levels, etc., and then applies the risk calculation to predict the resultant rates of infringement of separation. These rates of infringement are then compared with radar recordings to ensure that the recorded and predicted rates are in agreement over a wide range of infringement radii and circumstances.

9. APPLICATION

9.1 The collision risk model (CRM) is applied to suitable routes selected by the evaluation authority. Data on

traffic densities, the route network environment and passing frequencies are made available for input to the model, which determines the separation required to achieve the required TLS.

10. CONTINUING PROGRAMME

10.1 In the European study, the immediate task is to continue the development of the deviation, detection and correction model with the inclusion of more complete scenarios and the validation of the early results.

10.2 Sensitivity analysis, which should be applied in the last stages of the model development, indicates those parts of the model that require future work through modification of the complexity or by developing more precise estimates of frequency of occurrence. The completed model can be used to calculate the risk associated with varying spacing minima and to determine what spacings will permit operations in accordance with the required TLS.

10.3 Further research should be concentrated on extending the understanding of ATC system loop error mechanisms and ATC intervention success rates, using both detailed data collections and additional real-time simulation studies. The impact of automatic deviation and other alerts or ATC tools need to be assessed as they are brought on line.

APPENDIX D

***Application of Risk Analysis to Airspace Planning
In Australia***

Appendix 10

APPLICATION OF RISK ANALYSIS TO AIRSPACE PLANNING IN AUSTRALIA

1. INTRODUCTION

1.1 The airspace planning methodology for the determination of separation minima outlines two basic methods of determining whether a system is acceptably safe. Firstly, comparison with a reference system can be made, provided there is an extensive history of system safety in terms of system flight hours. It is noted that this method is impractical for low traffic density.

1.2 The second method is to evaluate system risk against a threshold TLS. Safety critical parameters have to be identified and their effect on collision risk modelled. The risk analysis process follows the traditional steps of system definition, setting evaluation criteria, hazard identification, frequency estimation, consequence modelling, risk estimation, risk evaluation and risk reduction measures, if required. A TLS of 1.5×10^{-8} fatal accidents due to collisions per system flight hour is recommended.

1.3 The guidance material recommends techniques such as mathematical modelling, expert judgement and comparison with other similar operations. It also suggests using panels of operational experts guided by a trained facilitator, who will also use the large amount of accumulated knowledge on likely error rates in other industries.

1.4 This paper describes the use of just such an approach by Airservices Australia to address the risk of various airspace classification and technology options for the sparsely settled interior of continental Australia. A base case has been established for existing risk levels and an airspace risk model (ARM) developed.

1.5 The major part of Australia, outside the eastern seaboard, capital cities and major towns, is uncontrolled airspace, and will eventually be categorized as ICAO Class G. There are concerns about the collision risk that regular public transport (RPT) may be exposed to at certain uncontrolled rural aerodromes such as Dubbo, Ayers Rock

and Kununurra. These aerodromes have a mandatory broadcast zone (MBZ) and may require ICAO Class E airspace en route.

2. DUE DILIGENCE

2.1 The application of engineering techniques to the preservation of life and the protection of property assets has been well established in the process industries (Reference 1)¹. Until recently, however, these techniques have seen little application in other industries. A multidisciplinary approach to risk management needs to consider both technology and human factors.

2.2 A common law duty of care exists for a safe work place and systems of work. The obligation to ensure that risk is "... as low as reasonably practical (ALARP)" is also enshrined in Australian Occupational Health and Safety (OH&S) legislation. To be found guilty of negligence, the answer to all four of the following questions needs to be "yes", on a balance of probability basis.

2.2.1 Question 1: Causation

Did the injury occur because of the "unsafe" matter on which the claim of negligence is based?

2.2.2 Question 2: Foreseeability

Is it possible to foresee that this injury could happen?

2.2.3 Question 3: Preventability

Is there a practical alternative to doing this job this way or with equipment within the employer control?

1. All References are listed at the end of the appendix.

2.2.4 Question 4: Reasonableness

What is the balance of the significance of the risk versus the effort required to reduce it?

2.3 Probability criteria are often used to judge risk for critical or catastrophic outcomes (single or multiple fatalities). Where risks are close to acceptable, one must demonstrate that the "... cost of reduction would exceed the improvement gained", while in the higher risk band, risk is tolerable "... only if reduction is impractical or if cost is grossly disproportionate to the improvement gained".

3. METHODOLOGY

3.1 Hazard and risk analysis techniques originated in the aerospace industry in the 1960s. They have significantly improved safety levels in the so-called high hazard chemical, petrochemical and nuclear industries. At the same time, principles of highly protected risk have been developed for fire protection in the manufacturing, paper and power industries.

3.2 A "cause-consequence" approach to modelling risk (Reference 1) was adopted to develop the airspace risk model. The approach combines fault tree and event tree techniques focused on a central event; the point in time at which control over potentially damaging energy is lost. These techniques have been applied to hazardous problems in a range of industries, both in Australia and overseas.

3.3 The concept of risk always has two elements, namely the frequency with which a hazard occurs and the consequence(s) of the hazardous event (Reference 2). An energy-damage approach is used in developing models to quantify the consequences of unwanted events and a time-sequence approach to identify the cause and quantify the likelihood.

4. APPLICATION

4.1 An airspace risk model has been developed to objectively determine risk levels associated with current and proposed methods of operating Australian airspace. The work began with a review of uncontrolled terminal airspace in relation to ICAO classifications. By inspection, it initially focused on aircraft transiting from the en-route to the circuit environments, as this was considered to be the highest risk area.

4.2 The ICAO model provides for a range of airspace types (A-G) with differing levels of service. The Australian

Airspace Classification Scheme (AACS) initially proposes minimal changes by keeping existing airspace boundaries and services, but revising nomenclature in accordance with ICAO recommendations. Due to safety concerns for IFR operations and pending further risk analysis, Class G airspace will require mandatory notification of IFR operations.

4.3 Aircraft have traditionally relied on radio calls to provide the "alert" component of the "alerted see-and-avoid" principle. At MBZ aerodromes, carriage of radio is mandatory while at common traffic advisory frequency (CTAF) aerodromes, it is not. The mandatory carriage and use of radio at MBZ aerodromes is confined to a volume of airspace usually of 15 NM radius and up to 5 000 ft above ground level (AGL).

4.4 Reference 2 defines a hazard as a physical situation with a potential for human injury. The term is taken to include danger to persons in a mid-air collision. In the terminal area just outside the circuit, arriving aircraft are both descending and manoeuvring from a variety of tracks, while aircraft departing are climbing and also manoeuvring.

4.5 The most likely type of collision pairs will depend on location and weather. They can be categorized according to whether aircraft are flying according to visual flight rules (VFR) or instrument flight rules (IFR). The latter range from low-capacity private/charter aircraft generally with only one pilot (IFR1), to high-capacity RPT aircraft operated by two pilots (IFR2).

4.6 Nine types of collision pairs are possible:

- a) VFR/VFR in VMC (1 case);
- b) IFR1/VFR and IFR2/VFR in VMC (2 cases); and
- c) IFR1/IFR1, IFR1/IFR2 and IFR2/IFR2 in both VMC and IMC (6 cases).

4.7 The collision pair analysis considers both visual and instrument meteorological conditions (VMC and IMC).

5. AIRSPACE RISK MODEL (ARM)

5.1 The ARM focuses on the "near miss" as the critical event. A near miss is considered to occur when two (or more) aircraft come within defined horizontal and vertical limits, without being aware of each other's presence. For modelling purposes, a critical pair of aircraft is one where they come within 1.0 NM horizontally and 500 ft vertically. If they hit they become a "collision pair".

5.2 Cause-consequence modelling (Reference 1) combines traditional fault tree and event tree techniques by focusing on a central event: the point in time at which control over potentially damaging energy is lost.

5.3 Statistical averages are used to estimate the possible consequences of particular collision pairs. A societal risk approach considers the cumulative frequency of N or more fatalities occurring.

5.4 The ARM, which has thus far been applied mainly to the terminal area of an uncontrolled aerodrome, proposes that three phases *all* have to fail for a potentially conflicting pair of aircraft to become a critical pair:

- a) there is a breakdown in ATC separation procedures or, as in the case of uncontrolled aerodromes, an ATC separation service is not provided;
- b) the considered action phase fails. This phase includes ATS alerts when relevant. It is based on pilot coordination by radio and separation by procedural means such as separate altitudes or specific tracking details. Typically, it covers a four-minute period, between five minutes and 60 seconds from potential impact. Considered action by either aircraft will avoid a critical pair; and
- c) the evasive action phase fails. This phase is any situation where visual acquisition and avoidance is necessary, but typically between 60 seconds and 12 seconds from potential impact. It is affected by the

geometry of the critical pair, pre-warning (radio, other knowledge of aircraft), aircraft size, colour, visibility, crew vigilance and workload. Evasive action by either aircraft will avoid a critical pair.

5.5 In focusing on the near miss as the critical event, the loss of control of the situation is identified as the point at which movement of the control surfaces of an aircraft at risk would not have any significant effect by the time the collision point was passed: no matter what the pilot does, luck will rule the result. This is about 12 seconds before any collision/near miss.

5.6 The cause-consequence diagram is centred on the critical event from which consequences flow and towards which there are causal events, with time depicted as flowing from left to right across the page. The elements of the model are:

- a) loss of control — 12 seconds before mid-air collision or near miss;
- b) contributing events — considered action and evasive action phases; and
- c) range of outcomes — event tree analysis questions.

5.7 Figure A-10-1 represents the "AND" logic that ALL five identified causes have to fail in order for loss of control to occur. On the right side of the model, the balance of probabilities between outcomes is estimated.

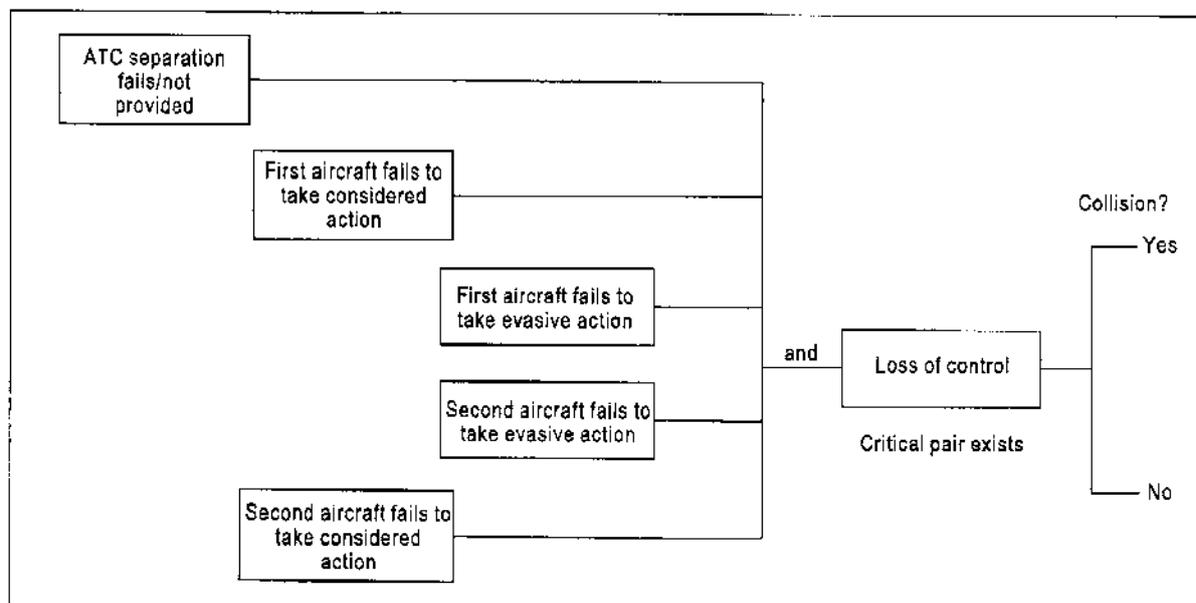


Figure A-10-1

5.8 The formulae used in the model are derived from the normal rules of combining probabilities.

Where an event can occur if either of the contributing events occur, i.e. there is more than one cause or failure mode, this is called an "OR" gate:

$$A \text{ OR } B = A + B - A * B$$

Note that the subtraction term is necessary so as not to double count the intersection of the two events. If both events have a failure probability of 1 in 10:

$$A \text{ OR } B = 0.1 + 0.1 - 0.1 * 0.1 = 0.19$$

(= 19% = 1.9×10^{-1} = 1.9 E-1 in scientific notation)

Conversely, where a control measure *D* is proposed to guard against an unwanted event *C*, this is logically an "AND" gate as both *C* must trigger and *D* must fail for loss of control to occur:

$$C \text{ AND } D = C * D$$

e.g. if both events have a failure probability of 0.1:

$$C \text{ AND } D = 0.1 * 0.1 = 0.01$$

(= 1% = 1.0×10^{-2} = 1 E-2 in scientific notation)

5.9 A traffic alert process will obviously fail if an aircraft cannot receive a call OR if no traffic alert is provided. Further, the provision of a traffic alert can come from ATS AND from the second aircraft, i.e. both must fail for there to be no alert. This is shown in Figure A-10-2.

5.10 An aircraft cannot receive a call if it has no receiver capability — receiver not installed OR receiver fails. The pilot can also fail, either by selecting the wrong frequency OR failing to listen. This part of the model is shown in Figure A-10-3.

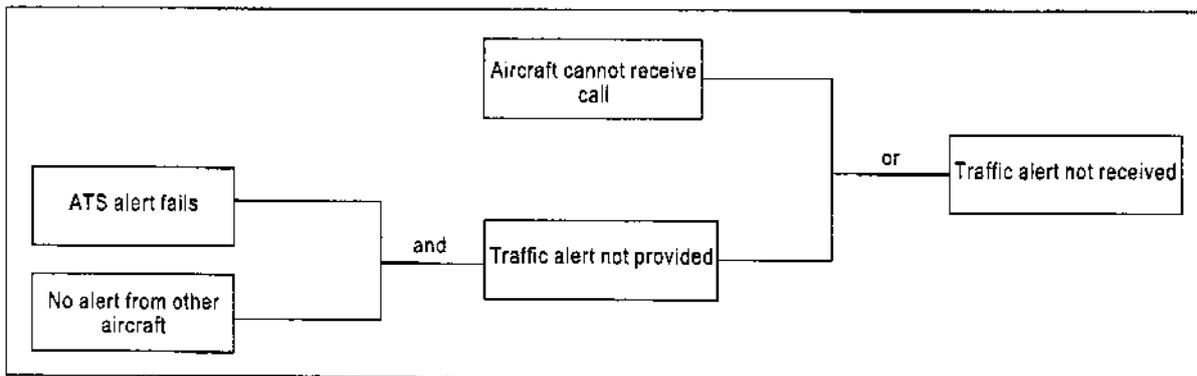


Figure A-10-2

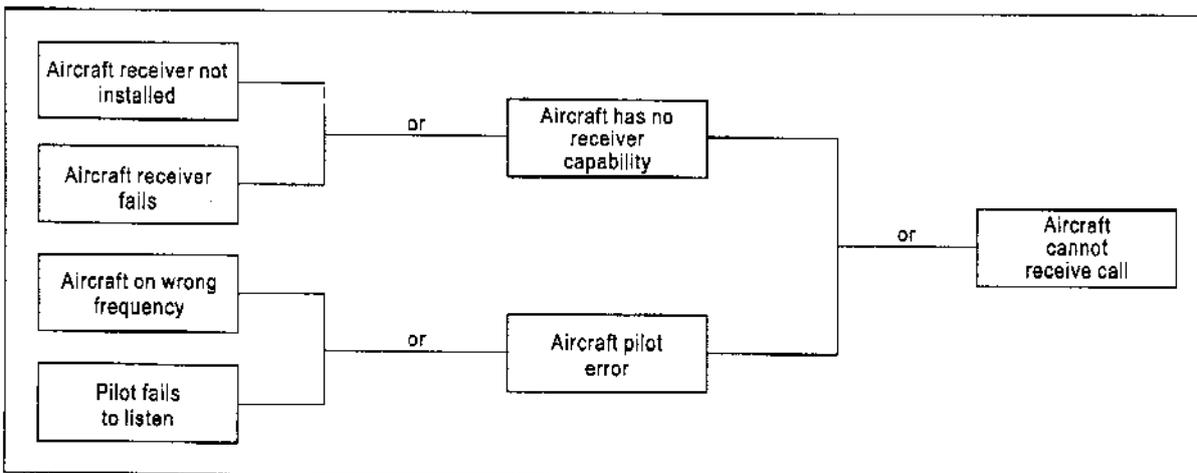


Figure A-10-3

5.11 Considered action fails if both aircraft fail to see each other OR if an aircraft is aware but makes an error. In this context “see” can have a broader meaning: the pilot of one aircraft “sees” the other in the “mind’s eye”, i.e. forms a mental picture of the other aircraft’s location. The only option for an unalerted aircraft is visual acquisition, which is unlikely in the considered action phase. Even if one aircraft is aware of the other’s position, it can still make an error, either by failing to respond to a potential threat, or by responding incorrectly (see Figure A-10-4).

5.12 Evasive action fails if both aircraft fail to see each other OR an aircraft is aware but makes an error. In this context “see” has only one meaning — unalerted visual acquisition. Other possibilities have already been taken into account in the considered action time-frame. By way of giving an example of where, in the model, a particular control technology would be considered, the role of ACAS is also depicted (Figure A-10-5).

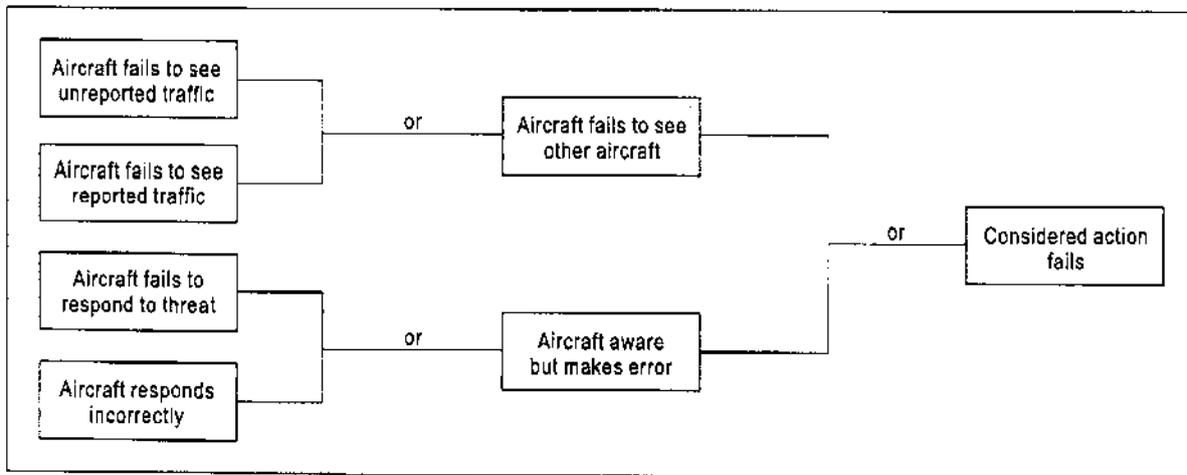


Figure A-10-4

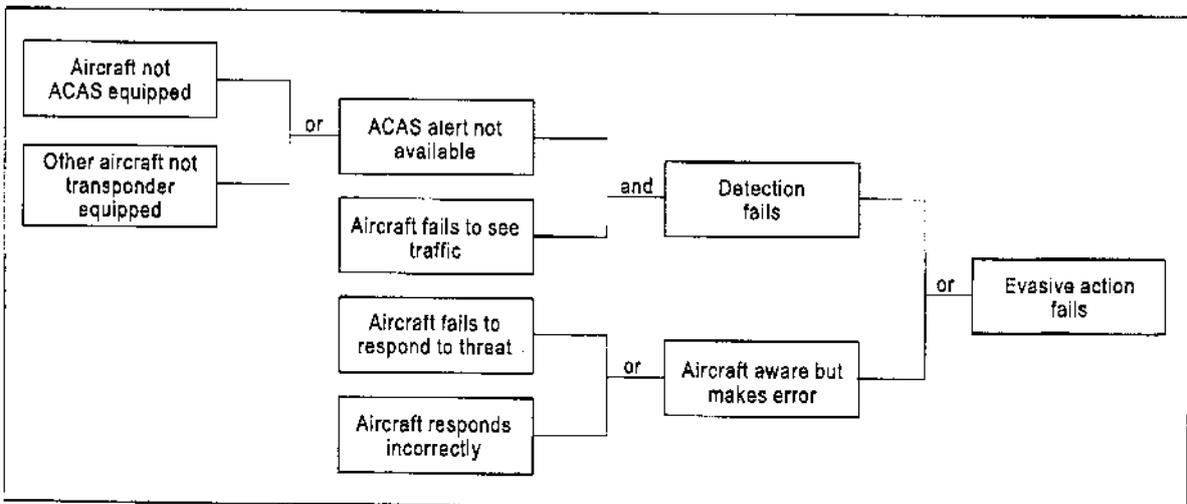


Figure A-10-5

6. QUANTIFICATION OF THE MODEL

6.1 The ARM was developed and quantified by a study team of operations and research personnel and consulting risk engineers. Probabilities for some components of the model were based directly on empirical data (e.g. equipment fit), some on indirect or extrapolated data (e.g. visual acquisition) and some on subjective data (e.g. human factors). The model and its probabilities were then scrutinized by a safety panel made up of a cross-section of industry representatives with current operational experience. While the panel accepted the model and some of the empirically derived probabilities, it derived probabilities for some components of the model by an iterative voting process.

6.2 An aircraft equipment survey conducted in 1994 (Reference 3) indicates that 5 per cent of VFR aircraft do not have radio installed, but that all IFR aircraft have radio installed.

6.3 Several incidents of aircraft receiver failure are reported by the Bureau of Air Safety Investigation (BASI) each week out of roughly 150 000 movements in Australia. Allowing for under-reporting, the failure rate of 1×10^{-4} (1 E-4) for electronic equipment typically adopted in process industry risk analysis (e.g. Reference 1) is regarded as realistic.

6.4 BASI reports suggest a failure probability of 8 in 100 000 for aircraft on the wrong frequency. The safety panel felt this figure would be highly dependent on experience. For VFR pilots it was considered ridiculously low. The panel voted for figures of 9 E-4 for IFR2 aircraft and 8.7 E-3 for VFR aircraft, i.e. the idea of the factor of 10 applying to VFR was agreed. By interpolation, a figure of 2.5 E-3 is used in the model for IFR1.

6.5 A mean probability of 1.3 E-2 was adopted for VFR pilots failing to listen, 1.2 E-3 for IFR2 pilots, with the interpolated value for IFR1 then being 4.03 E-3 .

6.6 Failure rates of ATS alert are likely to be very low, say 1 in 1 million for radar or notification failures and 1 in 100 000 for processing or communications errors.

6.7 The study team suggested figures of 1 E-3 for an IFR pilot and 1 E-2 for a VFR pilot for failure to make calls. This reflects the textbook difference between an experienced competent operator and one who is merely trained. The safety panel decided on a figure of 1.4 E-3 for IFR2 and 6.2 E-2 for VFR pilots, giving 9.2 E-3 for IFR1 pilots.

6.8 The panel adopted 2.7 E-3 for an IFR2 pilot failure to respond to an identified threat, because they are trained

to organize and initiate separation. An estimate of 5.4 E-2 was adopted for VFR failure to respond to an identified threat, the corresponding figure for IFR1 being 1.22 E-2 .

6.9 A typical IFR pilot who responded incorrectly once in 1 000 times would therefore do so about once every three years. The safety panel agreed this was close to the mark, adopting a mean of 1.1 E-3 . For VFR the figure was 1.72 E-2 and for IFR1, 4.43 E-3 .

6.10 Failure to act under clear and present danger was equated to personal experience of one mistake in 1 000 flights (a professional pilot would typically make 1 000 flights in two years). The safety panel adopted a mean of 1.15 E-3 for IFR2 pilots, 1.31 E-3 for VFR pilots and for IFR1 pilots, 1.23 E-3 .

6.11 As to aircraft responding incorrectly, note that pilots have no practice or testing in conducting evasive manoeuvres in potential conflict situations. Information on two recent near misses was considered by the panel, which adopted a mean of 2.34 E-3 for IFR2. For VFR, the figure was 4.75 E-3 and for IFR1, 3.34 E-3 .

7. MODEL RESULTS

7.1 The failure rate for IFR/IFR conflict pairs not being alerted ranged from 0.22 per cent to 1.89 per cent. In MBZs, the failure rate was 9.12 per cent for VFR/VFR pairs, and ranged from 2.44 per cent to 7.71 per cent for IFR/VFR pairs. In CTAFs, failure rates for VFR/VFR and IFR/VFR pairs were found to be very sensitive to VFR radio-participation rates, ranging from 15.45 per cent to 59.65 per cent.

7.2 Failure to detect an aircraft more than one minute away in the considered action phase was considered to range from 78 per cent to 94 per cent probability for pilots who were mentally alert but not "alerted". A figure of 5.7 E-3 was adopted by the panel for an IFR2 pilot's failure to realize the need for considered action when alerted. A mean failure rate of 8.9 E-2 was adopted for VFR pilots because their training does not emphasize enough situational awareness or thinking ahead. By interpolation, 2.36 E-2 was adopted for IFR1 pilots.

7.3 The evasive action figures were based on tables of cumulative probability up to the loss of control point of 12 seconds from potential impact. The critical factor was identified to be the size of the target aircraft. The failure probabilities adopted ranged from 24.8 per cent for an IFR2 looking for a VFR aircraft to 11.3 per cent for a VFR looking for an IFR2 aircraft.

7.4 The ratio between collision pairs and critical (near miss) pairs was considered to be about 1:300. Modelling of Dubbo aerodrome in New South Wales has been used to estimate the likelihood of a critical pair (near miss) existing on a given trip. Overall, with 25 000 movements in a year, 250 critical pairs were found, i.e. 1 per cent of total movements.

7.5 Applying the 1:300 ratio gives the conditional collision probabilities shown in Table A-10-1.

7.6 The likely average consequences for each collision pair are 20 fatalities for IFR2/IFR2, 11-12 if there is one IFR2 involved and 3.0-4.5 for collisions involving VFR/IFR1.

7.7 The relative risk results show that for IFR collision pairs, likelihood decreases sharply as consequence increases. This reflects the societal risk concept that society has a much greater aversion to high-consequence events. The model is sensitive to IMC where risk increased by an order of magnitude compared with VMC because the see-and-avoid contribution is not possible in IMC. However, risk is not significantly greater in either case if ATS is not provided. This is due to very high radio participation rates by IFR pilots.

7.8 For IFR/VFR pairs in MBZs, likelihood decreases by an order of magnitude as consequence increases, i.e. the risk (which is the product of likelihood times consequence) remains constant. There is a factor of 3 increase in risk from an MBZ up to a CTAF 90 per cent and a further factor of 2.5 increase in risk between the most optimistic and the most pessimistic assumptions about CTAF participation rates. Figure A-10-6 shows some of the relative risk results.

7.9 The results for pilots being completely unalerted are 1-2 orders of magnitude greater than CTAF 70 per cent. A key conclusion therefore relates to the issue of *alert*. The probability of collision is high when both aircraft are unaware of the other. Any option, such as MBZ, that enables the aircraft to be aware of each other is a major benefit. With ACAS, the probability of loss of control is further reduced for each aircraft pair so equipped.

7.10 The "risk triangle" concept initially promoted by the UK Health and Safety Executive (Reference 4) and VRF Handbook (Reference 5) places the ALARP range between 10^{-4} per year (100 chances per million) and 10^{-5} (1 chance per million) per year for individual risk criteria for a critical exposed group. By comparison with tables of risks to individuals (Reference 6), this is saying that risks which are

Table A-10-1

Collision pair	VFR/VFR	IFR1/VFR	IFR2/VFR	IFR1/IFR1	IFR1/IFR2	IFR2/IFR2
Configuration						
Unalerted	7.84 E-5	1.61 E-4	7.07 E-5	2.76 E-4	2.34 E-4	6.28 E-5
CTAF 70%*	3.31 E-5	2.93 E-5	1.27 E-5			
CTAF 80%*	2.32 E-5	1.96 E-5	8.24 E-6			
CTAF 90%*	1.43 E-5	1.15 E-5	4.67 E-6			
MBZ	4.93 E-6	3.85 E-6	1.29 E-6			
IMC no ATS				1.10 E-5	3.80 E-6	6.54 E-7
IMC ATS				7.12 E-6	1.80 E-6	4.55 E-7
VMC no ATS				1.19 E-6	2.02 E-7	1.69 E-8
VMC ATS				7.92 E-7	1.00 E-7	1.23 E-8

* Refers to the percentage of radio-equipped aircraft that make radio calls.

more dangerous than driving a car are likely to be unacceptable, whereas those that are about as likely as being struck by lightning are trivial.

7.11 Individual risk focuses attention on critical exposed groups such as crew members, who may be involved in 500 movements per annum. The Dubbo collision pair analysis shows individual risk of being in a mid-air collision is 23 chances per million per year for an IFR1 at an MBZ. This risk rises to 40 chances per million in CTAF 90 per cent, 57 chances per million in CTAF 80 per cent and 79 chances per million in CTAF 70 per cent.

7.12 The results plotted in Figure A-10-7 show MBZ risk as "tolerable" (less than 25 chances per million for IFR1 crew) and CTAF 80 per cent risk as "barely tolerable" (up to 57 chances per million for IFR1 crew) depending on radio participation rates. In this ALARP region, the obligation remains to reduce risk "as low as reasonably practicable".

7.13 Risks of different consequences are often compared on the basis that risks are similar if a tenfold increase in severity is accompanied by a tenfold decrease in likelihood. However, it appears that once the death threshold has passed, the community has a much greater aversion to multiple fatality incidents. Figure A-10-8 shows the cumulative probability of N or more fatalities compared to tentative societal risk criteria.

7.14 Further work is needed across the aviation industry as a whole regarding the risk parameters: passengers killed, safe passenger kilometres flown, safe passenger seat kilometres flown, etc.

8. DISCUSSION

8.1 Risk analysis techniques are advocated as an essential ingredient in determining safety policy.

8.2 Unalerted see-and-avoid constitutes an unacceptable risk. The size of the target aircraft is the critical factor. Probabilities of failure to acquire the target vary from 11.3 per cent for VFR aircraft looking for a two-pilot IFR aircraft, to 33 per cent for a single IFR pilot acquiring a small VFR aircraft in the evasive action phase.

8.3 The model is extremely sensitive to the CTAF VFR radio participation rate and surveys are in hand to further explore this issue.

8.4 The risk analysis clearly indicates that the current IFR to IFR separation procedures for uncontrolled airspace provide a high degree of safety, placing the risk of mid-air collisions between IFR aircraft in the trivial régime. However, when considering the effect of operating in an area with no mandatory radio requirement (outside MBZs), the risk of a two-pilot IFR aircraft coming into conflict with VFR aircraft becomes a higher but tolerable risk. The risk of conflict between pairs of single-pilot IFR aircraft and single-pilot IFR/VFR pairs is significantly higher again, and enters the area of barely tolerable risk.

8.5 Further work has commenced on where to set limits/criteria for establishing an MBZ over a CTAF, and what risk reductions might be achieved for what dollars spent on implementing new technologies such as ACAS.

8.6 The cause-consequence modelling approach can be calibrated to give an assessment of the existing risk of the particular system under study. By testing such models against both the available data and the experiences of senior management and technical personnel in the industry concerned, one can ensure that the model accurately reflects the best available information and knowledge at the time when it is used to make decisions regarding risk acceptance and risk reduction, if required.

9. NEXT STEPS

9.1 The first step is to recognize that although the basic structure of the ARM is unlikely to change, the quantitative results presented here are preliminary. As further research is conducted, particularly in the critical areas of probability of seeing other aircraft, and the near miss to collision ratio, then the results will change.

9.2 Secondly, the ARM needs to be refined to consider several classes of IFR aircraft, notably the low (less than 10 passenger seats), medium (10-38 seats) and high (greater than 38 seats) capacity RPT aircraft. This is important because the ARM is sensitive to the number of likely fatalities in a mid-air collision.

9.3 Thirdly, the relationship between absolute risk and risk acceptance criteria needs to be addressed. In particular, should risk criteria be based on some critically exposed group, such as RPT pilots or frequent flyers, or on some concept of overall risk? This will influence such things as the criteria for upgrading an aerodrome from a CTAF to an MBZ, or from an MBZ to a control tower.

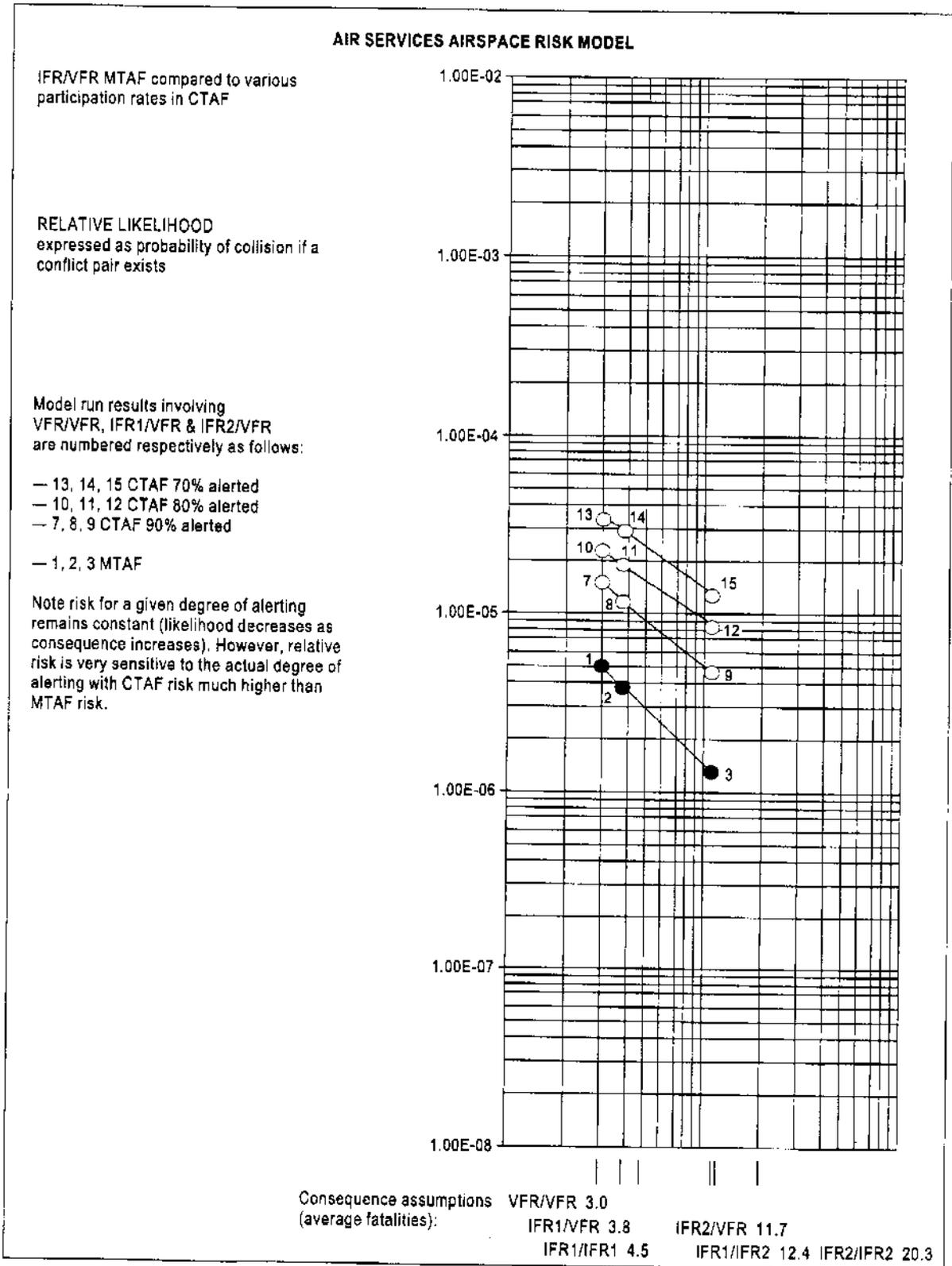
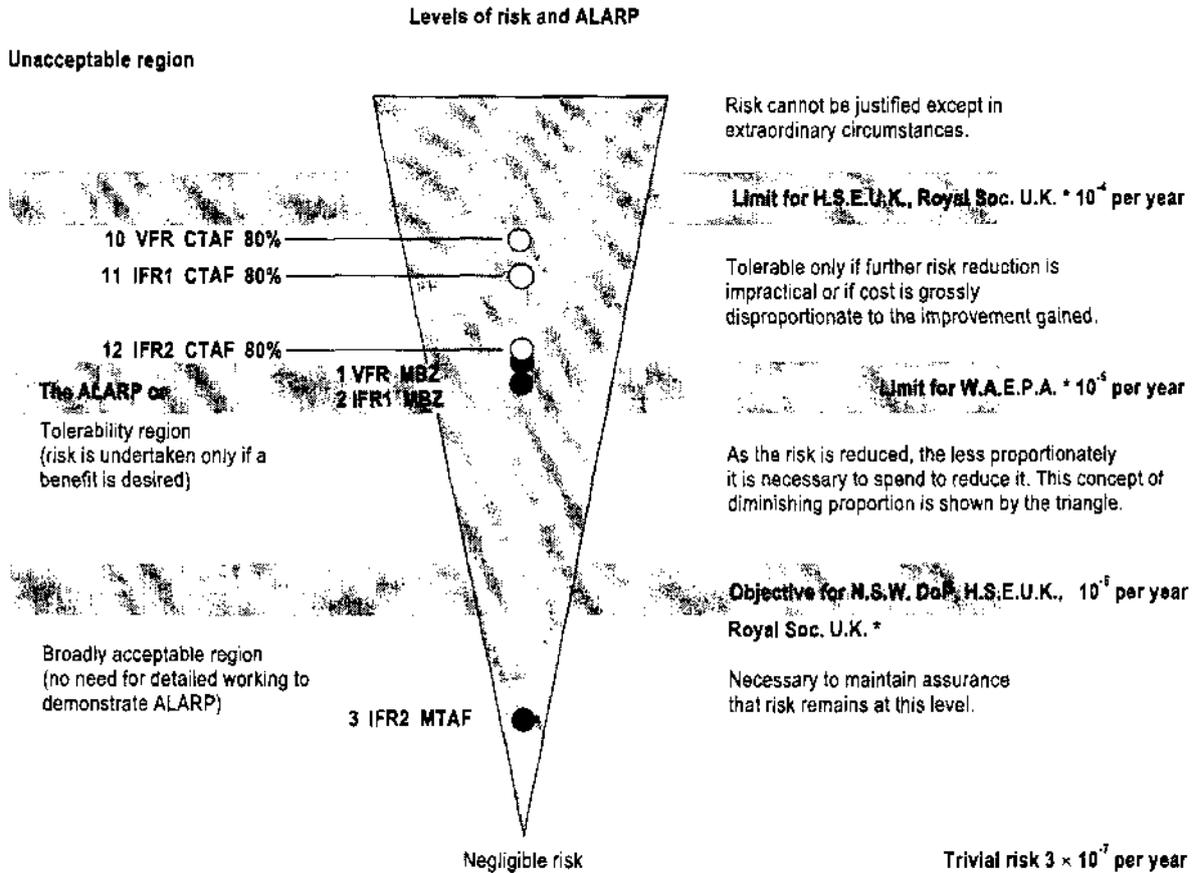


Figure A-10-6. Relative risk results



Individual Risk Criteria for Critical Exposed Group compared to Airspace Risk Model
Results for aircrew for Dubbo terminal area ICAO Class G uncontrolled airspace.

Note.— This diagram (without the quantification) appears in IEC 1508 as Figure B1.

Figure A-10-7. Individual risk criteria for critical exposed group compared to Airspace Risk Model results for aircrew for Dubbo terminal area — ICAO Class G uncontrolled airspace

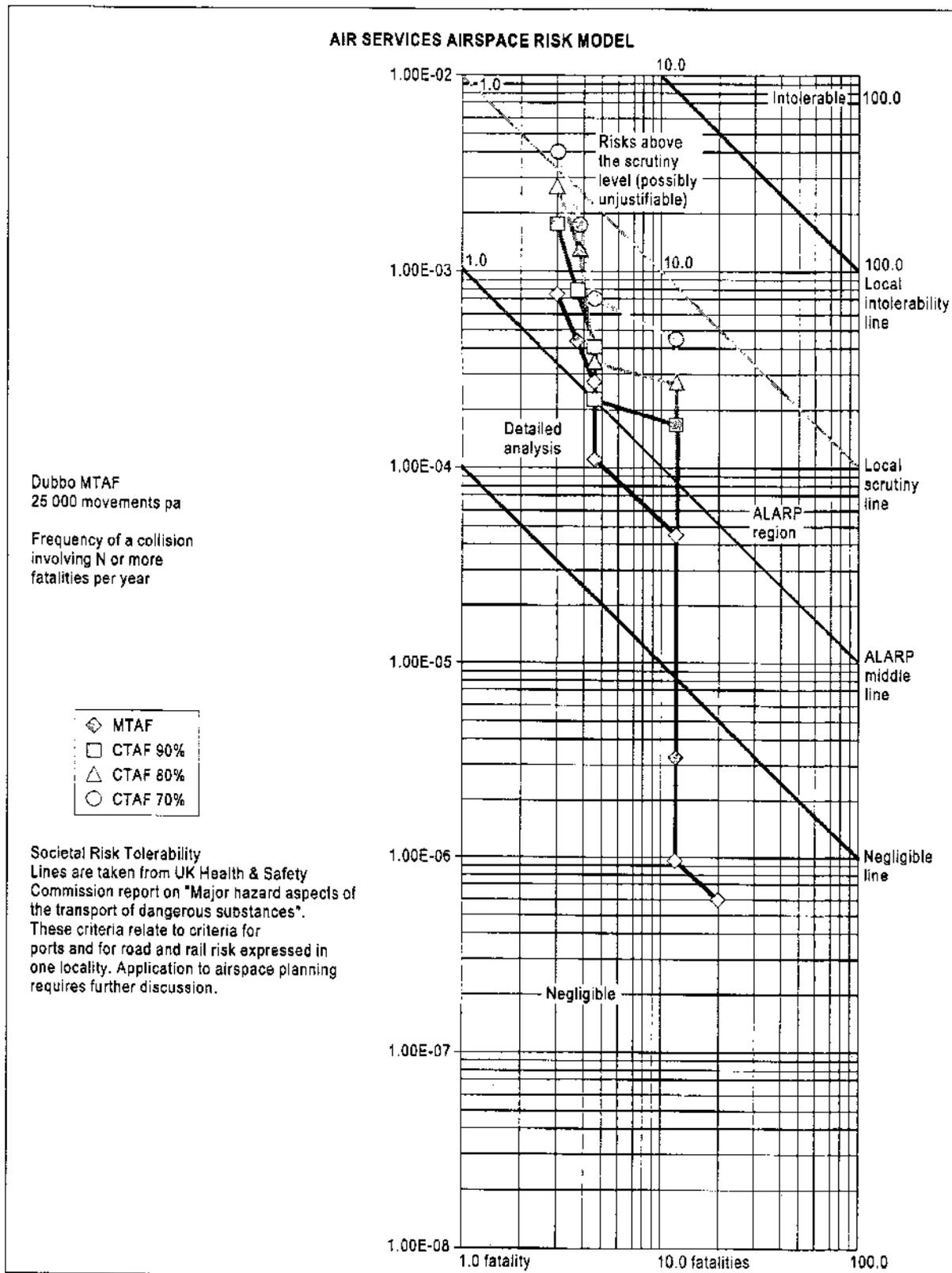


Figure A-10-8. Societal risk results

9.4 The fourth step is based on the recognition that the results so far are based on only one of Australia's larger uncontrolled hub aerodromes. Are these results applicable to all uncontrolled aerodromes? Traffic data surveys have been conducted at several other locations, to which the study team is now applying its modelling techniques to test the general applicability of the model.

9.5 The fifth step is to extend the application of the model to cover the en-route phase of flight, comparing the risk with the levels of service in Classes G and C. This requires completing the hitherto undeveloped part of the model on ATC separation services. When this is done, the ARM will be almost complete, and can then be applied to all classes of airspace.

9.6 The subsequent steps will therefore be to progressively apply the ARM to the higher classes of airspace, from D to A, and also to factor in such technological developments as the use of TCAS.

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APPENDIX E

*Terms of Reference
Canadian Aeronautical Study*



Terms of Reference

**Review of Air Navigation Services
Mackenzie River and Liard River Areas of the Northwest Territories**

Aeronautical Study

**Prepared by:
NAV CANADA
Level of Service and Aeronautical Studies
Edmonton, AB**

January 2007

Terms of Reference

Mackenzie River and Liard River Valleys Aeronautical Study

1.0 Purpose

The purpose of the Terms of Reference (TOR) is to provide a framework for an Aeronautical Study to review the ANS requirements in the region of the Mackenzie River and Liard River valleys in the Northwest Territories in advance of the proposed Mackenzie Valley Gas Pipeline project.

2.0 Scope

The intent of this Aeronautical Study is to identify service and airspace requirements to support safe and efficient IFR and VFR aircraft operations. The study will identify customer needs, issues and concerns and will consider the operating environment, including all expected flying activity in the area. It will consider airspace design, airport and en route traffic services, Instrument Approach Procedures, STARs, SIDs, IFR and VFR routes, communications, surveillance, ATS and pilot procedures, aviation weather services and navigation services. The study will recommend the best way to structure the airspace and provide air navigation services to meet the safety and efficiency goals of aircraft operators and their customers.

3.0 Methodology

The study team will:

- Interview customers and stakeholders to obtain their needs, issues and concerns;
- analyse the concerns and issues raised by the stakeholders;
- develop possible solutions and/or options;
- conduct HIRA as required;
- identify those solutions or options which may be implemented on a priority basis;
- prepare a final report;
- present recommendation to Senior Management for approval;
- co-ordinate with the appropriate managers who would be involved with the technical and operational implementation of proposed service changes;
- ensure the maximum practical customer and user support for proposed changes; and
- co-ordinate with Transport Canada with respect to regulatory review.

The study team will ensure that consultation with users, customers and affected or interested stakeholders is sufficient prior to making any recommendations to senior management.

Business cases will validate recommendations where required.

4.0 Safety Management

The manager responsible for implementing any decisions resulting from this aeronautical study will prepare a project safety management plan. The plan will include mitigation and monitoring actions identified through this study that are required to implement the change in service. This includes a 90-day and a one-year review following implementation.

In addition, the plan will include a methodology for responding to safety concerns emerging during this study, which require immediate action.

5.0 Human Resources

The Study Leader will rely upon and obtain the assistance of specialists in specific fields of expertise within NAV CANADA and may require expert assistance external to the company.

Team membership will be based on a multi-discipline, matrix organization. Representation will be obtained on an as needed basis for key technical, operational and support areas. Additional members will be identified during the course of the study and will be expected to participate on specific tasks on an as required basis. The duration of those tasks may vary from a few days to two weeks. A key focus of the study project manager will be to minimize impact of all work assignments on other projects underway.

The level of effort and duration will be calculated during the planning phase of the project.

6.0 Workplan

A work plan will be developed following the initial management team meeting.

7.0 Aeronautical Study Team Members

The following resources will be required:

Project Manager		Manager, Level of Service and Aeronautical Studies - West
Analyst		Level of Service and Aeronautical Studies
Analyst		Level of Service and Aeronautical Studies
Analyst		Level of Service and Aeronautical Studies
Airspace Specialist		Manager, Airspace Planning and Design
Operations Specialist		CNS Service Design
Surveillance Engineering		CNS Engineering - West
Contributor		Weather Services Specialist, Aviation Weather Services
Contributor		Site Manager, Inuvik FSS
Contributor		Site Manager, Yellowknife Control Tower and FSS and Norman Wells FSS
Contributor		Manager, North Bay FIC
Contributor		MACCO, Edmonton ACC
Contributor		Manager, ANS Plans and Program Coordination
Contributor		Manager, ATS Standards and Procedures
Contributor		GM Edmonton FIR
Contributor		MAO, Edmonton FIR
Contributor		Manager, AIS HO and Production Planning

8.0 Finance

The costs related to the conduct of this study, travel and consultation will be funded by the Level of Service and Aeronautical Studies Branch.

9.0 Materiality of the Change

It is possible that the recommended changes may represent material changes. In that event, NAV CANADA will send official notices according to Civil Air Navigation Services Commercialisation Act.

10.0 Communications

LOS & Aeronautical Studies will conduct the consultation activities with the support of the Director Communications.

11.0 Consultation

The following users and stakeholders will be consulted:

ABORIGINAL PIPELINE GROUP (APG)
ADLAIR (YELLOWKNIFE)
AIR NORTH (WHITEHORSE)
AIR TINDI YELLOWKNIFE)
AKLAK AIR (INUVIK)
ARCTIC SUNWEST AVIATION (YELLOWKNIFE)
BUFFALO AIRWAYS (HAY RIVER)
CANADIAN BUSINESS AIRCRAFT ASSOCIATION
CANADIAN HELICOPTERS (NORMAN WELLS, INUVIK)
CANADIAN NORTH (YELLOWKNIFE)
CONOCOPHILLIPS CANADA (NORTH) LIMITED
DEPARTMENT OF NATIONAL DEFENSE (440 SQN)
EXXONMOBILE CANADA PROPERTIES
FIRST AIR (OTTAWA)
GREAT SLAVE HELICOPTERS (YELLOWKNIFE)
GOVERNMENT OF THE NORTHWEST TERRITORIES
GWICH'IN HELICOPTERS (INUVIK)
HIGHLAND HELICOPTERS (RICHMOND)
IMPERIAL OIL RESOURCES VENTURES LIMITED
KENN BOREK AIR (INUVIK)
NAV CANADA EMPLOYEES
NORTH CARIBOO (FORT ST. JOHN)
NORTHERN AIR TRANSPORT ASSOCIATION
NORTHWESTERN AIRLEASE (FORT SMITH)
NORTH-WRIGHT AIR (NORMAN WELLS)
RCMP (YELLOWKNIFE)
SAHTU HELICOPTERS (NORMAN WELLS)
SHELL CANADA LIMITED
TRANSPORT CANADA (PRAIRIE & NORTHERN REGION)
URSUS AVIATION (TULITA)
VILLERS AIR SERVICE (FORT NELSON)

Additional users and stakeholders may be added to the consultation process as required.

12.0 Decision Maker

Kathleen C. Fox – Vice-President, Operations – NAV CANADA

APPENDIX F

Campbell River (Canada) Aeronautical Study



AERONAUTICAL STUDY

Review of the Control Zone, Mandatory Frequency Area, the Aerodrome Traffic Frequency Area and the Delivery of Airport Information Services at Campbell River, BC

PREPARED BY:

NAV CANADA
Level of Service & Aeronautical Studies - West

December 2004

**The information and diagrams contained in this Aeronautical Study are for
illustrative purposes only and are not to be used for navigation.**

Initiation

1.1 Background

Transport Canada - Pacific Region has identified frequency congestion as a significant safety concern at Campbell River. They believe this is due to the volume of traffic, pilot procedures and, flight service specialist procedures. This includes repetitious passing of routine information, over-solicitation of aircraft position reports, passing of non-pertinent traffic, passing of IFR clearances on the Mandatory Frequency (MF), repeated transmissions to aircraft and providing non-flight-related information to pilots. This frequently results in pilots not being able to make timely position reports. It also makes it difficult for other pilots in the Mandatory Frequency Area (MFA) and the flight service specialists to maintain situational awareness, thereby increasing the risk of collision. Transport Canada representatives are supportive of any changes in the provision of the airport information service that will contribute to the reduction of the frequency congestion at Campbell River.

The purpose of this Aeronautical Study is to review the Control Zone (CZ), the Mandatory Frequency Area (MFA), the Aerodrome Traffic Frequency (ATF) Area and, the delivery of airport Information in order to identify safety issues related to frequency congestion.

1.2 Aeronautical Study Team

Project Manager	Brian Stockall	Manager, LOS and Aeronautical Studies - West
Study Team Leader	Brian Stockall	Manager, LOS and Aeronautical Studies - West
Contributors	Gerry Nourry Joe Oster	Manager - Campbell River Flight Service Station Supervisor - Campbell River Flight Service Station
	Brett Oram	Analyst - Level of Service and Aeronautical Studies
	Rob Bishop	Analyst , Level of Service and Aeronautical Studies

1.3 Stakeholders

703 West Coast Floatplane Association
Central Mountain Airways - Smithers
Corilair Charters - Campbell River
DND - 442 Sqn - Comox
DND Terminal Control Unit - Comox
E & B Helicopters - Campbell River
Helifor Inc. - Campbell River
Helijet Airways - Richmond
MJM Aviation - Campbell River

NAV CANADA Flight Service Station - Campbell River
Transport Canada - Pacific Region
Parallel Aviation - Campbell River
Pacific Coastal Airlines - Richmond
Rush Air - Campbell River
Vancouver Island Airways - Campbell River
Vancouver Island Helicopters - Campbell River
West Coast Helicopters - Campbell River

2.0 Preliminary Analysis

2.1 Methodology

An Aeronautical Study Team was established that included a Level of Service and Aeronautical Studies manager, and a LOS and Aeronautical Studies analyst as team leader. On-site meetings and telephone interviews were held with key stakeholders. The NAV CANADA Site Manager and Team Supervisor provided information on aircraft, airport and FSS operations. The team analysed the nature of aircraft operations at and in the vicinity of the airport and developed the preliminary risk assessment. The Expert Panel format was used for a two-day customer meeting and for team deliberations.

2.2 Environment

2.2.1 Geography and Climate

The city of Campbell River is located on the coast, mid-way up the east side of Vancouver Island. The Vancouver Island Range stretches the length of Vancouver Island. These significant landforms play a major role in the shaping of the climate and weather of the island. Low clouds and poor visibility frequently occur along the narrow Discovery Passage.

2.2.2 Campbell River Airport

The airport is owned and operated by the District of Campbell River and supports scheduled airline passenger service, air cargo, charter flights, flight training (including air cadets), parachute jumping and general aviation.

The airport elevation is 346' ASL. Manoeuvring areas consist of one runway; 11/29, which is, 5,000' long and 150' feet wide with taxiway access to both ends and the middle of the runway. Taxiway C, which provides access to the button of runway 29, is limited to an aircraft weight of 44,000 lbs. A standard left-hand circuit is used for runway 29, but a right-hand circuit is used for runway 11.

The Campbell River FSS facility is at ground level with visibility to the south-west only. The facility is currently not equipped with NARDS or ATIS.

The Campbell River Flight Service Station provides Airport Advisory Service (AAS) 16 hrs per day from 05:30 to 21:30 local and METARS from 06:00 to 21:00 to support a 13 hr TAF (08:00 to 21:00). Flight Information Services En Route (FISE) is provided 24 hrs on frequency 126.7 MHz via RCO to Kamloops FIC. Comox Terminal (DND) provides ATC service.

A NDB, a DME and an ILS serve the Campbell River Airport. The approaches currently published are RNAV (GPS) RWY 29, NDB RWY 11, LOC (BC)/DME RWY 29 and ILS or LOC/DME RWY 11. When the FSS is closed (21:30 to 05:30 local) the Comox altimeter setting is to be used for all procedures. When using the remote altimeter setting 90' must be added to all procedure altitudes and pilots must verify that the runway is unobstructed. Straight-in localiser (LOC) minima are not authorised when the Comox altimeter setting is used.

Currently there are three air carriers providing scheduled passenger service to Campbell River; Central Mountain Air, Pacific Coastal Airlines and Helijet Airways operating Beechcraft 1900D and Shorts SD360 aircraft. There are 2 helicopter operators based at the airport using Bell 206 Vertol 107 and Chinook helicopters.

The airport is heavily used for flight training. There is a flying school, a skydiving school, and an ultra-light flight school based at the airport. Additionally, a helicopter flight school, based off the airport, uses the airport for training, as does a heavy helicopter operator, who uses the airport for

recurrent training. As the Campbell River airport is the only ILS equipped airport on Vancouver Island or the Lower Mainland of BC which can easily accommodate IFR training, the airport is routinely frequented by DND from Comox, as well as aircraft operators and flying schools from Victoria, Vancouver and Boundary Bay. Due to the rugged mountainous terrain of Vancouver Island, both wheel and float equipped aircraft operating in accordance with visual flight rules, flying between Victoria and Port Hardy, and points in between, follow the coast.

Campbell River Aircraft Movements - TP577

YEAR	TOTAL	ITINERANT	LOCAL
2003	40907	23071	17836
2002	42957	23251	19706
2001	43110	23960	19140
2000	38018	22902	15116
1999	32854	22966	9888

There is a considerable seasonal variation in the monthly aircraft movement figures with 2,000 - 2,500 movements per month during the November - March timeframe increasing to 3,500 - 9,000 per month in the period May - September. Much of the summer increase can be attributed to the DND air cadet flight training activity, conducted under contract by the local flying school.

2.2.3 Campbell River Hospital Heliport

The hospital is located close to downtown Campbell River, near the coast and 3.6 NM north-east of the airport. The helipad is a 75' x 75' concrete pad located adjacent to the hospital. The helipad elevation is 228' ASL - 118' below that of the airport. Pilots using the helipad must avoid the build-up areas of the city. They are restricted to a single arrival and departure path - 081° to the coast with a 12% slope. The helipad is certified for multi-engine helicopters only and prior notice is required for its use. Retro-reflective markers and take-off and landing area floodlighting provide lighting.

2.2.4 E & B Helicopters Heliport

This busy private heliport has four landing pads and is located 5.3 NM north of the airport and .5 NM west south-west of the float base. The elevation of the heliport is 7' ASL. Operating a fleet of Robinson R22 and R44 and Bell 206 JetRanger helicopters, E & B conducts flight training and charter operations from this location.

2.2.5 West Coast Helicopters Heliport

The heliport is located 6 NM north-west of the airport, adjacent to the Campbell River float base at an elevation of 7' ASL. The heliport serves as a base for charter operations using AS350 aircraft.

2.2.6 Campbell River Water Aerodrome

The float base is located on the coast north of the city and 6 NM north-west of the airport. Take-offs and landings are conducted in a designated area in Discovery Passage, which lies between Vancouver Island and Quadra Island. The water aerodrome serves as a base for the following charter operators who operate DHC2, C185 and BE18 aircraft: Corilair Charters, MJM Aviation, Rush Air and Vancouver Island Air, as well as Sealand Aviation, a MRO facility specialising in DHC2 Beavers and other float planes.

2.2.7 Airspace

A Class "E" control zone (CZ), with a radius of 5 nautical miles, is centered on the airport to a height of 3300 feet ASL. Overlying and surrounding the Campbell River control zone is the Comox military terminal control area, the airspace classification being Class E airspace above 700' ASL. Below this, the airspace is Class G.

2.2.8 Air Traffic Services

Airport information service is currently provided 16 hours per day by the Campbell River FSS from 1330-0530Z (0530-2130 local time). This service consists of airport advisory and vehicle control service, the provision of relevant local information and the relaying of IFR ATC clearances. FSS personnel conduct aviation weather observations (METAR) during the hours of FSS operation.

Visibility from the single-story FSS facility is poor with only a portion of the manoeuvring area and the approach to runway 11 being available to the flight service specialists. Because of this lack of visibility, flight service specialists have to request position report updates from pilots on a frequent basis.

The Comox Military Control Unit provides IFR control service. Primary and secondary radar coverage extends to the ground in the vicinity of the airport. This radar information is currently not available to the flight service specialists in the FSS as they are not equipped with a radar display (NARDS). This equipment is scheduled for installation early in 2005.

The Canada Flight Supplement (CFS) does not contain VFR Terminal Procedures Chart (VTPC) for Campbell River and no formal VFR reporting points have been established.

2.2.9 Traffic

The geographic location is a major influence on the traffic flow into and out of the airport. The Vancouver Island Range is located to the west. The Strait of Georgia and Discovery Passage is to the east. There are fishing and logging camps to the north and east. Vancouver, Victoria and the USA are to the south. The majority of itinerant traffic (estimated at 75%) arriving and departing Campbell River flows to and from the south and east.

Itinerant IFR aircraft movements at Campbell River consistently exceed 5,000 per year. In addition to the three air carriers operating several daily scheduled passenger flights, privately owned and corporate business jets regularly use the airport, the Campbell River area being world famous for its salmon fishing. Since the majority of IFR arrivals are from the south and the departures are also to the south and the close proximity of CFB Comox, ATC clearances are both numerous and complex.

A significant number of the itinerant pilots (both IFR and VFR) are unfamiliar with the airport, leading to non-flight related questions, such as to where to park, refuel, obtain customs service, etc. These numerous and sometimes lengthy questions, and the responses are currently carried out on the MF.

2.2.10 Communications

A Mandatory Frequency Area (MFA) is centered on the Campbell River airport with a radius of 5 nautical miles and a vertical limit of 3300' ASL. The mandatory frequency (122.0) is used for air-ground communications during the hours when the FSS is operating. Outside of operating hours of the FSS, pilots broadcast their intentions on the MF in accordance with CAR 602.98. Comox Terminal provides service to IFR aircraft on frequencies 123.7 and 227.6 outside of the MFA.

An aerodrome traffic frequency (ATF) (122.5), with a radius of 3 nautical miles and a vertical limit of 2,000' ASL is centered on the water aerodrome, located 6NM north-west of the airport. The ATF abuts, but does not overlap the CZ and MF area.

The common ATF for water aerodromes on the West Coast is 123.2. Given the number of water aerodromes, their proximity and the low in-flight altitude of floatplane operations on the coast, most pilots monitor this frequency and use it for in-flight information exchange. It is the standard pilot-to-pilot in-flight frequency on the coast. Transport Canada recommends that pilots operating below 1,000' ASL monitor 123.2 for advisories of imminent blasting operations, as this is the frequency used by logging companies.

2.3 Study Assumptions and Constraints

This review is conducted under certain assumptions as follows:

- The current procedures for aircraft operations at uncontrolled airports are considered to be safe.
- The common practice for aircraft operations to be conducted at altitudes of 500' or less in the coastal environment is considered to be safe.
- Pilots will fly in accordance with CARs.

2.4 Consultation

A consultation meeting on the National Level of Service Aeronautical Study was held in Campbell River on May 26, 2004. During this meeting a number of issues related to Campbell River frequency congestion and MF procedures were raised. A subsequent two-day expert panel workshop was held in Campbell River on June 22-23 to further identify issues, concerns and possible solutions. Additionally, a letter describing the proposal along with a diagram of the proposed airspace change was mailed to all above-named stakeholders.

2.5 Issues

2.5.1 Frequency Congestion

In recent years there have been concerns by local users and flight service personnel about the frequency congestion in the vicinity of Campbell River and the problems attributed to it. Contributing to the frequency congestion are several factors. Total aircraft movements at Campbell River have been in excess of 40,000 per year since 2001. This traffic is comprised of a mix of IFR and VFR itinerant aircraft and local IFR and VFR training operations. Also contributing to the frequency congestion are floatplanes, passing through the zone en route via the Discovery Passage or the Strait of Georgia or landing at the Campbell River waterdrome.

Pilots operating between 250' and 500' ASL along the coast and over the Strait of Georgia and Discovery Passage are able to communicate with the FSS. However, the communications often have to be repeated due to intermittent signal coverage because the FSS is located at the airport, which is at an elevation of 330' ASL. This increases the number of radio transmissions and adds to frequency congestion.

During the summer, a significant number of the pilots arriving at Campbell River are unfamiliar with the airport. The flight service specialists, in response to pilots' questions advise itinerant aircraft, where to park, where to get fuel, where to go for customs etc. The majority of itinerant pilots ask these questions on the MF every time they arrive in Campbell River, which at times adds considerably to the frequency congestion on the MF.

As a result of the relatively large number of IFR aircraft (arrivals and departures) at Campbell River and the close proximity of Comox airport, IFR clearances are both numerous and complex.

The number and complexity of IFR clearances relayed by the flight service specialists on the MF contributes to frequency congestion.

The frequency congestion has led to complaints from aircraft operators that pilots are unable to properly broadcast their intentions or make the mandatory MF calls. This means that pilots flying in the vicinity do not have the benefit of accurate situational awareness. This might lead to conflicts with other aircraft. The flight service specialists also have difficulty providing effective Airport Advisory Service due to frequency congestion as it becomes difficult for them to maintain an accurate traffic picture as well.

2.5.2 Delays

Local helicopter operators provide MEDEVAC service to Campbell River, landing at the helicopter landing area at the hospital, which is located 3.6 NM north-east of the airport and 118' below the airport elevation. Since the flights are conducted in accordance with VFR, when weather conditions are below VFR minima, the pilots must obtain Special VFR (SVFR) authorisation in order to enter the control zone and depart the hospital. When IFR aircraft are operating into or out of the airport, these pilots experience delays in obtaining SVFR authorisation. In 2003, E&B Helicopters requested that the control zone be modified to remove a portion of the control zone below 500' ASL to permit MEDEVAC helicopters to operate into and out of the hospital heliport without having to obtain SVFR authorisation.

2.5.3 Special Visual Flight Rules (SVFR)

Once the helicopter has discharged the patient, it is no longer a MEDEVAC and the pilot is unable to request priority to depart the hospital and return to his base. During consultation it was reported that pilots are, however, unable to communicate with FSS below 250' ASL after their departure from the hospital. This prevents the pilot from requesting SVFR authorisation prior to departure. When IFR aircraft are operating into or out of the airport, pilots experience delays in obtaining SVFR authorisation or may have the request denied, even though the helicopter is already in flight in the CZ. The pilot must then return to the hospital.

Many itinerant aircraft follow the coastline, transiting the eastern side of the control zone at less than 700' ASL. Since the flights are conducted in accordance with VFR, when weather conditions are below VFR minima, the pilots must obtain special VFR (SVFR) authorisation in order to enter and transit the control zone. Pilots operating at less than 700' have difficulty communicating with Campbell River FSS due to poor reception and are unable to communicate with the FSS at 500' or less. Pilots are often unable to report clear of the control zone. Since pilots of MEDEVAC helicopters are unable to communicate with the FSS in flight below 250' ASL and when on final to the hospital they are unable to report down at the hospital. Stakeholders stated that this results in delays to pilots requesting IFR clearances or other pilots requesting SVFR authorization since they must wait until the status of the original aircraft has been determined by the flight service specialist before subsequent SVFR requests can be approved or IFR clearances obtained.,

Float plane Pilots operating below 250' ASL along the coast and over the Strait of Georgia and Discovery Passage are unable to communicate with the FSS. They are therefore unable to properly make the mandatory MF calls to the FSS and when they broadcast their intentions they frequently cause interference with transmissions by the flight service specialist, which they are unaware of. Some of these pilots also transit the CZ along the coast below 500 ASL without obtaining SVFR authorization, being unaware that below VFR weather conditions exist at the airport.

2.5.4 Position Reporting

Concerns have been expressed regarding the lack of adequate depiction of local reporting points and frequency areas in the vicinity of Campbell River. An ATF is in place for the 2 heliports and the water aerodrome located northwest of the airport on the edge of the CZ/MFA. Itinerant pilots, unaware of the ATF monitor the MF, over-flying the heliports and water aerodrome without communicating with, or being aware of, the local traffic. Some reporting points are commonly used by local pilots, but some pilots use different names for the same location. Some commonly used VFR reporting points are the same as those used by IFR pilots, but the names used by the VFR pilots are different than those used by the IFR pilots. This creates uncertainty on the part of both flight service specialists and pilots as to the location of other aircraft in the area. Pilots operating within the MFA along the coast below 250' ASL are unable to communicate with the FSS to report their position and receive traffic information. This creates uncertainty on the part of pilots as to the location of other aircraft in the area.

3.0 Risk Estimation and Risk Evaluation

The expert panel estimated and evaluated the risks as described in sections 3.1 through 3.4.

3.1 Frequency Congestion

Frequency congestion hampers communications, which in turn are vital for situational awareness and traffic flow. Frequency congestion may be the cause of traffic conflict, which in turn may lead to a collision. Based on recent in flight conflicts and experiences of the pilot members of the expert panel, the risk of an air to air collision was estimated as low with high consequences. This risk is unacceptable.

3.2 Delays

Delays result in extra operating costs to stakeholders. In addition, in a MEDEVAC situation, a delay may have serious consequences on the life and health of a patient. The expert panel estimated the probability of unusual delays due to frequency congestion as low with minor consequences. Delays are, nevertheless, unacceptable to customers because of cost.

3.3 SVFR

Difficulties in pilots obtaining SVFR clearances cause delays, which are costly to operators. As well, there may serious consequences on the life and health of a patient during MEDEVAC. MEDEVAC pilots who were team members or interviewed stated that the probability of delays under SVFR conditions was high with moderate consequences. This is unacceptable to users and to patients.

3.4 Position Reporting

The lack of standard reporting points and the inability to communicate with the FSS causes confusion. This leads to errors in situational awareness, which in turn may lead to collision. The expert panel thought that the probability of an air to air collision in these circumstances was rare to low with high consequences. This is an unacceptable risk.

4.0 Risk Control

4.1 Options

The following options were considered:

1. Maintain the status quo at Campbell River
2. Raise the base of the control zone to 500' ASL in the section of the control zone overlying the hospital and extending to the coast of the island and maintain the MF area in its current size.
3. Raise the base of the control zone and the MF area to 500' ASL in the section of the control zone overlying the hospital and extending to the coast of the island.
4. Raise the base of the control zone and the MF area to 500' ASL in the section of the control zone overlying the hospital and extending to the coast of the island. Increase the size and shape of the water aerodrome ATF. Depict these changes on a VFR Terminal Procedures Chart (VTPC) in the Canada Flight Supplement (CFS) and Water aerodrome Supplement (WAS) (Fig 1).
5. Establish VFR reporting points in and adjacent to the control zone and depict these in the new VTPC (Fig 1); and
 - Review the use of a separate frequency to pass IFR clearances and non-flight-related information to aircraft on the apron;
 - Install an ATIS. This will remove the necessity to communicate airport information thereby relieving frequency congestion.
 - Install a radar display (NARDS). This will solve the FSS specialist situational awareness problem, which in turn will help alleviate frequency congestion.

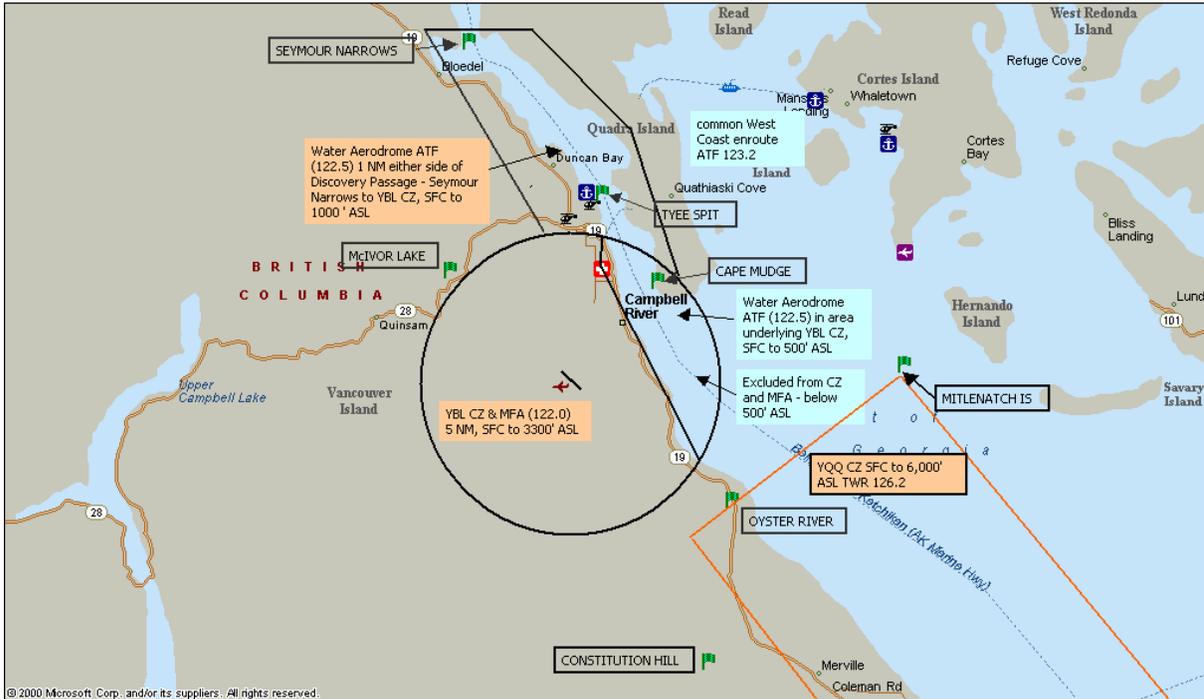
Option 1 was not considered further as this configuration is not meeting the needs of the MEDEVAC service providers, the floatplane operators, and the flight service specialists and contributes to frequency congestion within the MF area.

Option 2 is not recommended, as it does not meet the needs of the floatplane operators, the flight service specialists or contribute to reducing frequency congestion within the MF area.

Option 3 is not recommended. While it would meet the needs of the MEDEVAC service providers, the floatplane operators, and the flight service specialists and contributes to reducing frequency congestion within the MF area, it does not address the safety concerns in the vicinity of the 2 heliports and the water aerodrome.

Options 4 and 5 are recommended as they will meet the needs of the MEDEVAC service providers, the floatplane operators, and the flight service specialists, contribute to reducing frequency congestion within the MF area and address the safety concerns in the vicinity of the 2 heliports and the water aerodrome

Fig.1 VTPC with Control Zone and Mandatory Frequency Area Adjustment and ATF Extension as per options 4 & 5.



5.0 Action/Monitoring

5.1 Recommendations

It is recommended that executive management approve the service delivery proposal to:

- Raise the base of the control zone to 500' ASL in the section of the control zone overlying the hospital and extending from the hospital south-east to the CZ boundary on the coast and from the hospital north to the CZ boundary on the coast;
- Raise the base of the MF area to 500' ASL in the section of the MFA overlying the hospital and extending from the hospital south-east to the MFA boundary on the coast and from the hospital north to the boundary on the coast;
- Extend the existing helicopter/float base ATF (122.5, 3NM 2,000' ASL) north-west to cover the Discovery Passage to the Seymour Narrows, (sfc - 1000' ASL) and south-west below the control zone (sfc - 500' ASL).
- Establish VFR reporting points in and adjacent to the control zone and depict these in the new VTPC.
- Review the use of a separate frequency to pass IFR clearances and non-flight-related information to aircraft on the apron;
- Install an ATIS.
- Install a radar display (NARDS).

5.1.1 Change Management Table

Current System	Proposed System	Changes	Impacts
CZ - 5 NM diameter to 3300' ASL	Base of CZ raised to 500' ASL in eastern portion over coast.	CZ exclusion below 500' ASL over coast.	Permits MEDEVAC flights to/from the hospital without the need for SVFR authorisation.
MFA - 5 NM diameter to 3300' ASL	Base of MFA raised to 500' ASL in eastern portion over coast.	MFA exclusion below 500' ASL over coast.	Pilots will be able to operate low-level along coast without the risk of delays and without contributing to frequency congestion.
Waterdrome and heliport ATF - 2 NM to 1500' ASL	ATF extended north to Seymour Narrows (1000' ASL) and south beneath MFA.	Extend ATF north and south.	Pilots will be able to monitor and make position reports on common low-level frequency.
No common reporting points. Frequency areas described in CFS.	Reporting points and frequency areas depicted on VTPC.	Develop common reporting points. Design VTPC.	Pilots will be aware of common reporting points and areas for frequency use.
MF used for IFR clearances and non-flight related information	Use a separate frequency to provide IFR clearances and non flight related information.	Develop unit procedures and amend site manual.	Congestion will be relieved on the MF.
All advisory information is repeated to each pilot.	Install an ATIS.	Develop unit procedures and amend site manual. Publish the ATIS frequency in the CAP and CFS.	Congestion will be relieved on the MF.
No radar information available to assist with situational awareness.	Install NARDS.	Develop unit procedures and amend site manual.	Congestion will be relieved on the MF.

5.2 Implementation

5.2.1 Communication

The overall intent of the communications plan is to facilitate an orderly service transition, monitor results, and gather data relative to the service change.

Publication Changes

Publication	Cut-off Date to Regional AIS Office	Effective Date
DAH	16 February 2005	12 May 2005
WAS	3 January	17 March 2005
CFS	16 February 2005	12 May 2005

5.2.2 Implementation Plan

The implementation plan for the amendment of the CFS will be predicated directly upon the Aeronautical Information Services AIRAC schedule.

Communication/Implementation Responsibilities

Section	Task	Notable dates	Comments
LOS & Aeronautical Studies - West	<ol style="list-style-type: none"> Advise GMAO the results of this study. Prepare draft "Notice" for Intranet/Internet and send to LOS & Aeronautical Studies HQ. After TC Review, notify local stakeholders of change. Develop VTPC. Notify AIS of required CFS change. Perform scheduled monitoring activities. 	<p>On approval of this study. No later than 15 February 2005.</p> <p>No later than 1 March 2005. No later than 16 February 2005. No later than 16 February 2005.</p>	<p>HQ LOS & Aeronautical Studies will inform LOS & Aeronautical Studies - West when review is complete.</p> <p>Effective date of publication change to be 17 May 2005.</p>
ANS Plans & Programs	<ol style="list-style-type: none"> Prepare DAH amendment. 	On approval of this study.	
AIS Vancouver	<ol style="list-style-type: none"> On notice from LOS & Aeronautical Studies - West prepare a Publication Amendment Change (PAC) to amend the CFS. 	No later than 16 February 2005.	
AIS Head Office	<ol style="list-style-type: none"> Receive PAC from AIS Vancouver. Publish AIRAC notice. 	No later than 2 March 2005.	Anticipate AIRAC to be published early April 2005.

5.3 Safety Management

The manager responsible for implementing any decisions resulting from this aeronautical study will prepare a project safety management plan. The plan will include mitigation and monitoring actions identified through this study that are required with the implementation of the recommended changes.

5.4 Monitoring

Following implementation of the proposal, NAV CANADA will undertake a follow-up review of the effects of the change 90 days and one-year after implementation. The Monitoring Plan will seek to confirm that the following areas have not been adversely affected to an unacceptable level by the change in the control zone and MF area:

- a. Flight safety,
- b. User operations.

Comments and data will be gathered from stakeholders and internal data sources for measurement against items a) and b) above. Indicators will include, but not be limited to any of the following:

- Negative reports on any items listed above;
- Reports filed with the NAV CANADA Regional Safety Manager;
- Reports filed with Transport Canada – CADORS;
- Internal NAV CANADA reports.

Any required corrective action would be developed through a team-oriented approach to the situation. Reports will be filed with the Manager, Level of Service and Aeronautical Studies - West for review and recommendations.

APPENDIX 4

Aerodrome Airspace Model (Preliminary, Generic and Case Studies)

AMBIDJI
FOR
THE NEW ZEALAND CIVIL AVIATION AUTHORITY

Aerodrome Airspace Collision Risk Model

July 2007

R2A Document Control

Client: Ambidji for the New Zealand Civil Aviation Authority
Project: Aerodrome Airspace Collision Risk Model
Client Reference:
R2A Reference: 187-02

Version	Date	Issue/Nature of Revision	Prepared by:	Reviewed by:	Issue Authorised by:
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a.	Client	(2)	Mr Rob Graham & Mr Brian Jackson
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	Total	(3)	

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Risk is peculiar to time and place. So unless specifically indicated to the contrary, this report only applies to the particular situation or scenario that is the subject of this commission.

Ambidji for the New Zealand Civil Aviation Authority
Aerodrome Airspace Collision Risk Model
July 2007

CONTENTS

SUMMARY

- 1.0 OBJECTIVE
- 2.0 METHOD
 - 2.1 Legal Context
 - 2.2 Risk Context
 - 2.3 CAA Aerodrome Airspace Risk Model Development Methodology
- 3.0 TASKS COMPLETED
 - 3.1 Inception Meeting and Briefing of CAA Legal Counsel
 - 3.2 Industry Stakeholder Meeting – Wellington
 - 3.3 Preliminary Model Development – Gisborne
 - 3.4 Generic Model Development using Timaru data – Wellington
- 4.0 AERODROME AIRSPACE MOVEMENT COLLISION RISK MODEL
 - 4.1 Aerodrome Airspace Operations
 - 4.2 Aerodrome Airspace User Classes
 - 4.3 Generic Controls / Precautions
 - 4.4 Threat Barrier Diagram
- 5.0 APPLICATION
 - 5.1 Excel Workbook
 - 5.2 Inputs
 - 5.3 Outputs
- 6.0 OBSERVATIONS AND COMMENTS
 - 6.1 Utility
 - 6.2 Credibility
 - 6.3 Adaptability
 - 6.4 Limitations
- 7.0 GLOSSARY
- 8.0 REFERENCES

APPENDICES

- Appendix A Risk and Good Practice Briefing
- Appendix B Gisborne Development Risk Model Briefing
- Appendix C Preliminary Aerodrome Airspace Collision Risk Model
- Appendix D Timaru Development Study
- Appendix E Aerodrome Airspace Collision Risk Model

Ambidji for the New Zealand Civil Aviation Authority
Aerodrome Airspace Collision Risk Model
July 2007

SUMMARY

An aerodrome airspace collision risk model has been developed for the Civil Aviation Authority (CAA). It has been derived generatively, that is, by discussing the issues with aerodrome users (mostly pilots at Gisborne) and formulating a model which appears immediately intelligible to them.

The model was then tested against a further group including CAA staff for sensibility using Timaru data as a development site.

To test the complete utility of the model will require its full application at an aerodrome before being rolled out at other aerodromes.

The primary strength of the model is as a communication tool that facilitates robust internal conversations at each aerodrome and consequent external review. This transparency should enable defensible risk decision making, both by airport operators and regulators.

1.0 OBJECTIVE

The objective of this study is to develop an aerodrome airspace movement collision risk model for use in New Zealand by the Civil Aviation Authority and others, as required.

This is one of the elements of the project to be delivered by Ambidji for the development and proposed standards and practices for the management of aerodrome airspace risk.

2.0 METHOD

2.1 Legal Context

2.1.1 Statute

The CAA operates under the Civil Aviation Act (1990) and rules and regulations made under that Act. The CAA is a Crown entity with the principal functions of undertaking activities which promote safety in civil aviation at reasonable cost (CAA website viewed 14/05/07).

Statutory design decision makers (including those acting under delegation) may be negligent. The basis of negligence is 'duty of care' (Sid Wellik, CAA Solicitor 2005). The usual standard is what is accepted practice for a competent engineer.

Under the Health and Safety in Employment Act 1992 (HSE Act), employers in New Zealand are responsible for making sure the work done for them is safe and healthy. It requires employers to approach health and safety in the workplace in a systematic yet flexible way taking into account generalist information in Regulations, Codes of Practice, and best practice guidelines as well as from the experience of employees. Under the Act employers are required to take all reasonably practicable steps to make the workplace safe. Failure to ensure such may be negligent, and can lead to the significant costs associated with common law claims. It may also lead to statutory penalties for 'responsible' individuals. Under the provisions of the Act, the role of the Civil Aviation Authority is to administer and enforce the HSE Act in the aviation sector. The Act also covers crew working aboard the aircraft.

The HSE Act states that all reasonably practicable steps must be taken to make work safe. All practicable steps is defined in the Act to mean: *....all steps to achieve the result that is reasonably practicable to take in the circumstances, having regard to –*

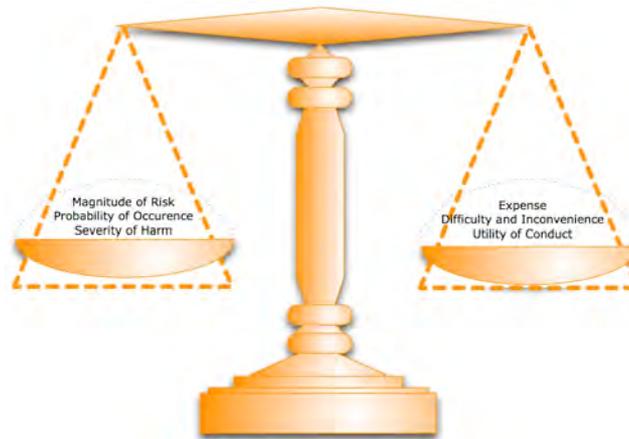
- a) the nature and severity of the harm that may be suffered if the result is not achieved; and*
- b) the current state of knowledge about the likelihood that harm of that nature and severity will be suffered if the result is not achieved; and*
- c) the current state of knowledge about harm of that nature; and*
- d) the current state of knowledge about the means available to achieve the result, and about the likely efficacy of each of those means; and*
- e) the availability and cost of each of those means.*

To avoid doubt, a person required by the Act to take all practicable steps is required to take those steps only in respect of circumstances that the person knows or ought reasonably to know about.

It appears that the HSE Act is a statutory statement of common law duty of care described in the following section.

2.1.2 Common Law

For risks not identified as 'intolerable', the common law principle applies, that is, the balance of the significance of the risk versus the effort required to reduce it. This is represented by the diagram below adapted from Sappideen and Stillman (1995).



How would a reasonable defendant respond to a foreseeable risk?

In order to meet the common law duty of care, it would appear that risk management is shifting away from the concept of 'acceptable' risk to 'not intolerable' risk. If an identified risk is found to be 'intolerable', that is prohibitively dangerous then the activity must be stopped. The concept that risks can only be 'tolerable' (meaning 'not intolerable') seems to be supported in the 2004 revision of the *Risk Management AS/NZS 4360:1999* which appears to have deleted all reference to the term 'acceptable' risk.

This appears to mean there is no lower limit to risk. If for 50 cents the risk of a small issue can be reduced even further, then in the event that it occurred, the failure to have spent that 50 cents will give rise to negligence. In practice, the lower limit appears to 'pixilate' meaning that despite best research efforts, it becomes unclear what effect allocating further resources actually has.

In part, this shift seems to be because the courts appear to be consequence driven. Risk is generally considered to be a combination of likelihood and consequence. However, after the fact, the likelihood is certain. Any view that the event occurs very, very rarely is not relevant. The expert witnesses then look to see what could have been done, which if it had been done, would have prevented the occurrence. (As an aside, being an expert in hindsight is not that difficult.) Risk per se is not relevant. It is only raised to assess the reasonableness of the possible precautions in view of the state of knowledge before the event.

2.1.3 Good Practice

The legal focus appears to be on ensuring that all sensible practicable precautions are in place taking into consideration recognised good practice. In making such an observation, the writers are not saying that risk assessments ought not to be done. It is just that they are part of a due diligence solution especially when trying to determine the efficacy of competing precautions and mitigations.

Overall for senior management and board members at least, liability management is very nearly identical to consequence management. Frequency and therefore risk management is not really an issue. If a serious loss event can credibly occur then it must be (seen to be) managed.

2.2 Risk Context

Any argument that an expert witness could formulate after an event needs to be considered prior to the event. The following table outlines the different ways in which risk arguments can be formulated. Each of the methods has different strengths and weaknesses depending on the culture of the organisation and the nature of a particular task. The best methodologies that might be used to demonstrate due diligence in the development of a safety argument are highlighted in the following table.

Risk Management Paradigm		Technique		
		<u>Expert reviews</u>	<u>Facilitated workshops</u>	<u>Selective interviews</u>
1.	The rule of law	Yes (Legal opinions)	Yes (Arbitration, moot courts)	Yes (Royal Commissions)
2.	Insurance approaches	Yes (Risk surveys, actuarial studies)	Yes (Risk profiling sessions)	Yes (<i>especially moral risk</i>)
3.	Asset based, 'bottom-up' approaches	Yes (QRA, availability & reliability audits)	Yes (HazOps, FMECAs etc)	Difficult
4.	Threat based 'top-down' approaches	Difficult in isolation	Yes (SWOT & vulnerability)	Yes (Interviews)
5.	Solution based 'good practice' approaches	Difficult to be comprehensive	Difficult to be comprehensive	Yes (Fact finding tours)
6.	Simulation	Yes (Computer simulations)	Yes (Crisis simulations)	Difficult
7.	Risk culture concepts	Yes (Quality audits)	Difficult	Yes (Interviews)

Risk management paradigm - technique matrix

The purpose of a common law safety argument is to ensure 'due diligence', not that target levels of risk or safety have been achieved or that accidents and incidents won't happen.

2.3 CAA Aerodrome Airspace Risk Model Development Methodology

The method adopted for the CAA Aerodrome Airspace Risk Review is based on a common law safety case approach which is a documented demonstration by the organisation that all statutory, regulatory and common law requirements have been met. It consists of a number of arguments that demonstrate that all reasonable practicable precautions are in place. A common law safety case essentially ensures that *due diligence* is (seen to be) demonstrated, not that accidents / incidents won't happen.

Conceptually the writers believe the argument should satisfy Lord Cullen's (2001) definition of a safety case namely:

A safety case regime provides a comprehensive framework within which the duty holder's arrangements and procedures for the management of safety can be demonstrated and exercised in a consistent manner. In broad terms the safety case is a document – meant to be kept up to date – in which the operator sets out its approach to safety and the safety management system which it undertakes to apply. It is, on the one hand, a tool for internal use in the management of safety and, on the other hand, a point of reference in the scrutiny by an external body of the adequacy of that management system – a scrutiny which is considered to be necessary for maintaining confidence on the part of the public.

In order to complete the review the following generic process will be applied at a particular site in order to develop the generic model.

- 2.3.1 Brief the CAA lawyers of the proposed due diligence process.
- 2.3.2 Hazardous scenario completeness check. Confirm that all credible, critical hazards have been identified. Information will be collected from history, aircraft types and activities, arrivals and departures and generative interviews with key stakeholders.
- 2.3.3 Construction of threat barrier diagrams and initial expert calibration of trials, barrier effectiveness and outcomes for an initial trial location. This step will also allow the identification of further potential barriers and precautions. These can also be expanded to cause-consequence models as required.
- 2.3.4 Stakeholder workshop to test the models.

There are multiple ways for safety case arguments to be constructed and presented. But if they are to act as a pre-trial case then the argument should be couched in a way that satisfies judge and jury in addition to boards and relevant government regulators and ministers. Such persons are not generally technologically or scientifically trained.

3.0 TASKS COMPLETED

3.1 Inception Meeting and Briefing of CAA Legal Counsel

An inception meeting and briefing was held at the CAA offices in Petone on Tuesday 15 May 2007. The following CAA personnel attended the session:

- Max Evans
- Merv Falconer
- Toby Farmer
- Graeme Harris
- Mike Haines
- Leslie MacIntosh
- Peter Nalder
- Chris Northover
- Alan Roberts
- Len Wicks

In attendance from the Ambidji project team were Brian Jackson, Rob Graham, Dave Park, Richard Robinson and Gaye Francis.

Graeme Harris provided an overview for the project team which was followed by a risk and good practice briefing by Richard Robinson which was subsequently presented to the meeting of industry stakeholders and is attached as Appendix A.

In discussion, Leslie MacIntosh noted that the liability focus of many common law jurisdictions such as Australia was greater than New Zealand as the ACC reduced the impact of liability claims. Nevertheless, the due diligence arguments that may be used to minimise liability remain similar.

3.2 Industry Stakeholder Meeting – Wellington

A half-day consultation session with industry stakeholders was held in Wellington on Tuesday 5 June 2007. The following stakeholders attended the session:

Derek Edwards	Aircraft Owners & Pilots Association
Bob Guard	Air Nelson Ltd
Fred Hansen	Airways NZ
Praveen Singh	Airways NZ
Richard Gates	Ardmore Airport Ltd
Tim Allen	Civil Aviation Authority
Terry Curtis	Civil Aviation Authority, Airline Flight Operations
Merv Falconer	Civil Aviation Authority
Mike Haines	Civil Aviation Authority
Graeme Harris	Civil Aviation Authority
Alan Roberts	Civil Aviation Authority
Bob Young	Civil Aviation Authority
Ian Calvert	CTC Aviation Training (NZ) Ltd
Doug Roberts	Eagle Airways
Wayne Taylor	Eagle Airways
George Rogers	Gliding NZ
Nick Taylor	Ministry of Transport
Hugh Feris	NZ Airline Pilots' Association
Jeremy Thompson	NZ Airline Pilots' Association
Johnny Walker	NZ Airline Pilots' Association

Ray Dumble	NZ Airports Association
John Funnell	NZPIA
Dale Webb	Mount Cook Airline
Mike Groome	RNZAC / Taupo Airport
Jim Jennings	RNZAF
Grant Waring	RNZAF
John Mathewson	Zeal 320

The briefing was presented by Richard Robinson and documented by Gaye Francis, R2A. Also in attendance from the Ambidji project team were Rob Graham and Dave Park.

The objective of the session was to outline the various risk management techniques and paradigms currently in use. In addition, an explanation of the proposed methodology for the development of the aerodrome airspace risk model was provided and why R2A believes such a process is able to demonstrate diligence so that any argument developed may be expected to survive legal scrutiny after an event. The presentation as circulated to the stakeholder group following the session is attached as Appendix A.

3.3 Preliminary Model Development – Gisborne

Gisborne was selected as the development site for the preliminary model. This was primarily completed on site in Gisborne on Wednesday 6 and Thursday 7 June 2007. The model was developed by collecting information during a number of generative interviews with the following stakeholders:

Andrew Reid	Owner and pilot, Air Gisborne
Andrew Cliff	Westwind Captain, Air National
Wayne Taylor	Manager Flight Operations, Air New Zealand Link
Phil Granger	Chief Controller Gisborne Tower, Airways New Zealand
Fred Hansen	Airways New Zealand
Wayne Ashworth	Owner and pilot, Ashworth Helicopters
Mike Beach	Eagle Air
Vernon Douglas	Eagle Air
Massey Lynch	Standards Pilot, Eagle Air
Nick Lennon	Eagle Air
Murray Bell	Airport Manager, Eastland Infrastructure
Matt Todd	Chief Executive, Eastland Infrastructure
Johnny Walker	Technical Officer, New Zealand Airline Pilots' Association
Koro Keepa	New Zealand Airline Pilots' Association / ATC
Wayne Thomas	New Zealand Airline Pilots' Association / ATC
Glen Thompson	Owner and pilot, private light aircraft
Geof McGregor	Owner and pilot, private light aircraft
Kevin Lloyd	Owner and pilot, private light aircraft
Paul Corrin	Owner and pilot, private light aircraft

The interviews were conducted by Richard Robinson and Gaye Francis, R2A. Rob Graham and Dave Park were also in attendance.

As a result of the interviews a series of preliminary models were developed and presented during a briefing session on Thursday afternoon. The following stakeholders attended:

Andrew Cliff	Westwind Captain, Air National
Wayne Taylor	Manager Flight Operations, Air New Zealand Link
Phil Granger	Chief Controller Gisborne Tower, Airways New Zealand
Fred Hansen	Airways New Zealand
Murray Bell	Airport Manager, Eastland Infrastructure
Johnny Walker	Technical Officer, New Zealand Airline Pilots' Association
Glen Thompson	Owner and pilot, private light aircraft
Paul Corrin	Owner and pilot, private light aircraft

The presentation given to the group is attached as Appendix B. It is also noted that the same presentation was given to CAA on Friday 8 June 2007.

Resulting from the development work in Gisborne, a preliminary generic model was developed for review. The outcomes of this are contained in a separate briefing paper attached as Appendix C.

3.4 Generic Model Development Using Timaru Data - Wellington

In order to refine the preliminary model a workshop was held at the CAA on Thursday 28 June 2007. The following participated in the session:

Terry Curtis	Airline Flight Operations, CAA
Toby Farmer	Aeronautical Services Officer, CAA
Murray Fowler	Flight Safety Advisor, CAA
Mike Haines	Acting Manager, Aeronautical Services, CAA
Graeme Harris	General Manager Personnel Licensing & Aviation Services, CAA
Dave Park	Astral
Alan Roberts	Aeronautical Services Officer, CAA
Wayne Taylor	Manager Flight Operations, Air New Zealand Link
Frank Usmar	General Aviation, Civil Aviation Authority
Johnny Walker	Technical Officer, New Zealand Airline Pilots' Association
Len Wicks	Aeronautical Services Officer, CAA

The session was facilitated and documented by Richard Robinson and Gaye Francis, R2A.

In order to test the utility of the model, data based broadly on Timaru aerodrome was used as a development study, the results of which are attached as Appendix D. The generic model was further refined the following day with input from many of the CAA stakeholders.

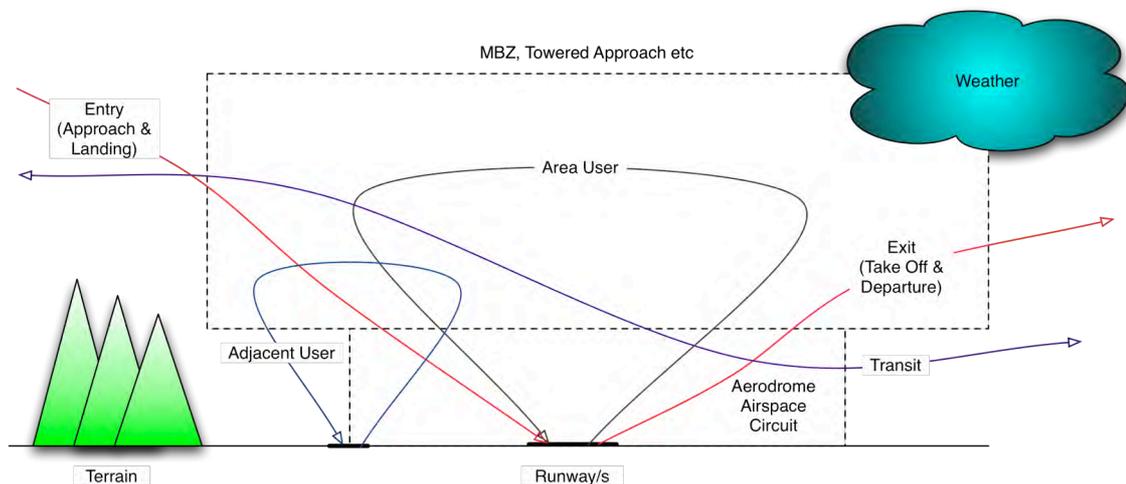
4.0 AERODROME AIRSPACE MOVEMENT COLLISION RISK MODEL

The aerodrome airspace movement collision risk model is an estimative risk model that demonstrates the change in risk for the addition or removal of different control options. It is designed to determine the change in risk for the various control options both at the loss of control points and in terms of an annualised estimate of persons at risk (see following sections).

The costs of the controls are to be determined by others at a later date. The decision to implement or remove controls would be made as a result of a cost/ benefit analysis of any proposal. This would have to take both safety and business case aspects into consideration. This task is also the responsibility of others.

4.1 Aerodrome Airspace Operations

The schematic below represents the identified modes of operation, both normal and abnormal / emergency within aerodrome airspace.



Operations include entry incorporating approach and landing, exit incorporating take off and departure, transit through the aerodrome airspace, users who remain within the aerodrome airspace such as sky diving aircraft, go around and emergency / priority landings.

A number of factors can add complexity to a particular aerodrome airspace and should be taken into consideration when developing the risk model at a specific aerodrome, namely:

- Weather
- Terrain
- Number and variety of aerodrome airspace activities including training and itinerants
- Multiple runway operations
- Restricted airspaces resulting in funnelling of traffic and increased traffic density
- Runway intrusion including railway line, animals etc
- Environment and activities adjacent to the aerodrome that may impact operations eg population centres
- Aging aircraft with both obsolete technology and retrofitted new technology
- Speed differentials at the aerodrome
- Pilot experience and currency issues
- ATC experience issues especially regarding different traffic.

The primary effect of most of these is to increase the likelihood of encountering an unexpected conflict craft especially when manoeuvring because of an initial conflict.

4.2 Aerodrome Airspace User Classes

Ten user groups have presently been defined, based initially on craft manoeuvrability conceptually defining the relevant collision envelopes. For the generic model, aerodrome airspace users have been classified as the following:

- i. Jets
- ii. Turbo props
- iii. Piston engines including microlights / ultralights
- iv. Gliders
- v. Helicopters
- vi. Sky divers
- vii. Hang gliders
- viii. Paraponters
- ix. Power parachutists
- x. Balloonists

The concept model is not constrained by these. Further breakdown may be contemplated especially for user group consultation and data gathering purposes.

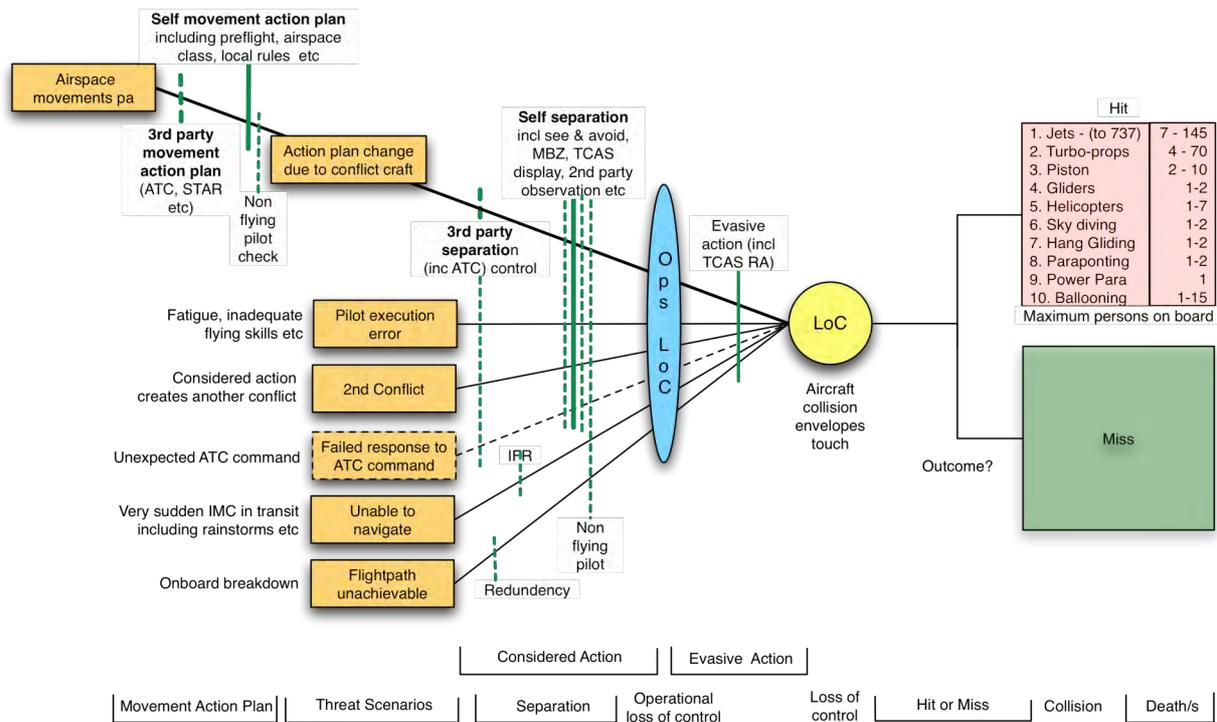
4.3 Generic Controls / Precautions

The following table lists the generic controls available to aerodrome airspace users to mitigate risk associated with collisions.

Operations	<ul style="list-style-type: none"> • IFR • VFR
Aerodrome Airspace	<ul style="list-style-type: none"> • Airspace classification including A/C/D/E/G, special use airspace • Air Traffic Control including multilateration • Area Flight Information Service (FIS) • Mandatory Broadcast Zone (MBZ) • Common Frequency Zone (CFZ) • Universal Communications • Transponder Mandatory Airport • 2nd party mutual observation
On-board	<ul style="list-style-type: none"> • Non flying pilot • IFR equipment • TCAS / ATAS • Radio equipment • Transponder
Aerodrome	<ul style="list-style-type: none"> • Flight scheduling • Special Aerodrome Rules (Part 91 & 93) • Published local procedures and education • Aerodrome Flight Information Service (AFIS) • Aviation Weather Information Broadcast (AWIB)

4.4 Threat Barrier Diagram

In concept, the aerodrome airspace risk model is based on a threat barrier diagram representing entry (arrival and landing), exit (take off and departure) and transit through the relevant aerodrome airspace for each of the user groups. This was developed through stakeholder consultation and reflects the views of the aerodrome airspace users.



The following sections describe the key elements of the model in detail.

4.4.1 Event Sequences

From the viewpoint of the first aircraft, the event sequences relevant to collision risk are seen to be:

- The action plan adopted at entry, exit and transit are effective and happens as planned, that is no conflict occurs.
- The potential conflict craft is detected and the action plan tactically modified by the implementation of appropriate separation.
- The potential conflict craft is detected and the action plan tactically modified but implemented in error (including failed response to ATC command) resulting in an operational loss of control at least.
- Potential conflict detected and subsequent further conflict results after action taken.
- The potential conflict craft is detected and the action plan tactically modified but the primary craft is unable to comply because of:
 - * Loss of navigational ability due to very sudden IMC (for example, rain storm) whilst in transit
 - * On board breakdown (for example, navigational equipment, engine failure) whilst in transit
 resulting in operational loss of control at least.

- f) Neither aircraft (or ATC if provided) saw or detected the other aircraft before the loss of control points.

The main threat scenario is the need for an aircraft having to change their movement action plan as a result of a conflict craft (top sequence in the threat barrier diagram). The other scenarios, pilot execution error, 2nd conflict, failed response to ATC (if present) command, unable to navigate or unable to achieve changed action plan as a result of an on-board breakdown are threats that result from a changed action plan. These are expected to be quite location and craft class specific.

4.4.2 Barriers / Precautions

The barriers are represented by the vertical lines in the model. The solid lines represent existing barriers or precautions and the dashed lines are possible further barriers.

For aerodrome airspace users there appear to be only three main barriers to mitigate the risk of a collision. They are; preparation and execution of a movement action plan, maintaining separation either by a 3rd party or by the actual user, and evasive action.

The various generic controls outlined in section 5.3 enhance these three main barriers. For example, the movement action plan can either be provided by a 3rd party including ATC or developed by the user. An aerodrome airspace user will use such tools as pre-flight information, airspace classification information and local rules to determine the appropriate action plan for a particular aerodrome.

Separation can either be provided by a 3rd party including ATC or by the airspace user. A MBZ, CFZ or TCAS display provide information to the user to achieve self-separation which enhance the base case of see-and-avoid.

Evasive action including a TCAS resolution advisory is the last barrier prior to the loss of control point.

4.4.3 Loss of Control

The model defined two loss of control points. The first is the aerodrome airspace operational loss of control defined as when two aerodrome airspace users come into conflict and evasive action is required to prevent the second loss of control point.

The second loss of control point is the collision loss of control point defined as being when the collision envelope of one craft touches another.

Barriers and precautions should be focussed prior to the loss of control points. The view of the stakeholders involved in the development of this model was that aircraft should aim not to reach the aerodrome airspace loss of control and that evasive action was not effective collision risk management tactics.

4.4.4 Outcomes

The model outcomes are represented by an event tree. There are only two possibilities, either the two craft miss or they collide. Previous risk work for other airspaces has indicated that the chance of two jets colliding once the collision envelope of one has touched the other aircraft is between 99 and 999 to 1.

The consequence of two craft colliding depend on the class of aircraft involved. For the collision, the model assumes that both craft are fully loaded with the maximum number of persons on board and all persons on board are at risk.

5.0 APPLICATION

5.1 Excel® Workbook

The aerodrome airspace collision risk model has been developed as an excel workbook. The template model is made up of 12 sheets consisting of a summary page, a collision consequence page and one page for each of the 10 aerodrome airspace classes identified in section 4.2 above. This is attached as Appendix E.

It is expected that for each of the aerodrome airspace classes at a particular aerodrome, one sheet will be completed. The sheet will initially be completed by users of that particular class and is then expected to be peer reviewed by each of the other aerodrome airspace class users at that aerodrome (and ATC, if present). Each sheet consists of two tables, the first for the main threat sequence of having to change their action plan due to a conflict craft and the second for the identified secondary threats. Data input requirements have been highlighted by the blue cells. All other cells in the model are calculated.

5.2 Inputs

The following section summaries the key inputs for the model. An explanation of all inputs is included on the *Jet* sheet (page 3) in the template model as attached in Appendix E.

Each of the aerodrome airspace classes is required to enter the number of entry, exit and transit movements per year at the aerodrome under consideration.

A success probability for each of the barriers (barrier effectiveness) relevant to that particular class is then determined for each of the aerodrome airspace entry, exit and transit movements. It is noted that if ATC is not present then the success probability is zero (default value).

The aerodrome airspace operational loss of control is then determined by summing the contribution of all the threat scenarios and barriers. This is an estimate by the aerodrome airspace classes of the likelihood (per annum) that two craft will be in a conflict situation that requires one craft to take evasive action.

® Excel is the registered trademark of Microsoft Corporation.

The collision envelope loss of control is then calculated by multiplying the aerodrome airspace loss of control point total by the evasion barrier failure probability. This is an estimate by the aerodrome airspace classes of the likelihood (per annum) that the collision envelope of one craft will touch another craft.

Based on previous risk work in the aviation industry the ratio of misses to collisions for jets is between 99 and 999 to 1. Taking this chance (or luck) barrier into consideration, the likelihood of a collision can then be determined.

The consequence of two craft colliding depend on the class of aircraft involved. For the collision, the model assumes that both craft are fully loaded with the maximum number of persons on board and all person on board are at risk. For example, if two jets collide with a maximum capacity of 145 then 290 persons are at risk. This calculation is completed on sheet 2 of the template workbook.

5.3 Outputs

The model estimates three key values; the aerodrome airspace loss of control point, the loss of control point of the collision envelope of one craft touching another craft and a value for persons at risk. The values from the calculation completed based on representative data for Timaru Aerodrome (see Appendix D) appears not inconsistent with other collision risk work by CAA.

6.0 OBSERVATIONS AND COMMENTS

The aerodrome airspace collision risk model has been developed through consultation with the stakeholders and reflects their views regarding aerodrome airspace collision risk. It assumes a generative approach with aerodrome airspace class users as, to be successful, it requires the constructive and robust input from them.

It has a number of potential strengths and weaknesses, some of which are noted below.

6.1 Utility

- 6.1.1 The model can test on a relative risk basis the deletion or addition of a craft class, variations in movements as well as testing for barrier changes especially ATC for a particular aerodrome. However, comparisons between aerodromes may be problematic and should be assessed carefully.
- 6.1.2 The use of complexity factors may be a simple way to apply threshold criteria for when the model is applied. For example, the number of craft classes, the number of particular craft class movements, the number of runways at an aerodrome, terrain considerations etc rather than attempting to assess preliminary 'risk targets'.
- 6.1.3 The model appears not to intrinsically require technical risk experts to use. Rather it requires a competent facilitator who is able to collect the required information from the class users in a generative manner and then transparently test the results back with them collectively.

6.2 Credibility

- 6.2.1 The model is expected to be reasonably robust in the sense that all class users will test the risk perceptions of all the other class users at a particular aerodrome. This may potentially cause some friction at an aerodrome. However much of the valuable precautionary insight should occur during this generative discussion process which should be independently documented. For example the runway light precaution described in 6.3.3 below was noted during the development study for Timaru.
- 6.2.2 Many of the model's calibration numbers may be assessed from CAA data and work. These would only be expected to be varied with particular explanations, for example, the evasive action success probability would not be expected to change for different aerodromes.
- 6.2.3 The model appears to be independently examinable by technical risk analysts in the sense that the primary barriers can be treated as fault (or success) trees. This enables the estimates given by the class users to be tested against result of other studies. This also allows the contribution of location specific precautions to the overall barrier to be estimated. For example, switching on the runway lights to advise non-radio/transponder equipped craft of an approaching passenger service.

6.3 Adaptability

- 6.3.1 The model can be easily modified to take into account other class or sub-class users if required. For example, piston craft could be sub-divided into passenger planes and ultralights.

6.4 Limitations

- 6.4.1 The model is peculiar to time and place and the class of user. It represents a snap shot of the perceived risk at a particular aerodrome at a particular point in time by the collective stakeholders at the aerodrome.
- 6.4.2 The model is silent on collision risks with terrain except in so far as terrain causes increased complexity by 'forcing' other craft in common traffic zones or patterns as estimated by the class users.
- 6.4.3 The model does not consider special military operations. Military craft operating under civil aviation rules are expected to be covered by the aerodrome airspace user classes defined in section 4.2.
- 6.4.4 ATC failure has not specifically been considered in the model. That is, the possibility that ATC could direct two aircraft to the same place at the same time creating a conflict.

7.0 GLOSSARY

ACC	Accident Compensation Commission
Aerodrome Airspace Movement	Entry incorporating approach and landing, exit incorporating take off and landing and transit through the aerodrome airspace.
AFIS	Aerodrome Flight Information Service
AWIB	Aviation Weather Information Broadcast
ATC	Air Traffic Control
CAA	Civil Aviation Authority
CFZ	Common Frequency Zone
FIS	Area Flight Information Service
LoC	Loss of control
MBZ	Mandatory Broadcast Zone

8.0 REFERENCES

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Ambidji for the New Zealand Civil Aviation Authority
Aerodrome Airspace Collision Risk Model
July 2007

Appendix A Risk and Good Practice Briefing



Aerodrome Airspace Risk Briefing

5 June 2007

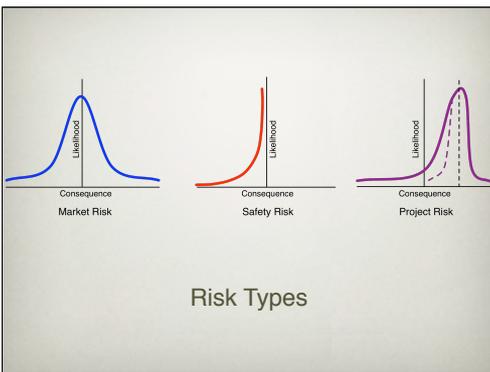


CAA Aerodrome Airspace Risk Methodology

The objective of this presentation is to outline the various risk management techniques and paradigms currently in use as well as explain the proposed methodology for this aerodrome airspace risk review.

It also describes why R2A believes such a process is able to demonstrate due diligence so that any argument developed may be expected to survive legal scrutiny after an event.

In making this presentation, R2A emphasises that we are not legal experts. Rather, the purpose is to demonstrate sufficient legal understanding to ensure that all risk work completed has a useful legal basis.



Technique >> Risk Management Paradigm	Expert Reviews	Facilitated Workshops	Selective Interviews
1. The rule of law	Yes (Legal opinions)	Yes (Arbitration, moot courts)	Yes (Royal Commission)
2. Insurance approaches	Yes (Risk surveys, actuarial studies)	Yes (Risk profiling sessions)	Yes (especially moral risk)
3. Asset based 'bottom-up' approaches	Yes (QRA, availability & reliability audits)	Yes (HazOps, FMECAs etc)	Difficult
4. Threat based 'top-down' approaches	Difficult in isolation	Yes (SWOT & vulnerability)	Yes (Interviews)
5. Solution based 'good practice' approaches	Difficult to be comprehensive	Difficult to be comprehensive	Yes (Fact finding tours)
6. Simulation	Yes (Computer simulations)	Yes (Crisis simulations)	Difficult
7. Risk culture concepts	Yes (Quality audits)	Difficult	Yes (Interviews)

Good Practice

.... the starting point should be an option which is known to be reasonably practicable (**such as one which represents existing good practice**). Any other options should be considered against that starting point, to determine whether further risk reduction measures are reasonably practicable.

Reference: UK Health & Safety Executive (2001) Reducing Risks, Protecting People. Appendix 3. Some issues relevant to assessing risk reduction options

Lord Cullen (2001)

A safety case regime provides a comprehensive framework within which the duty holder's arrangements and procedures for the management of safety can be demonstrated and exercised in a consistent manner. In broad terms the safety case is a document – meant to be kept up to date – in which the operator sets out its approach to safety and the safety management system which it undertakes to apply. It is, on the one hand, a tool for internal use in the management of safety and, on the other hand, a point of reference in the scrutiny by an external body of the adequacy of that management system – a scrutiny which is considered to be necessary for maintaining confidence on the part of the public.

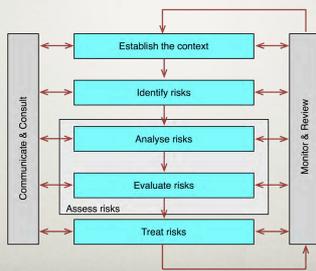
© Her Majesty's Stationery Office 2001. Transport, regulation and safety: a human perspective. The Transport Research Institute. 7th Anniversary Lecture, 10 December 2001.

Safety Argument Presentation

The overall point is that a successful due diligence argument demonstrates that all reasonable practicable precautions are in place. Risk assessment supports this but it is not an end in itself.

This is consistent with the Risk Management standard although not always expressed this way. It is really ensuring that any risk study is in context (Step 1) with statutory and common law duty of care.

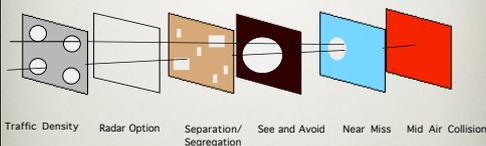
Risk Management Standard



Aerodrome Airspace Risk Process

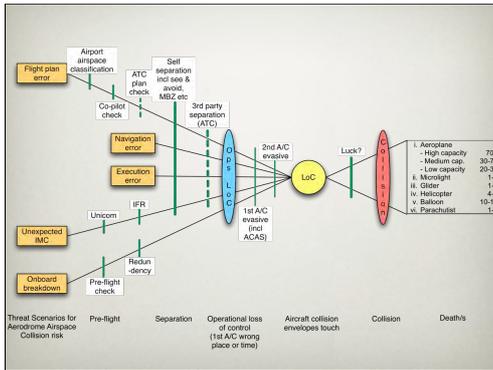
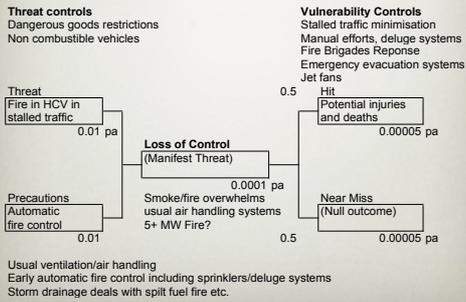
1. International risk methodology review.
2. Brief the CAA lawyers of the proposed due diligence process.
3. Hazardous scenario completeness check. Confirm that all credible, critical hazards have been identified. Information will be collected from incident history, vessel types, arrivals and departures and generative interviews with key stakeholders.
4. Construction of threat barrier diagrams and initial expert calibration of trials, barrier effectiveness and outcomes for an initial trial location. This step will also allow the identification of further potential barriers and precautions. These can also be expanded to cause-consequence models as required.
5. Stakeholder workshop to test the models.

Venn (Swiss Cheese) Diagrams



Venn Diagram Model of the Series of Failures Required for a Mid-Air Collision

HCV Fire in a Tunnel in Stalled Traffic



Gisborne Aerodrome Development Site

Generative interviews with each of the aerodrome airspace users to refine, test and calibrate the model/s for each user group.

One model page per user group.

The sum of the pages provides the model for the aerodrome airspace.

The generic model will have all anticipated aerodrome airspace user groups listed

This is relative risk model. Future changes of precautions will be subject to cost benefit analysis and decision making by others.





Generic User Group and Precautions

If time permits, generic completeness checks for:

1. Aerodrome airspace user groups and activities
2. Recognised good practice precautions



Risk & Reliability Associates

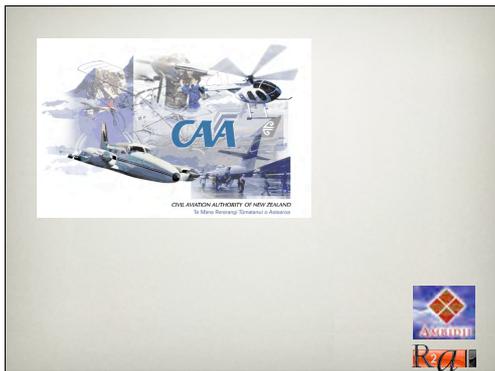
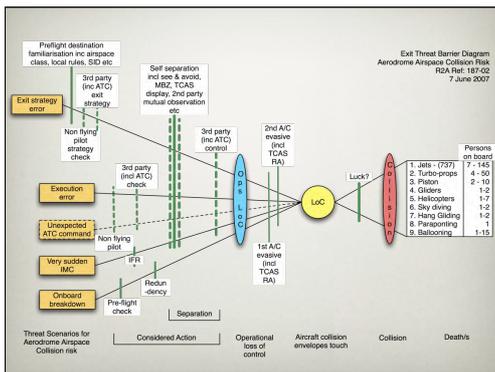
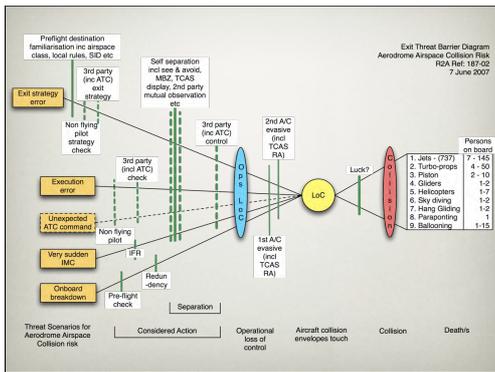
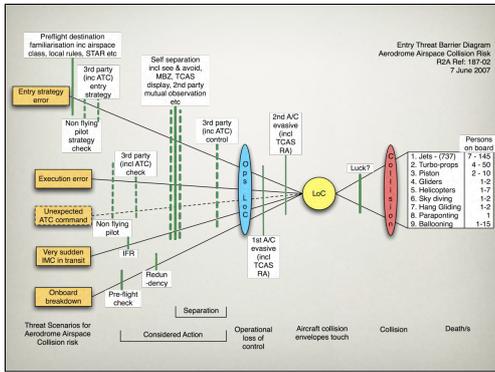
Consulting Engineers



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July 2007

Appendix B Gisborne Development Risk Model Briefing



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Aerodrome Airspace Collision Risk Model
July 2007

Appendix C Preliminary Aerodrome Airspace Collision Risk Model

AMBIDJI FOR THE CIVIL AVIATION AUTHORITY
Development and Proposal of Standards and Practices
for the Management of Aerodrome Airspace Risk
Preliminary Aerodrome Airspace Collision Risk Model
June 2007

1.0 OBJECTIVE

The purpose of this paper is to outline the preliminary aerodrome airspace collision risk model based on the development exercise at Gisborne.

2.0 CONCEPT SUMMARY

In concept, the aerodrome airspace risk model is based on a threat barrier diagram representing entry (arrival and landing), exit (take off and departure) and transit through the relevant aerodrome airspace for each of the user groups.

Ten user groups have presently been defined, based initially on craft manoeuvrability conceptually defining the relevant collision envelopes. This means that the present maximum size of the model for an aerodrome is 30 pages plus a summary sheet although for a typical aerodrome five user groups are anticipated creating a model size of 16 pages in total.

Each user group will complete the three threat barrier diagrams (entry, exit and transit) for their user group at the aerodrome under consideration. This would then be peer reviewed by the other user groups at that aerodrome (and ATC if applicable).

A risk calculation summary based on operational loss of control, loss of control (collision envelopes) and an annualised fatality rate would be determined. By changing the barriers both in type, efficiency and effectiveness for each user group for entry, exit and transit, a change in risk can be determined.

Conceptually the model should also be able to indicate the change in risk associated with increased user activities, user types, aircraft size and the like.

The model assumes a generative approach with aerodrome airspace users as, to be successful, it requires the constructive and robust input from them.

3.0 COMMENTARY

3.1 Overview

The aerodrome airspace risk model is a relative risk model that demonstrates the change in risk for the addition or removal of different control options. It is designed to determine the change in risk for the various control options both at the loss of control points and in terms of an annualised fatality rate.

The costs of the controls are to be determined by others at a later date. The decision to implement or remove controls would be made as a result of a cost/ benefit analysis of any proposal. This would have to take both safety and business case aspects into consideration. This task is also the responsibility of others.

3.2 Assumptions

In developing the model, the following assumptions have been made:

- 3.2.1 The flight deck crew have been appropriately trained and hold the relevant qualifications and competencies for the aircraft.
- 3.2.2 The collision envelopes for the different aircraft and activities vary depending on vertical & lateral maneuverability and acceleration.
- 3.2.3 The collision envelope of aircraft one can touch collision envelope of aircraft two or vice versa.
- 3.2.4 Military operations have been excluded from the model. The military are not bound to civil aviation rules although comply where and when practicable.
- 3.2.5 ATC failure has not been considered. That is, the possibility that ATC could direct two aircraft to the same place at the same time creating a conflict.
- 3.2.6 Wake turbulence has not been included in the collision risk model.

3.3 Complexity Factors

During the development stage at Gisborne it was observed that there are a number of factors that add complexity to an aerodrome airspace and should be taken into consideration when developing the risk model at a specific aerodrome, namely:

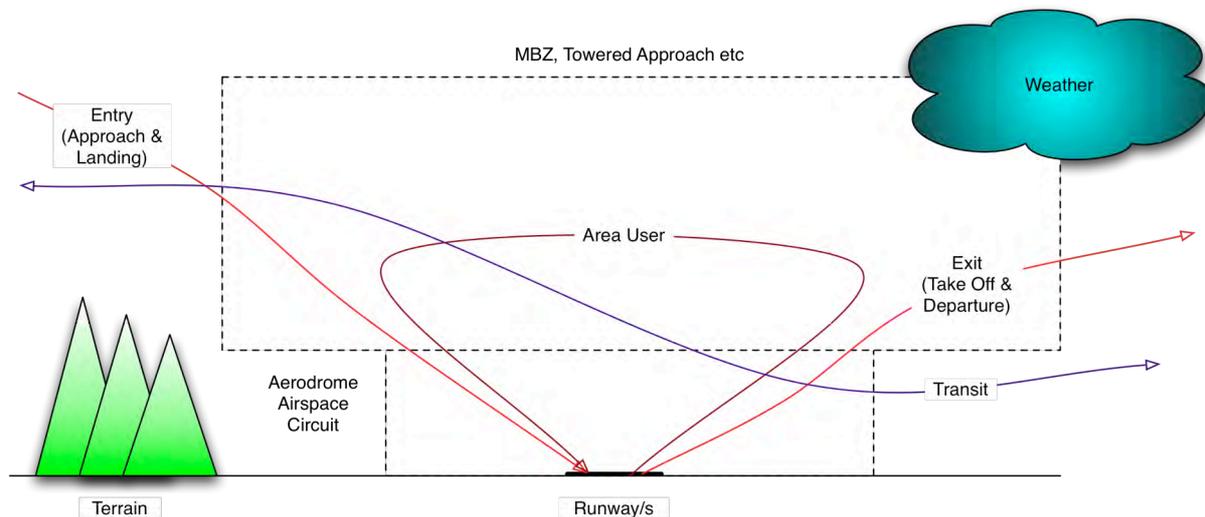
- Weather
- Terrain
- Number and variety of aerodrome airspace activities including training, itinerants
- Multiple runway operations
- Restricted airspaces resulting in funnelling of traffic and increased traffic density
- Runway intrusion including railway line, animals
- Environment and activities adjacent to the aerodrome that may impact operations eg population centres
- Aging aircraft with both obsolete technology and retrofitted new technology
- Speed differentials at the aerodrome
- Pilot experience and currency issues
- ATC experience issues especially regarding different traffic.

The primary effect of most of these is to increase the likelihood of encountering an unexpected conflict craft.

4.0 MODEL DEVELOPMENT

4.1 Aerodrome Airspace Operations

The schematic below represents the operational modes which may include normal and abnormal / emergency operations within an aerodrome airspace.



Concept Aerodrome Airspace

Operational modes are entry incorporating approach and landing, exit incorporating take off and departure, transit through the aerodrome airspace, users who remain within the aerodrome airspace such as sky diving aircraft and go around and emergency / priority landings.

4.2 Aerodrome Airspace User Groups

For the generic model, aerodrome airspace users have been divided into the following categories or groups. This was determined conceptually in terms of manoeuvrability and the perceived shape of the collision envelope associated with each.

Aircraft

- i. Jets
- ii. Turbo props
- iii. Piston engine
- iv. Gliders
- v. Helicopters

Activities

- vi. Sky diving
- vii. Hang gliding
- viii. Paraponting
- ix. Power parachuting
- x. Ballooning

The concept model is not constrained by these. Further breakdown may be contemplated especially for user group consultation and data gathering purposes.

4.3 Generic Controls / Precautions

The following table lists the precautions for airspace collision risk generally recognised as available to aerodrome airspace users which would need to be capable of representation in the model.

Operations	<ul style="list-style-type: none"> • IFR • VFR
Aerodrome Airspace	<ul style="list-style-type: none"> • Airspace classification including A/C/D/E/G, special use & restricted • Air Traffic Control including multi lateration, ADS-B, radar etc. • Area Flight Information Service (FIS) • Mandatory Broadcast Zone (MBZ) • Common Frequency Zone (CFZ) • Universal Communications • Transponder Mandatory Airport • 2nd party observation alerting other airspace users (for example, <i>I don't have you visual, request your current position</i>)
On-board	<ul style="list-style-type: none"> • Non flying pilot • IFR equipment • TCAS / ACAS • Radio equipment • Transponder
Aerodrome	<ul style="list-style-type: none"> • Flight scheduling • Special Aerodrome Rules (Part 91 & 93) • Published local procedures and education • Aerodrome Flight Information Service (AFIS) • Aviation Weather Information Broadcast (AWIB)

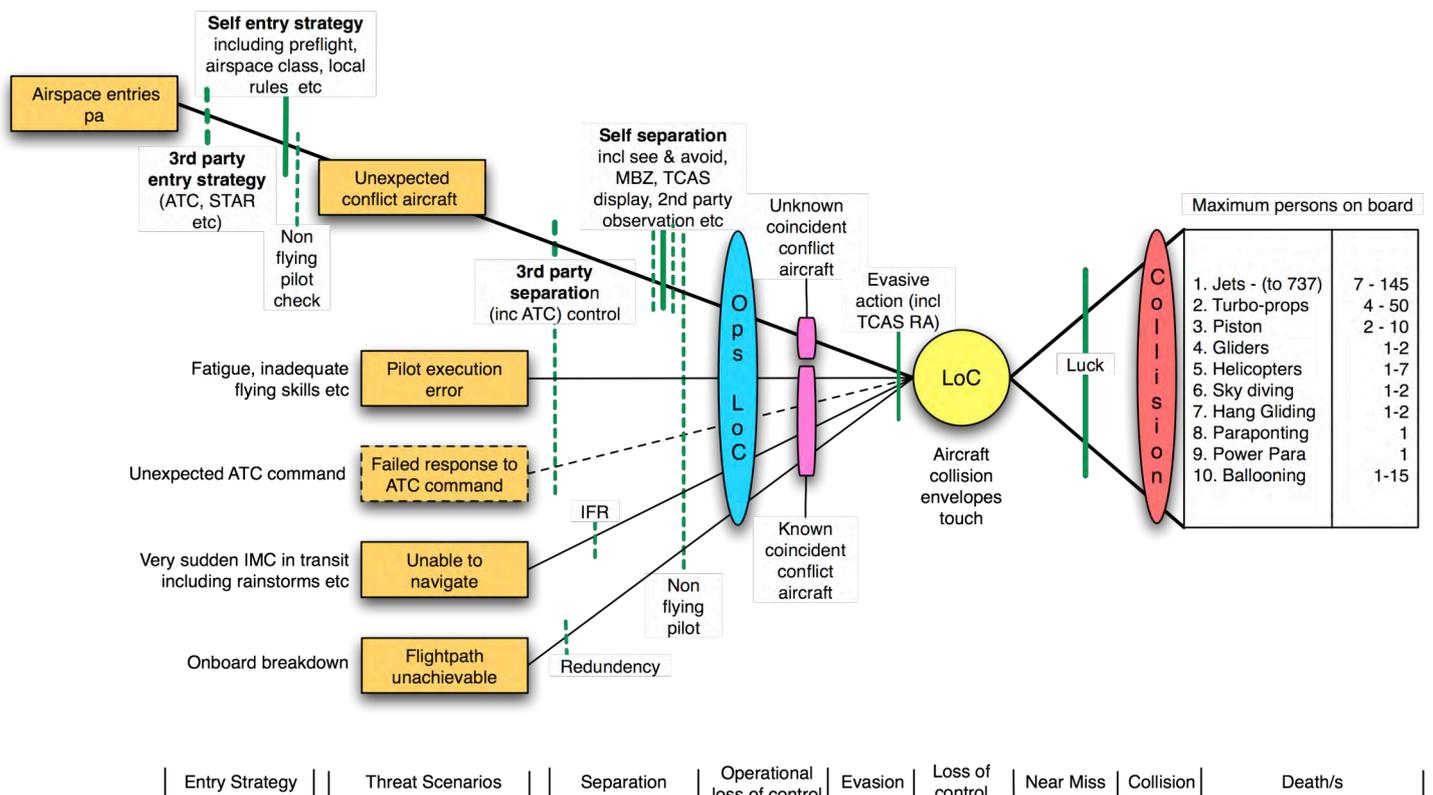
4.4 Event Sequences

From the viewpoint of the first aircraft, the event sequences relevant to collision risk are seen to be:

- a) The strategy adopted at entry, exit and transit are effective and executed as planned, that is no conflict occurs.
- b) The potential conflict craft is detected and the strategy tactically modified by the implementation of appropriate separation.
- c) The potential conflict craft is detected and the strategy tactically modified but implemented in error resulting in an operational loss of control at least.
- d) The potential conflict craft is detected and the strategy tactically modified but the primary craft is unable to comply because of:
 - * Loss of navigational ability due to very sudden IMC (for example, rain storm) whilst in transit
 - * On board breakdown (for example, navigational equipment, engine failure) whilst in transit
 resulting in operational loss of control at least.
- e) Neither aircraft (or ATC if provided) saw or detected the other aircraft before the loss of control points.

5.0 THREAT BARRIER DIAGRAMS

The following concept threat barrier diagram has been developed for the aerodrome airspace collision risk entry (approach and landing) phase. It expands the collision threat scenarios noted above, the relevant control / precautions, the operational and legal loss of control points and the outcomes.



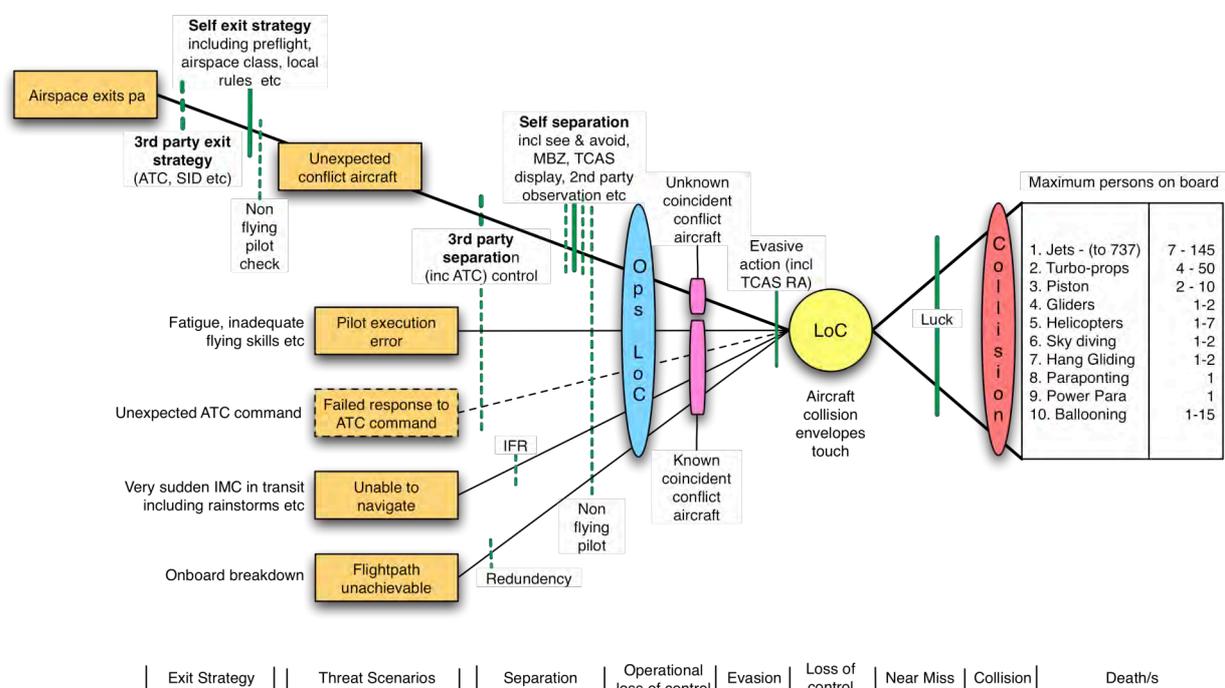
Preliminary Entry Threat Barrier Diagram

One of these threat barrier diagrams is required for entry, exit and transit phases as the threat scenario likelihoods and barrier efficiencies are expected to change for each phase. The concept and overall structure of each of the threat barrier diagrams is not expected to change. The other two preliminary threat barrier diagrams are shown on the following pages.

5.1 Threat Scenarios

The key threat scenario is encountering an unexpected second aircraft or activity resulting in the intended entry, exit or transit strategy having to be tactically changed. The other threat scenarios identified are reasons why an aircraft or aerodrome airspace user may unintentionally end up in a place and time other than that planned in the relevant strategy or modified by subsequent separation requirements, that is, in the wrong place or time. These include:

- i) Aircraft execution error (poor choice of tactics or pilot inability to maintain flight path),
- ii) Unexpected ATC command (only applicable if ATC present) and appearing as a subset of i),
- iii) Very sudden IMC (for example, a sudden storm) resulting in an inability to navigate, and
- iv) Onboard breakdown, for example, navigational equipment or engine failure.



Preliminary Exit Threat Barrier Diagram

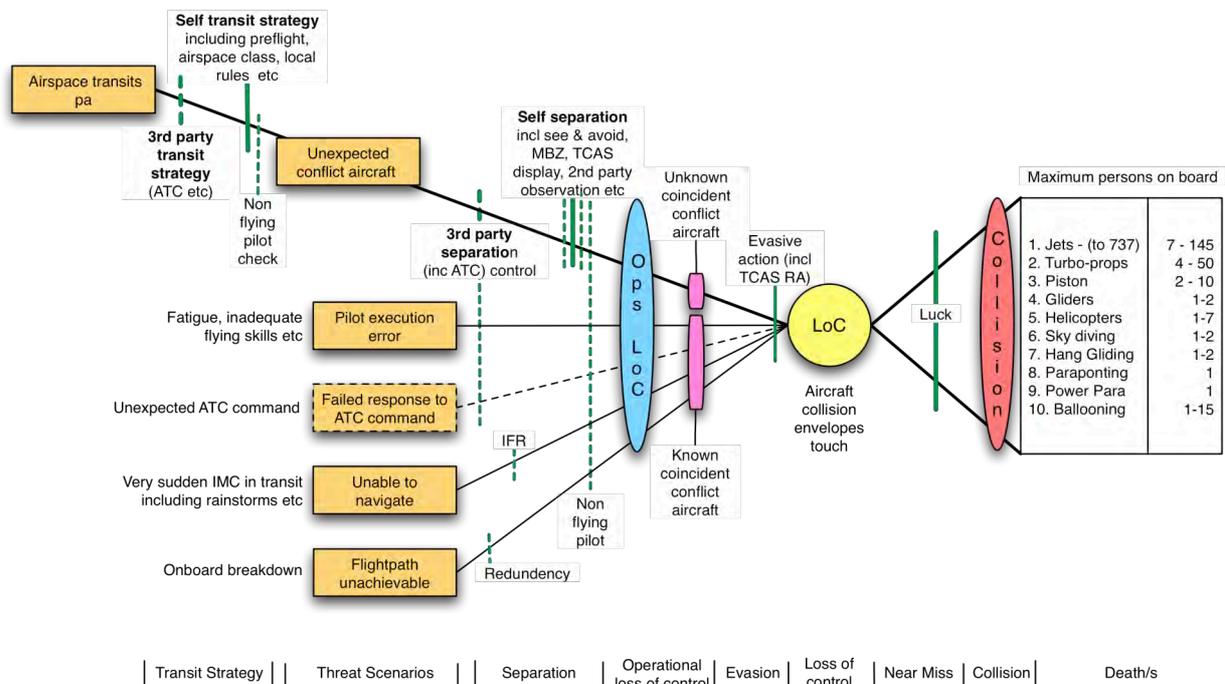
5.2 Barriers

There are two primary methods of preventing aerodrome airspace collisions, a good initial strategy and real time transit separation if a conflict craft is detected. Emergency evasive action is also available although universally regarded as undesirable.

Both the initial strategy and separation during transit can be maintained by a 3rd party like ATC or the pilot/s on the aircraft themselves. There are a number of precautions and controls as listed in section 4.3 above that can be used to enhance these barriers.

5.3 Loss of Control

Two loss of control points have been identified in the model. The first is the operational loss of control for the aircraft or activity considered as being in unplanned space and/or time and the second is the legal loss of control defined as when the collision envelopes of the two conflict craft or airspace activities touch.



Preliminary Transit Threat Barrier Diagram

5.4 Outcomes

Once the legal loss of control is reached and the collision envelopes of two aircraft touch, there are only two possible outcomes modelled. Either there is a near miss or a collision with fatalities expected.

With the 10 user groups currently identified, up to 55 collision pair types are possible. With 5 user groups (an expected number for regional airports) 15 collision pair types are expected.

In the first instance the fatalities per collision pair will be assessed on the maximum persons on board for the aircraft types. The ratio of the collision pair types will be initially determined by the ratios of the annualised movements of the types of aircraft and activities as reported by the airspace user groups.

Ambidji for the New Zealand Civil Aviation Authority
Aerodrome Airspace Collision Risk Model
July 2007

Appendix D Timaru Development Study

Timaru Development Study - existing arrangement

Craft Class	Total number of movements (pa)	Unexpected potential conflict aircraft (pa)	Airspace operational loss of control (pa)	Loss of control of kinentic energy (pa)	Collision likelihood (pa)	Years between collisions
Jets	10	1.5	0.015	0.0015	0.000015	66667
Turbo props	4000	6	0.06	0.006	6E-05	16667
Piston engines	21900	438	4.38	0.438	0.00438	228
Gliders	200	2	0.2	0.1	0.001	1000
Helicopters	2100	21	0.21	0.021	0.00021	4762
Total	28,210	468.5	4.865	0.5665	0.005665	177

Timaru Development Study - with AFIS installed

Craft Class	Total number of movements (pa)	Unexpected potential conflict aircraft (pa)	Airspace operational loss of control (pa)	Loss of control of kinentic energy (pa)	Collision likelihood (pa)	Years between collisions
Jets	10	0.3	0.0015	0.00015	0.0000015	666667
Turbo props	4000	3	0.015	0.0015	1.5E-05	66667
Piston engines	21900	328.5	1.6425	0.16425	0.0016425	609
Gliders	200	1	0.05	0.025	0.00025	4000
Helicopters	2100	10.5	0.0525	0.00525	5.25E-05	19048
Total	28,210	343.3	1.7615	0.19615	0.0019615	510

Timaru Development Study - with ATC

Craft Class	Total number of movements (pa)	Unexpected potential conflict aircraft (pa)	Airspace operational loss of control (pa)	Loss of control of kinentic energy (pa)	Collision likelihood (pa)	Years between collisions
Jets	10	0.09	8.1E-05	8.1E-06	8.1E-08	12,345,679
Turbo props	4000	4	0.002	0.002	1.8E-05	55,556
Piston engines	21900	197.1	0.17739	0.017739	0.00017739	5,637
Gliders	200	1.8	0.00162	0.00081	8.1E-06	123,457
Helicopters	2100	18.9	0.01701	0.001701	0.00001701	58,789
Total	28,210.00	221.89	0.198101	0.0222581	0.00022058	4,533

change in risk: 0.00551942

Turbo Props

Passenger aircraft turbo prop
EagleAir - 4 services per day

	Entry	Exit	Transit	Totals pa	
	Total number of movements (pa)	2000	2000	0	4000
Strategy	3rd party strategy success probability	0	0	0	
	Self entry strategy success probability	0.998	0.999	0.9	
	<i>Strategic barrier success probability</i>	0.998	0.999	0.9	
	<i>Strategic barrier failure probability</i>	0.002	0.001	0.1	
	Unexpected conflict aircraft (pa)	4	2	0	6
Sep- aration	Third party separation success probability	0	0	0	
	Self separation success probability	0.99	0.99	0.5	
	<i>Separation barrier success probability</i>	0.99	0.99	0.5	
	<i>Separation barrier failure probability</i>	0.01	0.01	0.5	
	Airspace operational loss of control (pa)	0.04	0.02	0	0.06
Eva- sion	Evasion barrier success probability	0.9	0.9	0.5	
	<i>Evasion barrier failure probability</i>	0.1	0.1	0.5	
	Loss of control of kinentic energy (pa)	0.004	0.002	0	0.006
Luck	Chance (success)	0.99	0.99	0.99	
	<i>Chance (failure)</i>	0.01	0.01	0.01	
	Collision likelihood (pa)	4E-05	0.00002	0	6E-05
	Years between collisions				16667

If ATC not present, success = 0
Based on experience of an estimate of 35 total occurrences over 5 years of a conflict pair and considered action needing to be taken.

Can be calculated Pr per trial * no of trials or estimated by the stakeholder user group

Conflict craft

	Entry	Exit	Transit	Totals pa	
	Total number of movements pa	1000	1000	100	2100
	Probability of pilot execution error per trial	0.01	0.001	0.05	
	Pilot execution error	10	1	5	16
Sep- aration	Third party separation success probability	0.99	0.99	0.99	
	Non flying pilot success probability	0.9	0.5	0.5	
	<i>Separation barrier success probability</i>	0.999	0.995	0.995	
	<i>Separation barrier failure probability</i>	0.001	0.005	0.005	
	Airspace operational loss of control (pa)	0.01	0.005	0.025	0.04
Eva- sion	Evasion barrier success probability	0.5	0.5	0.5	
	<i>Evasion barrier failure probability</i>	0.5	0.5	0.5	
	Loss of control of kinentic energy (pa)	0.005	0.0025	0.0125	0.02
Luck	Lucky?	0.99	0.99	0.99	
	<i>Unlucky</i>	0.01	0.01	0.01	
	Collision likelihood (pa)	0.015	0.0125	0.0225	0.05

Can be calculated Pr per trial * no of trials or estimated by the stakeholder user group

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Aerodrome Airspace Collision Risk Model
July 2007

Appendix E Aerodrome Airspace Collision Risk Model

APPENDIX 5

Criteria

Australia**Quantitative Criteria and References**

Parameter	Quantitative Criteria
Safety	Det Norske Veritas (DNV) Control Limits ¹ 10^{-3} per annum for pilots (workers) and 10^{-4} for passengers (public) probability of fatality ² . In certain circumstances ICAO may publish a target level of safety which must be satisfied before an activity can be implemented eg RVSM.
Value of Life	Bureau of Transport and Regional Economics
Capacity	Number of aircraft able to access services/facilities (eg runway/airspace)
Cost	Quantified costs of service/flow on costs to passenger/user/industry
Efficiency	Capacity delivered over user demand
Environment	Carbon Dioxide emissions, Oxides of Nitrogen and Sulphur, Particulate Matter, Hazardous Particles, Noise.

¹ These limits are currently (February 2007) endorsed by the Airservices Board as the intolerable.

² This is an interim (as at February 2007) criterion until a report from an independent consultant is received.

Collision Pair Collision Probabilities

Collision Pair	VFR/VFR	IFR1/VFR	IFR2/VFR	IFR1/IFR1	IFR1/IFR2	IFR2/IFR2
Configuration						
Unalerted	7.84 E-5	1.61 E-4	7.07 E-5	2.76 E-4	2.34 E-4	6.28 E-5
CTAF 70%	3.31 E-5	2.93 E-5	1.27 E-5			
CTAF 80%	2.32 E-5	1.96 E-5	8.24 E-6			
CTAF 90%	1.43 E-5	1.15 E-5	4.67 E-6			
MBZ	4.93 E-5	3.85 E-6	1.29 E-6			
IMC No ATS				1.10 E-5	3.80 E-6	6.59 E-7
IMC ATS				7.12 E-6	1.80 E-6	4.55 E-7
VMC No ATS				1.19 E-6	2.02 E-7	1.69 E-8
VMC ATS				7.92 E-7	1.00 E-7	1.23 E-8

A draft of CASR Part 71 contains trigger points as follows:

Trigger Points under the Australian System

Annual Movements	CTAF	MBZ	CA/GRS	ATC (D)	ATC
Total Movements	10,000 or	20,000 or	40,000 or	See Aerodrome Control Service	60,000
IFR Movements	3,000	>3,000	7,500		

Note 1. This table does not state the need for an assessment for aerodromes with operations of scheduled commercial aircraft of more than 30 seats capacity

Notes 2. The above table does not reflect the differing requirements that may be revealed by the results of an aeronautical study taken on a site-specific basis.

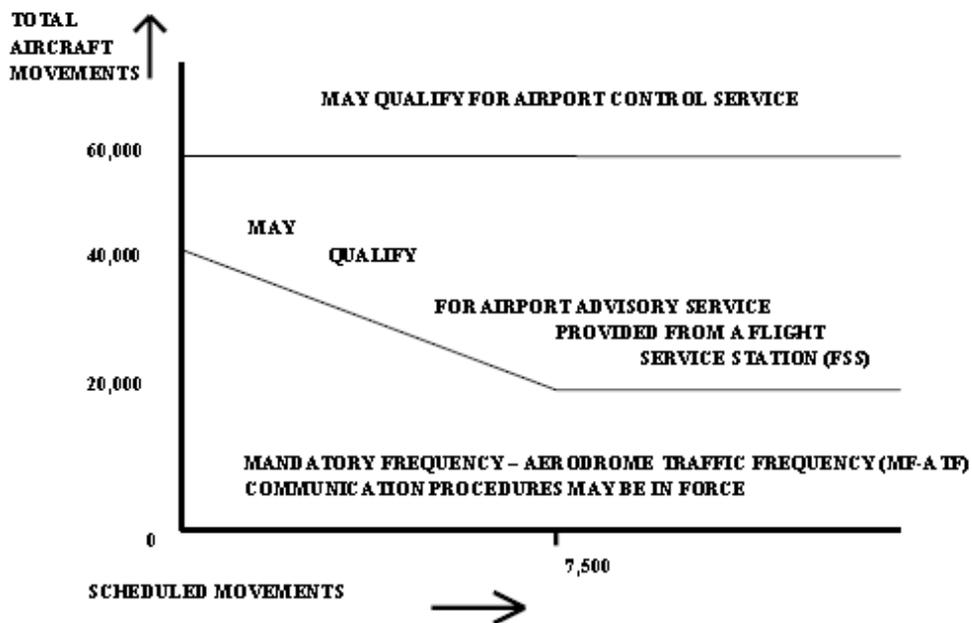
Aerodrome Control Service.

The provision of an aerodrome control service at an uncontrolled aerodrome must be assessed by an aeronautical study where total annual aircraft movements:

- (a) exceed 15,000 IFR or
- (b) exceed 60,000 of which at least 15% are IFR or
- (c) otherwise exceed 100,000.

Canada

FIGURE TWO
AIRCRAFT MOVEMENTS - AIRPORT TRAFFIC SERVICES CHART



Note: Depending on site-specific traffic mix and the risk control measures defined by an Aeronautical Study, airports meeting the above criteria may not qualify for airport advisory service using an FSS. Similarly, another airport with less than the required annual aircraft movements may qualify for this service. In all cases the Aeronautical Study shall document and demonstrate the site-specific need and the rationale for the level of service decision.

APPENDIX 6

Final Presentations – Attendance

APPENDIX 6: Final Presentations – Attendance**CAA Meeting: 2 August 2007, CAA Headquarters****Attendance List**

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Len Wicks	CAA	WicksL@caa.govt.nz
Chris Thomson	CAA	Thomsonc@caa.govt.nz
Graeme Harris	CAA	HarrisG@caa.govt.nz
Merv Falconer	CAA	FalconerM@caa.govt.nz
Dennis Hoskin	CAA	HoskinD@caa.govt.nz
Dave Park	Astral	dave@astral.co.nz
Rob Graham	Ambidji	rob.graham@ozemail.com.au
Steve Douglas	CAA (Director)	douglass@caa.govt.nz

Industry Meeting: 3 August 2007, Wellington Airport Conference Centre**Attendance List**

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Neil Kenny	Air Nelson	neil.kenny@airnz.co.nz

(continued next page....)

Industry Meeting: 3 August 2007, Wellington Airport Conference Centre

Attendance List (continued)

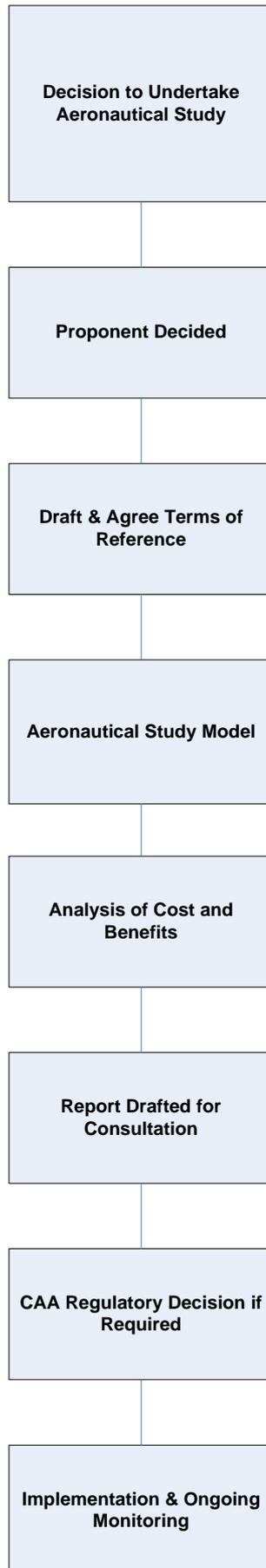
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Dennis Hoskin	CAA	HoskinD@caa.govt.nz
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Jim Jennings	Royal NZ Airforce	Jim.jennings@nzdf.mil.nz
Graeme Harris	CAA	harrisg@caa.govt.nz
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Richard Robinson	R2A	richard.robinson@r2a.com.au
Dave Park	Astral	dave@astral.co.nz

APPENDIX 7

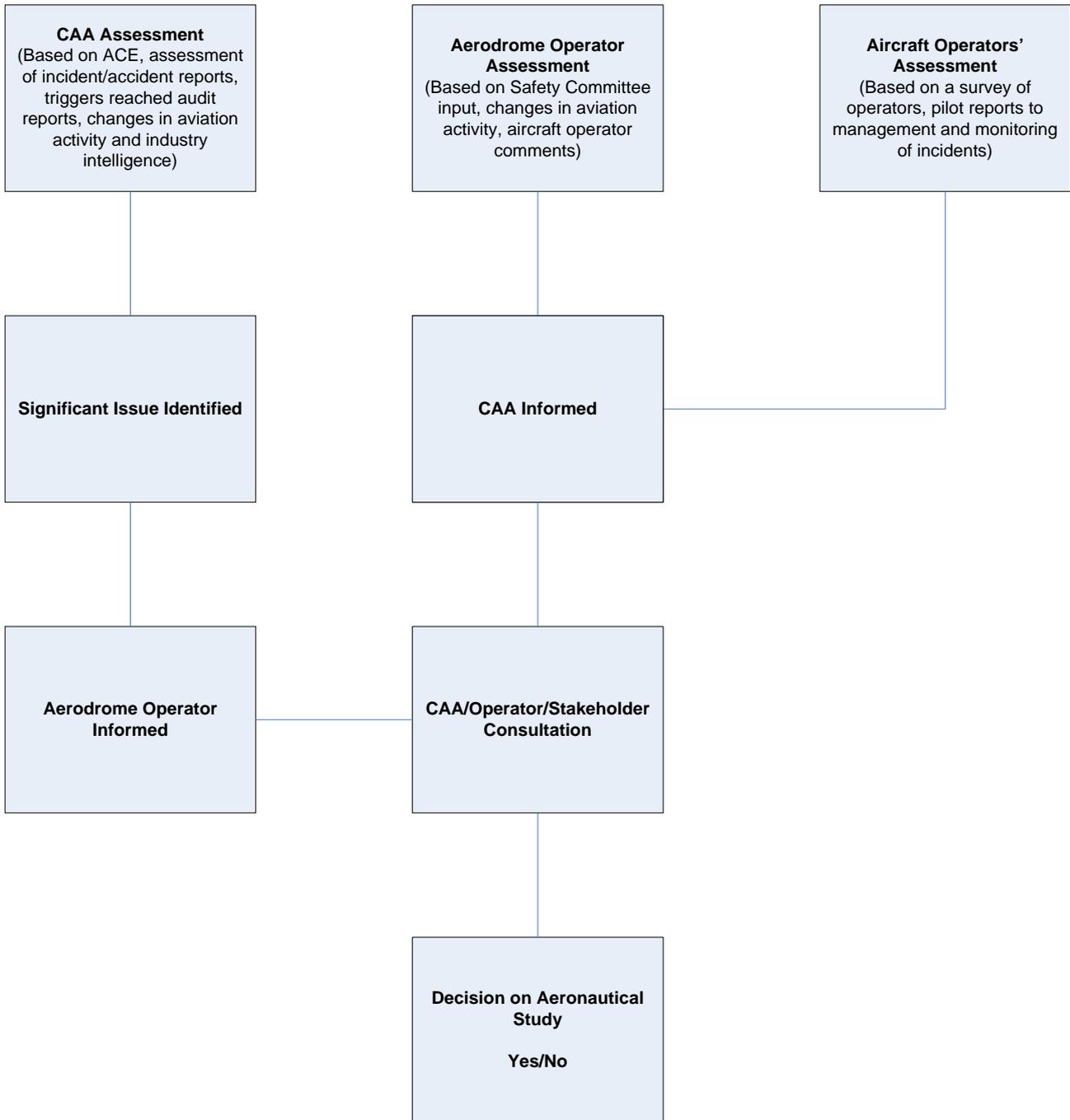
Process Diagrams

APPENDIX 7: Process Diagrams

Aeronautical Study Process



Ongoing Monitoring



Initial Priority List of Aerodrome Airspace for Aeronautical Study

