acona Understanding risk Improving performance

Nationaal Lucht- en Ruimtevaartlaboratorium

National Aerospace Laboratory NLR

**COMPANY CONFIDENTIAL**

NLR-CR-2005-102

# Safety and compatibility of mixed VFR/IFR air traffic at Geneva Airport

## Final deliverable of the CATCH project


| | |
|---|---|
| P.J. van der Geest | NLR |
| E.A.C. Kruijsen | NLR |
| C.G. Ramsay | Acona |
| D.H. Slater | Acona |


**National Aerospace Laboratory NLR**

The National Aerospace Laboratory NLR (Nationaal Lucht- en Ruimtevaartlaboratorium) is the central institute for aerospace research in the Netherlands. Since 1937 NLR is an independent non-profit organisation that provides technological support to aerospace industries, to operators of civil and military aircraft, of airports and of ATC systems, to authorities and to international organisations, all over the world.

NLR is a customer-oriented research organisation, working under national and international contracts in projects concerning aircraft development, aircraft operations, air traffic management and space technology. Depending on the project and the customer's preferences, NLR acts as sole contractor or as main contractor or subcontractor collaborating with other institutes or industries. Work under contract totals about 75 per cent of NLR's activities; NLR's programme for basic research and development of research equipment, funded by the government of the Netherlands, amounts to about 25 per cent.

NLR has two main establishments, one in Amsterdam and one in Noordoostpolder, Flevoland. Over two-thirds of the staff are graduates from universities or technical colleges. NLR owns a variety of research and test facilities and it holds an ISO 9001:2000 / AQAP-110 quality assurance certificate and several calibration accreditation certificates.

**NLR Amsterdam • Anthony Fokkerweg 2 • 1059 CM Amsterdam • The Netherlands • Telephone +31 20 5113113 • Fax +31 20 5113210**
**NLR Noordoostpolder • Voorsterweg 31 • 8316 PR Marknesse • The Netherlands • Telephone +31 527 248444 • Fax +31 527 248210**

**Web site: http://www.nlr.nl**

acona Understanding risk Improving performance

**Nationaal Lucht- en Ruimtevaartlaboratorium**

National Aerospace Laboratory NLR

**COMPANY CONFIDENTIAL**

NLR-CR-2005-102

# Safety and compatibility of mixed VFR/IFR air traffic at Geneva Airport

## Final deliverable of the CATCH project


P.J. van der Geest NLR

E.A.C. Kruijsen NLR

C.G. Ramsay Acona

D.H. Slater Acona



No part of this report may be reproduced and/or disclosed, in any form or by any means without the prior written permission of the owner.



Customer: Aéroport International de Génève
Contract number: 2494079
Owner: AIG
Division: Air Transport
Distribution: Limited
Classification: Company confidential
June 20, 2005


| Approved by author: | Approved by project manager: | Approved by project managing department: |
|---|---|---|
| 20-6 2005 | 20/6-05 | 20/6/05 |

## Summary

*General*

Geneva International Airport operates two parallel runways: one long, concrete runway and a shorter grass strip. The concrete runway is used predominantly by heavy aircraft flying under Instrument Flight Rules (IFR), and the grass strip is restricted to small single-engine aircraft (MTOW less than 2,000 kg) operating under Visual Flight Rules (VFR). The lateral spacing between the two runways is 250 metres, qualifying them as closely spaced parallel runways according to ICAO, with regards to wake turbulence separation minima. Mixing streams of heavy and light aircraft during, simultaneous, closely spaced arrivals and departures, in particular at a busy international airport like the airport of Geneva, requires specific attention to assure the safety and compatibility of such operations.

*History*

Already in 1957 the use of the airport by light aviation mixed with commercial air traffic was subject of political discussion. The Federal Office of Civil Aviation (FOCA) had expressed concerns that the presence of the light aviation might compromise safety and would be incompatible with the anticipated growth at the airport. Consequently, plans were made to move away the light aviation from the airport. However, these plans did never materialise.

*Objectives*

In light of the growing traffic volume, the question arises now whether the current mix of light aviation and commercial traffic still can be regarded as compatible, and can be allowed from a safety standpoint.
In order to address this issue the Aéroport International de Genève (AIG) has formulated the following research questions:

1. *Does the current mix of light (VFR) and heavy (IFR) air traffic operations at the airport of Geneva satisfy all safety criteria?*
2. *How will this develop in future? In the timeframe 2010 and 2020.*

It is the objective of the present study to answer these questions thoroughly and independent from the interests of any involved party.

*Study approach*

To meet stated objective three lines of activities have been carried out.

The first is an assessment whether the current mixed VFR/IFR operations are in compliance with the applicable rules and regulations. This includes a description of the relevant procedures and the operational concept at the airport. Further it includes identification of the applicable regulatory framework, and finally, an analysis of compliance is carried out.
The second line of activities concerns an evaluation of safety management practices and organisation at the airport (including the local skyguide ATC unit and AIG).
Safety management is today part of the regulatory framework, and an essential element of the safety assurance process. For this reason the current implementation of safety management at both organisations has been examined, in particular with reference to the current mixed VFR/IFR operations.
The third line of activities comprises a hazard assessment of the mixed VFR/IFR operation at Geneva airport. As acknowledged by ICAO itself [Doc9426, par 2.3.1/2.3.2], "*…. provisions concerning VFR operations have not kept pace with aviation developments in general […] A number of states, handling a considerable number of aircraft operations with a large mixture of IFR and VFR flights […] have found it necessary to introduce provisions supplementary to those of ICAO in order to restore an appropriate level of safety"* This indicates that showing mere compliance with the relevant rules and regulations is not sufficient to ensure safety. For this reason the study has incorporated a hazard assessment process. This process is aimed to identify the main hazards, associated with the current operation, and to establish whether these hazards are sufficiently controlled at present and are expected to remain controlled in the near and far future.

Above-mentioned activities included structured interviews with representatives of AIG (operations and safety officer), the local skyguide ATC unit (controllers and safety officer) and the Aéroclub de Genève (Groupe vol à moteur). Also interviews have been held with representatives of the French Community near the airport and a group of interest parties.
Further a structured hazard brainstorm was held, involving a panel of eight operational experts and three risk management specialists.
The information thus gathered has been complemented by supporting data and analysis, in particular concerning operations at other airfields, incident and accident analysis, analysis of VFR radar trajectories and meteorological conditions at the airport of Geneva.

*Analysis*

Based on the collected evidence the investigation concludes that not all regulatory requirements have been fully satisfied, in particular in the area of wake vortex separation criteria. No formal safety assessment is in place to demonstrate that the part of the operation that is not in compliance with these criteria is acceptably safe.

From the hazard identification process it has emerged that several hazards (i.e. potential unsafe conditions) do exist, related to the current mixed VFR/IFR operations, which currently appear not to be sufficiently mitigated. Amongst others, these hazards pertain to: wake turbulence, collision risk during simultaneous departures, the obstacle posed by the Forest of Ferney-Voltaire for grass runway operations, and the presence of unfamiliar VFR pilots in a complex and busy mixed VFR/IFR environment.
The tolerability of these hazards should be investigated further and, if necessary, mitigating measures should be taken as part of the appropriate safety management processes.

In the context of safety management it has been found that persons involved in the mixed VFR/IFR operations –controllers, pilots and airport personnel– are well-trained and safety conscious professionals. However, it has been also found that the safety culture and safety management systems at the airport should be developed further so that there is strong focus also on systematic, pro-active identification of hazards and management of risks that have not yet materialised into incidents/accidents. In this context it is important that a higher level of formalism is achieved, such that current informal practices based on good experience are laid down in procedures and are founded on a formal risk assessment approach.

*Final Conclusion*

The study reaches the following final conclusions in response to the main research questions.
The current mixed VFR/IFR operations at Geneva airport do not fully satisfy all safety criteria. This does not imply that current operations are unsafe, but that there are concerns about the level of safety. The mitigating measures that are presented as result of the investigation should be taken into consideration as part of the safety management processes at the airport in order to assure continued safety of the mixed VFR/IFR operations.
With respect to future developments it can be expected that the VFR traffic using the grass runway will be subject to a growing set of restrictions and limitations. It is envisioned that the compatibility of the mixed VFR/IFR traffic, in light of the anticipated traffic growth, may become so constrained that simultaneous use of the grass runway for VFR traffic and the concrete runway for IFR traffic is no longer practicable.
Where this point in future is reached is hard to predict, since it depends on technological developments and the readiness to invest in safety measures. However, if the predicted traffic growth is realised, the feasibility of sustained mixed VFR/IFR operations beyond 2020 is considered to be questionable.

## Résumé

*Généralités*

L'Aéroport International de Genève (AIG) utilise deux pistes parallèles: une piste longue en dur et une bande gazonnée plus courte. La piste en dur est principalement utilisée par des gros porteurs opérant en IFR (règles de vol aux instruments) et la bande gazonnée est restreinte aux petits avions monomoteurs (masse maximale au décollage inférieure à 2000 kg) opérant en VFR (règles de vol à vue). L'espacement latéral entre les deux pistes étant de 250 mètres, on peut les qualifier de pistes parallèles rapprochées selon l'OACI, en ce qui concerne les minimas de séparation relatifs à la turbulence de sillage.
Le flux mixte d'avions lourds (IFR) et d'avions légers (VFR) lors de départs et d'arrivées simultanés et rapprochés, en particulier à un aéroport international actif comme celui de Genève, demande une attention particulière pour assurer la sécurité et la comptabilité de telles opérations.

*Historique*

Déjà en 1957, l'utilisation de l'aéroport à la fois par l'aviation légère et le trafic commercial avait suscité une discussion politique. L'Office Fédéral de l'Aviation Civile (OFAC) avait fait part de ses inquiétudes sur le fait que l'aviation légère pourrait compromettre la sécurité et serait incompatible avec l'essor anticipé de l'aéroport. On envisageait par conséquent de faire quitter l'aviation légère de l'aéroport. Cependant, ces projets ne virent jamais le jour.

*Objectifs*

À la lumière de la croissance du trafic, la question se pose maintenant de savoir si l'utilisation combinée de l'aviation légère et du trafic commercial peut encore être considérée comme compatible et peut être autorisée d'un point de vue sécurité.
Afin d'aborder ce problème, l'Aéroport International de Genève (AIG) a formulé les axes de recherche suivants :

1. *La cohabitation actuelle de l'aviation légère (VFR) et de l'aviation lourde (IFR) à l'aéroport de Genève répond-elle à tous les critères de sécurité?*
2. *Qu'en sera-t-il à l'avenir? A l'horizon 2010 et 2020.*

L'objet de la présente étude est de répondre à ces questions de façon complète et indépendamment des intérêts de quiconque.

*Etude*

Pour répondre à l'objectif énoncé, trois domaines ont été étudiés.

Le premier domaine consiste à apprécier si les opérations mixtes actuelles VFR/IFR sont en conformité avec les règles et les règlements en vigueur. Ceci inclut une description des procédures adéquates et du concept opérationnel à l'aéroport. En outre, il comprend l'identification du cadre réglementaire applicable et finalement une analyse de conformité est menée.

Le second domaine d'études concerne l'évaluation des pratiques relatives à la gestion de la sécurité et à l'organisation aéroportuaire (incluant l'unité locale de contrôle aérien skyguide et l'Aéroport International de Genève AIG). La gestion de la sécurité fait partie aujourd'hui du cadre réglementaire et constitue un élément essentiel du processus d'assurance sécurité. Pour cette raison, l'implémentation actuelle de la gestion de la sécurité relative aux deux organisations a été examinée, en particulier en ce qui concerne les opérations combinées VFR/IFR.

Le troisième domaine comprend l'évaluation du risque des opérations mixtes VFR/IFR à l'aéroport de Genève. Comme il est reconnu par l'OACI lui-même [Doc9426, par 2.3.1/2.3.2], « *…les dispositions concernant les opérations VFR ne sont pas arrivées à suivre les développements de l'aviation en général […] Plusieurs Etats, traitant un nombre considérable d'opérations aériennes avec une importante cohabitation des vols IFR et VFR […] ont trouvé nécessaire d'introduire des dispositions supplémentaires à celles de l'OACI afin de rétablir un niveau approprié de sécurité.* »

*les dispositions relatives quant à la place du trafic VFR dans un espace aérien encombré n'arrivent pas à suivre les développements de l'aviation en général.*

Ceci indique que la simple démonstration de conformité avec les règles et règlements en vigueur n'est pas suffisante pour assurer la sécurité. Pour cette raison, l'étude a inclu un processus d'évaluation du risque. Ce processus a pour objectif d'identifier les principaux risques associés aux opérations actuelles et d'établir si ces risques sont suffisamment maîtrisés pour le moment et s'ils comptent rester maîtrisables dans un proche et lointain futur.

Les domaines mentionnés ci-dessus comprirent des interviews organisés avec les représentants de l' AIG (opérations et officier de sécurité), l'unité locale de contrôle aérien skyguide (contrôleurs et officier de sécurité) et l'Aéroclub de Genève (Groupe vol à moteur). Des interviews furent également menés avec les représentants de la Communauté Française proche de l'aéroport et un groupe d'intérêts particuliers. De plus, un brainstorming structuré du risque fut effectué, impliquant un groupe de huit experts opérationnels et trois spécialistes de la gestion du risque.

Les informations ainsi rassemblées furent complétées par un support de données et d'analyses, en particulier en ce qui concerne les opérations sur d'autres terrains, l'analyse des incidents et des accidents, l’analyse des trajectoires radar VFR et les conditions météorologiques à l’aéroport de Genève.

*Analyse*
Basée sur les témoignages recueillis, l’enquête conclut que tous les critères réglementaires ne sont pas complètement satisfaits, en particulier dans le domaine des critères de séparation relatifs à la turbulence de sillage. Aucune évaluation formelle de la sécurité n’existe afin de démontrer que la partie des opérations, non conforme avec ces critères, soit acceptable sur le plan de la sécurité.
Le processus d’identification du risque a fait apparaître que de nombreux risques (c’est-à-dire des conditions potentiellement dangereuses) existent en réalité, en ce qui concerne les opérations mixtes VFR/IFR, risques qui actuellement paraissent ne pas être assez atténués. Entre autres, ces risques se rapportent à la turbulence de sillage, au risque de collision pendant les départs simultanés, à l’obstacle posé par la Forêt de Ferney-Voltaire pour les opérations sur bande gazonnée et à la présence de pilotes VFR peu familiers à un environnement mixte VFR/IFR complexe et encombré.
La tolérabilité de ces risques devrait être davantage étudiée et si nécessaire, des mesures pour les atténuer devraient être prises comme faisant partie des processus appropriés de gestion de la sécurité.

En ce qui concerne la gestion du risque, on a trouvé que les personnes impliquées dans les opérations mixtes VFR /IFR – contrôleurs, pilotes et personnel de l’aéroport – sont bien formées et sont des professionnels soucieux de la sécurité. Cependant, il a été constaté que la culture de la sécurité et les systèmes de gestion de la sécurité à l’aéroport devraient être mieux développés pour que l’accent soit mis sur une identification systématique, pro-active des risques ainsi que sur la gestion des risques qui n’ont pas encore résulté en incidents ou accidents. Dans ce contexte, il est important qu’un plus haut niveau de formalisme soit mis en oeuvre de telle sorte que les pratiques informelles actuelles basées sur une bonne expérience soient établies sous forme de procédures, fondées sur une approche formelle d’évaluation du risque.

*Conclusion*
L’étude aboutit aux conclusions suivantes en réponse aux principaux axes de recherche :
Les opérations mixtes actuelles VFR/IFR à l’aéroport de Genève ne satisfont pas complètement tous les critères de sécurité. Ceci n’implique pas que les opérations actuelles soient dangereuses mais que des inquiétudes subsistent sur le niveau de sécurité. Les mesures pour atténuer les risques qui sont présentées comme résultat de l’enquête devraient être prises en considération

comme faisant partie intégrante des processus de gestion de la sécurité à l'aéroport, afin de s'assurer d'une sécurité prolongée des opérations mixtes VFR/IFR.
En ce qui concerne les développements futurs, on peut s'attendre à ce que le trafic VFR utilisant la bande gazonnée soit soumis à un ensemble croissant de restrictions et de limitations. Il est prévu que la compatibilité du trafic mixte VFR/IFR, à la lumière de la croissance anticipée du trafic, puisse devenir si contraignante que l'utilisation simultanée de la bande gazonnée par le trafic VFR et de la piste en dur par le trafic IFR ne devienne plus réalisable.
Il est dur de prévoir quand cela sera le cas, ceci dépendant des développements technologiques et de l'empressement à investir dans les mesures de sécurité. Cependant, si la croissance prévue du trafic se confirme, on considère la faisabilité des opérations prolongées mixtes VFR/IFR au-delà de 2020 discutable.

## Contents

(137 pages in total)

## List of Acronyms and Abbreviations

| | |
|---|---|
| AAIB | Aircraft Accident Investigation Bureau (Switzerland) |
| ADREP | ICAO accident/incident database |
| AIG | Aéroport International de Genève (the airport authority) |
| AIP | Aerodrome Information Publication |
| AGL | Above Ground Level |
| APAPI | Abbreviated Precision Approach Path Indicator |
| ASRS | Aviation Safety Reporting System |
| ATC | Air Traffic Control |
| ATCO | Air Traffic Controller |
| ATM | Air Traffic Management |
| ATMM | ATM Manual |
| ATS | Air Traffic Service |
| BASI | Bureau of Air Safety Investigation |
| CAA | Civil Aviation Authority |
| CATCH | Compatibility of mixed VFR/IFR Air Traffic at Geneva airport (CH) |
| CDF | Cumulative Distribution Functions |
| CTR | Control Zone |
| DME | Distance Measuring Equipment |
| ESARR | Eurocontrol Safety Regulatory Requirement |
| FHA | Functional Hazard Assessment |
| FOCA | Federal Office of Civil Aviation (Switzerland) |
| GA | General Aviation |
| GE | Visual reference point for in CTR (East holding point) |
| GW | Visual reference point for in CTR (West holding point) |
| GPIP | Glide Path Intersection Point |
| GVA | IATA designator of Geneva airport |
| HAZOP | Hazard and Operability study |
| IATA | International Air Transport Association |
| ICAO | International Civil Aviation Organisation |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| ISMCS | International Station Meteorological Climate Summary |
| LFG | Bundesgesetz über die Zivilluftfahrt (December 21, 1948) |
| LSGG | ICAO designator for Geneva airport |

| | |
|---|---|
| MTOM | Maximum Take-Off Mass |
| MTOW | Maximum Take-Off Weight |
| MSL | above Mean Sea Level |
| NASA | National Aeronautics and Space Administration (US) |
| NLR | National Aerospace Laboratory (The Netherlands) |
| NMAC | Near Mid-Air Collision |
| NTSB | National Transportation Safety Board (US) |
| NVFR | Night VFR |
| NW | Visual reference point for North-West entry into CTR |
| OAG | Official Airline Guide |
| PAS | Passeiry DVOR/DME |
| PPR | Prior Permission Request |
| RNAV | Area Navigation |
| RWY | Runway |
| SARP | Standard and Recommended Practice |
| SE | Visual reference point for South-East entry into CTR |
| SID | Standard Instrument Departure |
| SMS | Safety Management System |
| SPR | St-Prex VOR/DME |
| SSR | Secondary Surveillance Radar |
| STAR | Standard Arrival Route |
| SVFR | Special VFR |
| THR | Threshold |
| TMA | Terminal Manoeuvring Area |
| US | United States |
| VFG | Visual Flight Guide |
| VFR | Visual Flight Rules |
| VIL | Verordnung über die Infrastruktur der Luftfahrt (November 23, 1994) |
| VMC | Visual Meteorological Conditions |
| VOR | Very high frequency Omni-directional Range |
| VORDME | Combination of VOR and DME beacon |
| VVR | Verkehrsregeln für Luftfahrzeuge |

# 1 Introduction

## 1.1 General

Geneva International Airport (IATA code: GVA) operates two parallel runways 05-23: one long, concrete runway and a shorter grass strip. The concrete runway is used predominantly by heavy aircraft flying under Instrument Flight Rules (IFR), and the grass strip is restricted to small single-engine aircraft (MTOW less than 2,000 kg) operating under Visual Flight Rules (VFR). The lateral spacing between the two runways is 250 metres, qualifying them as closely spaced parallel runways. Figure 1-1 presents a plan view of the airport [AIP].

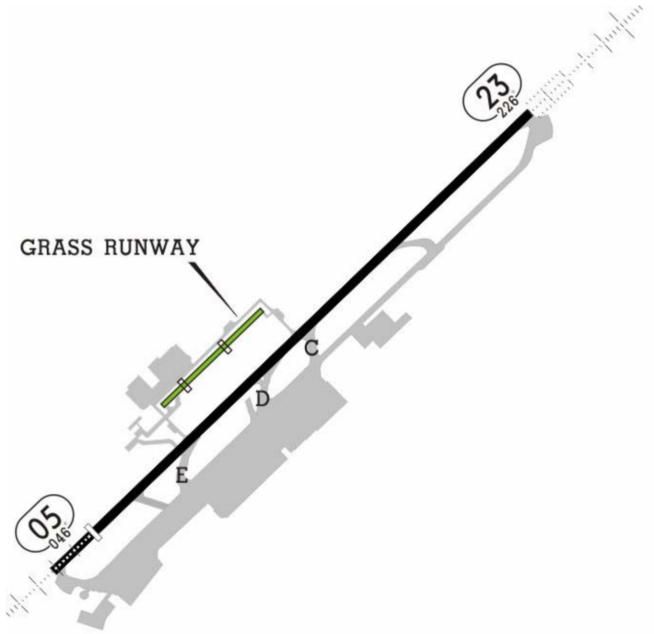


*Figure 1-1. Aerodrome layout of Geneva International Airport (GVA).*

In general, mixing streams of heavy and light aircraft in closely spaced arrival and departure procedures around airports requires specific attention to assuring the safety of such operations. This is mainly due to the large variations in airspeed, climb rate and turn radius that characterise these different categories of aircraft. When in addition one part of the traffic stream adheres to VFR and the other part operates under IFR, safety issues are compounded, since VFR operations (using see-and-avoid to prevent collisions with terrain and other aircraft) are inherently subject to a level of unpredictability that may be less compatible with high density IFR traffic. If such a mix of heavy/light and VFR/IFR traffic operates to and from closely spaced parallel runways, special conditions and/or limitations may be imposed to assure a satisfactory level of safety.

This report presents a detailed investigation of the safety and compatibility of the mixed VFR/IFR traffic operations at Geneva airport, taking into account the current situation as well as projections into the future.

### 1.2 The study motive

Already in 1956 a masterplan has been drafted, by the Swiss-French Convention, for the use of the airport of Geneva-Cointrin in service to the French and Swiss community near the airport. This plan did not specifically address the use of the grass runway. Consequently the issue of compatibility of traffic using the concrete and grass runway has not been clearly arranged or agreed, as part of the original masterplan.

In 1957 the further extension of the airport and the use of the airport by light aviation mixed with commercial air traffic became subject of political decision making. The Federal Council presented its concerns in a message to the Swiss Federal Assembly [GF7437]. The message stated that the Federal Office of Civil Aviation (FOCA) reluctantly had agreed to allow light aviation (for sport and tourism) on commercial airports. FOCA feared especially that safety would be compromised by the presence of the light aviation. Consequently, the authorities of Geneva had indicated to be determined to improve the infrastructure at other airfields in the Southern region of Geneva and to place them at the disposal of the motorised private aviation.

However, the removal of the light aviation from Geneva to another place never materialised.
The airport of Geneva remained the home base of one of the largest aeroclubs in Switzerland. To date the airport accommodates a substantial volume of light aviation, including training flights, which uses the grass runway in parallel with a high volume of commercial air traffic on the main runway.

The question arises whether this mix of light aviation and commercial traffic can be regarded as compatible, and can be allowed from a safety standpoint. This question is particularly relevant in light of the fact that already in 1957 the contemporary aviation authorities indicated to be reluctant to allow such operations and that in the mean time the combined traffic volume has grown markedly.
This issue has become over the years subject of growing concerns, and has lead to dispute between the authorities of Geneva and the French community near the airport.

The present study is meant to evaluate the issue of the mix of light and heavy aircraft operations at the airport, and in particularly address the safety aspects of these operations.

### 1.3 The study objective

The mandate for the study has been clearly phrased in the contract letter from the Aéroport Internationale de Genève (AIG). For reason of completeness and consistency, the main questions to be addressed have been repeated below in the French language:

1. *La cohabitation actuelle de l'aviation légère (VFR) et de l'aviation lourde (IFR) à l'aéroport de Genève répond-elle á tous les critères de sécurité?*
2. *Qu'en sera-t-il à l'avenir? A l'horizon 2010 et 2020.*

These questions have been translated into English as follows:

1. *Does the current mix of light (VFR) and heavy (IFR) air traffic operations at the airport of Geneva satisfy all safety criteria?*
2. *How will this develop in future? In the timeframe 2010 and 2020.*

It is the objective of the present study to answer these questions thoroughly and independently from the interests of any involved party.

### 1.4 The scope

The scope of the study has been limited to review the safety of air traffic engaged in simultaneous operations to and from GVA's parallel runways, and then only during the part of the final approach and landing, and during take-off and initial climb. More specifically, the scope of the study is limited to the VFR traffic circuit positioned North of the grass strip, the VFR arrival and departure routes crossing overhead the concrete runway, helicopter initial arrival and departure routes, and operations over the extended centreline of the concrete runway in both directions. The vertical dimension of the airspace under study extends from the ground up to approximately 2500ft above ground level (this includes the circuit, which is flown at approximately 1000ft above ground level). Therefore the study is limited to operations confined within the CTR of GVA.

An evaluation of the safety of ground operations is left outside the scope of this study.
An evaluation of third party risk (i.e., the *consequences* of accidents related to airport operations for people on the ground) is also specified to be out of scope of the present study.

The primary study objective is to assess whether the current mixed VFR/IFR operations are in compliance with the applicable rules and regulations. Because safety management is an

essential element within the current regulatory framework, the safety management organisation both of the ATC unit at Geneva, and the airport is assessed as part of this study.
Anticipating that the current regulatory framework would leave substantial freedom to interpret and implement the applicable rules and associated guidelines, on the basis of “good controllership” and “good airmanship”, it was regarded essential to complement the study with a so-called hazard identification. This process concerns the identification of hazards involved in the current operation and the measures taken to control or mitigate these hazards.
This hazard identification process shall however not be regarded as a complete safety assessment process. A safety assessment process comprises in general four essential steps: identification of hazards, establishment of the frequency of occurrence, the determination of the severity, and the formulation of the acceptability of the hazards.
The present study merely addresses the first step of this process, in agreement with the study assignment. The completion of a full safety assessment has been left to a possible next phase of the investigation.

### 1.5 The study set-up

The study has been set-up along several lines.
First of all an inventory has been made of rules and regulations applicable to the mixed VFR/IFR operation at hand. This comprises international standards and recommended practices, as specified by ICAO, as well as the relevant Swiss legislation.
Next the concept of operation (i.e. the way the mixed VFR/IFR operations at Geneva airport are conducted and controlled) has been determined. In this context several interviews were held with representatives of the local skyguide ATC unit, including active tower controllers, as well as with representatives of the airport and the aeroclub. In addition the general ATC procedure manuals of skyguide and the specific ATC manual for Geneva have been reviewed.
Using these sets of information an analysis has been made of compliance of the concept of operation with the applicable set of regulations.

Concurrently, data and information have been gathered in order to support as much as possible a data driven approach towards evaluating the operational characteristics and the associated safety level of the airport. This supporting information concerns:

- analysis of world-wide accidents and incidents involving mixed VFR/IFR operation, including the contributing factors;
- analysis of accidents and incidents (mostly airproxes) near the airport Geneva, including contributing factors;
- a brief literature study concerning the effectiveness of the see-and-avoid concept, which is the basic principle of safe separation of VFR traffic;

- a review of operations at other medium-large airports within Europe, in order to establish to which extent operations at Geneva are special, in terms of intensity of mixed VFR/IFR operations and the use of a closely spaced parallel, grass runway;
- analysis of VFR tracks as recorded by the Secondary Surveillance Radar at Geneva in August 2004, in order to get an impression of the accuracy with which VFR traffic adheres to intended departure and arrival routes, as well as the VFR circuit;
- a brief analysis of the wind and turbulence characteristics at Geneva airport.

The gathered information provides valuable and founded information concerning the special characteristics of mixed VFR/IFR operations at Geneva airport. This information is subsequently used to support the hazard identification process.
The hazard identification process has been based on the following activities:

- structured interviews with representatives of airport user community, involving ATC controllers, representatives of the airport and the aeroclub;
- interview with representatives of the French community near the airport;
- interview with representatives of several interested party groups;
- structured brainstorm meeting with safety and ATC experts and persons with direct experience with the operations at Geneva airport. This group included a.o. a commercial airline pilot, VFR instructor, ATC Tower Controller, helicopter pilot, VFR pilot, and regulatory expert.

Finally, a review has been conducted of the active safety management processes within the ATC unit at Geneva and the airport itself. For this purpose structured interviews have been held with the safety officers of skyguide Geneva, and of AIG.

### 1.6 The report set-up

This report has been set-up to reflect clearly the various lines of work within the investigation.
Chapters 2, 3 and 4 focus on establishing the analysis of compliance of the current VFR/IFR operations at Geneva airport with applicable regulatory framework.
Chapter 2 starts with description of the concept of operation at Geneva airport.
Chapter 3 describes the regulatory framework.
Chapter 4 processes the results of the previous two chapters to evaluate the level of compliance of the described operation with the applicable regulatory framework. Chapter 4 concludes with a number of findings concerning the level of compliance.

Chapter 5 provides supporting information that is of relevance for the present investigation in general and the subsequent hazard assessment in particular. This supporting information concerns:

- comparison with other airports in terms of traffic volume and characteristics;
- incident and accident analysis;
- the practicality of the see-and-avoid principle;
- analysis of radar trajectories of VFR traffic;
- wind and turbulence climate at Geneva airport.

Chapter 6 focuses on the hazards that are identified to be associated with the current operation. It first describes the actual hazard identification process and the main results, in the form of a key hazard list. Subsequently, all identified hazards are reviewed and a first assessment of their severity is made. Because no full safety assessment process has been performed (since this was not part of the agreed scope of the study) identified hazards have not been formally classified in terms of their acceptability. Therefore, no formal recommendations are done with respect to potential measures to mitigate potential unacceptable risks. However, some of the identified hazards are assessed as sufficiently serious to consider mitigating measures.
For this reason these possible measures are given as considerations, and not as formal recommendations.

Chapter 7 is entirely devoted to the review of the safety management processes of both the ATC unit at Geneva airport and of AIG itself. It has been mainly based on the results of structured interviews of the safety officers of both organisations. The current regulations as specified by ICAO and Eurocontrol have been used as main framework. However, also experiences from other domains where safety management processes are well developed are used as yardstick.

Chapter 8 concludes with future projections of the current mixed VFR/IFR operations, based on projections of traffic growth, operational, technological and regulatory developments. Based on these projections it is assessed how various hazards may develop in future and how they may affect the future of mixed VFR/IFR operations.

Finally, in Chapter 9 all conclusions, recommendations and considerations are summarised.

# 2 Description of mixed VFR-IFR operations at GVA

The operations at GVA are described in accordance with the scope of the CATCH safety study, as described in [ProjPlan]. In this way, the description is limited to those operations that are relevant to the safety study.

## 2.1 Geometry of the operations

The operations are obviously largely defined by the geometry of the runways at Geneva Airport, as illustrated by Figure 1-1. The two runways are oriented in parallel, with approaches in the magnetic directions 046° and 226°, warranting their names of 05 and 23. This report designates the runways as *grass RWY* and *concrete RWY* [orientation], for reasons of conciseness. As mentioned before, the centrelines of both runways are separated 250 metres laterally. This is close, in aviation terms. For instance, regulations addressing operations on parallel *instrument* runways regard a pair of parallel runways as "closely spaced" when the distance between their centrelines is less than 1525 metres [Doc4444]. The landing thresholds of the grass and concrete runways are displaced longitudinally (i.e., in the direction of the approach and landing) by approximately 2250m. This means that, when a VFR aircraft on final approach to grass RWY 23 has the threshold of concrete RWY 23 abeam to its left, it still has approximately 2250m to go to the grass RWY 23 threshold. Note that the landing threshold of the grass RWY 23 is displaced from the beginning of the grass RWY 23 by 303m. The reason for this follows later. In the opposite direction, 05, the longitudinal displacement is far less: approximately 1000m. Note that the grass RWY 05 and concrete RWY 05 thresholds are both displaced from their respective runway beginnings (by 187m and 330m, respectively).

The displacement of the landing thresholds is operationally significant, since this causes VFR aircraft on final to the grass runway to fly higher than IFR aircraft to the concrete runway, when they fly alongside each other, see Figure 2-1. This effect is enhanced by the steeper approach angle enforced on the VFR aircraft approaching the grass runway by the abbreviated precision approach path indicators (APAPIs)[1]. The grass RWY 23 APAPI indicates a nominal approach angle of 4.15°[2] and the grass RWY 05 APAPI indicates a nominal approach angle of 4.00°. The instrument approaches have different approach angles, varying from 3.00° for the ILSses to 23 and concrete RWY 05 to 3.66° for the not-often used VORDME approach to concrete RWY 05. The approach procedures are further addressed in paragraph 2.4.3.

---

[1] An APAPI is a system consisting of lights and lenses next to the landing threshold of a runway, indicating to the pilot the nominal descent path to that runway. When the aircraft is on the nominal descent path towards the runway, the pilot sees one white light and one red light. When the aircraft descends below the nominal descent path, both lights turn red and when the aircraft climbs above the nominal descent path, both lights turn white.

[2] As of January 2005 the nominal slope of the grass RWY 23 APAPI has been adjusted to a slope of 4.50°.

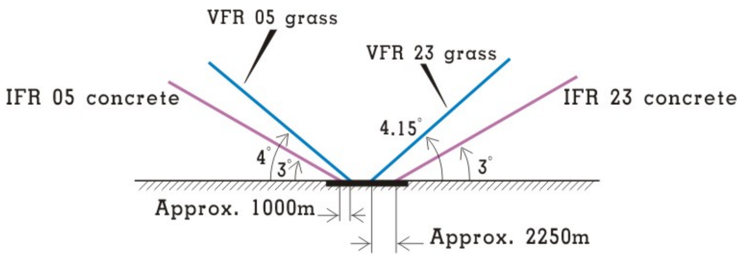


*Figure 2-1. Vertical segregation between VFR traffic approaching the grass runway and IFR traffic on the ILS approaching the concrete runway due to threshold displacement and difference in approach angles.*

When single-engine aircraft use the concrete runway for landing, they must aim to touch down not at the normal landing threshold, but quite some distance down the runway, as specified in the [AIP]. The touchdown aiming points are defined abeam exits C and E for easy visual identification from the landing aircraft. These aiming points are more or less next to the ends of the grass runway. Therefore, the landing area is exactly next to the grass runway, so that aircraft can vacate the concrete runway at exits located abeam the opposite end of the grass runway, see Figure 1-1. Due to this procedure the time that small aircraft occupy the concrete runway after landing is minimised.

## 2.2 Airspace Design

The airspace relevant to this study is contained in the Geneva Control Zone (CTR). Figure 2-2. presents the lateral dimensions of the CTR. Vertically, it extends from the ground up to 4000ft MSL, which equals approximately 2500ft above aerodrome elevation. The CTR has been classified as Class D Airspace, according the international standard adopted by ICAO and documented in [Annex11]. In Class D airspace, both IFR and VFR flights are permitted and all flights are provided with *air traffic control service*. IFR flights are *separated* from other IFR flights. However, IFR traffic is *not separated* from VFR traffic but only receives *traffic information* in respect of VFR flights. VFR flights are *not separated* from IFR flights – or from other VFR flights – but do receive traffic information in respect of all other flights.

[Annex11] defines the italicised terms as follows:

*Air traffic control service*: A service provided for the purpose of:

a) preventing collisions between aircraft; and
b) expediting and maintaining an orderly flow of air traffic.

*Separation* by an air traffic control unit shall be obtained by at least one of the following:

a) vertical separation,
b) horizontal separation, obtained by providing:

1) longitudinal separation, by maintaining an interval between aircraft operating along the same, converging or reciprocal tracks, expressed in time or distance; or
2) lateral separation, by maintaining aircraft on different routes or in different geographical areas;

c) composite separation, consisting of a combination of vertical separation and one of the other forms of separation contained in b) above.

The minimum separation to be used is specified in [PANSOPS] or ICAO regional supplementary procedures [Doc7030].

*Traffic information:* Information issued by an air traffic services unit to alert a pilot to other known or observed air traffic which may be in proximity to the position or intended route of flight and to help the pilot avoid a collision.

The above description of Class D airspace implies that air traffic controllers have to be able to continuously communicate with all pilots, and therefore all IFR and VFR pilots must maintain a continuous two-way radio listening watch for communication on the relevant radiotelephony frequency, as designated by the aerodrome controller. The [AIP] also explicitly states that VFR pilots are required to obtain a clearance by GVA TWR to fly in the CTR.

VFR pilots must remain in visual meteorological conditions, which for Class D airspace are defined as follows:

| | |
|---|---|
| minimum distance from clouds: | 1500m horizontally<br>300m (1000ft) vertically |
| minimum flight visibility: | 5km (below 10000ft, which applies to the GVA CTR), in daylight. |

When the flight visibility drops below 5km and/or the cloud base drops below 1500ft (AGL), VFR pilots may request to proceed in the CTR under a Special VFR (SVFR) clearance, see paragraph 2.5.2 below. In Switzerland, pilots are also given the opportunity to fly VFR at night, see paragraph 2.5.1 below.

VFR aircraft are *not* required to carry an SSR transponder in the GVA CTR. This means that the aerodrome controllers rely on visual contact with the aircraft under their control, supported by primary radar information.

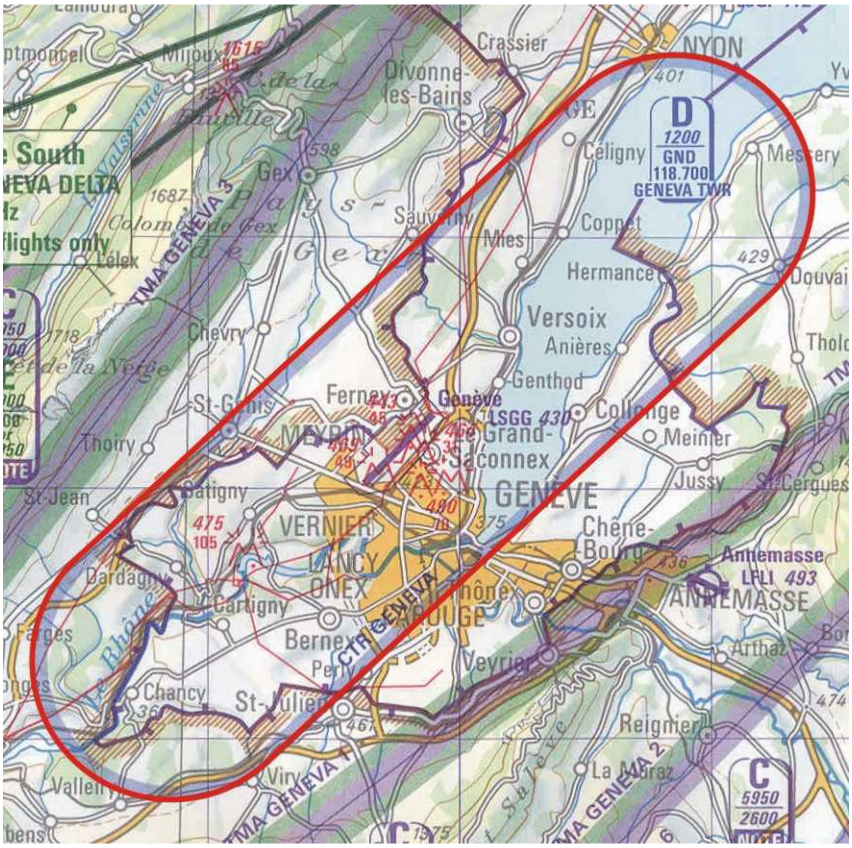


*Figure 2-2. Genève CTR. The red line denotes its lateral boundary [AIP].*

## 2.3 Departure Procedures

Aircraft taking off from grass RWY 05 face a rather formidable hurdle in the form of high trees immediately after take-off, as depicted in Figure 2-3. Small single-engine aircraft operating from the grass runway may have insufficient climb performance to clear these trees vertically, especially when heavily loaded. The only alternative may be to fly *around* the patch of trees. This is only possible towards the east – i.e., towards the concrete runway (to the right in Figure 2-3). Locally based pilots may be expected to be familiar with the trees and to ask for a clearance for take-off from the concrete runway when their aircraft is heavily loaded or when weather conditions have an adverse effect on performance. Unfamiliar pilots however may discover the actual height of the trees only when already airborne, and suddenly swerve towards the concrete runway.

*Figure 2-3. Trees just beyond the departure end of runway grass RWY 05. The aircraft in the picture is on short final grass RWY 23.*

After take-off, all aircraft shall navigate according their flight rules (IFR or VFR) on specified departure routes leading them out of the CTR, see Figure 2-4. IFR aircraft will pick up a Standard Instrument Departure procedure (SID) as cleared by ATC. SIDs are designed according [PANSOPS] and disseminated for operational use in the [AIP]. The objective of an instrument departure procedure is to enable aircraft operating under IFR to safely reach the IFR airways system. The primary concern for the design of instrument routes is obstacle clearance, i.e. to prevent collisions with the ground or obstacles. Almost all SIDs from concrete RWY 05 and concrete RWY 23 have initial segments that keep departing IFR aircraft well clear of the VFR circuit and the VFR routes, by specifying that the aircraft stay on the extended runway centreline until reaching at least 5000ft MSL, before initiating the first turn. Thus, IFR aircraft on these SIDs will leave the CTR "though the roof" at 4000ft while still tracking the concrete runway extended centreline.

The notable exception to the above are the KONIL departures from concrete RWY 23, which specify a tight right turn at minimum 1900ft MSL (~500ft AGL), but not before 3NM from the GVA VOR, to establish on a north-easterly track. This will take any aircraft on these SIDs through the VFR circuit area for the grass runway.

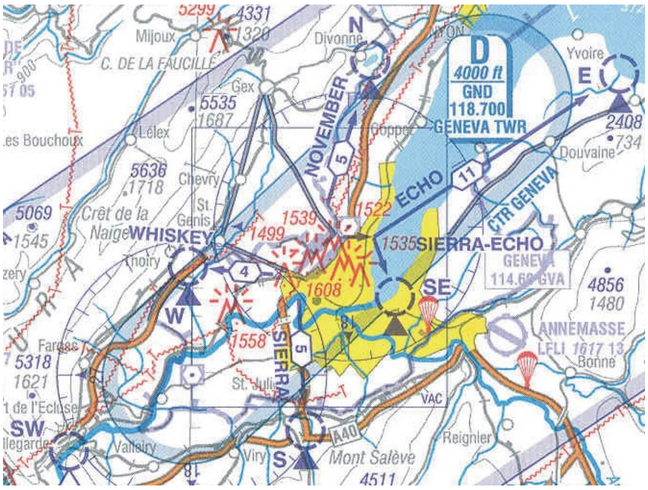

*Figure 2-4. VFR departure routes convey VFR aircraft out of the Geneva CTR*

A departing VFR aircraft will have to pick up a departure route according an ATC clearance as well – the big difference with IFR SIDs is that VFR departure routes must be navigated by reference to landmarks, instead of by radio-navigation aids (or RNAV equipment). The objective of VFR departure routes is to enable VFR aircraft to safely exit controlled airspace[3]. Note that there is no exact specification of the accuracy with which VFR pilots shall adhere to the nominal VFR route tracks.

The GVA VFR departure routes as specified in the [AIP] prescribe an initial turn away from the concrete runway (i.e. a left turn for aircraft departing grass RWY 05, and a right turn for those departing grass RWY 23). The aircraft shall initially remain in the VFR circuit (see paragraph 2.4.2) and pick up the departure routes towards the North and West from logical points in the circuit, climbing to minimum 2500ft MSL and maximum 3500ft MSL, see also Figure 2-4. For those aircraft wishing to leave towards the South, Southeast or East, a special procedure has been established, see Figure 2-5. According to this procedure the aircraft must climb in the circuit to at least 2500ft, and when on downwind it must obtain a clearance from the aerodrome controller to cross overhead the concrete runway. When cleared to cross, the aircraft navigates to landmarks across the concrete runway and exits the CTR along the specified departure route. When IFR traffic permits, the aerodrome controller may issue an instruction to a VFR aircraft waiting for departure to make an opposite turn after take-off, i.e. directly crossing the concrete runway, to expedite its exit from the CTR.

[3] When a VFR aircraft exits the GVA CTR (while flying below 3500ft), it enters uncontrolled airspace and is not obliged to follow any prescribed route, nor are such routes specified.

Note that after take-off from grass RWY 05, the VFR pilot must track the extended centreline of the grass RWY 05 for a few miles before turning left into the circuit, to avoid overflying the town of Ferney (for noise abatement reasons). Any drift due to crosswind should be compensated by steering into the wind. VFR pilots must use landmarks on the horizon ahead of the aircraft to determine their ground track. However in the initial climb the aircraft will have a high pitch attitude, and especially in single-engine piston aircraft the horizon will not be visible ahead of the aircraft. Therefore, crosswind compensation may be a problem in the initial climb and the VFR aircraft may drift towards the extended centreline of the concrete RWY 23, when northerly or westerly winds prevail.
The initial climb after take-off from grass RWY 23 is considered to be less of a risk, since VFR aircraft should in this case stay just north of a railroad track, which diverges from the extended centreline of the concrete RWY 23.

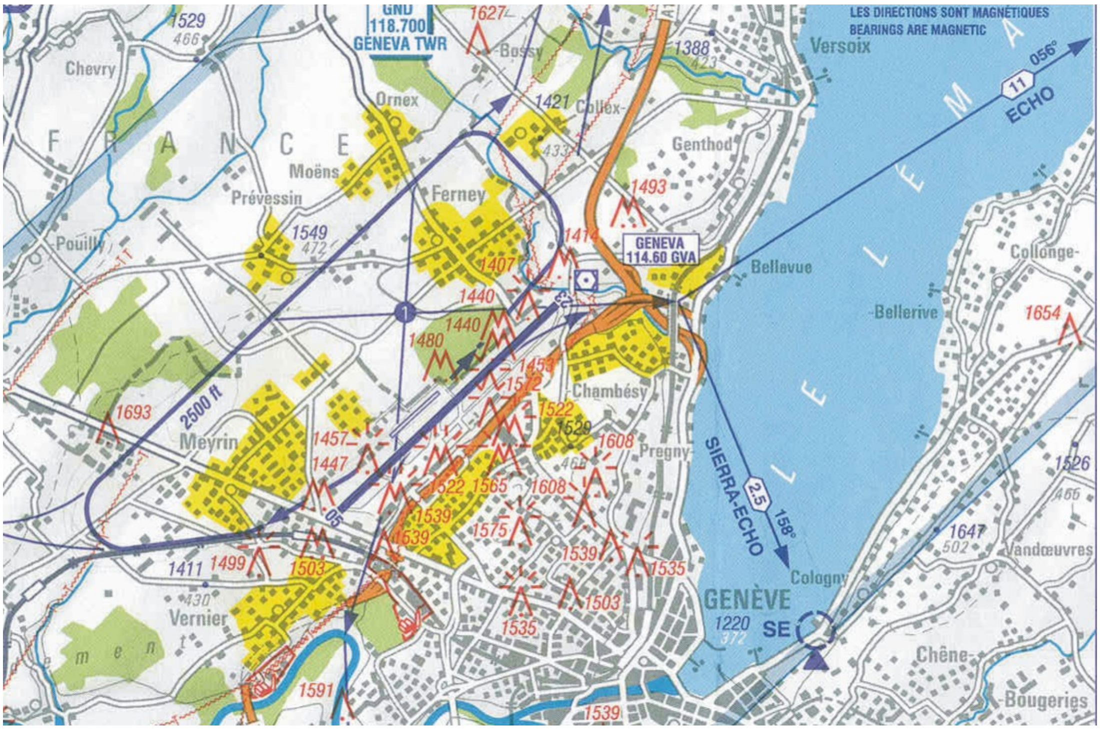

*Figure 2-5. Geneva VFR circuit and overhead crossing tracks [AIP].*

## 2.4 Arrival and Approach Procedures

Similar to prescribed departure routes that convey IFR and VFR aircraft from their take-off runway to the IFR en-route environment and outside controlled airspace, respectively, also prescribed arrival routes have been established. A significant difference with departure routes is that the routes leading to the landing runway are divided into arrival routes and approaches, since (especially instrument) approaches require a different set of regulations from arrivals. This

Section treats the VFR arrival routes and VFR and IFR approaches to GVA. IFR arrival procedures are outside the study scope, since they lie outside the CTR.

### 2.4.1 VFR Arrival Procedures

VFR aircraft wishing to land at GVA shall overfly one of four waypoints N, W, E, or S, situated just outside of the CTR, see Figure 2-6. Waypoints are in this case significant landmarks, presented in detail on the VFR Area Chart for GVA in the [AIP]. Arriving aircraft shall contact the aerodrome controller 5 minutes prior to the estimated time overhead the arrival waypoint. From these waypoints, aircraft shall fly to one of two intermediate waypoints, SE or NW, which are located on the CTR boundary approximately abeam the runway midpoint. At these positions, they turn towards the airport, to position themselves on the downwind leg of the circuit, at 2500ft MSL. Aircraft flying via SE have to overfly the concrete runway, for which extra procedures have been established: minimum altitude is 3000ft MSL and the aircraft must obtain crossing clearance before passing GE. If they do not have this clearance in time, they should enter a holding pattern (fly in circles) over GE.
Whenever traffic permits, ATC may issue clearances that deviate from the prescribed procedures, e.g. to expedite the traffic flow. Often-used shortcuts are to clear a VFR aircraft onto a “direct base leg”, i.e. from any point on the arrival route direct to the final approach.

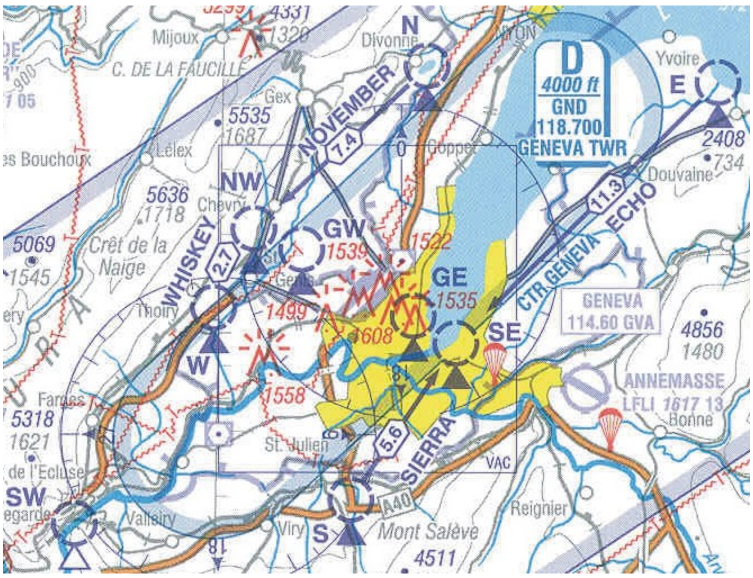


*Figure 2-6. VFR arrival routes to Geneva [AIP].*

Note that the arrival procedures use many of the same waypoints as the departure procedures, without different altitudes being specified for the different procedures. Even though the routings between these waypoints are different for departure and arrival procedures, departing and arriving aircraft will converge on these waypoints. Since the [AIP] does not prescribe different altitudes for departure and arrival procedures (actually, all VFR traffic on these routes has to operate in a relatively small altitude band between 2000 or 3000 and 3500ft MSL), converging aircraft may even be at the same altitude.

### 2.4.2 VFR Approach Procedures

The VFR arrival routes deliver the aircraft on downwind in the circuit, at 2500ft MSL. All VFR pilots are trained to fly circuits from day one, so designing the final part of arrival routes to resemble a circuit makes any VFR pilot feel at home. From the end point of the arrival routes, the aircraft must complete the circuit via downwind, base and final in a standard way.
The VFR aircraft may be cleared to land on the grass or on the concrete runway. In the latter case, pilots must fly the circuit as if they were going to land on the grass, until they pass the concrete threshold. At this point they line up with the concrete centreline, to land at the VFR touchdown points as described in paragraph 2.1, see Figure 2-7.

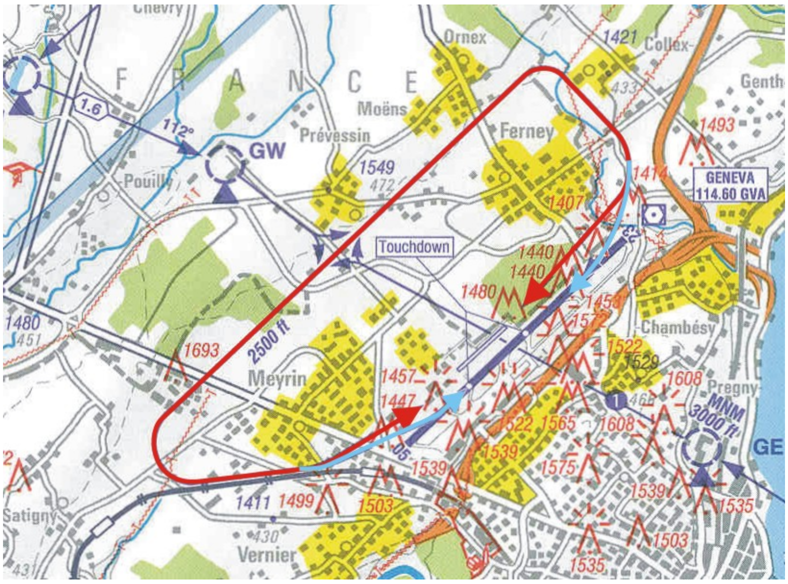


*Figure 2-7. Red line denotes VFR circuit, light blue arrows show track to follow when landing on the concrete runway [AIP].*

When landing on the grass runway, pilots must adopt a higher-than-standard descent angle to safely clear obstacles close to the grass runway. To aid them in selecting the flattest (least steep) approach angle that still safely clears the obstacles, APAPIs have been installed, as already mentioned in paragraph 2.1. See also Figure 2-8. The approach angles necessary to clear the obstacles, and indicated by the APAPIs are sufficiently steep to potentially cause descent performance problems for some aircraft under unfavourable weather conditions (tailwind).

These aircraft cannot descent at these angles and at the same time maintain their final approach speed. The short landing distance left over beyond the displaced thresholds on both grass RWY 05 and grass RWY 23 however forces pilots to fly at not more than final approach speed during landing, in order to safely decelerate to taxi speed after touchdown, within the remaining runway distance. VFR pilots familiar to GVA have indicated that they intentionally descend below the APAPI nominal approach path to be able to touch down before the nominal touchdown point. The [AIP] includes a note that the APAPI indications are not usable on “short final”. It is not clear at what distance from the threshold this begins.

*Figure 2-8. Approach to grass RWY 23, over the same trees as depicted in Figure 2-3. Close inspection of the illustration reveals that the APAPI lights to the left of grass RWY 23 are both red, indicating that the aircraft is below the nominal approach path.*

It requires good airmanship to judge the final turn so as to properly line up with the runway centreline, especially in crosswind conditions. At GVA, lining up with the grass centreline is somewhat harder than normal because the grass runway is rather hard to identify among the taxiways and other airport markings surrounding it. This may lead to pilots overshooting the final turn and may even lead to undue proximity to IFR traffic. Pilots familiar with GVA may use the APAPI lights to identify the grass runway, since these are located to the left of the touchdown zone for both grass RWY 05 and grass RWY 23. Pilots unfamiliar with GVA however cannot be expected to use this aid for the following reasons:

- the exact location of the APAPI lights is not indicated on the Visual Approach Chart for GVA in the [AIP], which the pilot will most probably use when flying in the circuit, but on the airport layout chart (LSGG AD INFO 1 in the [AIP]), and even on this chart the APAPI positions are hard to find accurately; and
- APAPIs are not intended for lateral guidance.

This implies that especially pilots unfamiliar with GVA may overshoot the final turn and come close to the concrete runway extended centreline.

The missed approach procedure for VFR aircraft is not explicitly mentioned in the [AIP], but on the other hand, this is not mentioned anywhere in the regulations. One can however reasonably expect a VFR aircraft to stay in the circuit after executing a go-around.

#### 2.4.3 IFR Approach Procedures

IFR aircraft approaching GVA normally are guided by the electronic signals of the Instrument Landing System (ILS) installed for both concrete RWY 05 and concrete RWY 23. Aircraft using these systems approach on the runway centreline with a descent angle (called glide slope) of 3 degrees, with normally only small deviations from this nominal flight path. When for any reason the ILS installations are not usable, pilots may elect to use VORDME approach procedures. These are based on lateral guidance from the GVA VOR beacon, with a vertical profile defined by multiple crossing altitudes established every 2nm on final. These vertical profiles have a descent angle of 3.04° for the VORDME concrete RWY 23, and 3.66° for the VORDME concrete RWY 05[4].

The aerodrome controller can also clear an IFR flight to execute a visual approach provided the pilot can maintain visual reference to the terrain and:

- the reported ceiling is at or above the approved initial approach level for the aircraft so cleared; or
- the pilot reports at the initial approach level or at any time during the instrument approach procedure that the meteorological conditions are such that with reasonable assurance a visual approach and landing can be completed. Separation shall be provided between an aircraft cleared to execute a visual approach and other arriving and departing aircraft.

For successive visual approaches, radar or non-radar separation shall be maintained until the pilot of a succeeding aircraft reports that it has the preceding aircraft in sight. The aircraft will then be instructed to follow and maintain own separation from the preceding aircraft.

[4] the descent angles for these VORDME approach procedures are higher than those for the ILS (which are considered optimum for instrument approach procedures) because the lack of electronic vertical guidance in these approach procedures requires a higher clearance from the terrain below, ref [PANSOPS].

Missed-approach procedures from the concrete RWY 05 require aircraft to track radial 226 inbound to SPR VOR, which is the same as the runway extended centreline, while climbing to 7000ft. Missed-approach procedures from the concrete RWY 23 specify flight on track 226° towards PAS VOR (which should keep the aircraft on the extended centreline – but not necessarily, since the procedure does not require pilots to track the *radial* towards PAS, and track-keeping may be sloppy during the initial missed approach due to pilot workload), followed by a left turn back to SPR while climbing to 7000ft. Aircraft with a bad climb performance (e.g. due to engine trouble) following this procedure may cross the VFR departure and arrival routes towards the SE waypoint at sufficiently low altitude to interfere with VFR traffic.

## 2.5 Special Procedures

As already mentioned in paragraph 2.1, the Swiss authorities facilitate VFR operations in weather conditions worse than those prescribed for VFR operations in Class D airspace. The Special VFR and Night VFR regulations described below are internationally accepted extensions of VFR operations in controlled airspace.

### 2.5.1 Special VFR

According to [Annex2], a *Special VFR Flight* is a VFR flight cleared by air traffic control to operate within a control zone in meteorological conditions below VMC. SVFR flights are allowed at GVA, and transition from VFR to SVFR is mandatory in the GVA CTR when the ground visibility drops to less than 5km and/or when the ceiling is less than 1500ft AGL (ref. [AIP]). When SVFR weather conditions prevail, all VFR departures and arrivals are subject to prior permission, to be obtained from ATC.

### 2.5.2 Night VFR

The [AIP] states that arriving aircraft shall reach the circuit at least 30 minutes before the end of the evening civil twilight (this time is also mentioned in the [AIP] for every day). However the Swiss authorities allow Night VFR flight from specified aerodromes, among which is GVA. The following special regulations for NVFR apply:

- the minimum meteorological conditions for flight in Class D airspace apply (see paragraph 2.2), except for SAR flight and urgent transport flights executed by helicopters;
- an aircraft may request an SVFR clearance when the above meteorological conditions cannot be met;

- when a pilot can maintain continuous visual contact with the aerodrome and with the consent of the aerodrome controller, a NVFR flight may also depart or continue when minimum visibility and distance to clouds for Class D airspace are not met.

#### 2.5.3 Communication Failure

In case of a failure of the radiotelephony equipment, VFR aircraft are required to leave the CTR via the shortest way and proceed to an alternate airport, unless they were already cleared to join the aerodrome circuit (see [AIP]). In that case, they may finish the circuit and land. When they carry an operating ATC transponder, it should be set to the international comm failure code 7600. Note that VFR aircraft are *not* required to carry a transponder in the GVA CTR.
Note that this regulation may lead to unexpected behaviour of pilots experiencing a communication failure. Their perception of “the shortest way out” of the CTR may differ substantially from that of the aerodrome controller, and it may also interfere with IFR traffic.

IFR aircraft experiencing a communication failure must adhere to the procedures specified in the [AIP], which lead to the pilots executing a normal instrument approach, after initial manoeuvring outside the CTR.

# 3 Regulations applicable to mixed VFR-IFR operations at GVA

## 3.1 Introduction

All aeronautical operations within Swiss airspace are governed by Swiss law. The Swiss aviation law is largely based on the ICAO template, like in many other countries world-wide. This law contains ordinances that elevate parts of the set of ICAO standards and recommended practices to law.

The Swiss authorities publish the Aeronautical Information Publication for Switzerland [AIP]. According [Annex15], an AIP is intended primarily to satisfy international requirements for the exchange of aeronautical information of a lasting character essential to air navigation. When practicable, the form of presentation is designed to facilitate their use in flight. An AIP constitutes the basic information source for permanent information and long duration temporary changes. The AIP contains a special section (also issued separately) for VFR pilots.

Similarly, the air traffic services provider of Switzerland, skyguide, publishes the ATM Manual for Switzerland [ATMM-CH], containing general information and instructions to air traffic controllers. Additionally, skyguide publishes manuals containing special procedures for air traffic services at the two major airports in Switzerland, Zürich and Geneva [ATMGVA].

The structure is illustrated in Figure 3-1.

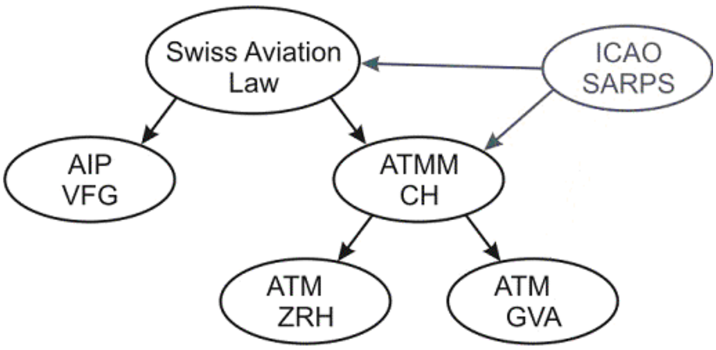


*Figure 3-1. Organisation of Swiss aviation regulations.*

## 3.2 Swiss Aviation Law

The Swiss law governing aviation in Swiss airspace is the Loi fédérale sur l'aviation civile du 21 décembre 1948 [LFG]. This general framework law is directly based on the Convention on International Civil Aviation (the Chicago Convention of December 7, 1944), which was ratified by the Swiss government in 1947. The LFG was elaborated into several orders, among which are:

- Der Verordnung vom 4. Mai 1981 über die Verkehrsregeln für Luftfahrzeuge [VVR]. This is a direct adaptation of the Rules of the Air as registered in ICAO [Annex 2].

- Der Verordnung vom 23. November 1994 über die Infrastruktur der Luftfahrt [VIL].
  This decision states that the standards and recommended practices registered in ICAO Annexes 10 (Aeronautical Telecommunications) and 14 (Aerodromes) and their technical regulations are directly applicable to aerodromes, obstacles and to the construction of air traffic control installations (with the exception of officially declared departures from these standards and recommended practices).

### 3.3 ICAO Standards and Recommended Practices

The Annexes to the Convention on International Civil Aviation (the Chicago convention) contain standards ("shall") and recommended practices ("should"). Standards must be adopted by countries that have ratified the Chicago Convention, as has Switzerland. Deviations from the standards are allowed, provided that a Notification of Difference is submitted to ICAO (cf. Art. 38 Chicago Convention). Countries that have ratified the Chicago Convention may decide not to adhere to recommended practices, as ICAO provides these as advisory material only. The Annexes applicable to the GVA operations under study are:
Annex 2: Rules of the Air [Annex 2]
Annex 11: Air Traffic Services [Annex 11]
Annex 14: Aerodromes [annex 14]

### 3.4 ICAO Procedures for Air Navigation

This study does *not* include a check whether the instrument departure and arrival procedures for GVA have been designed according [PANSOPS], since this process and its safeguarding are so well-established world-wide that it is assumed that FOCA approval of the procedures implies their compliance with the formal safety regulations.
ICAO has issued Procedures for Air Navigation Services – Air Traffic Management [Doc4444] that regulate air traffic services. As mentioned earlier, these procedures have been integrated into [ATMM-CH].

# 4 Analysis of compliance

For all aviation procedures and documents, ICAO, Eurocontrol or major civil aviation authorities have published sets of applicable standards, regulations, guidelines, templates, and recommended practices. The procedures and documents under study have obviously been designed based on internationally accepted practice. The question is however, whether the design of the airspace around GVA and the procedures under study were based on the proper set of rules and regulations, and whether they have been implemented *correctly* in accordance with the applicable set of requirements.

## 4.1 General Compliance

The introduction to ICAO Document 9426, the Air Traffic Services Planning Manual [Doc9426], formulates the basic principles governing airspace and procedure design as follows:

*"The application of the existing {ICAO} provisions concerning VFR flights in a mixed IFR/VFR environment differs considerably amongst and within States, depending mainly on the traffic volume, composition and complexity. In many States, VFR operations create no specific problems and the application of the basic ICAO provisions has been found to be sufficient to meet the required level of safety and service. In some States, including those where large numbers of general aviation flights are conducted, it has also been found that the authorisation to conduct VFR flights at night has not caused any significant problems.*
*As traffic increases at and around an aerodrome there may be a need to introduce specific provisions for VFR operations. As a first step, the requirement for two-way radiocommunciation capability by all aircraft operating into or in the vicinity of the aerodrome should be considered. This requirement will provide the ATS with the possibility of improving its service to both VFR and IFR flights concerned.*
*Where traffic density and prevailing meteorological conditions warrant a further tightening of ATS provisions, it may be necessary to segregate VFR flights from IFR arrivals and departures. The introduction of VFR corridors and/or VFR routes, entry and exit points and holding fixes should then be considered. As an alternative or as a complement to the above, it may also be advisable to upgrade the airspace around an aerodrome {to Class D or higher} in order to enable ATS to separate both IFR and VFR flights by subjecting the latter to air traffic control procedures and clearances. As a consequence of airspace upgrading, it may also be necessary to impose additional pilot qualifications and specific requirements regarding the carriage of navigation equipment in aircraft for operation in that airspace.*
*At aerodromes with a significant number of IFR operations, traffic schedules for VFR flights during peak traffic hours may have to be considered. Alternatively, specific types of VFR operations, e.g. pilot training exercises, etc. may have to be rescheduled, restricted or even curtailed during specified periods.*
*In recent years the speed and altitude capability of light aircraft has increased considerably. In addition to the existing requirements of the various types of aircraft engaged in VFR operations, new types of activities, such as hang gliding, power-driven hang gliding have been introduced and must now be considered in relation to the provisions regarding VFR operations. There is, therefore, a growing awareness that the provisions*

*concerning VFR operations have not kept pace with aviation developments in general, especially as regards aircraft performance and traffic composition.*
*A number of States, handling a considerable number of aircraft operations with a large mixture of IFR and VFR flights and which experience a wide variety of weather conditions, have found it necessary to introduce provisions supplementary to those of ICAO in order to restore an appropriate level of safety in their areas. As existing ICAO provisions give little guidance in this respect, the specific national provisions, developed individually to cater for specific circumstances, tend to vary from State to State, thus creating difficulties for pilots engaged in international VFR operations."*

It is beyond doubt that the number of operations at GVA warrants active control of both IFR and VFR traffic, and also the tailoring of VFR operations to IFR traffic peaks. The study of the manuals supplied to the persons that have a role in the operations at GVA, i.e. the [AIP], [ATMM-CH] and [ATMGVA] revealed no “show-stopping” deviations from internationally established regulations and practices. This finding was no surprise, since the internationally established regulations and practices are in most cases used as design templates for the airspace design and classification and for the design of procedures at GVA.

However, the introductory text of ICAO Doc 9426 repeated above contains one noticeable remark: “*ICAO provisions for the accommodation of VFR traffic in congested airspace are not keeping pace with aviation developments in general*”. Interviews by the study team with persons acting in the operations at GVA revealed that many operational practices were not governed by regulations, but by “good controllership” and “good airmanship”, “corporate culture” and “practice”. The very existence of all these informal practices illustrates that the operations at GVA may have outgrown the ICAO provisions. They are “filling the gaps” left by the ICAO provisions. In light of the formal introduction of a safety management system at the air traffic service provider, it is important to formalise these informal practices and also formally assess their safety.

### 4.2 Deviations from ICAO provisions

The [ATMMCH] translates the ICAO Procedures for Air Navigation Services for Air Traffic Management [Doc4444] into regulations applicable to all Swiss air traffic controllers. It contains the following table of deviations from [Doc4444]:

*Table 4-1. [ATMM-CH] deviations from [Doc4444]*

| number & subject | ICAO reference | [ATMM-CH] reference | explanation |
|---|---|---|---|
| 1. definitions | | | definition of obstacle free zone reworded for clarity |
| 2. licensing rules | | | |
| 3. administration | | | |
| 4. airspace structure | | | special regulations concerning flight in airspace class E and G |
| 5. radar procedures | | | description of the points at which radar vectoring is terminated |
| 6. separation of aircraft | [Doc4444] §5.10.2 and §11.4.3.1.2 and §12.4.1.8 | section 7 §4.1 and §4.2 | issuance of traffic information and essential traffic information |
| 7. approach control | [Annex2] §5.1.2 and [Annex11] §2.21 | section 8 §5.4 | visual departures |
| 8. approach control | [Doc4444] §4.9.1 and §8.7.4.4 | section 8 §3.3 | wake turbulence categories and separation |
| 9. aerodrome control | | | braking action |
| 10. aerodrome control | | | requirement to transmit current time removed |
| 11. aerodrome control | [Doc4444] §7.8.3 and §7.9.2 | section 9 §4.7.3 and §4.9.3 | reduced runway separation between aircraft using the same runway |

### 4.2.1 Separation of aircraft

As indicated under item 6 in the table above, skyguide deviates from [Doc4444] regarding the provision of essential traffic information. The differences are as follows:

- The skyguide traffic information message contains information about the altitude difference with the essential traffic, whereas the [Doc4444] message does not.
- The skyguide traffic information message contains no information on the wake turbulence category of the essential traffic, whereas [Doc4444] prescribes this when relevant.
- [ATMM-CH] contains a rule that when, for any reason, the required separation distance is or will be infringed, essential traffic information shall be transmitted to all aircraft involved.

No valid reason could be found for not including the wake turbulence category of essential traffic, as prescribed by [Doc4444]. The skyguide message does include the aircraft type of the essential traffic, but one cannot expect pilots to know by heart the wake turbulence category of all aircraft types they might encounter.

### 4.2.2 Visual departures

[Annex2] and [Annex11] contain standards on the minimum flight altitude of IFR flights. In short, they state that except when necessary for take-off or landing, an IFR flight shall be flown at a level which is not below the minimum flight altitude established by the State whose territory is overflown, or, where no such minimum flight altitude has been established:

a) over high terrain or in mountainous areas, at a level which is at least 600 m (2 000 ft) above the highest obstacle located within 8 km of the estimated position of the aircraft;
b) elsewhere than as specified in a), at a level which is at least 300 m (1 000 ft) above the highest obstacle located within 8 km of the estimated position of the aircraft.

In Swiss airspace, ATC may allow IFR aircraft to execute a “visual climb”, i.e. with visual reference to obstacles and terrain, for the first part of the climb after take-off. [ATMGVA] limits this to 4000ft. The visual departures are mentioned in [Doc7030], and the procedure in place at GVA is therefore considered as compliant with ICAO provisions.

### 4.2.3 Wake turbulence categories and separation

[Doc4444] states that wake turbulence separation shall be based on a grouping of aircraft into three categories, based on maximum take-off mass, as follows:

| | | |
|---|---|---|
| HEAVY | | MTOM >136000kg |
| MEDIUM | 7000kg < | MTOM < 136000kg |
| LIGHT | | MTOM < 7000kg |

Skyguide has adopted a slightly different grouping of aircraft, by sub-dividing the ICAO MEDIUM class into two classes (MEDIUM and SMALL), leading to the following weight cataegories:

| | | |
|---|---|---|
| HEAVY | | MTOM >136000kg |
| MEDIUM | 40000kg < | MTOM < 136000kg |
| SMALL | 7000kg < | MTOM < 40000kg |
| LIGHT | | MTOM < 7000kg |

In general it is recognised that the ICAO MEDIUM weight class definition covers a very large weight range, in terms of the associated wake turbulence hazard. It is therefore not uncommon to sub-divide the ICAO MEDIUM weight class in two classes. For instance the UK follows a similar deviation from the ICAO recommended practice.

The wake turbulence separation minima established by skyguide follow those prescribed by [Doc4444], despite the different categorisation, with some exceptions.

These will be addressed in the present paragraph, with respect to their impact on separation practices during approaches and departures, with focus on the mixed VFR/IFR operations.

*Separation of arriving aircraft*

First of all it has to be observed that according to [Doc4444] the ATC unit is not required to apply wake turbulence separation for arriving VFR aircraft.

Within [Doc4444] this has been specified as follows:

5.8.1.1 The ATC unit concerned shall not be required to apply wake turbulence separation:
- for arriving VFR flights landing on the same runway as a preceding landing HEAVY or MEDIUM aircraft; and
- between arriving IFR flights executing visual approach when the aircraft has reported the preceding aircraft in sight and has been instructed to follow and maintain own separation from that aircraft.

5.8.1.2 The ATC unit shall, in respect of the flights specified in 5.8.1.1, as well as when otherwise deemed necessary, issue a caution of possible wake turbulence. The pilot-in-command of the aircraft concerned shall be responsible for ensuring that the spacing from a preceding aircraft of a heavier wake turbulence category is acceptable. If it is determined that additional spacing is required, the flight crew shall inform the ATC unit accordingly, stating their requirements.

The [ATMGVA] is more conservative than [Doc4444] regarding the first regulation, since it specifies that wake turbulence separation shall be applied behind a heavy aircraft, except when the following aircraft will fly above the preceding heavy aircraft all the time[5]. There is however no requirement for the controller to issue a caution of possible wake turbulence as specified in the second regulation.

For timed approaches, skyguide prescribes the following non-radar separation minima to aircraft landing behind a HEAVY or a MEDIUM aircraft:

a) SMALL and MEDIUM behind HEAVY – 2 min
b) LIGHT behind HEAVY or MEDIUM – 3 min

This regulation is more conservative than [Doc4444] when a SMALL aircraft follows a MEDIUM aircraft ([Doc4444] does not prescribe a minimum separation for this combination), but it is less conservative when a LIGHT aircraft follows a SMALL aircraft ([Doc4444] requires a separation of 3 minutes for this combination).

[5] the [ATMGVA] also acknowledges that in case the preceding heavy aircraft makes a go-around, the following aircraft must be instructed to turn away from the concrete runway immediately.

The above deviation for non-radar separation is not mentioned in the table in [ATMM-CH] (Table 4-1). Also, no reasoning could be found for the different categorisation of aircraft.

*Separation of departing aircraft*

For wake turbulence separation of departing aircraft, [Doc4444][6] specifies the following:

5.8.3.1 A minimum separation of 2 minutes shall be applied between a LIGHT or MEDIUM aircraft taking off behind a HEAVY aircraft or a LIGHT aircraft taking off behind a MEDIUM aircraft when the aircraft are using:

a) the same runway;

b) parallel runways separated by less than 760 m (2 500 ft);

{…}

5.8.3.2 A separation minimum of 3 minutes shall be applied between a LIGHT or MEDIUM aircraft when taking off behind a HEAVY aircraft or a LIGHT aircraft when taking off behind a MEDIUM aircraft from:

a) an intermediate part of the same runway; or

b) an intermediate part of a parallel runway separated by less than 760 m (2 500 ft).

Clearly, based on the specifications of [Doc4444], the concrete and grass runway shall be regarded as a single runway, in relation wake turbulence separation of departing aircraft.
The [ATMGVA] however states that the runways at GVA shall be considered as separate as regards wake turbulence, except for HEAVY aircraft (Chapter 2, section 3.2.4 and Chapter 9, section 3). This implies that the 3-minute wake turbulence separation prescribed by [Doc4444] for a LIGHT aircraft taking off behind a MEDIUM or SMALL aircraft is *not* applied at GVA. Interviews with skyguide personnel confirmed this regulation. The reason for this deviation is not mentioned, although it is likely to be the expedition of traffic flows.
This deviation from international regulations is considered to have a significant impact on safety, and therefore should be founded on a formal assessment of its safety.

*Other separation practices*

[ATMGVA] includes a few other regulations regarding wake turbulence that are specific to GVA:

[6] In a formal sense [Doc4444] is strictly applicable to instrument runways. At Geneva airport the runway lay-out consists of one (concrete) instrument runway and one (grass) non-instrument runway in parallel. Therefore it could be argued that par. 5.8.3.1 and 5.8.3.2 of [Doc4444] are not applicable to the situation in Geneva. However these paragraphs address the wake turbulence separation criteria for departing aircraft. The wake turbulence hazard is not depending on the type of runway (either instrument or non-instrument) and therefore from a safety standpoint should be considered to be applicable to the situation in Geneva. This approach is fully in agreement with [Annex14, Volume 1, par. 3.1.10] where it is stated that for non-instrument runways the procedures for wake turbulence categorisation of aircraft and wake turbulence separation minima, as laid down in [Doc4444], should be taken into account.

- Helicopters hover-taxiing on the aerodrome movement area shall take into account wake vortex separation when a HEAVY aircraft departs.
- Aircraft crossing overhead the runway (as part of VFR departure or arrival procedures) are subject to wake vortex separation: all aircraft shall cross at least 2 min behind a departing or landing HEAVY aircraft, and LIGHT aircraft shall cross at least 2 min after a MEDIUM departing or landing aircraft.

These regulations are more restrictive than those specified in [Doc4444].

### 4.3 Conclusion

For all aviation procedures and documents, ICAO, Eurocontrol or major civil aviation authorities have published sets of applicable standards, regulations, guidelines, templates, and recommended practices.

The study has found that the procedures and documents regarding mixed VFR/IFR operations on the concrete and grass runways at GVA in general have been designed based on internationally accepted practices. Segregation of VFR traffic from IFR traffic, and limitations imposed on the use of the grass runway at times of heavy IFR traffic properly reflect the status of the GVA CTR as busy airspace.

However, as ICAO itself acknowledges, internationally accepted provisions for VFR traffic in congested airspace are lagging behind the international development of civil aviation. Many aspects of mixing VFR traffic with dense IFR traffic are just not properly covered by ICAO SARPs. Thus, many operational procedures employed by GVA’s air traffic service provider, skyguide, are based on “good controllership” and “corporate culture”. They are conveyed from on-the-job instructors to new controllers without formal backing in the form of written procedures and safety analyses.

Within the present study it could not be established, that this form of informal information dissemination has led to actual shortcomings in awareness of the desired practices at the ATC unit Geneva. However, in light of modern safety management and quality assurance methodologies, the procedures for the GVA CTR should be formalised and supported by safety analyses. This will be further addressed in chapter 7.

VFR pilots flying in the GVA CTR face some peculiarities that are not explicitly mentioned in documentation, but which may influence flight safety:

- High trees of the Forest Ferney-Voltaire close to the departure end of grass RWY 05 present obstacles that may be incompatible with the climb performance of aircraft departing from grass RWY 05.
- The VFR arrival procedures use many of the same waypoints as the VFR departure procedures, without different altitudes being specified for the different procedures.

- At GVA, lining up with the grass centreline when turning final is somewhat harder than normal because the grass runway is rather difficult to identify among the taxiways and other airport markings surrounding it.
- The [AIP] includes a note that the APAPI indications are not usable on “short final”. It has not been specified at what distance from the threshold this begins.

Above mentioned issues may have a negative impact on the safety of VFR traffic operating to and from the grass runway, especially for pilots which are unfamiliar with these issues.
This is addressed further in Chapter 6.
From a procedure design standpoint it is recommended here to reconsider the VFR departure and arrival routes, such that they are either segregated laterally, or that prescribed altitudes or altitude bands for VFR departure routes are different from those prescribed for VFR arrival routes.

The regulations specified in [ATMM-CH] and [ATMGVA] regarding wake turbulence separation and cautionary messages deviate from ICAO regulations in [Doc4444] in several ways:

- The 3-minute wake turbulence separation prescribed by [Doc4444] for a LIGHT aircraft taking off behind a MEDIUM aircraft is not applied at GVA.
- The wake turbulence category of essential traffic is not mentioned in essential traffic information messages, as prescribed by [Doc4444]. The skyguide message does include the aircraft type of the essential traffic, but one cannot expect pilots to know by heart the wake turbulence category of all aircraft types they might encounter.
- Controllers are not required to issue a caution of possible wake turbulence to VFR aircraft or IFR aircraft on a visual approach behind a MEDIUM or HEAVY aircraft as specified in [Doc4444].

These deviations from the current ICAO wake turbulence separation regulations may have a negative impact on the safety of the VFR traffic that operates mixed with IFR traffic. These deviations should be brought in line with internationally accepted regulations, or alternatively have to be backed by formal safety analyses.

# 5 Supporting information

## 5.1 Introduction

This chapter provides supporting information that is of relevance for the present investigation in general and the hazard assessment of the mixed VFR/IFR operations that is subject of the next chapter in particular.

This supporting information concerns:

- comparison with other airports in terms of traffic volume and characteristics;
- incident and accident analysis;
- the practicality of the see-and-avoid principle;
- analysis of radar trajectories VFR traffic;
- wind and turbulence climate at Geneva airport.

## 5.2 Comparison with other airports

In order to get an impression of the volume and type of operations at Geneva airport as compared to other major international airfields in Europe, a table has composed showing the traffic volume at European airports with more than 100,000 scheduled movements per year in 2003.

These data is presented in Table 5-1, and provides the number of scheduled movements, commercial movements, general aviation (GA) & other movements and total number of movements.

For these the following definitions apply, in agreement with the [ACIreport]:

- *Movement*: a landing or take-off of an aircraft or helicopter at an airport;
- *Scheduled movement*: a landing or take-off of an aircraft operating a scheduled service;
- *Commercial movement*: movements by aircraft and helicopters operated for commercial transport operations involving passengers, freight and/or mail;
- *General aviation & other*:
  Movements of aircraft and helicopters belonging to:
  - companies with an air taxi or air work license;
  - an individual, a flying club or a company whose main objective is not to provide revenue passenger transport;
  - positioning, test and training flights of airline, state and military aircraft.

The data in Table 5-1 originates from the [ACIreport] and the Official Airline Guide (OAG). The OAG is a comprehensive database containing scheduled flight operations data for airports located worldwide.

Table 5-1 has been complemented with the following airport characteristics: the availability of a grass runway, and the classification of the airspace in the Control Zone (CTR).

From this table the following observations are made.
First, Geneva airport has to be characterised as a medium-large international airport, ranking 24 in Europe in terms of the total air traffic volume. In general it is noticed that general aviation traffic constitutes only a small part of the total traffic volume (usually less than 10%) at the considered airports.
There are a few exceptions from this general picture. The most significant exception is however Geneva airport with almost 30% of the movements attributed to general aviation.
From the observed airports Geneva airport is ranking by far as first in terms of the volume of general aviation accommodated.
It should be noted here that general aviation traffic could be IFR as well as VFR traffic.

*Table 5-1 Characteristics and traffic volume 2003 for Major European Airports:*

| | | | Movements | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Airport | STATE | Scheduled | Commercial | GA + other | Total | %GA of total | Grass | CTR Airspace |
| 1 | PARIS-CHARLES DE GAULLE | FRANCE | 469276 | 505634 | 9391 | 515025 | 1.8% | no | Class A |
| 2 | LONDON-HEATHROW | UNITED KINGDOM | 462376 | 457027 | 6623 | 463650 | 1.4% | no | Class A |
| 3 | FRANKFURT | GERMANY | 430922 | 450797 | 8068 | 458865 | 1.8% | no | Class D |
| 4 | AMSTERDAM | THE NETHERLANDS | 364802 | 392997 | 15303 | 408300 | 3.7% | no | Class C |
| 5 | MADRID | ESPANA | 365958 | 382862 | 942 | 383804 | 0.2% | no | Class D |
| 6 | MUNICH | GERMANY | 329302 | 332991 | 22611 | 355602 | 6.4% | no | Class D |
| 7 | ROME, DA VINCI (FIUM)-ARPT | ITALIE | 290706 | 299431 | 1400 | 300831 | 0.5% | no | Class D |
| 8 | BARCELONA | ESPANA | 256766 | 278860 | 3161 | 282021 | 1.1% | no | Class D |
| 9 | ZURICH | SUISSE | 223736 | 234627 | 34765 | 269392 | 12.9% | no | Class D |
| 10 | COPENHAGEN | DENMARK | 241406 | 255855 | 3147 | 259002 | 1.2% | no | Class D |
| 11 | BRUSSELS | BELGIQUE | 199598 | 231377 | 20856 | 252233 | 8.3% | no | Class C |
| 12 | LONDON-GATWICK ARPT | UNITED KINGDOM | 183518 | 234899 | 7832 | 242731 | 3.2% | no | Class D |
| 13 | STOCKHOLM-ARLANDA ARPT | SWEDEN | 210432 | 220684 | 10799 | 231483 | 4.7% | no | Class C |
| 14 | MILAN-MALPENSA ARPT | ITALIE | 194394 | 213554 | 3356 | 216910 | 1.5% | no | Class D |
| 15 | VIENNA | AUSTRIA | 186910 | 195067 | 21564 | 216631 | 10.0% | no | Class D |
| 16 | MANCHESTER | UNITED KINGDOM | 151962 | 191820 | 15306 | 207126 | 7.4% | no | Class D |
| 17 | PARIS-ORLY ARPT | FRANCE | 204948 | 202894 | 3873 | 206767 | 1.9% | no | Class D |
| 18 | STANSTED | UNITED KINGDOM | 153504 | 171320 | 15157 | 186477 | 8.1% | no | Class D |
| 19 | DUSSELDORF | GERMANY | 164088 | 172132 | 14027 | 186159 | 7.5% | no | Class D |
| 20 | NICE | FRANCE | 123608 | 168827 | 12467 | 181294 | 6.9% | no | Class D |
| 21 | DUBLIN | IRELAND | 150046 | 162933 | 14848 | 177781 | 8.4% | no | Class C |
| 22 | ATHENS | GREECE | 145696 | 153222 | 16908 | 170130 | 9.9% | no | unknown |
| 23 | PALMA, MALLORCA IS. | ESPANA | 109108 | 166695 | 2293 | 168988 | 1.4% | no | Class D |
| 24 | GENEVA | SUISSE | 111212 | 115046 | 48703 | 163749 | 29.7% | yes | Class D |
| 25 | ISTANBUL | TURKEY | 116566 | 146958 | 14869 | 161827 | 9.2% | no | unknown |
| 26 | HELSINKI | FINLAND | 139388 | 155417 | 6036 | 161453 | 3.7% | no | Class C |
| 27 | STUTTGART | GERMANY | 102960 | 111303 | 38199 | 149502 | 25.6% | no | Class D |
| 28 | HAMBURG | GERMANY | 124766 | 126878 | 22485 | 149363 | 15.1% | no | Class D |
| 29 | BERLIN-TEGEL ARPT | GERMANY | 129510 | 134563 | 6361 | 140924 | 4.5% | no | Class D |
| 30 | BIRMINGHAM | UNITED KINGDOM | 114578 | 116527 | 11584 | 128111 | 9.0% | no | Class D |
| 31 | LISBON | PORTUGAL | 111176 | 112456 | 5202 | 117658 | 4.4% | no | Class D |
| 32 | LYON | FRANCE | 105558 | 113987 | 315 | 114302 | 0.3% | no | Class D |

For Geneva Airport it is reported that from the 48,703 general aviation movements in 2003, 29,702 were IFR movements (61%) and 19,001 VFR (39%).
From the VFR operations 9797 movements (fixed wing aircraft) were conducted on the grass strip, and 4,376 on the concrete runway. In addition 4,828 VFR helicopter movements were made.

Unfortunately, information concerning the distribution between IFR and VFR traffic volumes is not readily available for other airports. However, it is known that the two largest airports in Europe (Paris-Charles de Gaulle and London-Heathrow) do not allow any VFR traffic operations on the airport at all, because the CTR at those airports is classified as Class A.
For the other airports it can be expected that some portion of the general aviation traffic will be VFR traffic, as allowed by their CTR airspace classification (C or D).
However, it is concluded that the VFR traffic volume at Geneva airport is relatively very high, based on the fact that the VFR traffic volume alone exceeds in the majority of cases the total volume of general aviation at other airports.

Therefore, in the context of the present study it has to be observed that the mix of VFR and IFR traffic at Geneva airport is quite unique on a European scale, as far as the large percentage of VFR traffic is concerned.
Another element that is unique for Geneva airport, is the fact that a large portion of the VFR traffic is operated from a grass runway, located close to the adjacent main runway. None of the other major airports within the list still operates a grass runway.

Obviously, there are other international airports within Europe that operate a grass runway in parallel with a main concrete runway. However the IFR traffic volume at these airports is in general substantially less than at the airport of Geneva.
For instance the airport of Basel-Mulhouse is such an airport. This airport accommodated in 2003 59,844 commercial movements and 28,145 general aviation movements.
So, the overall traffic volume is substantially below the level of Geneva. Moreover, specific restrictions in Basel-Mulhouse apply to operations from the grass runway, because these operations are only allowed for aircraft based at the airport, or with special Tower instructions. Such restrictions do not exist for the airport of Geneva.

Within Switzerland there are two other airports that operate international commercial air traffic, in combination with general aviation traffic using a grass runway, i.e. Bern and Lugano. However on these airports the volume of commercial traffic is very low (less than 10% of the volume at Geneva).

Based on the data presented in this paragraph it is concluded that the operation of mixed VFR/IFR traffic at Geneva airport (both on a European scale and within Switzerland) is quite unique in terms of the high intensity of the mixed operations in combination with the operation of a substantial amount of light VFR traffic from a closely spaced parallel grass runway.

It should be noted that there are no international or national regulations that limit or restrict the volume of mixed VFR/IFR operations accommodated at an airport. However, many major international airports have adopted the policy to discourage such intense mixed operations.

### 5.3 Incident and accident analysis

*General*

In order to get an impression of the potential risks involved in mixed VFR/IFR traffic operations a brief study has been conducted into accidents and incidents that have occurred in the past in relation to this sort of operations. The study has been limited to accidents and incidents close to the airport. Main data sources were the ADREP database, the NTSB accident database and the NASA ASRS database.

The ADREP database is an initiative of ICAO. According to ICAO Annex 13 aircraft accident investigations should be conducted by the state of occurrence, though this state may delegate the investigation to the state of registry or state of operator. ICAO recommends that serious incidents should also be investigated. Information regarding the results of the investigation is usually made available by the (air) accident investigation authority of a country or any other party in charge of the investigation in the form of a preliminary and/or final report. The ICAO offers a standard report format, which has been adopted by ICAO member states throughout the world. Member states are urged to submit information for inclusion in the ICAO Accident/Incident Reporting (ADREP) database using a standard ADREP report format.

The NASA Aviation Safety Reporting System (ASRS) collects, analyzes, and responds to voluntarily submitted aviation safety incident reports in the United States. Pilots, air traffic controllers, flight attendants, mechanics, ground personnel, and others involved in aviation operations submit reports to the ASRS when they are involved in, or observe, an incident or situation in which aviation safety was compromised.

The NTSB accident database contains a survey of accidents and serious incidents that have occurred in the United States.

To get also insight into particular causes and contributing factors of accidents and incidents around Geneva airport, also reports from the Swiss AAIB have been analysed, These reports concern both accident reports and airprox reports concerning occurrences close to Geneva airport.

*Incidents & accidents worldwide.*

The search for accidents, satisfying the criteria “mixed VFR/IFR traffic *and* within the Terminal Area of the airport *and* mid-air collision” revealed a low number of accidents.

In fact only one accident, involving a commercial carrier operating IFR and a light aircraft operating VFR could be identified. This particular accident occurred on September 9, 1969, between a Douglas DC-9 and a Piper PA-28 in Indianapolis, resulting into a crash of both aircraft, killing all passengers aboard (83 in total).

Searches with slightly modified key-words resulted in a list of mid-air collisions or near mid-air collisions (NMAC), involving larger transport aircraft and light general aviation aircraft.

It should be noted that these occurrences have not necessarily resulted in fatal accidents. In some cases a collision between an airliner and a light aircraft results into a level of structural damage that does not preclude a safe landing.

It should also be noted that in the US frequently IFR flights are cleared for a visual (VFR) approach if weather conditions permit (VMC). Some of the accidents occurred when the commercial aircraft was indeed cleared for such approach, and therefore in strict definition not during mixed VFR/IFR operation.

The results of the database search are shown in Table 5-2 below.

This table shows merely the cases found. Within Appendix A more details are given concerning these occurrences, including a short description of the event (narrative).

*Table 5-2 Accident and serious incidents with mixed VFR/IFR traffic*

| Date | Aircraft #1 | Aircraft #2 | Country | Occurrence |
|---|---|---|---|---|
| 9/9/1969 | MCDONNELL-DOUGLAS DC-9 | PIPER PA-28 | US | Mid-air |
| 7/20/1970 | BOEING 737-100 | PIPER PA-28 | Spain | Mid-air |
| 1/9/1971 | BOEING 707-300 | CESSNA 150 | US | Mid-air |
| 6/6/1971 | MCDONNELL-DOUGLAS DC-9 | Experimental | US | Mid-air |
| 8/4/1971 | BOEING 707-300 | CESSNA 150 | US | Mid-air |
| 12/4/1971 | MCDONNELL-DOUGLAS DC-9 | CESSNA 206 | US | Mid-air |
| 7/27/1973 | BOEING 727-100 | CESSNA 172 | US | Mid-air |
| 1/9/1975 | CONVAIR 240 | CESSNA 150 | US | Mid-air |
| 5/18/1978 | DASSAULT Falcon 20 | CESSNA 150 | US | Mid-air |
| 9/25/1978 | BOEING 727-100 | CESSNA 172 | US | Mid-air |
| 12/20/1984 | BOEING 747-100/200 | Unknown | US | NMAC |
| 3/14/1993 | BOEING 727-200 | CESSNA 206 | Mexico | Mid-air |
| 6/8/1999 | AIRBUS A320 | Socata TB-21 | Germany | NMAC |
| 10/17/2000 | BEECH 90 KING AIR | GULFSTREAM GIII | US | Mid-air |

From the descriptions in Appendix A, it can be concluded that there are some common factors (i.e. factors or circumstances that have occurred in several of the events) involved in this type of accidents.
These factors are:

- Failure of the see-and-avoid concept
- Communication errors
- Training flights

From these factors “see-and-avoid” related problems are the most cited.
It should be noted that, as far as could be established, none of the identified accidents and incidents involved mixed VFR/IFR operations from closely spaced parallel runways.

Another source of incident information is the NASA ASRS safety database. Processing of these data is quite cumbersome, due to the fact that the ASRS is in fact a voluntary reporting system, and information can be mainly gathered by analysing the narratives of the reports. Moreover, the quality of the recorded ASRS data is varying in nature, depending on the level of detail provided in the individual incident report. An extensive study of the relevance of the data in the ASRS database for mixed VFR/IFR operations is therefore considered outside the scope of the present study.
However, NASA has used results of the ASRS database for a study into the problems associated with visual flight in air carrier operations [NASA166573]. The results of this study are considered relevant for the present investigation, and some of the results are quoted here for this reason.
In total 353 incident reports, related to visual approaches, have been studied.
It was found that there were nine categories of contributing factors in these incidents. These contributing factors, with their associated error types have been summarised in Table 5-3 below.

*Table 5-3 Contributing factors in visual flight incidents [NASA166573]*

| Contributing Factors | Error types |
|---|---|
| Inadequate accomplishment of procedural steps related to sighting | airport sighting errors<br>traffic sighting errors |
| Parallel runway operations | overshoot/drift into adjacent lane<br>crisscrossing through adjacent lane<br>line-up in wrong lane<br>controller or pilot random errors |
| Presence of uncontrolled VFR aircraft | traffic sighting deficiencies |

| | |
|---|---|
| Reduced cockpit visibility conditions | visual perception deficiencies |
| Traffic mix - airspeed performance differential | parallel runway related errors<br>ATC spacing misjudgements<br>flight crew traffic sighting errors<br>flight crew technique errors<br>flight crew spacing errors |
| Traffic mix -simultaneous departures and arrivals | ATC co-ordination errors/misjudgements<br>pilot encroachment of approach lane<br>altitude deviations<br>errors related to intersecting runway operations<br>opposite direction traffic same runway |
| Communications misunderstandings and errors | expectation errors<br>transposition and other miscellaneous errors |
| Workload restrictions | various errors |
| Hasty misjudgements | flying technique errors |

The consequences of above mentioned factors are:

- *conflicts*
- *unstabilised approaches*
- *altitude deviations*
- *landings without tower clearance*
- *approaches or landings on wrong runway*
- *descent toward terrain, obstruction, etc.*

In most of the cases a combination of factors resulted in a given consequence.
Conflict with other aircraft occurred in 244 of the 353 investigated cases.
One combination of contributing factor and consequence appeared to be quite dominant (68 cases), viz. "*traffic sighting errors"/"conflict with other traffic*". In most cases the causes of these errors were aircraft related. The traffic sighting errors were categorised as follow:

- *sighting of called traffic apparently not accomplished*
- *apparent loss of initial sighting*
- *apparent non-sighting of aircraft by traffic that "has you in sight"*
- *identifying the wrong traffic as the called target*
- *incomplete exchange of sighting information*

Parallel runway operations formed also a significant class, resulting in 63 conflicts with other aircraft. In 20 of those cases the cause was *"lane overshoot or drift"*.

Also from this study it was concluded that separation based on visual sighting of other traffic has its limitations. The study determined that in 7 cases the "see-and-avoid" principle had completely failed, and that the fact that the aircraft did not actually collide was a factor of mere coincidence or luck.

It should be noted here that the presented NASA study is considered not to be entirely representative for the situation at Geneva airport, because the main focus has been on VFR cleared IFR air carrier operations in the presence of other light VFR traffic. At Geneva airport such clearances are not commonly given. On the other hand, as a consequence of the definition of the Control Zone (CTR) at Geneva airport as Class D airspace, light VFR traffic is self responsible for separation from IFR traffic. Therefore, the findings as presented above, are considered to be highly relevant for the operations at Geneva airport.

Based on the present paragraph it is concluded that there are several factors that may lead to inadequate separation of VFR traffic from other traffic in the terminal area. The most dominant factor appears to be the inherent shortcomings of the "see-and-avoid" principle. For this reason in paragraph 5.4 some more attention is given to the practicality of the "see-and-avoid" principle, in particular in relation to operations in high density traffic areas.

*Accident(s) and incidents at and around Geneva airport*

In order to get an impression of the factors involved in accident(s) and incidents at Geneva airport related to the mixed VFR/IFR operations at this airport, reports of the Swiss AAIB have been analysed, as far as relevant for the present study.

The cases that were identified mainly concerned reports of air-proximity events and a single accident, occurring within the Terminal Manoeuvring Area of Geneva airport.

The accident did not involve a mixed VFR/IFR operation, but concerned a case of loss of control during landing on the grass runway. In this particular case the aircraft swerved, out of control, away from the concrete runway. However, being a loss of control case, the aircraft could have swerved towards the concrete runway as well, creating a potential risk for traffic on this runway. For this reason this particular accident is considered relevant.

Results of the analysis are shown in Table 5-4 below.

*Table 5-4 Accident and Incidents at and around Geneva airport*

| Aircraft/ Flight | Date | Circumstance | Event | Remarks |
|---|---|---|---|---|
| 1.BAW730<br>2.unidentified | 7-7-98 | IFR APPR | Airprox | BAW descended in the TMA to class E airspace, unauthorised, resulting in close proximity to uncontrolled traffic. Min separation 1 nm & 200 ft |
| AS 202B, HB-HFA | 4-8-98 | Landing G05 | Loss of control, crash | Student first Solo flight |
| 1.HB-CVK &<br>2.KL 1927 | 10-7-99 | VFR TO G05, IFR APPR C05 | Airprox | VFR climbed through cleared altitude, unauthorized manoeuvre, communication problems |
| 1.KLM1933<br>2.unidentified | 12-9-99 | IFR APPR 05 | Airprox, | Unauthorized intrusion Class C airspace Min. separation 1.3 nm & 600 ft |
| 1.KLM1931<br>2.HB-OQS | 1-2-00 | IFR APPR 23, VFR TO C23 | Runway incursion | Premature alignment of a light aircraft on the runway in operation, in front of a commercial aircraft in landing phase: lack of precision in the line-up clearance. |
| 1.SWR836<br>2.HB-GEC | 21-3-01 | IFR TO C23, VFR crossing runway | Runway incursion | Improper phraseology, unauthorized crossing, non-interference of ATC and Ground controller. |
| 1.KLM1929<br>2.F-BVCF | 11-12-01 | IFR APPR, VFR to ALBI | Airprox | Deteriorating weather, VFR lost orientation, deviated to Geneva.<br>Min separation 1.8 nm.<br>Factors: The closure of the control position Geneva Terminal (TMA).<br>The transfer of communication by Chambéry Approach to an inactivated control frequency. The defective message in automatic transmission on the TMA frequency. The lack of detection of the aircraft by Geneva Approach Control. |
| 1.SAS615<br>2.F-BPKI | 1-10-02 | IFR TO | Airpox | Unauthorised entry of a VFR aircraft into controlled class C airspace.<br>Factors: closure of the TMA control |

| Aircraft/ Flight | Date | Circumstance | Event | Remarks |
|---|---|---|---|---|
| | | | | position, erroneous control instructions issued by the DELTA controller, the absence of training for the DELTA controller to perform the function of a TMA controller. |
| 1.HB-ZBY Eurocopter SA365 2. unidentified | 15-2-03 | IFR helicopter ILS APPR 05 | Airprox | Unauthorized entry of an uncontrolled VFR aircraft within controlled airspace category C, followed by an Airprox with an IFR helicopter established on the ILS runway 05. Insufficient preparation VFR The closure of the control position Geneva Terminal (TMA). |
| 1.AZA593 2.F-GLHK | 15-3-03 | IFR TO 055, VFR APPR G05, deviated to C05 | Airprox | VFR asked to deviate to concrete. Heavy workload controller. Did not authorise request immediately Min separation 0.5 nm & 500 ft |
| 1.F-GSIX Piper PA32 2. BVR101 CL604 | 25-5-04 | IFR APPR 05 (downwind) | Airprox | VFR unauthorized intrusion Class C airspace |
| 1. Avro RJ1H 2. HB-PIC, Piper PA18 | 22-6-04 | IFR TO | Airprox | Close encounter between a VFR flight joining the aerodrome traffic circuit by overflying runway axes right ahead of a departing IFR flight. |
| 1.LX-DSL LJ45 2.F-BPKS, DR221 | 23-7-04 | IFR ILS APPR 05 | Airprox | IFR private flight had to take evasive action to avoid F-BPKS, perpendicular crossing. VFR flying within controlled airspace class C of Geneva TMA, without ATC clearance and without radio contact. |

In total 13 reported events were found in the period 1998 – 2004.
Based on these reports the following list of factors contributing to these events can be established:

- Unauthorised entry in controlled airspace

- Communication problems (phraseology)
- High ATCO Workload
- Closure of the TMA control position
- Late request for concrete in stead of grass runway
- Loss of control during training flight
- Unauthorised overflying runway axes right ahead of a departing IFR flight
- Incorrect VFR inbound, close to departing IFR

This list of factors shows some resemblance with the list of factors found in world-wide accidents and incidents. The factors "*communication problems*" and "*training flights*" were also present in the world-wide set of factors.
The factor "*unauthorised entry in controlled airspace"* appears to be dominantly present in the Geneva dataset, whereas this factor did not appear significantly in the world-wide dataset.
On the other hand "*insufficient see-and-avoid"* is a very dominant factor in world-wide accidents and incidents, whereas at Geneva this factor does not show-up clearly in the dataset.

### 5.4 The practicality of the see-and-avoid principle

In this paragraph a brief summary is given concerning the practicality of the see-and-avoid principle for separation of VFR traffic, especially in relation to operations in high-density terminal areas.
Many studies have addressed the problems associated with the concept of relying on visual acquisition of other aircraft to resolve potential conflicts. See for instance [FAA78-8], [Baxa], [Graham], [Milhollon] and [Aarons]. Of particular interest are the studies of the Australian Accident investigation Bureau [BASI] and [Weber1 & Weber2] that clearly describe the limitations of the see-and-avoid principle. They address the geometrical and physical aspects of visual conflict detection and the inherent shortcomings of the human eye and of the human reaction times in this respect. The BASI report was prepared in 1991, in response to a series of mid-air collisions, involving light VFR aircraft, in the 80's within Australian airspace. This study addresses specifically the role of the see-and-avoid principle in relation to the constantly growing traffic volume. The BASI report comes to a number of unambiguous conclusions, stating:
"*The see-and-avoid principle … is subject to serious limitations. It is likely that the historically low number of mid-air collisions has been in a large part due to low traffic density as much as the successful operation of see-and-avoid. [..] Unalerted see-and-avoid … is not sufficiently reliable to warrant a greater role in the air traffic system. See-and-avoid is considered completely unsuitable as a primary traffic separation method for scheduled service.[…] The CAA should take into account the limitations of See-and-Avoid when planning and managing*

*airspace and should ensure that unalerted See-and-Avoid is never the sole means of separation of aircraft providing scheduled services.* ”

In another study by the US National Transport Safety Board concerning mid-air collisions in U.S. civil aviation [NTSB1], dating back to 1969, similar conclusions were drawn, and the future applicability of the see-and-avoid concept in high-density terminal areas was questioned as follows:
“*The major problem in the mid-air collision accidents was the failure of the pilot to adhere to ‘seen-and-be-seen’ concept – a concept that well may be, at least in high-density terminal areas, on its way to becoming outmoded, unsafe, and incompatible with saturated operating environments.*”

In the context of effectiveness of see-and-avoid it is considered also relevant to pay some attention to the largest accident that has happened so far with a mixed VFR/IFR operation in the terminal area of an airport. This accident occurred on September 9, 1969 near the airport of Indianapolis in the US. The accident has been described in NTSB report [NTSB-70-15]. For completeness it is mentioned here that this accident did occur during a single runway operation. The involved aircraft were a Douglas DC-9 (IFR) and a Piper PA-28 (VFR). Both aircraft collided and crashed, when approaching the airfield under good visibility conditions (>15 mi), killing all persons aboard both aircraft (83 in total).
The accident report stated the following as the probable cause of the accident

- the inadequacy of the see-and-avoid concept under the circumstances of this case;
- the technical limitations of the radar in detecting all aircraft;
- the absence of [..] regulations which would provide a system of adequate separation of mixed VFR and IFR traffic in terminal areas.

Factors contributing to the accident that are mentioned in the report are the large speed difference between both aircraft, and the present regulation that permits VFR aircraft operations only 500 ft below clouds in airport approach areas.

Because this accident has occurred over 35 years ago, it can be expected that modern radar technology in general will be able to better detect all aircraft in the terminal area. Moreover current regulations require a larger separation from cloudbase (viz. 300 m) than the 500 ft that was mentioned here. Nevertheless, it is a clear illustration of the limitations of the see-and-avoid concept, with in this case catastrophic consequences.

In relation to the mixed VFR/IFR traffic operation within the Control Zone of Geneva airport it has to be noted that this takes place in airspace, defined as Class D (see also paragraph 2.2). Within this class of airspace it is VFR traffic's own responsibility to ensure separation from other traffic (VFR as well as IFR) based on the see-and-avoid principle. However, within Class D airspace ATC is required to provide information (and traffic avoidance advice) about other VFR and IFR flights. Also ATC has the authority to sequence and separate VFR from IFR traffic by means of clearances (i.e. clearance to enter the CTR, take-off and landing clearances and runway crossing clearances). This type of operation can therefore not be regarded as relying fully on "unalerted see-and-avoid", as was mentioned in the BASI study quoted above.

### 5.5 Analysis of radar trajectories VFR traffic

During August 2004, the Airport of Geneva has conducted a measurement campaign to establish flight trajectories of VFR traffic operating at the airport. These measurements were performed with the Secondary Surveillance Radar (SSR), located on the airport near the grass runway (WGS84 Latitude : 46° 14' 14.4201", Longitude : 06° 06' 04.8598"). During this month the VFR traffic has been explicitly requested to keep their transponders switched on, such that the SSR could track this traffic and record position and altitude.
In total 1265 VFR tracks were recorded from which 1116 appeared to be suitable for further processing (the remaining tracks were not clearly identified in terms of runway destination or aircraft type; aircraft or helicopter).

The distribution of the recorded flights is given in Table 5-5.
From this table it can be concluded that the grass runway accommodated in this particular month approximately twice the VFR volume of the concrete runway. Also it is shown that the grass runway 23 was used more than twice as much as grass runway 05.

*Table 5-5 Number of VFR flights recorded by SSR in August 2004*

| Runway | Arrivals | Departures | Total |
|---|---|---|---|
| Grass RWY 05 | 87 | 106 | 193 |
| Grass RWY 23 | 200 | 244 | 444 |
| *Grass total* | 287 | 350 | 637 |
| Concrete RWY 05 | 43 | 27 | 70 |
| Concrete RWY 23 | 96 | 154 | 250 |
| *Concrete total* | 139 | 181 | 320 |
| Helicopter | 97 | 62 | 159 |
| *Grand total* | 523 | 593 | 1116 |

It should be noted that the number of movements recorded is actually substantially higher than shown in this table, because of the fact that many of the recorded trajectories, especially from the grass runway concerned circuit flying, such that one flight in fact comprised two movements (one take-off and one landing).

The radar measurements of the VFR traffic have been used for two purposes.
First they can provide a global impression of the accuracy with which the arrival and departure procedures are flown by the VFR traffic at Geneva airport. For this reason the recorded tracks have been plotted on an abstract lay-out of the airport, including the location of the grass runway, the concrete runway, the VFR circuit, navigation beacons, and the radar station. The locations of these elements have been plotted by transforming their known WGS84 co-ordinates to the so-called Swiss Grid. Using the Swiss Grid (that provides a linear co-ordinate system) the measured radar returns of aircraft position (given in relative position to the radar system) can be plotted on the correct scale.
Results of plotting the radar trajectories on the airport map are presented in Appendix B.
The radar trajectories of the VFR traffic in August 2004, operating on grass runway 05, grass runway 23, concrete runway 05, concrete runway 23, helicopter arrivals and helicopter departures are shown in separate graphs. From these figures, a global impression of the accuracy of the VFR trajectories can be gained. It is shown that significant deviations from the prescribed routes (intentionally or unintentionally) can occur, especially at greater distances from the runway thresholds. Close to the runway thresholds the required tracks are in general flown with good accuracy.

The second objective of analysing the radar measurements is to get an estimate of the probability that VFR traffic operating on the grass runway is overshooting the grass runway centreline during take-off and approach. This gives an indication of the likelihood of overshoots with the associated potential consequence of reduced separation with traffic on the concrete runway.
It is emphasised here that the present analysis has used only a limited set of data, and assumes that the operation in the month of August 2004 is representative for the behaviour of the VFR traffic over the full year.

For this reason the analysis results that are presented shall be merely regarded as an *indication* of the risk. A formal collision risk calculation, taking into an assessment of all assumptions and of the validity and accuracy of the dataset is out of scope for the present study.

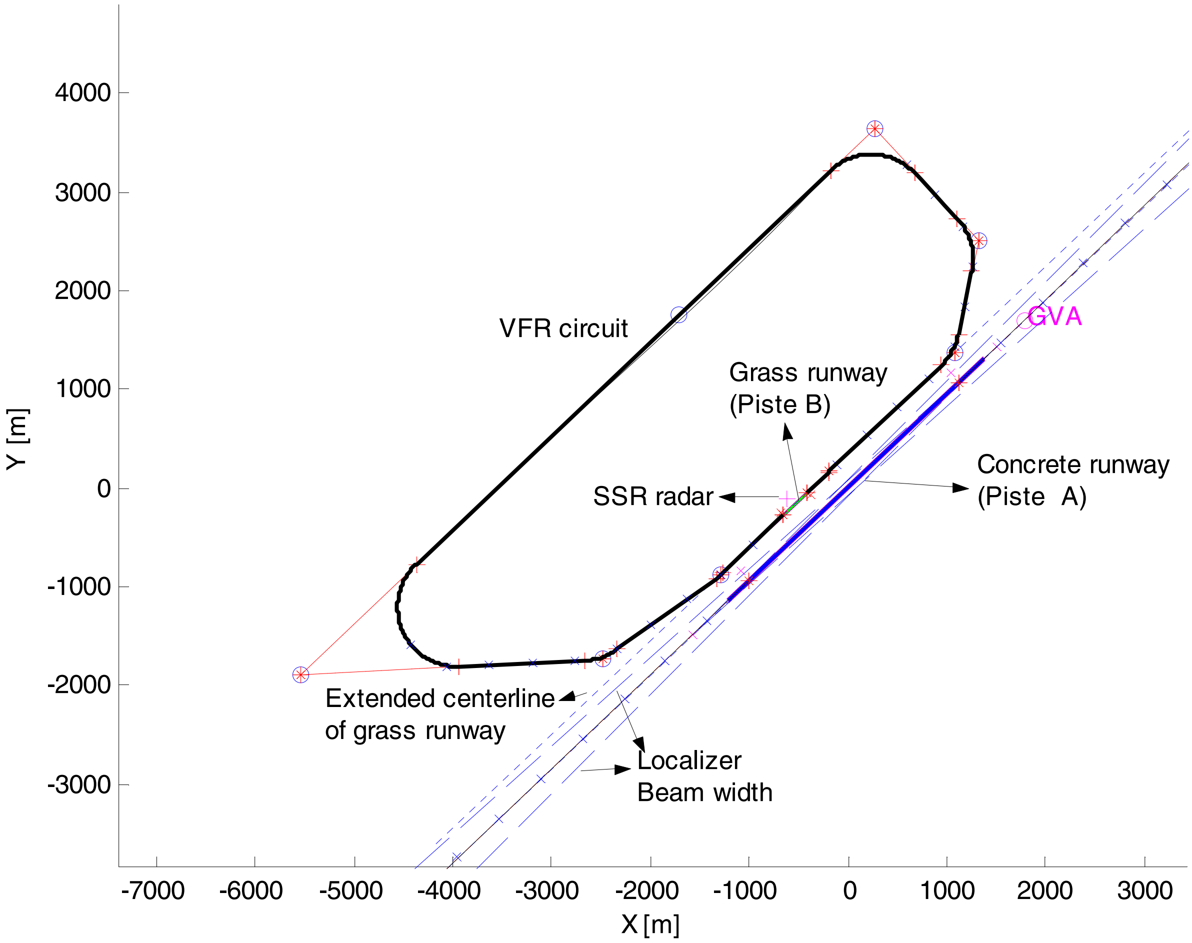


*Figure 5-1 Projection of GVA in Swiss Grid (origin at airport reference point)*

The data provided by the radar station has been used as provided by AIG. No effort has been done to further process the data to enhance the data quality or accuracy. The data has been given with a 4 seconds update rate. This means that between two radar returns a VFR aircraft may travel 100-200 m (with airspeed ranging 50 to 100 kts). This means that position errors can occur when interpolating between two successive datapoints. Concerning the general radar position determination accuracy AIG radar experts have indicated that the system has been used in “fine” control mode providing an angular accuracy of .022° and a ranging accuracy of 1/128nm. Due to the close proximity of the aircraft targets to the radar high position determination accuracy can be expected (< 20 m). Visual inspection of the recorded tracks confirmed the rather high quality of the radar data. Nevertheless also some anomalies (e.g. track jumps) were detected. These were removed as far as possible and relevant.

For the present analysis 6 windows relative to both ends of the grass runway have been defined. These windows have been positioned such that they coincide with a given altitude of the nominal approach paths, as defined by the slope of the APAPI. The chosen altitudes (AGL) ranged from 200 to 700 ft. Since the slope of the APAPI for runway 05 (4º), differs from the slope of the APAPI on runway 23 (4.15º), the associated distances to the runway threshold also slightly differ (the distance is defined by the equation: *d=altitude/tan[slope]*).
For each window the intersection points with the measured tracks have been determined. This obviously involves interpolating between radar datapoints. Also it should be noticed that the number of valid intersections per window can vary, because the number of valid radar returns in general reduces with decreasing altitude.
The raw results of the calculating the intersection points of the VFR trajectories with each window are shown in Appendix B (figures B-7 and B-8).
Based on the calculated intersection points a statistical analysis is performed to estimate the probability that per window a given deviation from the runway centreline will occur. For this purpose for each window a so-called cumulative probability density function (CDF) has been constructed based on the raw data. Subsequently the CDF has been fitted by a "best-fitting" distribution. The simplest of such a distribution is the so-called normal (Gaussian) distribution. It appeared however that for many windows this fit was not appropriate, because of the fact that the raw CDF usually showed a certain skewness. This means that the CDF is asymmetrical with respect to the mean of the dataset. This can be explained from the fact that the data indicates that in general there is a tendency of the VFR traffic to fly approaches or take-offs from the grass way with a preference to deviate more towards the inside of the circuit, and try to avoid overshoots towards the concrete runway. From a statistical viewpoint skewed distributions are less easy to fit accurately. In this particular case best fits were found with multi-Gaussian fits, which can fit skewed distributions by a weighted combination of Gaussian fits. An example of this multi-Gaussian fitting process is shown in Figure 5-2. It is clearly shown that a single Gaussian (symmetrical) fit through the data would clearly overestimate the probability of deviations towards the concrete runway, and underestimate deviations away from the concrete runway.
It is also shown that the multi-Gaussian fit provides an excellent fit through the data, and that by using this fitting process best estimates can be made of given deviation probabilities, based on the available data.

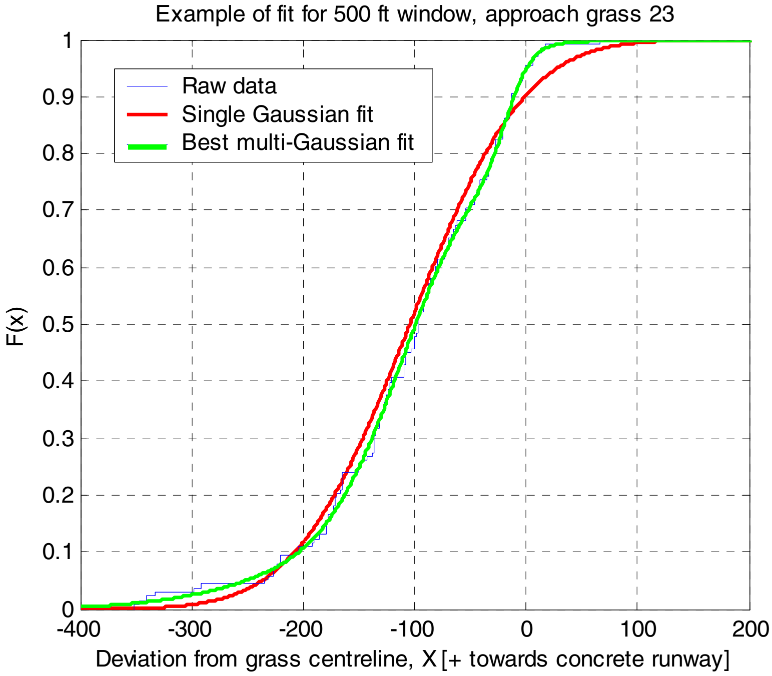


*Figure 5-2 Example of multi-gaussian fitting process*

Based on the described statistical analysis, the deviations have been calculated associated with a probability of exceedance of .001/movement (i.e $P_{.001}$ for exceedance away from the concrete runway and $P_{.999}$ towards the concrete runway). This means that such a deviation is expected to occur once or twice per year, per runway both in approach and take-off. Estimating deviations associated with lower probabilities has not been attempted, because due to the relative low number of datapoints this would lead to high uncertainty in the results.

Statistical results are summarised in the following Table 5-6, showing mentioned probabilities as well as other statistical properties of the analysed data.

It is emphasised here that given probabilities should not be interpreted as collision risk. Estimation of collision risk would entail the determination of probability of lateral deviation of both VFR and IFR traffic simultaneously, as well as the probability of vertical separation. As mentioned in paragraph 1.4 estimating actual collision risk is outside the scope of the present investigation.

*Table 5-6 Statistical results of the analysis of the VFR radar track data.*

| Window | 200 ft | 300 ft | 400 ft | 500 ft | 600 ft | 700 ft |
|---|---|---|---|---|---|---|
| **Approach grass RWY 05** | | | | | | |
| Distance to THR [m] | 685 | 1121 | 1557 | 1992 | 2428 | 2864 |
| Nr. of valid radar returns | 38 | 48 | 51 | 52 | 53 | 49 |
| Deviation $P_{.001}$ [m] | -80 | -93 | -290 | -536 | -991 | -1091 |
| Deviation Minimum [m] | -53 | -76 | -248 | -470 | -779 | -985 |
| Deviation Mean [m] | 30 | 7 | -80 | -182 | -437 | -767 |
| Deviation Maximum [m] | 62 | 52 | 52 | 66 | -80 | -261 |
| Deviation $P_{.999}$ [m] | 76 | 64 | 107 | 126 | 30 | -194 |
| **Approach grass RWY 23** | | | | | | |
| Distance to THR [m] | 537 | 957 | 1377 | 1797 | 2218 | 2638 |
| Nr. of valid radar returns | 114 | 126 | 136 | 138 | 140 | 115 |
| Deviation $P_{.001}$ [m] | -86 | -136 | -169 | -448 | -771 | -1117 |
| Deviation Minimum [m] | -69 | -105 | -177 | -352 | -769 | -999 |
| Deviation Mean [m] | 18 | 6 | -12 | -104 | -335 | -666 |
| Deviation Maximum [m] | 61 | 53 | 99 | 66 | 59 | -22 |
| Deviation $P_{.999}$ [m] | 67 | 66 | 105 | 94 | 55 | 41 |
| **Take-off grass RWY 05** | | | | | | |
| Distance to THR [m] | 537 | 957 | 1377 | 1797 | 2218 | 2638 |
| Nr. of valid radar returns | 24 | 56 | 59 | 58 | 59 | 53 |
| Deviation $P_{.001}$ [m] | -89 | -198 | -349 | -551 | -1119 | -1113 |
| Deviation Minimum [m] | -59 | -189 | -282 | -473 | -941 | -998 |
| Deviation Mean [m] | 11 | -25 | -51 | -139 | -330 | -592 |
| Deviation Maximum [m] | 103 | 120 | 146 | 120 | 132 | -225 |
| Deviation $P_{.999}$ [m] | 104 | 144 | 189 | 181 | 233 | -40 |
| **Take-off grass RWY 23** | | | | | | |
| Distance to THR [m] | 685 | 1121 | 1557 | 1992 | 2428 | 2864 |
| Nr. of valid radar returns | 93 | 119 | 142 | 149 | 147 | 125 |
| Deviation $P_{.001}$ [m] | -112 | -521 | -993 | -898 | -1111 | -1020 |
| Deviation Minimum [m] | -202 | -454 | -975 | -952 | -962 | -997 |
| Deviation Mean [m] | 2 | -43 | -112 | -186 | -434 | -712 |
| Deviation Maximum [m] | 92 | 92 | 77 | 25 | -1 | -453 |
| Deviation $P_{.999}$ [m] | 116 | 116 | 157 | 187 | 164 | -428 |

The following figures show the calculated results (mean, and the estimated .001/movement exceedance boundaries) in an airport map lay-out, for operations both on grass RWY 05 (Figure 5-3 ) and grass RWY 23 (Figure 5-4). These figures illustrate to which extent overshoot of the centreline of the grass runway can be expected to occur with a reasonable probability of occurrence.

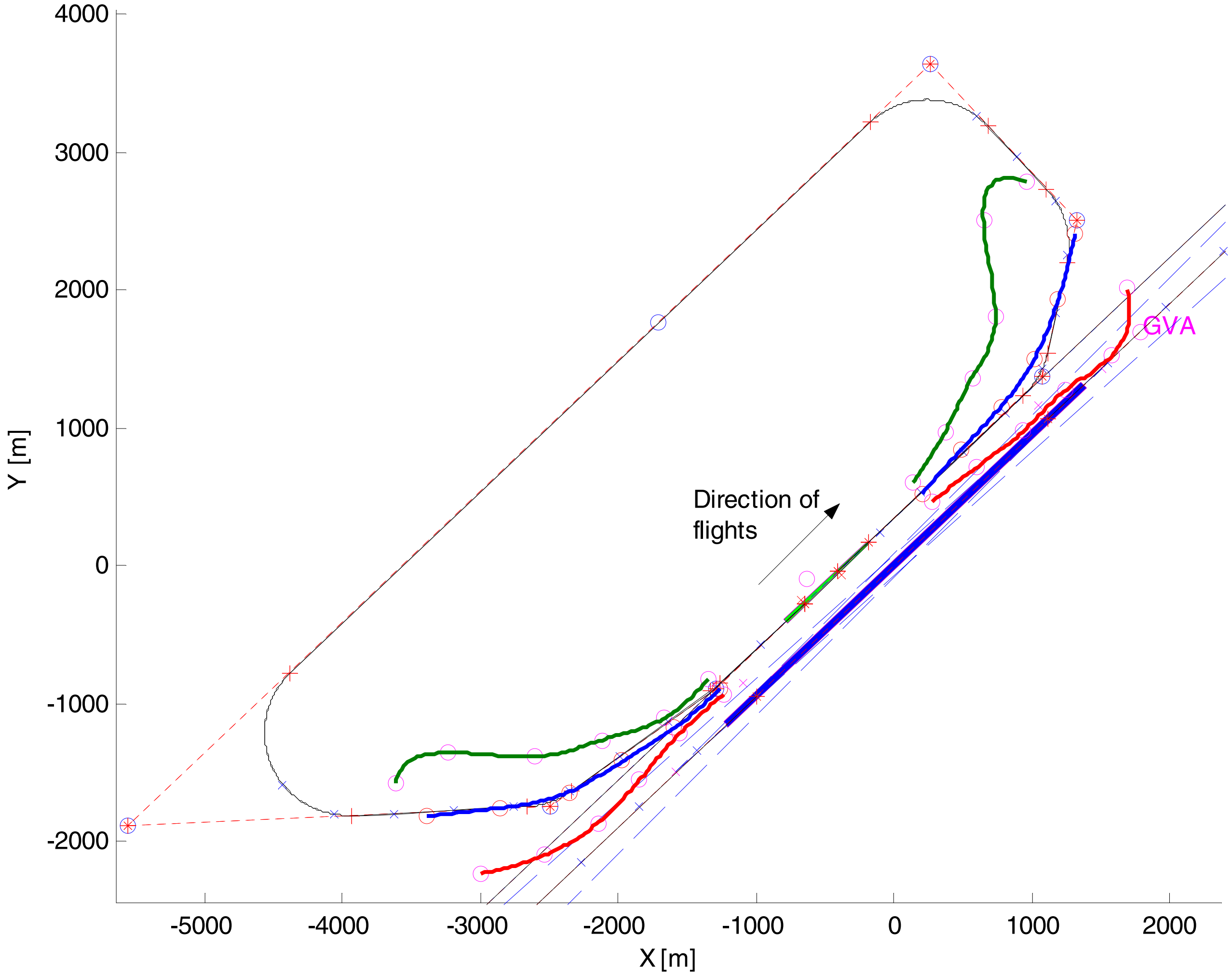


*Figure 5-3 Estimated mean (blue) and exceedance probability (.001/movement) boundaries (green line: inside circuit, red line: outside circuit) of VFR traffic on grass runway 05, based on August 2004 radar measurements*

Based on these results the following conclusions are drawn.
First of all it appears that the magnitude of overshoots during approaches is significantly less than for take-offs. The approaches flown to runway 05 and runway 23 are quite similar in terms of accuracy. The same is true for the take-offs from both runways. The accuracy of the approach trajectories is such that in general no conflict with traffic on the concrete runway is to be expected.

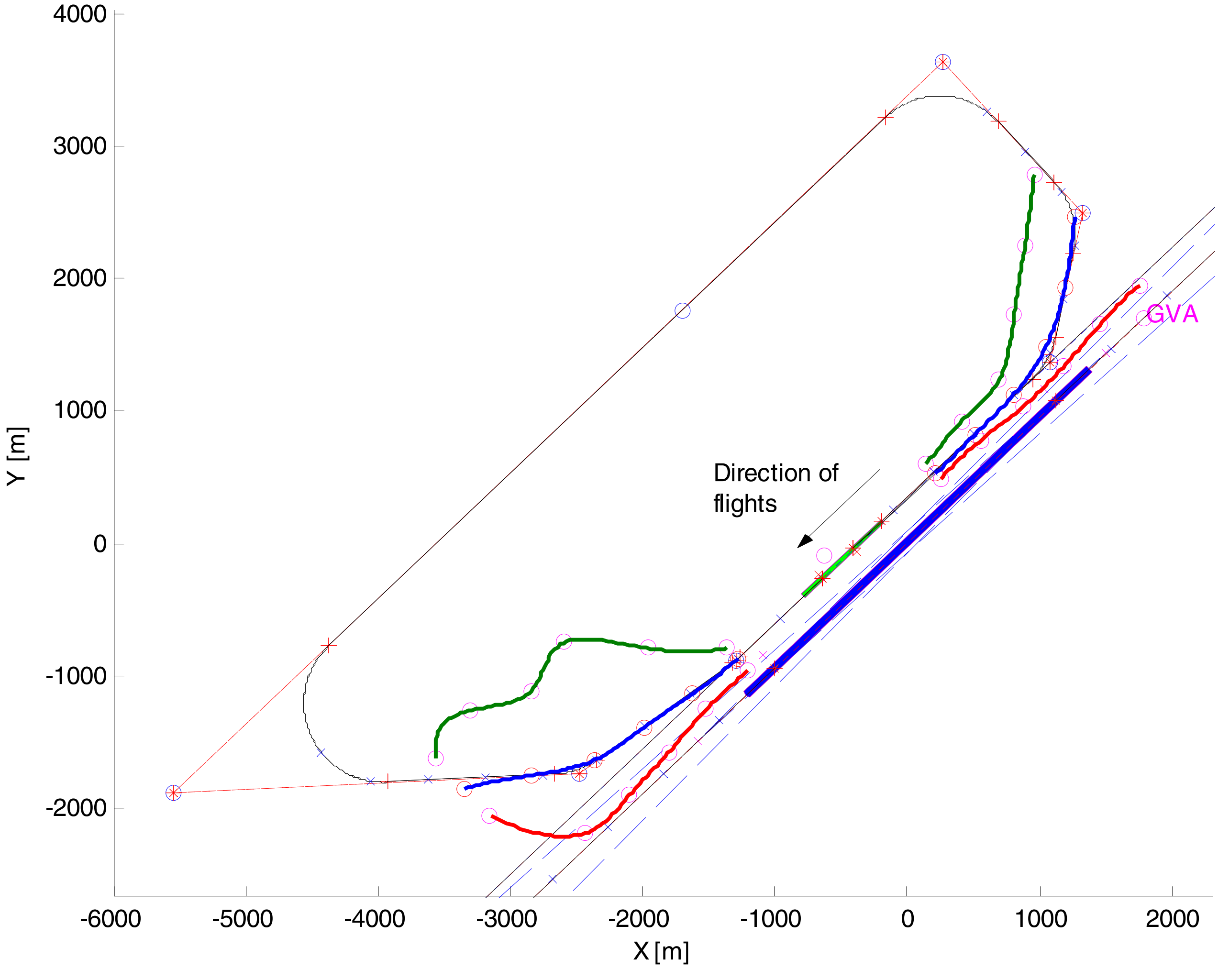


*Figure 5-4 Estimated mean (blue line) and exceedance probability (.001/movement) boundaries (green line: inside circuit, red line: outside circuit) of VFR traffic on grass runway 23, based on August 2004 radar measurements*

It appears that the approach to grass runway 05 is slightly more critical than the approach to grass RWY 23. The $P_{.999}$ contour just touches the outside of the localizer beamwidth about .5 to .7 nm from the threshold of concrete RWY 05. In general a half beamwidth deviation at this point of an approach will be qualified as an unstable approach and therefore lead to a missed approach manoeuvre. Therefore, the actual collision risk for simultaneous traffic approaching runways 05 is considered to be low, also taken into account that there will be also some vertical separation as result of the staggered thresholds (~200 ft).
As shown the lateral dispersion during take-off is significantly larger than during approach. For take-off in direction 05 and 23 deviations may occur that will bring the departing light traffic on the grass runway close to the centre line of the traffic on the concrete runway. Moreover, also vertical separation is less assured during take-off because high performance commercial airliners operating may climb sufficiently fast to intersect the vertical path of the light traffic.

It is emphasized here that all conclusions above are subject to the assumption that the radar trajectories, as recorded by the Geneva SSR in August 2004, are representative of the light traffic tracking performance in general.
Consequences of the results of this analysis will be further discussed in paragraph 6.3.3.

### 5.6 Wind and turbulence

A brief study has been conducted into the windclimate at Geneva airport.
This study has been based on data from the International Station Meteorological Climate Summary ISMCS Database. This database gives detailed climatological summaries for 2600 locations worldwide. These locations include National Weather Service stations, domestic and overseas Navy and Air Force sites, and numerous foreign stations.
This database comprises statistical data on the meteorological conditions for Geneva airport over a 20 years period.
Based on these data a so-called probability windrose has been determined, showing the probability of the wind exceeding a certain windspeed in a given direction.

This figure is shown in Figure 5-5 below. As shown the dominating wind directions at Geneva airport are from the north-east and south-west. From this it is concluded that runway orientation of the runways at Geneva airport (directions 046° and 226°) is favourable with respect to the dominating wind direction. Significant crosswind will be fairly rare.
Based on the probability windrose and the runway orientation at Geneva the availability of the runways in combination with a given crosswind can be calculated. The result is depicted in the following Figure 5-6.

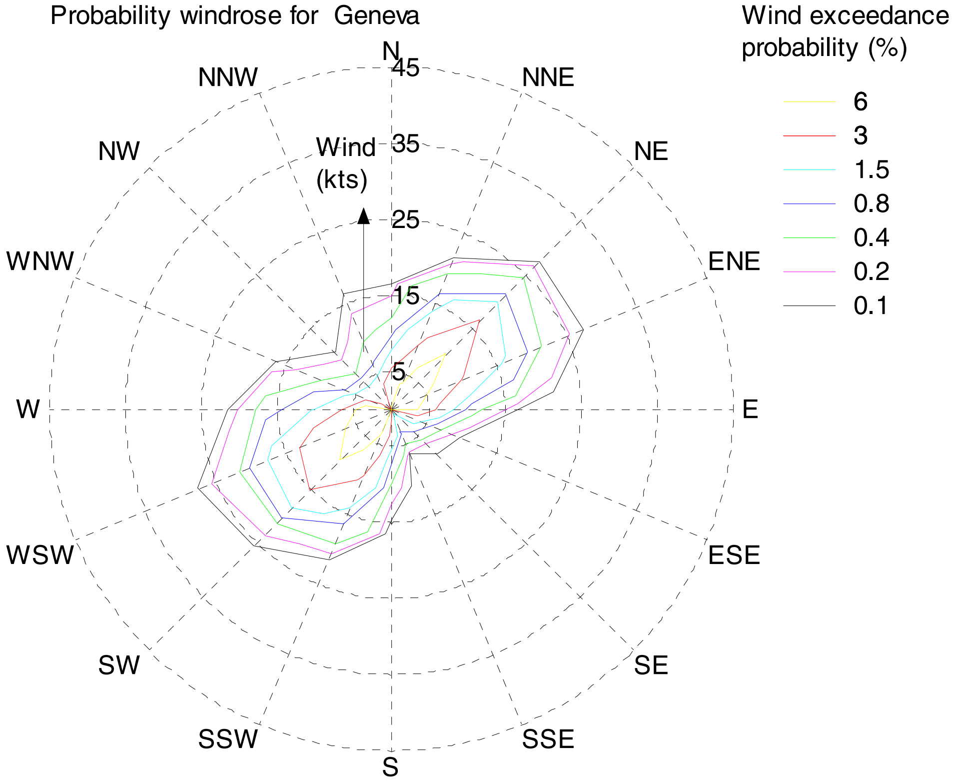


*Figure 5-5 Probability windrose for Geneva airport*

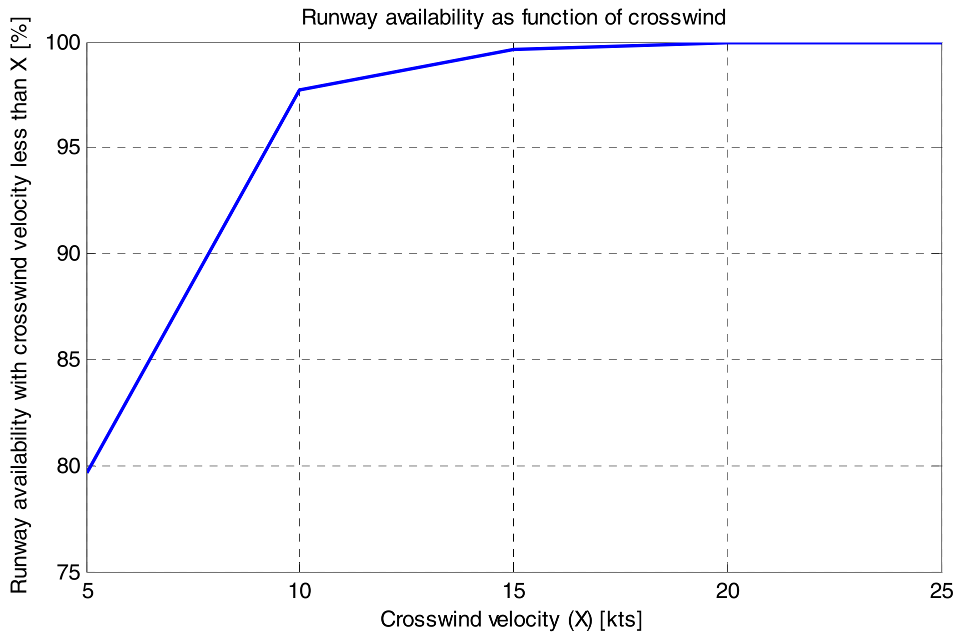


*Figure 5-6 Runway availability as function of crosswind*

It is shown that in about eighty percent of the time (on a yearly basis) crosswind is less than 5 knots, and that the probability of crosswind exceeding 15 knots is less than 0.5 %.
It is therefore concluded that the windclimate at Geneva is fairly benign, and that the presence of moderate or severe wind is usually combined with a direction that is well aligned with the runway orientation.

It is expected that this will have a positive effect on the accuracy of track keeping performance of the air-traffic at Geneva airport, because crosswind is one of the factors that may cause aircraft to drift from their intended track, especially during take-off.

A possible negative side-effect of the benign windclimate at Geneva airport, is that it may create conditions that the wake turbulence generated by air traffic at Geneva may persist for relative long periods of time. In general high wind and turbulence are important factors in accelerating the wake vortex decay process.

The level of turbulence at the airport has not been investigated. However, in general it can be stated that the level of turbulence is a function of the magnitude of the windvelocity and the terrain roughness around the airport. Although the windclimate at Geneva, as described above, should be classified as fairly benign, the terrain roughness around Geneva may give rise to some particular turbulence or windshear problems. Especially the forest of Ferney-Voltaire to the north-east of the grass strip may give rise to a shielding effect from wind with north-easterly direction. This may expose aircraft taking off from grass runway 05 to effects of increased turbulence or downdraft in case of moderate to strong winds from north-east direction. Similarly aircraft landing on grass runway 23 with some tailwind may be exposed to such wind effects, though to a lesser extent.

Although no incidents are reported at Geneva airport that can be contributed to mentioned wind effects, the potential hazard of it should not be neglected, especially for pilots unfamiliar with the local conditions at Geneva.

# 6 Hazard assessment

## 6.1 Introduction

This chapter describes the process of hazard identification and hazard assessment that has been applied to the mixed VFR/IFR operations at Geneva airport.
This process follows the general guidelines as provided by the regulatory framework of the Eurocontrol Safety Regulatory Requirements [ESARR3] and [ESARR4].
In agreement with these requirements the following definitions have been used:

- Hazard: *A potentially unsafe condition*.
- Hazard Identification: *The process of determining what can happen, why and how*.
- Hazard Assessment: *An evaluation of hazards based on engineering, operational judgement and/or analysis methods.*

Within [ESARR3] hazard assessment has been described as an integral part of safety management, whereas [ESARR4] focuses on the actual conduct of safety assessment and risk mitigation. The processes defined within [ESARR4] concern hazard identification, risk assessment and risk mitigation.
These processes include:

1. Determination of the scope, boundaries, interfaces, functions and environment of the constituent part being considered;
2. Determination of the safety objectives to be placed on the constituent part, incorporating :
   (i) an identification of ATM-related credible hazards and failure conditions, together with their combined effects,
   (ii) an assessment of the effects they may have on the safety of aircraft, as well as an assessment of the severity of those effects,
   (iii) a determination of their tolerability, in terms of the hazard's maximum probability of occurrence, derived from the severity and the maximum probability of the hazard's effects.
3. Derivation, as appropriate, of a risk mitigation strategy;
4. Verification that all identified safety objectives and safety requirements have been met.

For the present project however a complete safety assessment has been agreed to be out of scope for the current phase (see paragraph 1.4). Therefore only a subset of mentioned activities has been performed. From the given list above the activities that have been performed are: #1 (see Chapter 1) and #2 (i) & (ii), which are the subject of the present chapter. Activities 2 (iii), 3 and 4 are not formally performed within the present scope.

Formal determination of risk tolerability is left to a potential extension of the present study, as part of a next project phase.
Nevertheless a first estimate of risk tolerability is addressed qualitatively on the basis of expert judgement, without a formal classification scheme.
A first risk mitigation strategy is provided by proposed measures that are given in consideration to mitigate the identified hazards.
Verification of this first estimate of risk tolerability and the identified risk mitigation measures is considered part of a possible next phase of the current project.

Finally, it should be emphasised that negative influences on safety can also arise from unexpected outcomes of interactions, especially between separately controlled systems or subsystem components in complex systems. This is why the interfaces between the safety management systems of interdependent organisations are so important. This is addressed in Chapter7.

### 6.2 The hazard identification process

Three main processes have been adopted in the CATCH project to identify hazards related to the mixed VFR/IFR air traffic at Geneva Airport (see summary in Figure 6-1).

First, as part of the mobilisation and familiarisation activities in September 2004, the project team had a preliminary visit and discussions with senior members of AIG. This was augmented by flights of the VFR circuit, piloted by the chief instructor of the Aeroclub Geneva. The detailed project plan was defined following this activity.

Secondly, in October 2004 an official Kick-off meeting was held in which the project plan was further clarified. At the same time initial information gathering was initiated by means of meetings with AIG representatives (including the radar track specialists) and skyguide representatives.

Thirdly, interviews were held in December 2004 with key experts from AIG and skyguide, and with other interested parties. Structured interviews were held with the skyguide Safety Officer for Geneva Tower and with the Chief Fire Officer and Head of Safety Division for AIG.

The structure of these interviews was designed both to identify hazards and to understand the status of the respective safety management systems of the two organisations (see Section 6) as well as interface issues.

Fourth, a “structured brainstorm” was held on 13 January 2005 specifically to identify hazards and to develop the understanding of how these affect safety management. This brainstorm involved a panel of eight operational experts and was facilitated by three risk management specialists. The brainstorm verified and extended the interview process for hazard identification.

Structured brainstorm is a formalised set of processes that have been recommended by Eurocontrol in its “Safety Assessment Methodology” guidance [SAM] issued to help providers of air traffic management services to comply with ESARR4. Application of this process is relatively new in the ATM and airport industries, but has been the norm for many decades in the offshore oil and gas, chemical and nuclear industries, where it is more commonly known as “HAZOP” – Hazard and Operability study.

Effective hazard identification involves a combination of knowledge and experience of what has happened in the past to threaten safety, and rigorous exploration of what might happen in the future but has not yet been experienced. The process therefore requires being both creative and systematic. Multiple formats of brainstorming activity were therefore adopted to achieve creativity within a systematic and structured approach to hazard identification. To avoid initially pre-conditioning or constraining the panel’s creative thinking, the first part of the brainstorm involved silent “brain-writing”, where the individual experts wrote down in silence their own ideas about the hazards associated with the mixed VFR/IFR operations. This process was then expanded to include panel discussions among the operational experts in two groups, followed by a plenary session to consolidate the initial list of hazards.

The second part of the brainstorm focused on “simultaneous operations matrices” which prompted the experts to identify which of the simultaneous operations among VFR-IFR, VFR-helicopters, and IFR-helicopters they considered safe or unsafe and why. This was an important part of the process, to focus on combinations of hazards by stimulating the identification of hazards that might be created or aggravated by different activities within VFR and IFR operations that are coincident in timing. Otherwise the brainstorming might have focused too narrowly on individual hazards in isolation, and thereby might have failed to assess particular combinations of unrelated events, to the detriment of the output [SAM, Guidance A and B2 to FHA. Chapter 3].

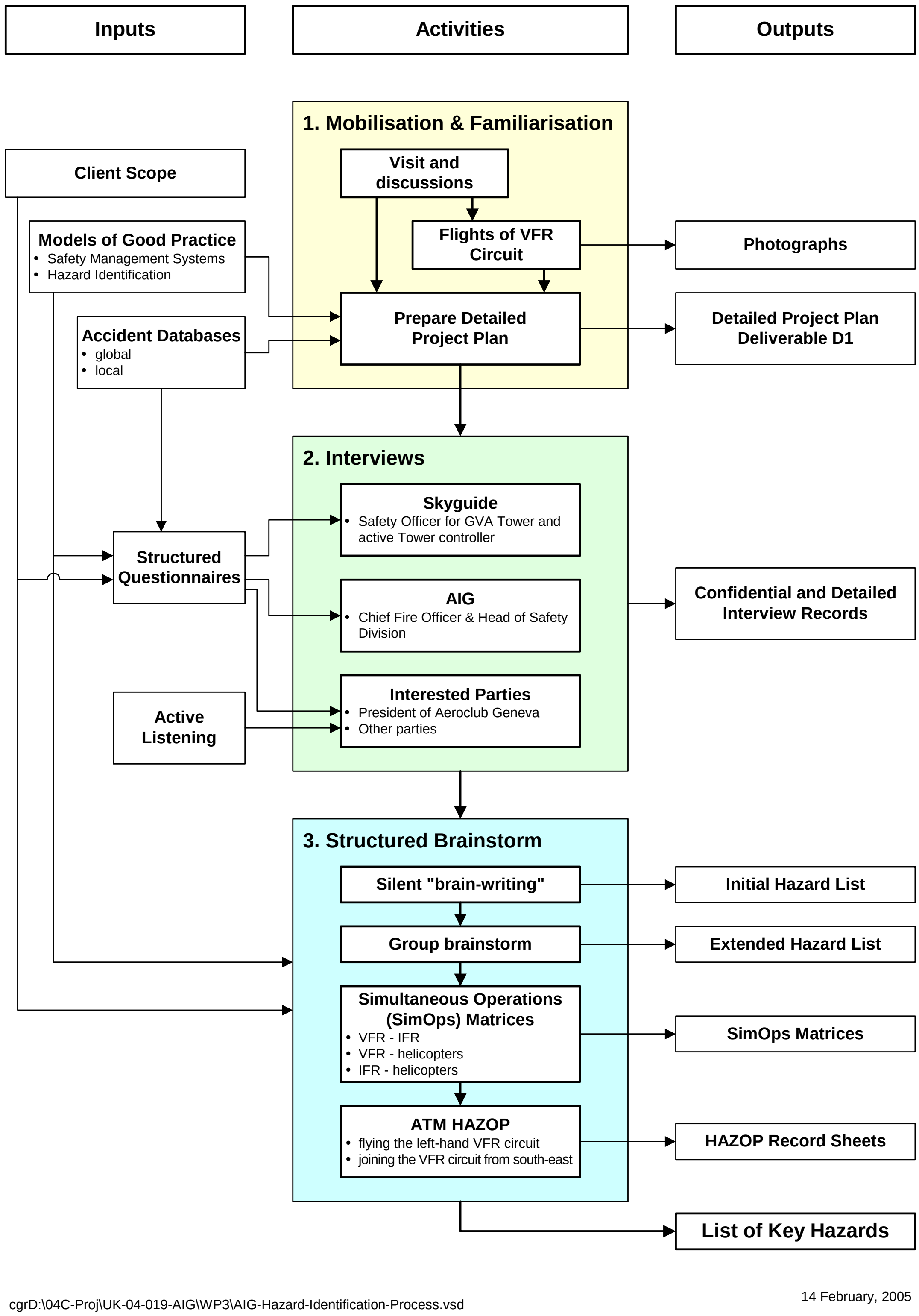


*Figure 6-1* Summary of 3-stage Hazard Identification Process

The third and final part of the structured brainstorm adopted rigorous, systematic ATM HAZOP, to increase the confidence in the thoroughness of hazard identification. However, comprehensive ATM HAZOP is a laborious process, and it was beyond the scope of the project to reach the completeness of a full safety assessment. It was recognised from the outset that this process could not be exhaustive in the time available. An exhaustive approach would have taken a trained HAZOP team several days to complete for all permutations of mixed VFR/IFR operations at Geneva Airport. The ATM HAZOP process was therefore applied to the critical activities – so-called "scenarios" – of (1) flying the VFR circuit and (2) joining the VFR circuit from the south-east.

These scenarios were decomposed into several "nodes", for which a short and unambiguous design intention could be defined. A take-off or landing typically involves several nodes for a particular flight path.

The design intention is what is planned or wanted to occur. This design intention was then systematically stressed by applying guide-words and prompt-words (see Table 6-1) which helped the panel of experts to discover hazardous deviations from the design intention, and to understand the potential causes. The list of guide-words and prompt-words is based on Acona's experience and on the Eurocontrol guidance for human error identification in [SAM, Part IV, Annex J].

*Table 6-1 HAZOP "Guidewords and Deviations" for flight operations*

| **Guideword** | **Deviation** |
|---|---|
| INFORMATION | less / none<br>more<br>wrong / corrupted / inconsistent<br>paradigm |
| COMMUNICATION | less / none<br>more<br>timeliness |
| ACTION | less / none<br>more / extra<br>out-of-time<br>out-of-sequence<br>impaired "see-and-avoid"<br>other than |
| CONTEXT / ENVIRONMENT | contributing factors |

The whole brainstorm process and outputs were extensively documented as deliverable D4 within the CATCH project [CATCH_D4]

The main hazards that were identified are summarised in the following paragraph. The subsequent paragraphs treat each of these hazards in depth and describe their relevance for the safety and compatibility of the mixed VFR/IFR operations

## 6.3 Identified Hazards

### 6.3.1 The Key Hazard List

As indicated in Figure 6-1 the primary result of the hazard identification process is the "List of Key Hazards".
The key hazard list has been assembled based on the results from the brainstorm process [CATCH_D4], combined with results from interviews and analysis of the mixed VFR/IFR operations on the basis of available documentation and supporting information (see also chapter 5). The list of key hazards has been structured by defining in a number of main categories that are closely related to types of incidents and accidents. In each main category one or more of specific hazards have been identified, related to the mixed VFR/IFR operations at Geneva airport. Each of these specific hazards is supported by results of the hazard identification process.
Below the main hazard categories are presented, including the associated specific hazards identified:

1) **The wake vortex hazard**
   a) *During Approach and Go-around*: this concerns the potential hazardous effect on light aircraft of wake turbulence caused by commercial airliners during mixed simultaneous operations on closely spaced parallel runways, in particular during approach and go-around phases of flight;
   *b) During Take-off:* this concerns the similar, potential hazardous effect of wake turbulence during take-off and initial climb phases of flight;
2) **Collision risk hazard**
   *a) Overshoot of centre line of grass runway*: this concerns the potential conflict between VFR aircraft lining up for the grass runway and aircraft operating to or from the concrete runway. It includes visibility aspects of VFR and IFR traffic, visibility of VFR traffic by controllers, the limitations of see-and-avoid principle, and the tasks and authority of controllers within Class D airspace.

b) *Collision risk with helicopters*: this concerns the potential conflict between helicopters and other fixed wing traffic, including the special characteristics of the heli-operations.
c) *Collision risk with VFR traffic crossing overhead*: this concerns the potential conflict between VFR crossing overhead the concrete runway with air traffic operating on this runway.

**3) Controlled flight into terrain hazard**

a) *The Forest of Ferney-Voltaire*: this concerns the hazard of the obstacle, formed by mentioned forest, to VFR traffic operating on the grass runway.

**4) Runway incursion hazard**

a) *The use of the grass taxiway*: this concerns the hazards associated with operations on a grass runway, including use of the taxiway, the runway lay-out and the quality of the markings.
b) *The forest of Ferney-Voltaire as an obstacle to traffic visibility*: this concerns the hazards associated with mentioned forest in terms of shielding approaching VFR traffic from spotting ground traffic and vice versa.
c) *Grass runway parking stand*: this concerns the hazard associated with the location of the grass parking stand.

**5) Runway excursion hazard**

a) *Displaced threshold of grass RWY 23*: this concerns the hazard of performance limitations of aircraft using grass runway 23, due to the displaced threshold.
b) *The effect of tailwind*: this concerns the hazard of tailwind on the operation of light aircraft on a short, grass runway, combined with the applicable runway assignment criteria.
c) *The effect of the grass runway condition*: this concerns the hazard associated with the grass runway condition on aircraft take-off and landing distance.

**6) Operational hazards**

a) *Unfamiliar pilots*: this concerns the hazard of VFR pilots that are unfamliar or insufficiently prepared to operate in the GVA CTR, as part of a mixed VFR/IFR operation.
b) *Training flights*: this concerns the hazard of performing VFR training flights with inexperienced student pilots within the GVA CTR.
c) *High ATCO workload*: this concerns the hazard of the complex tasks of the GVA tower controllers that are responsible for the safe operation of mixed VFR/IFR traffic. It includes the associated stress levels and workload.
d) *Communication problems*: this includes the hazard associated with specific communication problems that might impair the safe control of mixed traffic streams at GVA. It includes phraseology and language problems.

In the following paragraphs all identified hazards as reflected in the Key Hazard List will be assessed.

### 6.3.2 The wake vortex hazard

#### 6.3.2.1 General

As result from the hazard identification process it has been determined that several concerns exist with respect to the hazard of wake vortex for small aircraft operating from the grass runway close, and parallel, to large aircraft operating from the concrete runway.
In this section this hazard has been further analysed.

In general wake vortices are defined as two counter-rotating cylindrical air masses trailing aft from any air vehicle that is generating aerodynamic lift.
The strength of the vortices is governed by weight, speed and shape of the wing of the generating aircraft. The most severe wake vortices do occur when aircraft are heavy and slow (i.e. high lift and high lift-coefficient), which are precisely the conditions found during take-off and landing. The main hazard to an aircraft entering a wake vortex of a preceding aircraft is that it may experience a significant roll upset, and loss of altitude, to the extent of becoming uncontrollable.

In general the wake vortices descend behind the generating aircraft around 500 ft/min, until they reach the ground surface. At that point the wake vortices will move sideways with a velocity of around 3 – 5 knots. The total sideways velocity of the wake vortices is the sum of the ground-induced velocity and the present crosswind. This means that a wake vortex may remain stationary relative to the runway in the presence of a small crosswind, that counters the ground-induced cross velocity. Also it is possible that a wake vortex is blown into the path of aircraft operating from a closely spaced parallel runway.
It should be noted that the wake evolution as described here is only of a general nature. In practice the wake vortex phenomenon may show a fairly random character. For instance, a wake vortex may bounce against the ground surface and rise above the flight path of the generating aircraft.

More elaborate descriptions of the wake vortex phenomenon, and its potential hazardous effects, can amongst others be found in [Doc9426] and [AC90-23F].

Based on the runway lay-out of Geneva airport (250 meter lateral separation between the grass and concrete runway), it can be estimated that, depending on the magnitude of the present

(south-east) crosswind, it will take between 30 and 120 seconds to transport the wake vortex of an aircraft operating on the concrete runway to the centreline of the grass runway.
Within this time period the strength of wind vortex of a medium to large aircraft will in general be still of such strength that it may present a severe hazard to small aircraft operating from the grass strip. The actual probability of an encounter with a potentially hazardous wake vortex depends however also on the vertical separation between the flight paths of the traffic on the concrete and the grass runway. This will be further discussed in the next paragraphs.

Here it suffices to conclude that the presence of wake vortices at the centreline of the grass runway can not be excluded.
It should also be noted that several studies have found that the vortex problem was largely confined to small general aviation aircraft landing or taking off closely behind air carrier aircraft under VFR conditions [FAA75-6, CAA91015, CAA0197].
This underlines the relevance of the wake vortex problem for the situation in Geneva.

#### 6.3.2.2 Approach and Go-around

As shown in paragraph 4.2.3 the ICAO regulations [Doc4444, par. 5.8.1.1 and 5.8.1.2] do not require the ATC unit to provide wake turbulence separation for arriving VFR aircraft. It is therefore the own responsibility of a VFR pilot to stay clear from hazardous wake vortices generated by preceding landing aircraft.

Since wake turbulence is invisible to the eye, the presence of wake turbulence in the flight path of an arriving VFR aircraft can only be inferred from the observed position of the preceding aircraft and the expected trajectory of its wake turbulence. Due to the unpredictability of this trajectory, as mentioned above, this is clearly not easy to do.
Based on a substantial number of reports concerning wake turbulence induced accidents of VFR aircraft landing behind large air carriers [CAA0197, FAA75-6], it can be concluded that in general this process is prone to leading to insufficient separation margins.

The question is to which extent this potential hazard is applicable to the situation at Geneva airport. To assess this it is necessary to further analyse the particular situation, especially with respect to the vertical separation of the traffic on the grass and concrete runway.

In Figure 6-3 and Figure 6-4 the nominal approach paths to the grass and concrete runway 05 and runway 23 are shown (in top view). Based on the glide path angle of the ILS system to the concrete runway (3 degrees) and the glide path angle indicated by the APAPI system on the

grass runway (i.e. 4 degrees for approaches to runway 05, and 4.15[7] degrees for runway 23) the altitude profile of the approaches to both runways in both directions have been indicated, at particular points before the threshold. In Figure 6-2 a side-view has been presented of the nominal approach paths to both runways.
These figures show that approaches to the grass runway 23 in general are nominally around 500 ft above the glidepath for approaches to the concrete runway 23.
Due to this vertical separation it is expected to be very unlikely that small aircraft approaching on grass RWY 23 will be disturbed by wake turbulence from aircraft on a parallel approach.

For the approach to grass runway 05 it is shown that vertical separation is around 200 ft, near the threshold.
It is known from literature that wake vortices may bounce from the ground surface to up to 200 ft above ground level [Doc9426] and [AC90-23F]. Also, under light to medium crosswind conditions, wake vortices may be transported within 30 seconds, or more, to the vicinity of the centreline of the grass runway. Therefore, under certain circumstances, it can not be excluded that approaching light aircraft on grass runway 05 may be affected by the wake turbulence of large to medium air carriers landing on the adjacent concrete runway, shortly before the light aircraft.

Therefore, VFR traffic landing on grass runway 05 should be well aware of this potential hazard, and should be advised by ATC to maintain sufficient separation between landing on the grass runway and preceding aircraft on the adjacent concrete runway, especially under light to moderate crosswind from south-east direction.

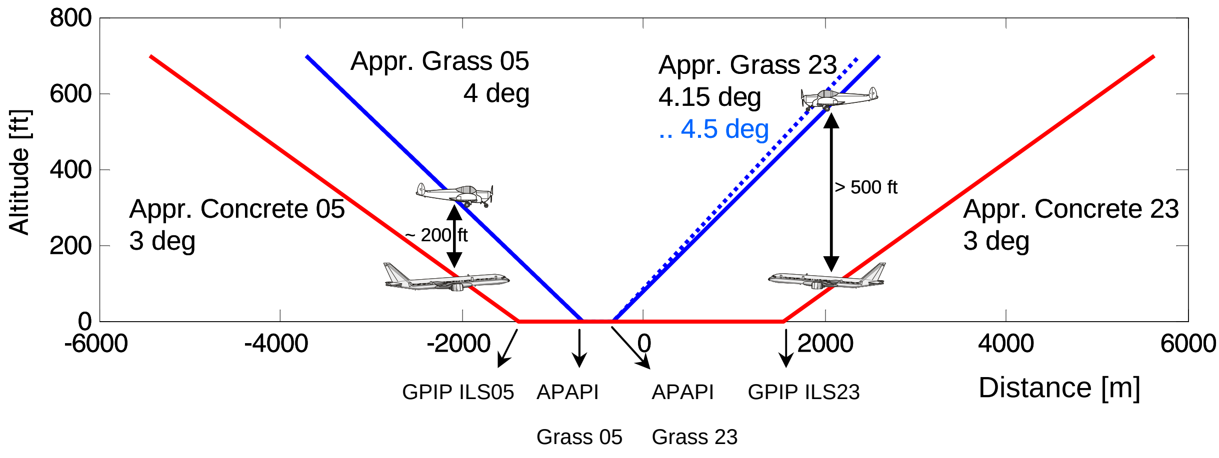


*Figure 6-2 Side-view of the nominal approach paths to the concrete and grass runways*

[7] To increase the clearance above the forest of Ferney-Voltaire, the nominal approach path angle of the APAPI for runway 23 has been increased recently to 4.5 degrees.

Another situation that may occur is that aircraft on the concrete runway execute a go-around, possibly at low altitude (~ 200 ft AGL). In such cases light aircraft, approaching the grass runway from either side should well aware that they may fly partially below the missed approach path from the aircraft on the adjacent runway. Again, under certain circumstances, the ensuing wake vortices may move into the flight path of light aircraft approaching the grass runway.

The likelihood that this will happen in this case is considered to be higher than for normal landing aircraft, as discussed above. On the other hand the occurrence of a missed approach is a rather rare event (in the order of 1 per 1000 flights). Therefore the overall hazard can not be considered unacceptable.
Nevertheless, light aircraft should be well aware of the potential hazard of the wake vortex from large aircraft, performing a missed approach. Therefore, the ATC unit shall issue a caution to light aircraft, when they are close to a large aircraft performing a go-around manoeuver.

The local ATC manual has identified this potential hazard and prescribes the instant isolation of the light aircraft in case of a missed approach on the concrete runway, as part of the standard procedures.

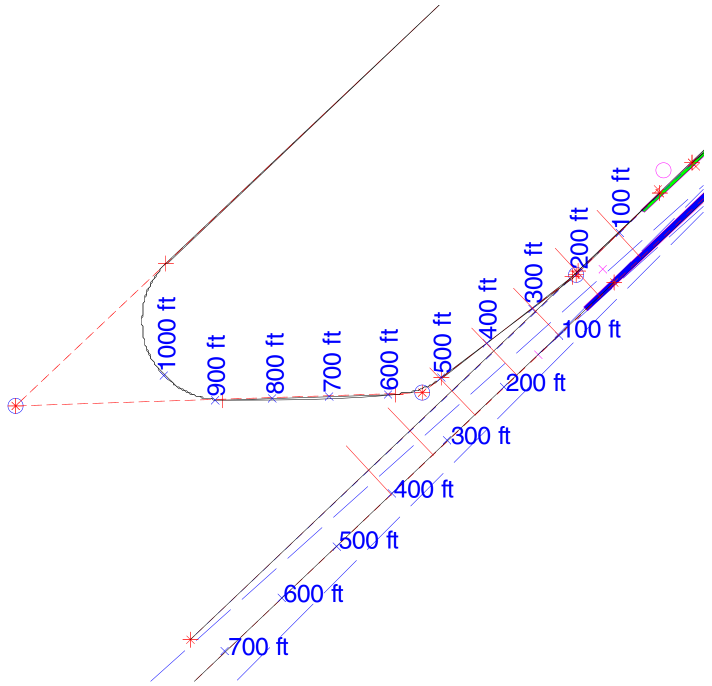


*Figure 6-3 Vertical separation of the approach paths to grass RWY 05 and concrete RWY 05*

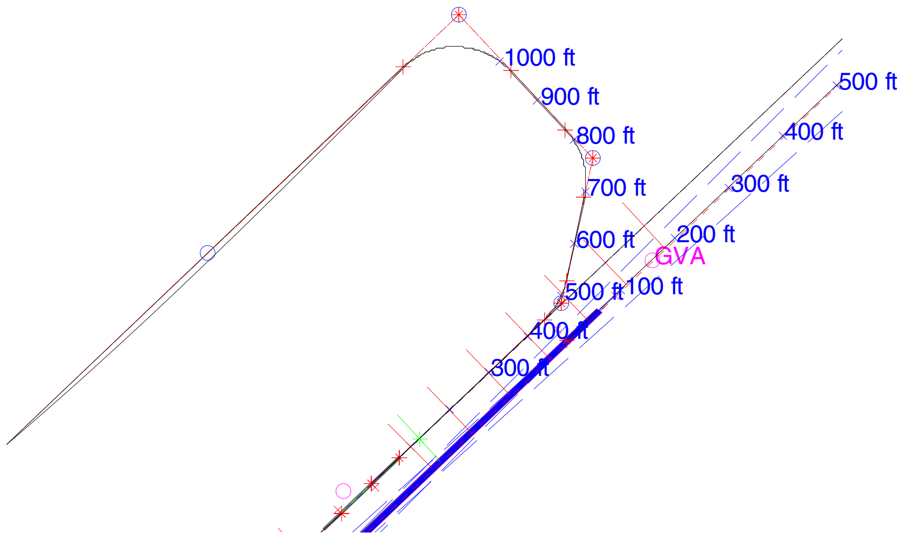


*Figure 6-4 Vertical separation of the approach paths to grass RWY 23 and concrete RWY 23*

#### 6.3.2.3 Take-off

As shown in paragraph 4.2.3 the ICAO regulations [Doc4444, par. 5.8.3.2] do require a 3 minutes separation minimum for light aircraft taking off behind a heavy (weight > 136,000 kg) or medium aircraft (7,000 kg < weight ≤ 136,000 kg) from closely spaced (<760 m) parallel runways. The shown requirement mentions this separation minimum in connection to taking off from an intermediate part of the runway. In relation to the runway lay-out of Geneva airport this requirement is considered applicable, because a take-off from the grass runway involves taking-off from a point corresponding to an intermediate point on the concrete runway.

As discussed earlier in Chapter 4 of this report, the current ATC procedures in Geneva appear not to be fully compliant with this requirement. For take-off of *light aircraft behind heavy* aircraft the requirement *is* applied, because in that case the grass and concrete runway are treated as a single runway. However, for *light aircraft taking off behind a medium aircraft* the requirement *is not* applied; in this case the two runways are considered as fully independent.

The logic for not fully complying with ICAO regulation 5.8.3.2 has not become clear during the present study. From a safety standpoint the regulation appears to be valid. When taking into account the specific runway lay-out at Geneva airport, it is clear that aircraft taking-off from the concrete runway, especially if it concerns modern medium weight aircraft (such as Airbus A320/321 and Boeing 737-800/900), most likely will climb above the flight path of light aircraft taking-off from the grass runway. In particular this is the case for take-off from runway 23. This may expose the light aircraft to the wake turbulence generated by the medium aircraft. Due to the close proximity of the grass runway, this wake turbulence may pose a hazard to the light aircraft taking off from the grass runway.

#### 6.3.2.4 Conclusion

It is concluded that the wake turbulence is considered in particular a risk for light traffic taking off from the grass runway in parallel with medium to heavy weight aircraft taking off from the concrete runway. For this reason it is argued that either full compliance with ICAO regulations (viz. ICAO doc 4444, par. 5.8.3.2) should be implemented, or that it is shown by a separate safety assessment that the current practice is acceptably safe.
Another potential (but less severe) wake turbulence hazard has been identified for VFR traffic approaching on grass runway 05, simultaneously with medium to heavy weight traffic on the concrete runway 05. Vertical separation of this traffic is considered marginal from a wake turbulence standpoint. Because ICAO regulations do not require ATC to separate arriving VFR traffic in general, and also because the Control Zone at Geneva has been defined Class D, it remains the VFR traffic’s own responsibility to remain clear of potentially hazardous wake

turbulence in this case. However, the importance of the advisory role of ATC in this respect should be emphasised in order to avoid that VFR traffic would be insufficiently aware of the potential wake turbulence risk.

### 6.3.3 Collision risk hazard

As result of the hazard identification process the critical hazards have been determined that may contribute to the risk of collision between VFR and IFR traffic at Geneva airport.
These hazards are:

- Overshoot of centre line of grass runway towards the concrete runway;
- Collision with helicopters;
- Collision between IFR and VFR traffic that is crossing overhead the concrete runway when approaching from south-east.

These hazards are addressed in the following paragraphs.

#### 6.3.3.1 Overshoot of centre line of grass runway

There are several reasons that may cause VFR traffic to overshoot the centre line of the grass runway during approach or take-off, such as:

- Unfamiliarity with the local situation
- Unclear grass runway markings (approach)
- Unclear visual reference points
- Drift due to crosswind
- General navigation errors

Due to the close proximity of the grass runway to the concrete runway, it may be expected that such overshoots may lead, under specific circumstances, to unsafe proximity with IFR traffic on the concrete runway.
It should be realised that VFR traffic approaching the extended centre line of the grass runway, for example flying with a typical airspeed of 30 to 40 m/s, may traverse the distance between the concrete and grass runway (250 m) within 12 to 20 seconds, when no line-up manoeuvre would be carried out. This leaves little time to initiate avoidance manoeuvres. Because the separation of the VFR traffic is primarily based on the see-and-avoid concept, with inherent delays in reaction times and other shortcomings (see paragraph 5.4), it can be argued that risk of collision between IFR and VFR traffic is not to be excluded a priori.

<u>*Collision risk during approach*</u>

In order to get a feeling of the accuracy with which the line-up with the grass runway is performed during approach, and of the accuracy of the departure trajectories after take-off, VFR tracks measured by the SSR at Geneva airport in August 2004 have been analysed. The results of this analysis have been presented in paragraph 5.5. It has been shown that in general the line-up with the grass runway is performed fairly accurate. Overshoots during approaches are in general fairly small. The probability of significant overshoots that would bring the VFR traffic on the edge of the ILS Localizer beam of the concrete runway is estimated to be in the order of .001/movement. Actual collision risk has not been calculated for this operation, because this was outside the scope of the present study.

Nevertheless the mentioned possibility of VFR traffic nearing the area in which the IFR traffic will operate, combined with relatively small vertical separation (~200 ft) when VFR and IFR traffic is approaching parallel to the grass and concrete runway 05, raises the question if such operation can be considered sufficiently safe from a collision risk viewpoint.
From interviews with air traffic controllers it appears that this risk is mitigated by ATC working practices providing appropriate clearances and traffic information, including traffic avoidance advice (see also paragraph 2.4). However, due to the fact that the Control Zone at Geneva airport is qualified as Class D airspace, the authority of ATC in assuring separation between VFR and IFR traffic is limited. The effectiveness of the separation procedures is therefore dependent on what can be regarded as “good controllership” and “good airmanship”. These qualities are however, formally, not very well defined.

It can thus be questioned whether the “un-formalised” practices are sufficient to adequately control the collision risk, as described here, especially in light of the relatively high intensity of the mixed VFR/IFR operations at Geneva airport (see paragraph 5.2).

From this perspective it is doubtful whether the definition of the Control Zone as Class D airspace can be considered compatible with the high volume of mixed VFR/IFR traffic at Geneva airport.
In order to provide ATC with more authority and responsibility to assure separation of VFR and IFR traffic, the CTR airspace classification might be reconsidered. Definition of the CTR as Class C airspace appears to be better in line with current and future traffic volume at Geneva airport.

*Collision risk during take-off*

The analysis of the VFR take-off trajectories shows in general significantly larger deviations from the centre line than approach trajectories (see paragraph 5.5 and Appendix B). This means that collision risk during take-off is expected to be significantly higher than for approaches. This is aggravated by the fact that vertical separation during take-off is less assured as result of the take-off profiles of modern high performance airliners.

Therefore, in order to control the collision risk during take-off special measures have to be taken. Partially the risk is controlled by the current practice of timed separation of the VFR traffic behind heavy weight IFR traffic.

In the previous paragraph, it has already been indicated that application of timed separation should be extended to VFR traffic departing behind medium weight traffic (in agreement with ICAO regulations).

In light of the observed accuracy of the take-off trajectories of the VFR traffic it might be considered to extend the application of timed separation to any VFR traffic, departing from the grass runway, behind any IFR departure.

#### 6.3.3.2 Collision risk with helicopters

At the airport of Geneva a significant amount of helicopter operations take place. These operations are for the large majority VFR operations (about 4,800 VFR helicopter movements in 2003). Many of these helicopter operations have an ad-hoc character, such as hospital flights, emergency flights, search and rescue, etc.

*Conflicts with traffic on the concrete runway*

As shown in Appendix B the helicopter operations involve a significant amount of take-offs and arrivals in south-easterly direction, directly crossing the concrete runway overhead. Within this operation a potential conflict with traffic that operates simultaneously on the concrete runway can be envisaged. The fact that the helicopter operations have for a large extent an irregular character, inherent to their emergency function, means that planning of helicopter operations is in general not very well possible. It clearly may add to the workload of the Air Traffic Controller (specifically the Tower Controller) to accommodate these operations within a busy IFR traffic environment.

On the other hand, the flying characteristics of helicopters enable flight at very low speed (or even hovering) and very steep climb or descent gradients. This enables ATCOs to hold a helicopter on a specific spot, in order to assure separation from landing or departing air traffic on the concrete runway. Also, by letting cross helicopters directly over the concrete runway, it is prevented that helicopter trajectories to come close to the approach path of landing aircraft on the concrete runway.

From interviews with air traffic controllers and discussion with an experienced, local, helicopter pilot it appears that the helicopter operations are conducted mainly by experienced pilots that are very familiar with the procedures and special operations at the airport. Air traffic controllers indicate that they are in general able to accommodate the helicopter operations without requiring exceptional controller skills or workload, also owing to the special helicopter flight characteristics.
The helicopter pilot indicated that the outside vision from a helicopter is in general much better than that of fixed wing aircraft, and thus enhances the possibilities of spotting other aircraft (and consequently enhances the effectiveness of the see-and-avoid principle).

Further, it has been indicated that other helicopter operations, like training flights and recreational flights, are fairly rare at the airport of Geneva (a few hundreds a year).
Therefore, despite the fact that the helicopter operations have a specialized and ad hoc character, the directly involved pilots and ATCOs appear to be able to safely manage this traffic at the airport.
This is confirmed by the fact that no incidents are known, as far as could be established, involving VFR helicopter operations.

Nevertheless it should be realised that the mentioned VFR helicopter operations do have a special and irregular character. This will remain a source of risk for the operations at the airport. This risk is presently contained by the large experience of the involved persons in this type of operations. However, it is known that such situations may lead to over-confidence or complacency. Therefore, it is considered essential that the safety of the VFR helicopter operations is continuously monitored in order to prevent adverse safety trends to develop, especially as result of increasing traffic volumes or other operational changes.
This shall be an inherent function of the safety management system at the airport.

*Conflict with VFR traffic within the VFR circuit*
Apart from a potential conflict with traffic on the concrete runway, also potential conflicts may arise with light aircraft in the VFR circuit, and helicopters operating north of the airfield (see also appendix B). Since these conflicts may arise between VFR traffic, the ATC responsibility is limited to traffic avoidance advisories. The main principle of separation remains therefore see-and-avoid. It appears that helicopter pilots in general apply also the principle of vertical separation when traversing the VFR circuit, by flying below the circuit altitude.

Based on the fact that no serious incidents are known, as a consequence of mixed helicopter and fixed wing operations within the confines of the VFR circuit, it may be assumed that the risks have been sufficiently contained by the mentioned separation practices.
However, also this operation remains prone to errors of over-confidence and complacency, and therefore shall be an element of continuous monitoring, as part of the safety management system at the airport.

#### 6.3.3.3 Collision risk with VFR traffic crossing overhead

VFR traffic arriving from south-east of the airport, or departing in that direction has to overfly the concrete runway. This may create a potential conflict with traffic approaching to or departing from the concrete runway.
To avoid such conflicts, special procedures are in place (see paragraphs 2.3 and 2.4), that require the VFR traffic to obtain an ATC clearance before crossing the concrete runway, or otherwise fly a holding pattern over specific holding points. Also minimum altitude restriction apply for crossing overhead the concrete runway.
The crossing procedure has been designed to let the VFR traffic cross over the middle of the runway, in order to obtain maximum separation with air traffic on the concrete runway.
As shown in Appendix B, there is quite some spread in the accuracy with which the VFR traffic is crossing the concrete runway. This spread can be explained from the fact the VFR traffic has to navigate based on visual reference points, that can not always be accurately identified, especially within the urban area of Geneva. Nevertheless it is shown that in general crossing traffic will overfly the concrete runway passing between both runway ends, which is considered acceptable from a separation viewpoint

The crossing procedures, as in force at Geneva airport, are very similar to crossing procedures as found on many other airports. As such they are considered as a standard practice that in general will sufficiently assure the safe crossing of VFR traffic.

Main safety risk that can be envisaged is VFR traffic crossing the concrete runway without appropriate clearance. As can be concluded from the incident reports at Geneva airport, unauthorised VFR flights within the CTR are events that do occur with some regularity.
The probability of such events shall evidently be reduced as much as possible.
Because unauthorised flights are mainly caused by VFR pilots insufficiently familiar with the procedures at Geneva airport, measures to raise awareness shall be taken, or additional pilot qualifications shall be imposed.

#### 6.3.3.4 Conclusion

In the previous paragraphs the main collision risk scenarios have been discussed.
In summary the following conclusions are drawn concerning the main collision hazard:

- With respect to simultaneous parallel approaches of VFR and IFR traffic, approaches to runways 05 are considered most critical concerning the probability of significantly reduced separation. It is concluded that current practices and procedures to control collision risk are in line with the current CTR airspace classification (Class D). Since collision avoidance procedures associated with this classification basically relies on see-and-avoid principles, complemented by avoidance advisories from ATC, it may be questioned whether the present airspace classification is still compatible with the intense mixed VFR/IFR operations at Geneva airport. Upgrading the airspace to Class C should be considered, especially in light of anticipated traffic growth.
- With respect to simultaneous parallel departures of VFR and IFR traffic, it is shown that the accuracy of the VFR take-off trajectories is in general insufficient to guarantee lateral separation of VFR and IFR traffic. It is therefore recommended to consider application of timed separation for VFR traffic departing behind any traffic on the concrete runway.
- With respect of the collision risk associated with helicopter operations it has been established that this risk is primarily controlled by “good controllership” and “good airmanship”, based on extensive experience of the persons involved. It is recommended to continuously monitor the helicopter operations, as part of the appropriate safety management systems.
- Collision risk of IFR traffic with VFR traffic crossing overhead the concrete runway is controlled by a set of appropriate ATC procedures and clearances. However, this system will fail in case of communication errors and/or unauthorised airspace intrusions. Because unfamiliarity with local situation and procedures at Geneva airport is regarded as an important factor in the occurrence of communication errors it may be considered to require special authorization, including a check-out on Geneva procedures, for entry into the CTR of Geneva for pilots that are not based at Geneva.

### 6.3.4 Controlled flight into terrain hazard

From the hazard identification process it has been concluded that the main *“controlled flight into terrain (CFIT)”*- hazard to VFR traffic within the confines of the CTR is formed by the forest of Ferney-Voltaire.

#### 6.3.4.1 The Forest of Ferney-Voltaire

This forest is located north-east from the grass runway, on French territory, exactly on the extended centre line of the grass runway. The distance of the trees of this forest to the grass

runway 05 end is only 124m. The maximum height of these trees has been established, during a recent measurement in October 2004, at 24.1m.
It is evident that these trees present a significant obstacle for VFR traffic taking off from grass RWY 05 or landing on grass RWY 23.
In order to ensure sufficient vertical clearance with the trees several measures have been taken. First of all the threshold of grass RWY 23 has been displaced 303m from the beginning of the runway, away from the forest. In addition the nominal slope of the APAPI 23 has been set at a relatively steep angle of 4.15º.
After the recent tree height measurement, it has been determined that, due to the natural growth of the trees, the slope of the mentioned APAPI was insufficient to provide the required vertical clearance with the trees.
To solve this problem, either the threshold 23 should be placed further away from the trees (reducing the available landing runway length with another 64m), or the nominal slope of the APAPI should be increased to 4.5º.

From a safety standpoint both solutions have also negative implications for the VFR operations on the grass runway.
Replacing the threshold will inevitably lead to reduced landing distance on grass RWY 23, which may affect the practical usability of the runway for some VFR traffic. Moreover it would increase the risk of runway overrun.
Increasing the slope of the APAPI will not affect the available landing distance, but will confront the approaching VFR traffic with a rather unusual steep approach angle. A usual slope of the APAPI system is around 3.5º - 4º. Steeper slopes do occur, but a slope of 4.5º is rather rare. In Switzerland the only other airfield using an APAPI system with 4.5º slope is at Ecuvillens.
The consequence of a steep slope of the approach path is that it may increase the risk of unstabilised approaches. Speed and/or path control may be complicated, especially for lightweight, low drag aircraft.

In January 2005 it has been decided by AIG in consultation with FOCA to select the increased slope of the APAPI 23 as the solution to the obstacle clearance problem.
Consequently the location of THR 23 will remain unchanged, as well as the associated available landing distance. The mentioned change in the slope of the APAPI will be combined with a reduced available take-off distance for grass RWY 05 from 520m to 456m, in order to assure sufficient clearance with the trees during take-off. For a grass runway this is relatively short, and may in practice lead to weight restrictions of aircraft using this runway, depending on the present wind, temperature and runway condition (length of grass, softness, etc.).

The described measures are sufficient to comply with the minimum requirements for safety distances and obstacle limitations for ICAO Code 1 non-instrument runways, equipped with an APAPI.
Based on interviews with persons directly involved in this operation, the available safety margins are however regarded to be at the lower limit of what can be considered acceptable from an operational safety viewpoint.
The minimum clearance between the nominal slope of the APAPI and the trees is around 55 ft; at the maximum lower deviation ("2 reds") of the APAPI the margin is only 45 ft.

Especially for pilots, that are insufficiently prepared to operate with minimum safety margins, combined with the added difficulties of the steep approach path, potentially hazardous situations may arise. Also for take-off from grass RWY 05, the reduced available take-off length requires strict attention to take-off performance calculations to establish possible weight restrictions. Such calculations are not always straight forward, because they require the combination of several variables, such as temperature, wind, and runway condition. Moreover, performance manuals are not always fully explicit concerning corrections to be applied for operations on grass runways (see later). Therefore, pilots not fully aware of the effects of operating on grass runways, may easily come to false conclusions concerning actual performance limitations.
It can be envisioned that due to inaccurate calculation of take-off performance pilots may be forced to swerve towards the concrete runway in order to avoid overflying the forest with marginal clearance. This may lead to loss of separation with air traffic on the concrete runway. This particular hazard has been addressed in 6.3.3.1.

#### 6.3.4.2 Conclusion

The forest of Ferney-Voltaire presents a significant obstacle for VFR traffic approaching grass RWY 23, or taking of from grass RWY 05.
Recent adaptations to the slope of the APAPI 23 and the available take-off length of grass RWY 05 assure that the operations from the grass runway are still compliant with minimum obstacle clearance requirements. However, these adaptations are to the expense of added aircraft handling difficulties (speed and path control) during approach, and added performance difficulties during take-off. Pilots need to be fully aware of these added difficulties and need to be well prepared and trained to cope with them. It should therefore be considered to require special instruction to VFR pilots to demonstrate and brief them on the particular safety aspects related to the described operation before allowing them to perform mentioned approaches or take-offs.

Moreover, it should be recognised that the threat to the VFR traffic over time will continue to increase, due to the natural growth of the critical trees. Therefore it is essential that the safety of the VFR operation is actively monitored on a continuous basis. This monitoring should be an inherent element of the safety management system at the airport, in order to safeguard the operation in the future.

#### 6.3.5 Runway incursion hazard

As result of the hazard identification process several runway incursion hazards were established. It should be mentioned here that the CATCH proposal, as accepted by the contractor, specifically excluded addressing the runway incursion hazard as part of the present study. The reason for this was that the runway incursion hazard was considered less relevant for the determination of the compatibility of the mixed VFR/IFR operations. The light aircraft were expected to mainly use the grass runway, and would therefore not add to runway incursion risk, related to mixed VFR/IFR operations.
However, since during the brainstorm process some runway incursion hazards were specifically mentioned to be relevant, these issues will be briefly treated here.
The mentioned issues were:

- Use of the taxiway for the grass runway close to the concrete runway
- The forest of Ferney-Voltaire, shielding approaching traffic to be spotted by traffic at the holding point on the grass runway
- The parking stand on the grass runway and crossing persons

These issues will be briefly addressed in the following paragraph.

##### 6.3.5.1 The use of the grass taxiway

VFR traffic using the grass runway for take-off has to taxi over the grass taxiway to the holding point, before taking-off. For take-off on grass RWY 23, the intended taxiway is quite close (~125m) to the concrete runway centerline, and not very clearly marked. Therefore taxi errors might bring VFR traffic, unintentionally, very close to traffic on the concrete runway. This traffic might initiate avoidance manoeuvres in response, possibly leading to other hazards like runway excursion.

Also it has been mentioned that approaching VFR traffic may wrongly identify the taxiway as the landing runway. This could also lead to collision risk with taxiing traffic.
It was indicated that landings on the taxiway indeed have occurred in the past.
This should therefore be regarded as a serious hazard.

#### 6.3.5.2 The forest of Ferney-Voltaire as an obstacle to traffic visibility.

For take-off from grass RWY 23 a holding point has been defined near the beginning of runway 23.
This holding point is located around 150m from the forest of Ferney-Voltaire. Due to the height of the trees the visual acquisition of approaching traffic over the forest is clearly hampered. The line of sight from this point over the treetops is elevated approximately 7 to 8 degrees, such that approaching traffic can not be spotted by traffic holding for take-off.
This means that approaching traffic has to be spotted earlier during taxiing, and that no communication errors may occur in the process of getting the take-off clearance from ATC.
Any error in this process may lead to a conflict with approaching traffic over the forest.
Pilots must therefore be well instructed that approaching traffic can not be spotted from the holding point 23, and that they must adhere strictly to the take-off clearance procedures.

#### 6.3.5.3 Grass runway parking stand

A grass runway parking stand for visiting single engine aircraft has been defined between the grass runway and the concrete runway near the threshold of grass runway 05.
It can be envisaged that visiting pilots (and passengers) that park their aircraft on the parking stand are tempted to cross the grass runway to reach the general aviation centre directly opposite to the parking stand. The fact that the parking stand and the boundaries of the grass runway are not very clearly marked may contribute to this. Cases are known that persons indeed crossed the active grass runway.
Clearly this may create hazardous situations for both the crossing persons as well as the traffic active on the grass runway.

#### 6.3.5.4 Conclusion

Despite the fact that the runway incursion hazard has been treated only briefly here, it can be concluded that there are particular aspects, related to the actual grass taxiway and runway layout that may contribute to the runway incursion hazard.
Pilots of aircraft that are based at Geneva will probably be well aware of these aspects and will act accordingly to avoid hazardous situations. However, for unfamiliar pilots the specific layout of the runway and taxiway may contribute to the occurrence of potentially hazardous runway incursions.
It may therefore be taken into consideration to require from pilots that are not based at Geneva to receive special instruction or check-out with respect to the airport lay-out and local procedures before allowing them to operate at the airport.

#### 6.3.6 Runway excursion hazard

As outcome of the hazard identification process a number issues have been addressed that may contribute to the risk of runway excursions.
These issues are:

- Displaced threshold grass RWY 23, short available landing distance
- Tailwind
- Reduced braking performance due condition of the grass runway.

##### 6.3.6.1 Displaced threshold of grass RWY 23

Due to the displaced threshold on grass RWY 23, the available landing distance on this runway is substantially less than for approaches in the opposite direction (520m for RWY 23 vs. 636m for RWY 05). The relatively short available landing distance may result in weight restrictions for many VFR aircraft. For instance a typical light aircraft as the Cessna R172K with a take-off weight of 2,550 lbs requires around 1400ft (430m) under no-wind ISA conditions on a paved runway. On a grass runway 40% of the ground roll distance (~265ft or 80m) has to be added. Other factors, such as grass condition and wind (see later) may further affect the safe landing distance. So, for a typical light aircraft the currently available landing distance may be quite critical. A small error in the required performance calculations may therefore lead to runway excursions by overshooting the runway end.

##### 6.3.6.2 The effect of tailwind

Most commercial (FAR/JAR 25 certified) aircraft have been certificated to operate with up to 10 knots tailwind [NLR00-82]. Runway assignment criteria usually allow 5 to 7 kts tailwind before operations are switched over to the opposite direction.
At Geneva airport the grass runway and concrete runway are always used in the same direction. This means that in case of presence of tailwind the VFR traffic on the grass runway is subject to the same tailwind condition as the large commercial airliners on the main runway.
ATC Geneva has not specified a particular tailwind criterion to be used for runway assignment. The informal procedure is to allow 8 to 10 knots tailwind before switching the runway usage to the opposite direction, in case the grass runway is not in use. If the grass runway is in operation 5 knots tailwind is used as criterion for the runway switch. If a VFR aircraft approaching the grass runway would make a missed approach due to tailwind effects, the concrete runway is offered. Apparently, a 5 knot tailwind is allowed for departing aircraft from the grass runway.

For large airliners the effect of moderate (5 – 10 knots) tailwind on landing performance are in general acceptable, and are less relevant in light of the long available landing distance on the main runway. However, for light aircraft operating on the grass runway, any tailwind may

critically affect their landing performance. An increase of 15% of landing distance to account for 2.5 kt tailwind is quite common. The manual of the Cessna 172 [C172man] mentions an increase of 10% of the landing distance for each 2 knots of tailwind.
Therefore, it is concluded that operations on the grass runway with tailwind should be prevented as much as possible in light of the short available grass runway length and the major effect of tailwind on landing and take-off performance.
For this reason it should be considered to apply a zero tailwind criterion for runway assignment purposes when the grass runway is in use, or otherwise restrict the operations on the grass runway under tailwind conditions.
Moreover, it should be considered to formalise the tailwind criteria for runway assignment within the ATC procedure manual, in order to reflect the criticality of tailwind operations.

#### 6.3.6.3 The effect of the grass runway condition

It is known that the properties of the grass can have a significant effect on breaking performance of landing aircraft. Consequently the required safe landing distance may be substantially affected by the sort, length and condition of the grass. Some aircraft manuals (e.g. [SOCTB10]) provide performance corrections to take these conditions into account, discriminating between hard grass, short grass, high grass and wet grass. In mentioned example manual a maximum correction was found of 39% of the rolling distance to account for short, wet grass. Not for all aircraft such corrections have been specified within their associated flight manual. For instance in the manual of the Piper Warrior II [PA-28-161] it is stated that “the effects of soft or grass runway surface on take-off and landing performance are not considered in the performance charts”.
Therefore the actual calculation of aircraft landing performance on a grass runway will comprise substantial uncertainty.

It should be mentioned in this respect that the use of a grass runway has a number of inherent difficulties. Due to the natural growth of grass the condition of the runway will vary over time. Also the runway condition will be sensitive to moisture levels.
Maintaining a grass runway is labour intensive, and has some safety issues attached. Keeping the grass very short will attract birds, and therefore may increase the risk of bird strikes; leaving the grass to grow long will hamper rescue services to control the fire in case of a fire emergency.
So, from a safety standpoint a paved runway has to be preferred largely over a grass runway. Most likely this is the reason that other comparably large airports in Europe have no grass runways in operation anymore (see paragraph 5.2).

These factors combined with the short available runway length on the grass runway, may increase the risk of runway excursions, especially for pilots that are not experienced in this type of operation.
It could be considered to pave the current grass runway for safety reasons, as indicated above. However, it is questionable whether the required investments could be justified based on solving only a limited part of the hazards that have been identified.

#### 6.3.6.4 Conclusion

Several factors have been identified that increase the probability of runway excursions, when landing on the grass runway at Geneva airport. Especially runway 23 has a critically short available landing distance. Moreover, it is shown that calculation of the actual landing distance comprises substantial uncertainty, in particular for grass runway operations.
It is therefore recommended to consider several measures that mitigate the probability of runway excursion. These measures may imply:

- Limiting the landing operation on the grass runway 23 to headwind conditions only;
- Formalise the tailwind criteria for runway assignment purposes;
- Require special instruction or check-out for pilots not based at Geneva for grass runway operations;
- Advise unfamiliar pilots to use the concrete runway 05 in stead of the grass runway 05 for take-off and concrete runway 23 in stead of the grass runway 23 for landing

It may also be considered to pave the grass runway for safety reasons. However, it is felt that the associated investment probably can not be justified based on the fact that only a limited number of the hazards can be solved by this measure.

### 6.3.7 Operational hazards

The hazard identification process has established a number of operational hazards that may affect the safety of the mixed VFR/IFR operations at Geneva airport.
In particular the following hazards have surfaced:

- Unfamiliar pilots (no check-out at Geneva)
- Training flights (first solo at Geneva)
- High ATCO workload during busy periods
- Communication problems

These issues will be addressed in the following section.

#### 6.3.7.1 Unfamiliar pilots

In order to operate to Geneva airport as a VFR pilot no special qualifications are required. The airport is open to any visiting pilot (apart from particular busy periods when VFR traffic may be restricted, see later). Clearly any pilot entering the CTR and flying within controlled airspace has to be familiar with the procedures as laid down in the VFR guide and AIP and follow instructions and clearances by ATC. Other than that, VFR traffic is self responsible for separation with other traffic, based on the general VFR principle of “see-and-avoid”.
There are many airfields that allow VFR traffic in this way. However, the airport of Geneva has some particular characteristics that makes it special in a number of aspects.
These characteristics have been addressed in the previous paragraphs, in particular:

- The high intensity of mixed VFR/IFR operation, including helicopter operations (par. 5.2)
- The operation of two closely spaced parallel runways, one of which is a grass runway
- The presence of a significant obstacle (the forest of Ferney-Voltaire) at the extended centre-line of the grass runway
- The steep angle of the approach path towards grass RWY 23
- The short available take-off (grass RWY 05) and landing distance (grass RWY 23)
- The runway and taxiway lay-out of the grass runway and unclear markings
- Ambiguous visual reference points of the VFR arrival trajectory and VFR circuit
- The lay-out of the VFR circuit

These characteristics will make the airport of Geneva quite challenging for VFR pilots that are visiting the airport, especially when they intend to use the grass runway.
During the brainstorm process and from interviews with ATCOs and local pilots, the issue of unfamiliar pilots that may be insufficiently aware of mentioned characteristics of Geneva airport has been raised consistently as a potential hazard.

Visiting VFR pilots that feel uncomfortable with operation on the grass runway may request to operate from the concrete runway. To do so they need special authorization from Geneva Tower, and in particular cases a PPR (Prior Permission Request) is required. Other than this there are no further measures to regulate or control the VFR traffic to and from the airport.
It is questionable whether this level of freedom granted to visiting VFR traffic is, from a safety standpoint, still compatible with the complexity, and special characteristics, of the airport of Geneva.
Other medium-large international airports have taken measures to discourage VFR traffic, either by high charges, or special restrictions.

In this light it may be considered to require a check-out or instruction flight at Geneva airport for VFR pilots that want to operate to or from the airport. For pilots that are trained at the flight training school at the airport, this familiarisation will be evidently part of their training curriculum.

#### 6.3.7.2 Training flights

The airport of Geneva is the home base of one of the largest aeroclubs in Switzerland.
The Aéroclub de Genève operates in total 17 light aircraft and a single helicopter.
As part of their activities the aeroclub offers pilot training courses. An important part of these training courses concerns flight instruction.
On a yearly basis the number VFR training flights form a substantial part of the total VFR traffic. In 2003 4,196 training movements (take-off or landing) were conducted out of a total of 9,797 VFR traffic movements on the grass runway.
With respect to the training flights there are only a few restrictions. For instance training flights are not allowed on Sundays. In co-ordination with ATC Geneva training flights are scheduled such that they are minimised during peak IFR traffic periods. During specific, busy weekends, ATC will not allow training flights at the airport altogether.

In general, the training flights are perceived to be performed in a very professional manner, due to the well experienced flight instructors of the aeroclub, two of which are employed on a full-time basis. These instructors are intimately familiar with the special characteristics of the airport, and do transfer this knowledge during the instruction flights to the student pilots.
Therefore, despite the relatively high volume of VFR training flights at Geneva airport, the potential hazards involved in these flights, including potential interference with IFR traffic, are expected not to be more severe than for regular VFR flights.

However, there is one particular aspect of the training curriculum that appears less compatible.
Initial flight instruction is aimed to prepare student pilots to perform their first solo flight.
It should be realised however that the flying skills of students performing their first solo flight are still at an elementary level. A first flight will usually be accompanied with a high stress level, resulting from having full responsibility for the flight for the first time. Therefore it may be questioned, whether a first solo flight should be burdened by added complexities, such as the special characteristics of the airport. The fact that student pilots have received their training at Geneva, is considered not to be fully sufficient to let them be exposed safely to the complexities of the airport and the stress of the first flight at the same time.

Taking into account that an accident during a first solo flight at Geneva airport has already occurred in the recent past (see paragraph 5.3), it should be considered to not allow student pilots to perform their first solo flight from Geneva.

#### 6.3.7.3 High ATCO workload

In general the complexity of the tasks of air traffic controllers, and in particular Tower Controllers, is a condition for creating a high workload and high stress level. A recent study of the FAA [FAATN03/14] has investigated the complexity of tasks in Air Traffic Control Towers, and has identified the governing complexity factors, based on interviews with (62) Air Traffic Control Tower specialists.
In this study a number of factors have been identified that are of particular relevance for the level of complexity at Geneva airport. These factors are (with their importance ranking in brackets) *"High traffic volume (1)"*, *"Frequency Congestion (3)"*, *"Aircraft differing in performance characteristics (4)"*, *"Wake turbulence (8)"*, *"Unfamiliar pilots (12)"*, and *"Pilots weak mastery of English language (15)"*. Based on these factors, the task of the Tower Controllers at Geneva airport is considered to be fairly complex, and therefore involves high workload conditions.

Interviews with local air traffic controllers indicate that the workload of Approach and Tower controllers at Geneva is considered in general as acceptable. It is acknowledged that the presence of VFR traffic and the mixed VFR/IFR operation adds to the workload of the ATCO. Some ATCO's perceive this additional workload as a challenge, adding to their job satisfaction. However, this feeling is not shared by all ATCO's. The additional workload can reach a level that is unacceptable from a safety viewpoint. Incidents are known, where high ATCO workload has lead to sub-optimal or even insufficient communication, such as for instance by "forgetting" a landing clearance for a VFR aircraft on final approach, leading to an undue missed approach. Also high workload may negatively affect the capability of the ATCOs to provide sufficient traffic information and traffic avoidance advisories to VFR traffic, which is an essential task of ATC within Class D airspace.

To some extent the potential hazards, resulting from excessive ATCO workload, have been recognised by ATC Geneva. It has been established that excessive workload occurs particularly during specific periods of the year, when high VFR traffic volumes are to be expected. These periods are the weekends of the Car Show at Geneva, the Easter and Whit Monday, and the Sunday after Ascension Day.
In order to avoid ATCO overload special measures have been taken during these periods.

The main measure concerns opening a second controller position. This additional controller is tasked to either control the VFR traffic outside the CTR and assure a regulated traffic flow into the CTR, or control specifically all the traffic to the grass runway. For this purpose a special radio frequency has been assigned, such that radio communication does not interfere with the other air traffic communications.
This measure has been formally laid down in the GVA ATC procedure manual (Amendment 23, “Organisation par fort traffic”).

As such this might be perceived as evidence that the safety management process has been effective in this case; the potential hazard has been identified, measures to mitigate the hazard have been devised, implemented and formally laid down within the procedure manual. However, for effective management of safety, it is necessary to ensure that the measures taken to mitigate a hazard are sufficient to render the residual risks as negligible, or at least tolerable. Whether or not the measures taken are sufficient to prevent ATCO overload in all cases can not be judged within the present study. No evidence was seen either of a suitable performance criterion in relation to stress mitigation or of a documented and implemented system to measure whether the actual mitigation meets suitable criteria. Furthermore, anecdotal evidence of potentially impairing stress levels in Geneva Tower at times of peak traffic was cited by the AIG Fire Service; these senior personnel are professionally trained to recognise adverse stress levels, such as might create “tunnel vision”, from evidence including voice tone in radio communications. It is therefore possible that excessive stress is not fully managed.

The fact that measures have been taken to prevent excessive workload during certain periods means that if traffic volumes would increase further, also the periods of effectiveness of these measures would have to be extended accordingly.
For this reason it is imperative that the safety management system of ATC Geneva continuously monitors whether the measures taken are – and can remain – sufficient or have to be adapted to changing circumstances.

#### 6.3.7.4 Communication problems

As outcome of the brainstorm process communication problems were clearly identified as a significant hazard to the mixed VFR/IFR operations at Geneva airport.
Also the analysis of accidents and incidents, both world-wide and in Switzerland, has shown that communication problems are an important factor (see paragraph 5.3), specifically in relation to mixed VFR/IFR traffic.

It appears that communication problems are a quite universal problem. A recent study of NLR [NLR04-19] has inventoried communication problems, based on occurrence reports of airlines and air navigation service providers with Europe.
The study has identified many factors contributing to communication problems. Often cited as contributing to communication problems are language problems and using non-standard phraseology. These issues are of particular interest for the situation at Geneva airport.

Because both French and English are official ICAO languages, communication with ATC may officially be conducted in both languages. Since in the area of Geneva French is the official language, it can be expected that communication between VFR traffic and ATC will be mostly conducted in French. At the same time communication with IFR traffic will be mostly in English. Such mixed language communications in a mixed VFR/IFR traffic environment are not considered to be optimal from a safety standpoint.
This issue has also been addressed in a recent article in a skyguide publication ("*Tension between air traffic control and VFR aviation in Switzerland*", [SKYMAG]). A VFR-pilot representative has specifically stated that the uniform use of English in dealings with ATC would be ideal for safety reasons.
The feasibility of introduction of a single language for communication with ATC is currently investigated by the various stakeholders. However until such protocol is realised, the language issue will remain a factor that adds to the complexity of the operations at Geneva.

#### 6.3.7.5 Conclusion

A number of operational problems have been identified that are specifically related to Geneva airport and the mixed VFR/IFR operations.
Based on the observations in this section, it is concluded that the following measures should be taken into consideration:

- to require a check-out or instruction flight at Geneva airport for VFR pilots, that want to operate to or from the airport;
- to discontinue the current practice that allows student pilots to perform their first solo flight from Geneva;
- to structurally monitor the stress level of air traffic controllers involved in controlling mixed VFR/IFR traffic, as integral part of the safety management system;
- to encourage the use of English as the standard for communicating with ATC, and the use of standard phraseology.

# 7 Safety management at Geneva

## 7.1 Introduction

Safety is a vital business function. Lack of safety leads to unplanned losses and can be disastrous. Safety management is the process of steering this vital function within the organisation, its people and its technologies so that the hazards inherent in its activities are kept under control. Effective safety management, like the management of finance or of quality, therefore requires to be based on systematic, robust and resilient processes, which include appropriate checks and balances to ensure that the desired outcomes are achieved.

Safety management starts with a systematic identification of potential hazards. These hazards are developed into potential accident scenarios, which are used to identify measures that can be taken to prevent the accidents or to mitigate the consequences. A target level of safety is defined within the organisation's policy (or by a regulator), and actual safety performance is continuously monitored and compared with the target. If necessary, safety improvement measures are taken. Basically, this is the well-known plan-do-check-act Deming Cycle for effective management of quality.

Effective safety management therefore involves far more than the following of rules and adherence to historically "good practices". It requires an understanding of the system and the way that all its components interact, in order to apply suitable and sufficient influences that will control the behaviour and outputs from the system. It also requires a capability to detect emergent problems, often involving subtle changes in historically safe ways of acting, that may lead to unexpected and dangerous situations. In complex systems such as the aviation sector, multiple organisations are involved in the achievement of safety, but the outcome is vulnerable to the weakest link in the "supply chain" for safety.

Safety management, therefore, can be defined as *the systematic management of all activities to secure an acceptable level of safety* [REACH report, p33]. Safety management has two dimensions:

1. the safety management **process:** addressing the sequences of linked activities that have to be carried out to control the level of safety;
2. the safety management **organisation**: defining responsibilities, competence, commitment and communication of the involved organisations or persons.

A **safety management system** includes both of these vital dimensions. It sets out an organisation's safety policy, and defines the structure and practices by which the organisation manages safety as an integral part of its overall business. The design and maintenance of the safety management system is an explicit component of the corporate management responsibility. An effective safety management system ensures a formalised, explicit and pro-active approach to systematic management of safety, and therefore to ensuring freedom from unacceptable risk of harm. Just like in the plan-do-check-act cycle for quality management, this involves the concept of continuous improvement of safety, and safety improvement action programmes in partnership with all members of the supply chain.

### 7.2 Regulatory framework for safety management

The lead partners in the management of safety of operations at Geneva International Airport are AIG and skyguide. The airport (AIG) and the ATM service provider (skyguide) are currently regulated for safety management under different frameworks, although there is international recognition of the need for convergence and coherency in these frameworks. The regulatory framework is driven by international standards, as defined by ICAO in [Annex11] for Air Traffic Services and [Annex14] for Aerodromes. ICAO members States, such as Switzerland, are required to implement this framework.
Specific guidelines for the implementation of Safety Management Systems are provided in [Doc4444, Chapter 2] and [Doc9774, Part 5].

Noteworthy are the following deadlines for meeting safety management requirements, as specified in the respective Annexes.

In [Annex 11]:

> ***2.26 ATS safety management***
> *2.26.1 States shall implement systematic and appropriate ATS safety management programmes to ensure that safety is maintained in the provision of ATS within airspaces and at aerodromes.*
> *2.26.2 As of **27 November 2003**, the acceptable level of safety and safety objectives applicable to the provision of ATS within airspaces and at aerodromes shall be established by the State or States concerned. When applicable, safety levels and safety objectives shall be established on the basis of regional air navigation agreements.*

In [Annex 14, ammendment 4]:

> *1.3.1 As of **27 November 2003,** States shall certify aerodromes used for international operations in accordance with the specifications contained in this Annex as well as other relevant ICAO specifications through an appropriate regulatory framework.*

*1.3.4* ***Recommendation****.— A certified aerodrome should have in operation a safety management system.*
*1.3.6 As of* ***24 November 2005****, a certified aerodrome shall have in operation a safety management system.*

An additional part of the regulatory framework, which is applicable to European air traffic service providers, is formed by the Eurocontrol Safety Regulatory Requirements (ESARR). Switzerland is a member of Eurocontrol, and as such is bound by decisions taken under either the Eurocontrol Convention, and consequently has to implement and enforce within its legal order the safety regulatory requirements.

In the context of safety management [ESARR2] (*ATM occurrence reporting*), [ESARR3] (*use of safety management systems by ATM service providers*) and [ESARR4] (*Risk assessment and mitigation in ATM*) are most relevant. Especially [ESARR3] provides a general framework for effective safety management by ATM service providers. [ESARR3] requires all providers of ATM services to have established an SMS and put it into effect by 16 July 2003.

### 7.3 Safety management principles

Effective management involves agreeing objectives, defining a plan to achieve those objectives, formulating sets of detailed work activities (with performance criteria) to implement the plan, checking outcomes against the plan, and then planning and taking appropriate corrective action. Safety management, as a subset of general management, is no different. The core elements of an effective Safety Management System are listed in Table 7-1, and are mapped against the ESARR3 requirements in Figure 7-1. In principle, there are many ways of structuring the vital components of safety management systems, but Figure 7-1 suggests that, although many of the components are equivalent, the particular structure recommended under ESARR3 does not fit with sufficient clarity and simplicity into the plan-do-check-act approach to management of quality.

*Table 7-1* Core Elements of a Safety Management System

| **Element** | **Summary Description** |
|---|---|
| Policy | An effective safety policy sets a clear direction for the organisation to follow. |
| Organising | An effective management structure and arrangements are in place for delivering the policy. |

| | |
|---|---|
| Assessing Risk | All hazards are systematically identified, all necessary risk control measures are in place, and the control measures are sufficiently effective to meet necessary performance standards such that residual risks are tolerable when compared against appropriate risk criteria. |
| Planning & Implementing | There is a planned and systematic approach to implementing the safety policy through an effective safety management system. |
| Measuring Performance | Performance is measured against agreed standards (such as a Target Level of Safety) to reveal when and where improvement is necessary. |
| Auditing, Reviewing and Improving Performance | The organisation learns from all relevant experience (internal and external) and applies the lessons. |

These elements are a combination of (1) management arrangements, (2) systems, which determine how particular risks are to be controlled – risk control systems – and (3) workplace precautions. This three-component model is illustrated in Figure 7-2.

The plan-do-check-act cycle (see Figure 7-1) requires decision making by responsible persons, such as the management team, based on the results of the “checking” activity before the “doing” stage, which comprises the implementation of change. This decision making about the need for – and nature of – safety improvement actions (including cessation of unacceptably risky operations) is based on two parallel processes, both of which are vital in an effective safety management system [REACH, p34-35]:

- the safety monitoring process, in case the current level of safety is perceived not to be in conformance with the desired standard and therefore require corrective actions, and/or
- the risk assessment process, in case risks associated with potential threats to aviation safety are considered unacceptable and therefore require risk mitigating actions.

**Safety monitoring** is the process of assessing the current level of safety of the aviation system. This process may involve monitoring incidents, safety occurrences or other safety performance indicators. It certainly incorporates the investigation of accidents and major incidents as the most evident symptoms of safety deficiencies in the current system.

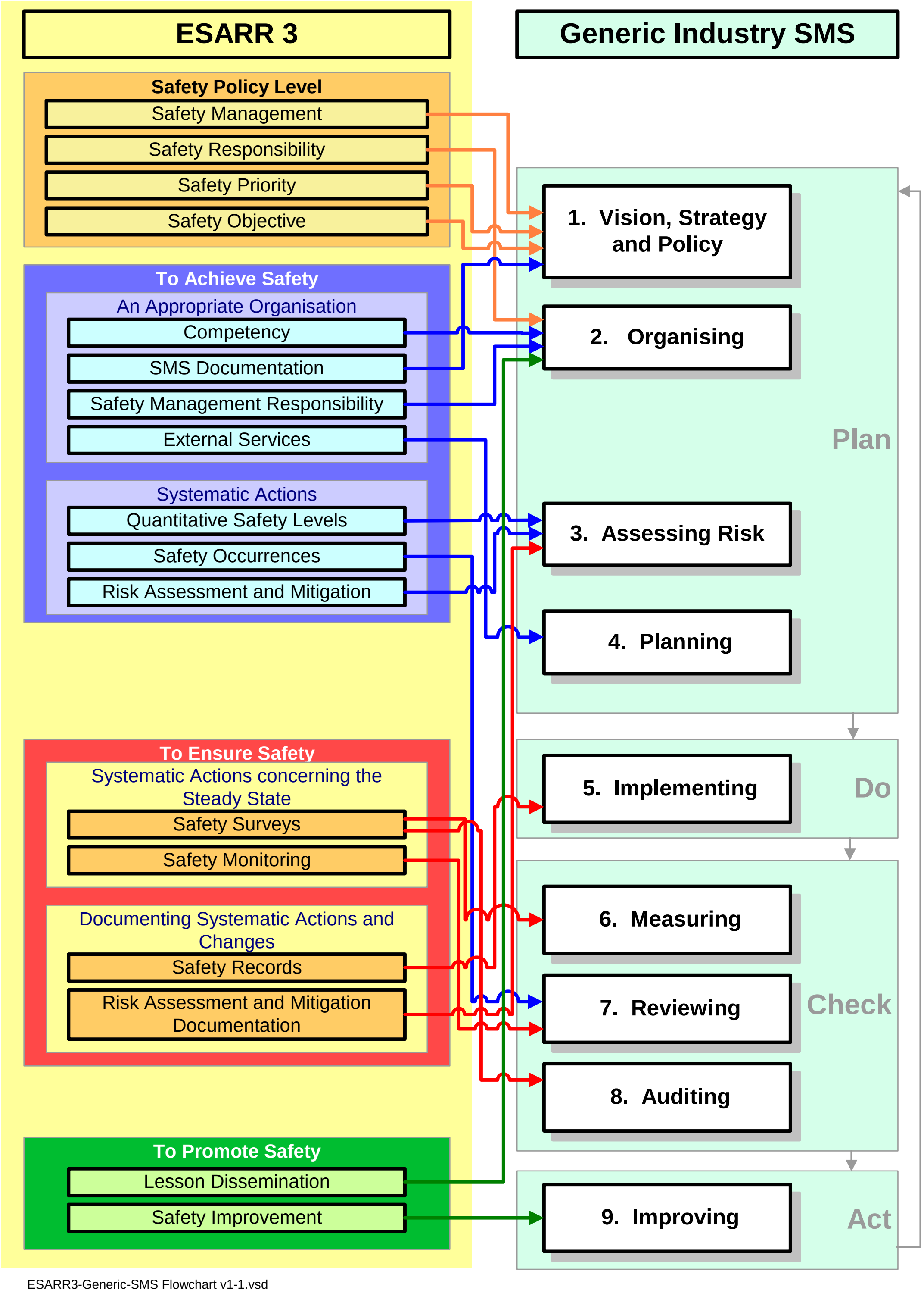


*Figure 7-1 Mapping of ESARR 3 Components onto a Generic SMS*

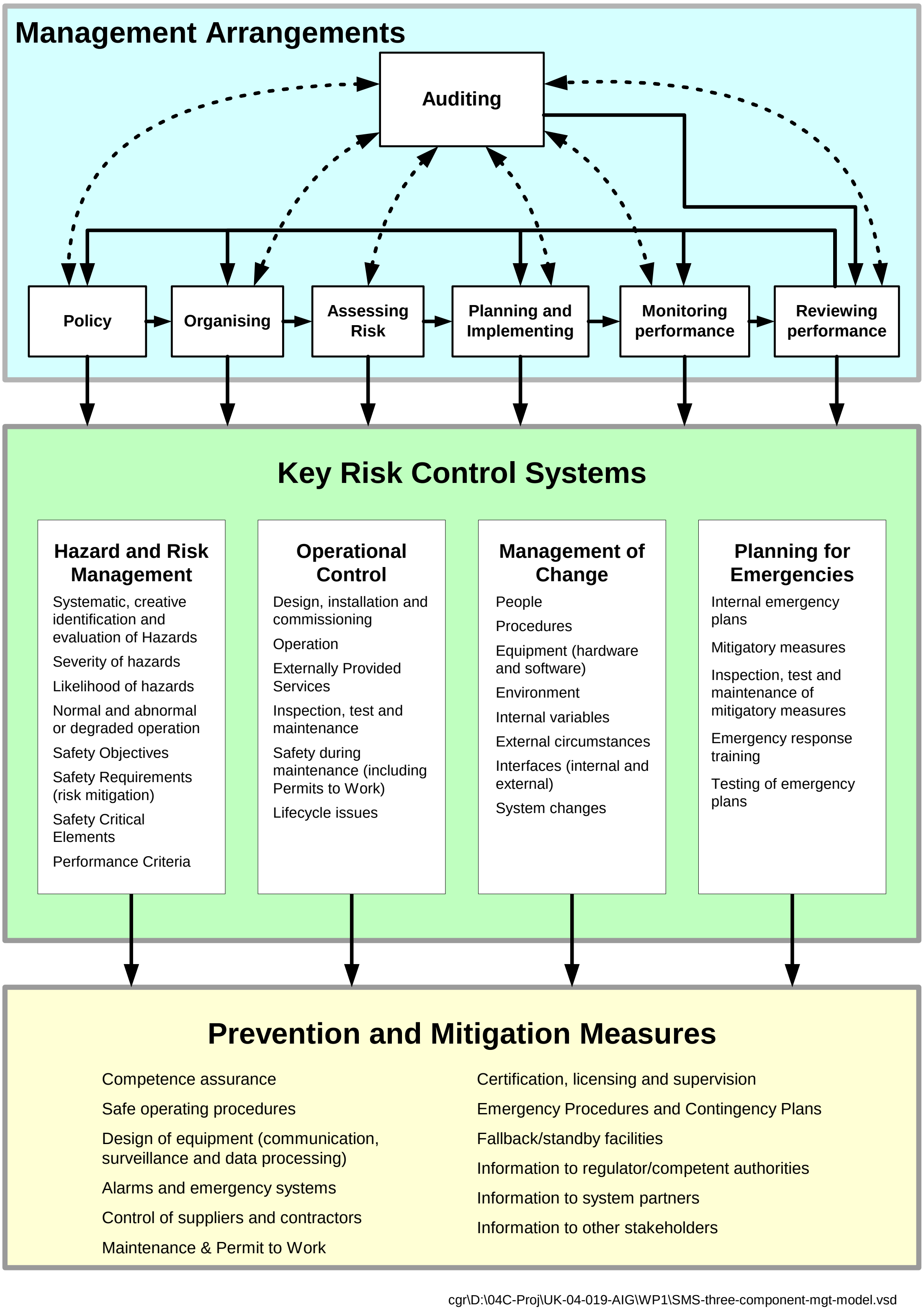


*Figure 7-2 Components of Effective Safety Management Systems*

**Risk assessment** is the process of assessing the risk (ie the combination of probability and severity of consequences) associated with potential safety threats and, if required, definition of proposed risk mitigating measures to be taken, together with standards (ie performance criteria) which the risk mitigation measures must achieve.

Safety monitoring is basically reactive to what has been experienced and to prevent its recurrence, whereas risk assessment seeks pro-actively to protect against threats that might emerge. Without safety monitoring, the hard-won lessons of history are not learned; and without risk assessment, the system is vulnerable to threats that have not yet materialised to cause harm. These potential safety threats can be of varying nature, such as technical developments (eg introduction of new, complex equipment), economic conditions (eg financial problems arising from an economic downturn), environmental pressures (eg introduction of noise abatement procedures), operational or procedural changes (eg introduction of new separation standards).

Both safety monitoring and risk assessment are vital to achieve effective safety management.

## 7.4 Safety management at Geneva

The scope of the CATCH project includes an evaluation of the safety management procedures, both at AIG and Skyguide, as far as relevant for the operation under investigation. It was beyond the scope of the project to audit the safety management procedures, and therefore the evaluation is based on limited interviews with local personnel. The output of this evaluation therefore has the status of perceptions and observations gained from the interviews. These perceptions and observations of the project team are listed below, for skyguide and AIG respectively. There may consequently be differences between these perceptions/observations and the wider management intents, but the relevant issue is how safety and risk management are perceived and implemented at the local work-faces in Geneva.

### 7.4.1 Perceptions of Skyguide Geneva Safety Management

*Safety promotion.*

Operational staff at skyguide in Geneva have seen much effort devoted to safety since the Überlingen crash. The message that safety is everyone's business within skyguide is being energetically pushed through the organisation.

*Policy and organisation.*

Effort has been devoted particularly to policy and to re-organising. Many new organograms have been circulated, to the extent that the safety management system is in danger of being misunderstood as the collection of organograms describing the safety roles that staff have been allocated. Organising and resourcing is only one of the seven elements of the management arrangements shown in *Figure 7-2 Components of Effective Safety Management Systems*, and management arrangements comprise only one of three main components of a full safety management system.

*Lesson dissemination.*
At the operational level, the focus is on monitoring incidents and learning from them. Pro-active risk management is seen as the role of a specialist group within skyguide, rather than as everyone's duty. Hazards are identified principally as a result of occurrences (something going wrong). Safety is seen as the absence of hazardous occurrences. There is a belief in the need to report such occurrences fully and openly, and to participate in analysing them to prevent recurrence.

*Risk control measures.*
When a hazard has been identified and a risk control measure is introduced, the effectiveness of that control measure is monitored by the absence of further hazardous occurrences. The reality does not appear to be widely appreciated that each risk control barrier is usually "semi-permeable", rather than 100% effective, and that quantitative performance criteria need to be set wisely to monitor for pre-cursors of hazardous occurrences. This appears to be a particular vulnerability of the reactive system as currently deployed, and is equivalent to assuming that hazard control measures are totally effective until recorded occurrences prove otherwise. If skyguide is indeed pro-actively managing risk at a more strategic level, then this is not yet sufficiently visible at the operational level to be of assured practical benefit.

*Perceived strengths*.
What is good is that more effort and more priority have been very visibly assigned to safety, and at an operational level there is a belief in the commitment by top management. The process of learning from incidents has been formalised within the safety management system, and is energised. There is clear evidence of a systematically designed safety management system being introduced from a strategic level.

*Perceived improvement needs.*
Implementation of modern safety management principles is significantly incomplete. The focus on organograms indicates an immature system, still being rolled-out, and not yet fully developed. Furthermore, it was commented to the project team that the mental model is still in transition, and this appears to be a particularly insightful comment. The focus on reactivity to

occurrences that have happened, with much less attention to pro-activity to predict what might happen (but has not yet happened) suggests that the organisation as a whole has not yet adopted modern pro-active practices. Such practices would first include identifying hazards both from experience and from predictive processes that are systematic and creative; then they would involve putting in place suitable and sufficient risk control measures with detailed and quantitative performance criteria that are monitored to give early warning whenever the risks in reality may not have been reduced to tolerable levels as robustly as has been predicted. It is not obvious whether the safety management system will soon have all these required components in place, especially since the concentration on prevention of recurrence of past occurrences appears to be wholly compatible with the emphasis in the skyguide Safety Policy. The current Safety Policy may have to be extended to facilitate such a vital transition to pro-active management of risk, and to help skyguide to become compliant with the requirements of ESARR3 for safety management systems and with ESARR4 for risk assessment and mitigation.

### 7.4.2 Perceptions of AIG Safety Management

*Safety management system.*
In 2003 the REACH study concluded [REACH, p149]:
*"Geneva airport has not yet implemented a formal safety management system, as recommended by ICAO Annex 14 standards. Therefore, most elements of a proper safety management system cannot be readily identified. There is no clear safety policy, the function of safety manager is not recognized within the organisation, and it is not clearly defined who is the accountable manager for safety within the organisation."*

From an interview with AIG's Chief Fire Officer, as the assigned safety officer, the impression is gained that the situation has not greatly changed since then.
Presently, as part of the on-going national initiative to certify all commercial airports within Switzerland, as required by the ICAO regulations, the aerodrome certification process has been initiated. However, progress appears to be relatively slow and resulting processes have not yet been clearly defined and embedded within formal procedures at the airport.

The REACH study also concluded that *"safety management within Geneva has a somewhat ad-hoc character, and mainly depends on the individual safety culture and safety practices within the operational department".*
The present investigation has confirmed and further strengthened this conclusion by establishing that the "*individual safety culture and safety practices*" – ad-hoc as they may be– are of very

high standard based on a high level of safety consciousness and professional skills of the directly involved personnel.

Quality management system.

AIG has a very beneficial precursor of an SMS in having implemented a formal quality management system that is certificated under the ISO 9001:2000 standard. A key feature of this standard is that it requires an organisation to plan and control its business through a formal systems approach and management of the business processes. The business processes for quality management are in many ways analogous to those for safety management, so AIG should be well placed to introduce formal control of safety management processes in the near future. However, ISO 9001 does not specifically require the proactive management of emergent threats or risks, although it could be argued that the principle is accommodated.

*Hazard identification and risk management.*

Although safety management has not been formally embedded within AIG's organisation, essential elements of safety management related to hazard identification and risk assessment are exercised within the organisation, based on a general understanding of risk management by the directly involved personnel. AIG's Chief Fire Officer as the assigned safety officer provided an illustrative example of a pro-active approach in December 2004. This concerned the problem of finding a balanced criterion for maintaining the grass runway in terms of an acceptable length of the grass. Very short grass would attract birds and increase the risk of bird strikes, while long grass would provide problems with fire extinguishing in case of a fire emergency. The following quote illustrates, in terms of safety management, a professional approach to this dilemma: "*We are trying to manage the bird population to control the risk of bird strikes, and we left the grass to grow very long, but I was concerned about our ability to put effective foam blankets onto long grass after an aircraft crash. We needed to get a solution to balance the interests, so we did some investigations, both practical and seeking the best advice available, eg from publications, from a specialist across the world, including at the UK CAA. We explored scenarios for grass cutting once, twice and three times per year, gathered and analysed information to check our approach was right, and made decisions. This was the first demonstration of working closely together on Safety Risk Management, including the skyguide TWR Chief who contributed statistics for bird strikes and general help overall*"

*Perceived strengths*.

What is good is the existing ISO 9001 certificated system for quality management and the fact that the certification of the safety management system is prioritised and planned by AIG for early 2006. Examples were evidenced of pro-active programmes to identify specials hazards (bird strikes and response to electrical hazards following a potential aircraft crash among the landing lights at a runway end), to investigate these hazards thoroughly, to explore potential risk control measures, and to implement the most effective of such measures including the use of performance standards, albeit that such use is not yet formalised. There is clear evidence of effective leadership and commitment to safety, as well as a demonstrated willingness to collaborate proactively with sector partners such as skyguide and the Aeroclub, at least within those business units of AIG consulted.

*Perceived improvement needs.*
Implementation of a safety management system is not yet commenced. Probably because of this major gap, the identification of hazards and the control of risks are neither systematic nor comprehensive. It is possible that the reported multiple cultures within various business units at AIG may inhibit the effective implementation of a positive safety culture throughout AIG. The key requirement is to move forward diligently and energetically with the planning and introduction of the formal safety management system, building upon the commitment to the ISO 9001 system, and extending throughout AIG the integrated adoption of safety monitoring (reactivity) and risk assessment (pro-activity).

### 7.5 Conclusion
Overall, safety management at Geneva has too many elements that are either incomplete or insufficiently formalised to give confidence in the systematic achievement of safety throughout the interdependent operations. Such missing or informal elements are not in compliance with the current safety management regulatory framework, as specified by [ESARR3], [Annex11] and [Annex 14].

The picture that emerges of the respective safety management systems (current and imminent) within skyguide and AIG is one of significant mis-match at present. Attempts to manage safety formally across such interfaces will therefore be inevitably challenging, but the continuing safety of the mixed VFR/IFR operations (and of all other inter-dependent operations) will become increasingly dependent on success in managing such interfaces.

The current mis-match might provide an opportunity for collaboration, as skyguide has strengths in some of the areas that AIG is weak, and vice-versa. Both organisations will need substantial (further) efforts to deploy effective and complete safety management systems. Comments from both parties suggest that circumstances might exist now to energise such collaboration successfully, with suitable leadership commitment.

# 8 Future projections

The previous chapters have described the mixed VFR/IFR operations at Geneva airport, the applicable regulatory framework, and the hazards that are associated with these operations.
This is all based on the present situation at Geneva airport. Within the current chapter it is assessed how future developments may affect the operations at Geneva airport, and in particular the safety of these operations.
For this it has to be determined what kind of changes are envisaged that might affect the operations at Geneva airport in the near (2010) and far (2020) future.
Categories of changes that can be envisaged are the following:

- Changes in traffic volume
- Changes in operational characteristics
- Technological changes
- Changes in applicable regulations

The possible effects of these changes are addressed in the following paragraphs.

## 8.1 Changes in traffic volume

*Near term*

Based on predictions provided by AIG, the airport anticipates moderate growth of the scheduled movements within the timeframe 2010. An increase from 111,000 movements in 2003 to around 133,000 (±1,500) in 2010 are foreseen. This represents an average yearly growth of the scheduled traffic volume of around 2.7%.
It is anticipated that all other traffic (general aviation, helicopter, VFR traffic) remains basically unchanged from the situation in 2003.
Therefore the total traffic volume at Geneva airport is anticipated to grow from around 164,000 movements in 2003 to 186,000 movements in 2010. The total volume is therefore expected to increase on average 1.8% yearly.
These growth figures are for the near term fairly modest, taking into account the fact that in general around 5% growth of aircraft movements is predicted within Europe for the near future.

Despite the fact that near term growth figures are characterised as modest, it does not necessarily mean that risk levels would increase in an equally modest way.
The anticipated traffic growth will have to be accommodated completely on the single concrete runway of Geneva. Because the runway, at certain peak periods, is already used at maximum capacity the growth will extend the peak periods and fill the off-peak periods. Since the grass runway operations are preferably conducted at off-peak periods, in order to reduce interference

with the IFR traffic, the risk exposure may increase disproportional with the overall growth of the overall traffic volume. It can be estimated that the traffic during off-peak periods will increase with 30% or more within the mentioned timeframe, depending on the daily traffic distribution.
Therefore, a significant increase in risk exposure can be expected, despite the modest overall traffic growth. Clearly the increased risk exposure has to be controlled in the future by specific measures to maintain the safety level at an acceptable level. These measures will have to extend beyond the measures that are given in consideration in this report in order to assure the acceptability of current the risk level.
What these measures could be is hard to indicate at present. Technological improvements can be envisioned that reduce for instance collision risk by means of more advanced collision avoidance systems, and associated datalink technology. These benefits have as yet still to mature, and it is questionable whether such technology would become cost-effective for light aircraft mainly flying under VFR. In absence of such technological improvements, most likely procedural solutions have to be found to contain the risk level of the mixed VFR/IFR traffic. This may lead to further restrictions to the VFR traffic on the grass runway.

*Far term*
In the far term (2020) the number of scheduled movements at Geneva airport is estimated to grow to 142,400 (±5,000). Based on the expected volume in 2010, this represents a low growth figure of on average 0.7% yearly in the timeframe from 2010 – 2020.
Also within this timeframe no growth of the other traffic is anticipated, such that the total volume of air traffic in 2020 is expected to be nominally around 195,500 movements.
The total volume of traffic is therefore expected to grow in the timeframe 2010 – 2020, on average with 0.5% yearly.
Again, because traffic growth will have to be accommodated by further filling of the gaps between subsequent traffic peaks, it can be expected that the risk level of the mixed VFR/IFR operations will further increase disproportional. To achieve the predicted volume of traffic in 2020 the main runway at Geneva would have to accommodate around 27 movements per hour, based on 365 day/year and 18 hour/day continuous availability of the runway. This means that there would be hardly any off-peak periods anymore, and the main runway would have to be used almost continuously at its full capacity.
It should be remembered that departing traffic operating from the grass runway would have to apply 3 minutes timed separation from departing (medium/heavy) traffic from the main runway for wake turbulence reasons. It may be expected that the fraction of medium and heavy aircraft of the total traffic volume will also increase substantially within the 2020 timeframe. Clearly,

combined this would lead to a situation that the grass runway would be effectively almost unusable in practice.
There are only a few technological developments that could enable the continued operations from the grass runway. Such technology would have to be able to predict and monitor the wake turbulence hazards, in order to be able to allow shorter traffic separation times. Such technology is currently in the initial research & development phase [ATCWAKE]. However, it is presently unclear if such developments will lead to feasible and cost-effective products. In any case, if this technology would materialise, the airport of Geneva would face substantial investments to enable VFR traffic operations from the grass runway.

### 8.2 Changes in operational characteristics

Changes in operational characteristics, such as arrival & approach procedures, runway lay-out, etc., may affect the prospects of mixed VFR/IFR operations in the near or far future.
As far as presently is envisaged there are however no changes planned that might significantly affect the operational characteristics. Due to the current location of the airport there appears no room for changes to the runway lay-out, such as adding a second main runway, or increase the lateral separation between the grass and concrete runway. Also there appears to be limited room for procedural changes to improve the compatibility of the mixed VFR/IFR traffic, especially in the light of the recent changes to the TMA (effective as of March 2003). These changes were implemented to optimise the safety of the mixed VFR/IFR traffic around the airport.
Therefore, it is concluded that the operational characteristics of the airport will remain basically unchanged in the near and far future, and therefore will not affect the compatibility of the mixed VFR/IFR traffic in the foreseeable future.

### 8.3 Technological changes

Technological developments may potentially affect the safety of the mixed VFR/IFR traffic in the future. These developments might have either positive or negative effects.

Potential positive effects may be expected from, for instance, wake vortex detection and warning systems that are currently in the research and development phase [ATCWAKE]. Also it may be envisioned that technology using accurate navigation equipment based on satellite navigation, coupled with collision and terrain avoidance systems comes within the realm of general aviation. Such technology could reduce or negate the limitations of the current basis VFR separation principle of “see-and-avoid”, and as such reduce (near-) collision risk.
The effectiveness of such technologies in future applications is however hard to predict.

Within the given timeframe this technology, if it would materialise, should be most likely regarded as an additional safety net, but is not expected to affect the actual compatibility of mixed VFR/IFR traffic substantially.

Technological changes with a negative effect could be the growing size of the airliners that might operate at Geneva airport. Larger aircraft will cause increased wake turbulence hazards. Also the increased size may reduce actual separation, and therefore increase collision risk.
It is not yet clear whether new large aircraft, such as the Airbus A380, will operate at Geneva airport in the foreseeable future. However, it would introduce additional safety issues affecting the compatibility between the VFR/IFR traffic mix. It should be noted that the half spanwidth of such an aircraft would seize 16% of the lateral separation distance between the grass and concrete runway.

To conclude, the effects of potential technological changes that might affect the safety and compatibility of mixed VFR/IFR traffic in the foreseeable future remain uncertain. Positive as well as negative effects can be identified. Therefore, the overall effect is considered to be neutral.

## 8.4 Changes in applicable regulations

The present assessment of the safety and compatibility of mixed VFR/IFR operations has been based on the currently applicable rules and regulations, as defined by ICAO (see chapter 1).
It can be envisioned however that the regulatory framework could change in the future to reflect operational or technological developments.
It is known that current regulations relevant to mixed VFR/IFR operations are not considered to be fully appropriate to completely assure the required safety level.
Within the ICAO Air Traffic Services Planning Manual [Doc9426] the following statement has been made that specifically address the current shortcomings of the regulations:
"*A number of States, handling a considerable number of aircraft operations with a large mixture of IFR and VFR flights and which experience a wide variety of weather conditions, have found it necessary to introduce provisions supplementary to those of ICAO in order to restore an appropriate level of safety in their areas. As existing ICAO provisions give little guidance in this respect, the specific national provisions, developed individually to cater for specific circumstances, tend to vary from State to State, thus creating difficulties for pilots engaged in international VFR operations.*"

Therefore, it could be envisaged that ICAO will take steps to amend the current rulemaking, such that safety assurance is not left to individual safety actions that may vary per state.

However, rulemaking within ICAO is a slow and tedious process, and currently there are, as far as could be established, no on-going initiatives to change the relevant regulatory framework. If such initiatives would be taken in the near future, it would still take a substantial period of time before this new rulemaking would become effective.

Moreover, it is expected that new rulemaking would not extend significantly beyond the measures that are already given into consideration within this report.

So, it is concluded that changes in relevant rulemaking, if they would materialise, would not affect the compatibility of the mixed VFR/IFR operations within the given timeframe.

## 8.5 Conclusion

Within the present paragraph it is addressed how specific developments could affect the compatibility of the mixed VFR/IFR traffic at Geneva airport.

It is concluded that operational, technical and regulatory developments that can be foreseen within the timeframe 2010 – 2020 are not expected to have a major effect on the compatibility of mixed VFR/IFR traffic.

The predicted growth of the traffic volume in the near term (2010) and far term (2020) is modest. However, to accommodate this traffic growth peak-traffic periods will have to be extended, and gaps between traffic peaks will have to be filled. This may lead to a disproportional increase of the risk exposure. Therefore, to mitigate the increased risk level, it is expected that additional measures need to be taken that may increasingly restrict the VFR traffic at Geneva airport. At the predicted traffic volume in 2020, mixed VFR/IFR operations involving the grass runway are considered practically incompatible.

# 9 Conclusions, recommendations and considerations

## 9.1 General

Within this chapter the information compiled in this report is combined to specifically answer the primary questions that are subject of the present investigation.
These questions (see paragraph 1.3) are repeated here for completeness:

- *Does the current mix of light (VFR) and heavy (IFR) air traffic operations at the airport of Geneva satisfy all safety criteria?*
- *How will this develop in future?*

These main questions are answered along two lines.
The first line of activities is to check whether the current operations and procedures are in compliance with the applicable regulatory requirements, in order to achieve a minimum required level of safety.
The second line of activities builds on the notion that mere compliance with the regulations is not fully sufficient to assure an acceptable level of safety. Safety assurance requires (pro-)active safety management. For this reason safety management systems are today an inherent part of the regulatory framework. Therefore, the present investigation has also addressed the safety management processes, as currently implemented within the local skyguide ATC unit and AIG itself.
An essential element of safety management systems is to identify hazards, or hazardous trends, in any operation or system such that associated risks can be controlled and, if necessary, mitigated to assure an acceptable level of safety. In this context, the present investigation has identified and analysed hazards associated with the current mixed VFR/IFR operations at Geneva airport. Based on this analysis conclusions are drawn whether these hazards are considered to be sufficiently controlled by the responsible organisations.

To answer the question concerning the developments in the near and far future, the effects of traffic growth, and foreseeable technical, operational and regulatory advancements have been assessed.

The resulting conclusions, recommendations and considerations of the investigation are summarised in the next paragraphs.

### 9.2 Compliance with the present regulatory framework

It is concluded that the procedures and documents regarding mixed VFR/IFR operations on the concrete and grass runways at GVA in general have been designed in agreement with internationally accepted practices.
However, it has been found that some procedures do not comply with the applicable rules and regulations. In particular, the following violations of wake turbulence separation criteria have been identified:

- The 3-minute wake turbulence separation prescribed by [Doc4444] for a LIGHT aircraft taking off behind a MEDIUM aircraft is not applied at GVA.
- The wake turbulence category of essential traffic is not mentioned in essential traffic information messages, as prescribed by [Doc4444].
- Controllers are not required to issue a caution of possible wake turbulence to VFR aircraft or IFR aircraft on a visual approach behind a MEDIUM or HEAVY aircraft as specified in [Doc4444].

These deviations from the current ICAO wake turbulence separation criteria may have a negative impact on the safety of the VFR traffic that operates mixed with IFR traffic.
Therefore the following is recommended to skyguide:

***Recommendation 1:*** *The wake turbulence separation criteria in use at Geneva airport shall be adapted in order to be fully compliant with the current regulations as laid down in [Doc4444].*

Apart from the above mentioned wake turbulence criteria, it is concluded that procedures for segregation of VFR traffic from IFR traffic, and limitations imposed on the use of the grass runway at times of heavy IFR traffic properly reflect the status of the GVA CTR as busy airspace. However, some of the procedures that extend beyond the minimum requirements of the regulatory framework have been based on evolved practices and experience from the past. These common practices are conveyed from on-the-job instructors to new controllers without formal backing in the form of written procedures and safety analyses. It could not be established that this form of informal information dissemination has led to actual shortcomings in awareness of the desired practices at the ATC unit Geneva.
However, it is concluded that mentioned informal establishment of procedures and dissemination of information are not in compliance with the current safety management regulatory framework, as specified by [ESARR3], [Annex11] and [Annex 14].
Therefore, the following is recommended to skyguide, as far as applicable:

***Recommendation 2:*** *Procedures for controlling mixed VFR/IFR traffic within GVA CTR shall be formalised as written procedures in the applicable procedure manuals. These procedures shall be supported by safety analyses and reviewed regularly for their continued effectiveness.*

A clear example of a procedure that should be formalised is the tailwind criterion for runway assignment purposes, for both single concrete runway and simultaneous concrete/grass runway operations.

In addition, the VFR departure and arrival routes should be reconsidered, such that they are either segregated laterally, or that prescribed altitudes or altitude bands for VFR departure routes are different from those prescribed for VFR arrival routes.

### 9.3 Safety Management

In the context of safety management it has been found that persons involved in the mixed VFR/IFR operations –controllers, pilots and airport personnel– are well-trained and safety conscious professionals.

The implementation of safety management principles at skyguide is an on-going and evolutionary process. Much progress has been made in the systematic learning from incidents to prevent their recurrence, but that is only part of the equation. It is important for skyguide to further develop its safety culture and safety management system so that there is strong focus also on systematic, pro-active identification of hazards and management of risks that have not yet materialised as incidents and occurrences. In this context it is important that a higher level of formalism is achieved, such that current informal practices based on good experience are laid down in procedures, founded on a formal risk assessment approach.

For each risk, the control measures need quantitative performance criteria that are set insightfully to allow skyguide's operational staff to monitor continuously for pre-cursors of hazardous occurrences and other vulnerabilities.

As part of this process, the imperfections in the current safety management system should be addressed with urgency.

AIG itself is in the initial stage of planning and implementing a safety management system, and is in that sense late in complying with the current regulations in force. Therefore, AIG should take initiatives to accelerate the implementation, building upon the existing ISO 9001 certificated system for quality management, and extending throughout AIG the integrated adoption of safety monitoring (reactivity) and risk assessment (pro-activity).

The operational initiatives that have occurred recently for cooperative projects in safety improvement, jointly by AIG and skyguide, should be encouraged and widened because ultimately the achieved safety of interdependent operations at Geneva depends on the effectiveness of the safety cultures within and across both organisations. It is through active and resilient working relationships that such cultures are built.

### 9.4 Risk mitigation considerations

Evaluation of the identified hazards involved in the operation of mixed VFR/IFR traffic has led to the following conclusions and risk mitigation considerations.

With respect to wake turbulence:

- The wake vortex hazard during simultaneous departures shall be mitigated by bringing the currently used separation criteria in agreement with the applicable regulations (see recommendation 1)
- The wake vortex hazard during simultaneous approach and landing on runways 05 should be mitigated by clear ATC wake avoidance advisories for VFR traffic approaching the grass runway.

With respect to collision risk:

- It appears that the probability of unsafe proximity between VFR and IFR traffic simultaneously departing from the grass and concrete runway can not be regarded as acceptably low. Measures, additional to the wake vortex separation criteria, should be taken into consideration to assure sufficient separation between VFR traffic (departing from grass runway) and light/small IFR traffic (departing from concrete runway).
- It is concluded that the basic principle of see-and-avoid for separation of VFR traffic has significant limitations. At Geneva airport these limitations are to some extent compensated by the traffic information service between VFR and IFR flights that is provided in Class D airspace. However, relying on the principle of alerted see-and-avoid is considered not to be fully compatible with the high volume of mixed VFR/IFR operations within the CTR of Geneva. For this reason upgrading the airspace classification from Class D to Class C should be considered in order to provide the aerodrome controller with full authority and responsibility for safe traffic separation within the CTR.

With respect to controlled flight into terrain:

- It is concluded that the Forest of Ferney-Voltaire is a major obstacle to the VFR traffic operating on the grass runway. Current obstacle clearance procedures are in agreement with the applicable regulations. However, this is to the detriment of significant aircraft performance and handling difficulties. It should be taken into consideration to assure that pilots are aware of these difficulties and demonstrate their ability to cope with them safely.

With respect to runway incursion:

- It is concluded that the position and lay-out of the grass runway, the associated taxiways and the parking stand are such that vulnerability for runway incursion may exist. Particular issues are the unclear grass markings and the obstruction of traffic visibility by the Forest of Ferney-Voltaire.

With respect to runway excursion:

- It is concluded that operations on the grass runway are prone to runway excursion, as a consequence of the short available landing distance on runway 23, the tailwind criteria used for runway assignment and the uncertainties associated with operations from a grass runway. It should therefore be taken into consideration to restrict operations on the grass runway to headwind operations only and to advise unfamiliar pilots to use the concrete runway in stead of the grass runway.

With respect to operations:

- It is concluded that the safety of mixed VFR/IFR operations may be negatively affected by a number of operational issues in particular related to the complexity and intensity of the mixed operations at Geneva airport. For this reason it should be considered to ensure the use of the airport by familiar and well-prepared pilots only. Without special approval from the local ATC unit, access to the airport CTR should be limited to aircraft based at Geneva airport or to pilots that have successfully performed a check-out flight at Geneva airport.
- In light of the complexity of their tasks, especially during peak traffic circumstances, it is considered prudent to monitor structurally and actively the workload and stress level of the aerodrome controllers.
- It is concluded that VFR training flights under supervision of experienced instructors can be accepted as part of the mixed VFR/IFR operations. However, it should be considered to discontinue the current practice of allowing student pilots to perform their first solo flight from Geneva airport.

## 9.5 Final Conclusion

The main question of the current investigation –*whether the mixed VFR/IFR operations satisfy all safety criteria*– can not simply be answered by yes or no.
The mere determination to what extent current procedures are in compliance with the applicable rules and regulations is insufficient to fully answer this question.

It should be recognised that Geneva airport accommodates a high volume of mixed VFR/IFR operations – in fact by far the highest volume within Europe in comparison with airports of similar size. ICAO itself recognises that for high intensity mixed VFR/IFR operations it is necessary to introduce provisions supplementary to those of ICAO in order to maintain an appropriate level of safety.
The present investigation has established that not all regulatory requirements have been fully satisfied, in particular in the area of wake vortex separation criteria and safety management practices (see paragraph 9.2 and 9.3), without support of a formal safety assessment.
It has been established that supplementary provisions have been implemented partly (for instance the "*organisation par fort traffic*", see paragraph 6.3.7.3).
However it must also be observed that a number of hazards have been identified within the present study that are not mitigated by any formal supplementary measure, or otherwise are shown to present an acceptable risk.

Therefore the formal answer to the question at hand is that the mixed VFR/IFR operations do not fully satisfy all safety criteria.
This does not imply that current operations are unsafe, but that there are concerns about the level of safety. The actual tolerability of the identified hazards has not been determined as this was outside the scope of the present study.
However, the mentioned concerns (see paragraph 9.4) should be taken serious. The mitigating measures that are presented as result of this investigation should be taken into consideration as part of the safety management processes at the airport in order to assure continued safety of the mixed VFR/IFR operations.

It is emphasised here that the persons involved in the mixed VFR/IFR operations –controllers, pilots and airport personnel– that have been interviewed within the context of this study are well-trained and safety conscious professionals. This is an important condition for safe operations. However, it is in itself not a guarantee that an acceptable level of safety is achieved. In general it has been found that operational practices are based on evolved experience and sound working methods. Nevertheless, it has also been found that these operational practices in general lack the procedural formalism and the underlying safety assessment that show that they are sufficient to assure an acceptable level of safety. This is considered an imperfection of the currently implemented safety management processes, as well at the local ATC unit and at AIG itself.

With respect to the second part of the research question at hand - *How will the safety of the mixed operations develop in future?*-, a simple straightforward answer can not be provided.

In principle the aviation system is organised around a framework of safety standards and guidelines, such that any operation can be made safe, by means of appropriate procedures or technical systems. This also applies to the mixed VFR/IFR operations at Geneva airport. However, in light of the anticipated growth of the IFR traffic volume at Geneva airport it can be expected that the VFR traffic using the grass runway will be subject to a growing set of restrictions and limitations. In future it is envisioned that the compatibility of the mixed VFR/IFR traffic may become so constrained that simultaneous use of the grass runway for VFR traffic and the concrete runway for IFR traffic is no longer practicable.
Where this point in future is reached is hard to predict, since it depends on technological developments and the readiness to invest in safety measures. However, if the predicted traffic growth is realised, the feasibility of sustained mixed VFR/IFR operations beyond 2020 is considered to be questionable.

# 10 References


[Aarons] "Head-down in the VFR world", R.N. Aarons, Business & Commercial Aviation, March 1994, p. 80-81.

[AC90-23F] "Aircraft Wake Turbulence", FAA Advisory Circular AC90-23F, 02/20/02.

[ACIreport] "2003 Worldwide Traffic Report", Airports Council International, Geneva, June 2004.

[AIP] "Aeronautical Information Publication Switzerland". Office Fédéral de l'Aviation Civile: Berne 2004.

[Annex2] "Rules of the Air". Annex 2 to the Convention on International Civil Aviation, Ninth Edition. International Civil Aviation Organisation: Montréal 1990.

[Annex11] "Air Traffic Services". Annex 11 to the Convention on International Civil Aviation, Thirteenth Edition. International Civil Aviation Organisation: Montréal 2001.

[Annex14] "Aerodromes – Volume I: Aerodrome Design and Operations". Annex 14 to the Convention on International Civil Aviation, Fourth Edition. International Civil Aviation Organisation: Montréal 2004.

[Annex15] "Aeronautical Information Services". Annex 15 to the Convention on International Civil Aviation, Twelfth Edition. International Civil Aviation Organisation: Montréal 2004.

[ATCWAKE] http://www.eurocontrol.int/eec/public/standard_page/APT_atc_wake.html

[ATMGVA] "Manuel ATM Genève". skyguide: Geneva 2004.

[ATMM-CH] "Air Traffic Management Manual for Switzerland".

[BASI] "Limitations of the See-and-Avoid Principle", BASI Research Report, April 1991.

# 10. References


[Baxa] "Simulation of uncontrolled terminal area traffic to evaluate the 'see and avoid' concept", E.G. Baxa & L.J. Morrissey, Proceedings 8th Annual Pittsburg Conference, Volume 8, Modelling and simulation, p275-279.

[C172man] Information Manual Cessna Model R172K, Hawk XP, Cessna Aircraft Company, Kansas, US, May 1980.

[CAA91015] "United Kingdom Civil Aviation Authority Wake Vortex Database: Analysis of Incidents reported between 1982 and 1980", CAA Paper 91015, CAA London, August 1991.

[CAA0197] "The Wake Vortex Reporting Programme", ATCEU Memorandum No. 197, CAA London, August 1993.

[CAA148828] "An investigation into wake turbulence incidents", CAA report R-148828, CAA London, November 1973.

[CATCH_D4] "Hazard List from Brainstorm meeting of CATCH project: Interim Deliverable D4", NLR/ACONA-Technical Note 2005-01, January 2005.

[Doc4444] "Procedures for Air Navigations Services – Air Traffic Management". ICAO Document 4444, Fourtheenth Edition. International Civil Aviation Organisation: Montréal 2001.

[Doc7030] "Regional Supplementary Procedures". ICAO Document 7030, Fourth Edition. International Civil Aviation Organisation: Montréal 1987.

[Doc9426] "Air Traffic Services Planning Manual" ICAO Document 9426, 1st (Provisional) Edition, Amendment 4 Dated December 30, 1992.

[Doc9774] "Manual on Certification of Aerodromes", ICAO Document 9774, First Edition, 2001.

[ESARR2] "Reporting and assessment of safety occurrences in ATM", ESARR2, Eurocontrol, ed. 2, ESARR2, November 2000.

# 10. References


[ESARR3] "Use of Safety Management Systems by ATM Service providers", ESARR3, Eurocontrol, July 2000.

[ESARR4] "Risk Assessment and Mitigation in ATM", ESARR4, Eurocontrol, April 2001.

[FAA78-8] "Collision Avoidance, an annotated bibliography", FAA, FAA-NA-78-8, 1978.

[FAA75-6] "Vortex related accidents over the ten year period 1964-73", FAA-EM-75-6, April 1975.

[FAATN03/14] "Complexity in Air Traffic Control Towers: A Field Study", DOT/FAA/CT-TN03/14, FAA Technical Center, Atlantic City, May 2003

[GF7437] Message du Conseil fédéral à l'Assemblée fédérale concernant l'agrandissement de l'aéroport de Genéve-Cointrin, Nr. 9437, June 28, 1957.

[Graham] "See and avoid/cockpit visibility", W. Graham, DOT/FAA/CT-TN/98/18, October 1989.

[LFG] Bundesgesetz vom 21. Dezember 1948 über die Zivilluftfahrt (Swiss federal law on civil aviation dated December 21, 1948)

[LFV] Verordnung vom 14. November 1973 über die Luftfahrt (Swiss decision on aviation, dated November 14, 1973)

[Milhollon] "Air-to-air visual detection data", A. Milhollon, et al., CDC Advanced Studies Lab, Report No. FAA-RD-73-40, April 1973.

[NASA166573] "Cleared for visual approach: human factors problems in air carrier operations", W.P.P Monan, NASA Contractor Report 166573], 1983.

[NLR00-82] "A Study on the Safety Aspects of Criteria Governing Cross- and Tailwinds", P.J. van der Geest, et al., NLR-CR-2000-082, March 2000.

[NLR04-19] "Air-ground communication safety study – An analysis of pilot controller occurrences", G.W.H. van Es, NLR-CR-2004-019, March 2004.

[NTSB1] "Midair Collisions in U.S. Civil Aviation – 1968, a special accident prevention study", NTSB, Washingthon D.C, July 1969.

[NTSB-70-15] "Aircraft Accident Report SA-417, Allegheni Airlines DC-9, N988VJ, and Forth Coorporation Piper PA-2, N7374J, September 9, 1969", NTSB, Washington D.C., July 1970.

[PANSOPS] "Procedures for Air Navigations Services – Aircraft operations". Volume I: Flight Procedures and Volume II: Construction of Visual and Instrument Flight Procedures. ICAO Document 8168, Fourth Edition. International Civil Aviation Organisation: Montréal 1993.

[ProjPlan] "Project plan CATCH project: Study into the *C*ompatiblity of mixed VFR/IFR *A*ir *T*raffic at Geneva Airport (*CH*)", P.J. van der Geest: NLR-Memorandum ATSF-2004-105. National Aerospace Laboratory NLR: Amsterdam 2004.

[PA-28-161] "Warrior II Information Manual", PA-28-161 Handbook Part no. 761 780, September 1985.

[REACH] "Aviation safety management in Switzerland – Recovering from the myth of perfection", P.J. van der Geest, et al., NLR-CR-2003-16, Amsterdam, June 2003.

[SAM] "Air Navigation System Safety Assessment Methodology", Eurocontrol EATMP, SAF.ET1.ST03.1000-MAN-01, Ed. 2.0, April 2004.

[SKYMAG] "Tension between air traffic control and VFR aviation in Switzerland", skymag, November 2004 - #9, p.24-25.

[SOCTB10] "Pilot's Operating Handbook, Socata TB-10", November 1988.

[VIL] Verordnung vom 23. November 1994 über die Infrastruktur der Luftfahrt (Swiss decision on aviation infrastructure, dated November 23, 1994)

[VVR] Verordnung vom 4. Mai 1981 über die Verkehrsregeln für Luftfahrzeuge (Swiss decision on rules of the air, dated May 4, 1981)

# 10. References


[Weber1] “The limits of the principle ‘see-and-avoid’, O. Weber.

[Weber2] “Statistical and flight mechanical studies on visual conflict detection and resolution in civil aviation”, O. Weber.

## Appendix A Description of world-wide accidents and incidents involving mixed VFR/IFR traffic

| Date: | Aircraft 1: MD-DOUGLAS DC-9 | Country: | Accident/Incident: |
|---|---|---|---|
| 9/9/1969 | **Aircraft 2:** PIPER PA-28 | US | Mid-air |

**Description:** DC-9 was under positive radar control of Approach Control descending from 6,000 feet to an assigned altitude of 2,530 feet at the time of the collision. The Piper was being flown by a student pilot on a solo cross-country in accordance with a VFR flight plan. The collision occurred at an altitude of approximately 3,500 feet.
The visibility in the area was at least 15 miles, but there was an intervening cloud condition which precluded the crew of either aircraft from sighting the other until a few seconds seconds prior to collision. Both aircraft were destroyed by the collision and ground impact.

| Date: | Aircraft 1: BOEING 737-100 | Country: | Accident/Incident: |
|---|---|---|---|
| 7/20/1970 | **Aircraft 2:** PIPER PA-28 | Spain | Mid-air |

**Description:** The 737 was authorized a direct VFR app to rwy 25. When the pilot reported position on the downwind leg he was instructed to report on final. The a/c was still on downwind leg when the pilot noticed a light a/c 15 - 20 m ahead. To avoid the collision the a/c was banked to the right but the left wing struck the light a/c. The 737 landed safely but the piper crashed. The piper pilot was on a local flight. He had been warned before take-off that a charter flight was carrying out a direct app to rwy 25.

| Date: | Aircraft 1: BOEING 707-300 | Country: | Accident/Incident: |
|---|---|---|---|
| 1/9/1971 | **Aircraft 2:** CESSNA 150 | US | Mid-air |

**Description:** B-707 300 ft below assigned altitude. C-150 student flight turning in congested control area in marginal flight visibility. Both crews unable to see and avoid. System permitted VFR operation in congested area in reduced visibility.

| Date: | Aircraft 1: MD-DOUGLAS DC-9 | Country: | Accident/Incident: |
|---|---|---|---|
| 6/6/1971 | **Aircraft 2:** Experimental | US | Mid-air |

**Description:** Both crews had only marginal capability to see and avoid. Other factor: ATC system limited, precluded efficient IFR/VFR separation. Other contributing factor: crew of DC-9 failed to request radar service. Other factor: very high closure rate between a/c.

# 11. Appendix A

| Date: 8/4/1971 | Aircraft 1: BOEING 707-300<br>Aircraft 2: CESSNA 150 | Country: US | Accident/Incident: Mid-air |
|---|---|---|---|

**Description:** Both crews had minimum opportunity to see and avoid due cessna high wing configuration and background light. Cessna instructor pilot gave initial familiarization flight at night in heavily congested area. Cessna radio was off.

| Date: 12/4/1971 | Aircraft 1: MD-DOUGLAS DC-9<br>Aircraft 2: CESSNA 206 | Country: US | Accident/Incident: Mid-air |
|---|---|---|---|

**Description:** Inadequacy of ATC facilities and services in terminal area. DC-9 descended onto CESSNA. Relative a/c flight paths and configurations physically limited each flight crews ability to see and avoid other a/c.

| Date: 7/27/1973 | Aircraft 1: BOEING 727-100<br>Aircraft 2: CESSNA 172 | Country: US | Accident/Incident: Mid-air |
|---|---|---|---|

**Description:** Flight check indicated holes in ATC radar system. Visibility restricted by high wing.

| Date: 1/9/1975 | Aircraft 1: CONVAIR 240<br>Aircraft 2: CESSNA 150 | Country: US | Accident/Incident: Mid-air |
|---|---|---|---|

**Description:** Reduced nighttime visibility of C-150 against a background of city lights. Human limitation inherent in the see & avoid concept, critical in terminal area.

# 11. Appendix A

| **Date:** 5/18/1978 | **Aircraft 1:** DASSAULT Falcon 20<br>**Aircraft 2:** CESSNA 150 | **Country:** US | **Accident/Incident:** Mid-air |
|---|---|---|---|

**Description:** A Cessna took off VFR for instruction. The a/c returned to airport. The a/c was turned over to a tower operator and issued instructions for a visual landing. The Falcon was on a jet familiarization flight with prefiled IFR flight plan calling for multiple ILS approaches. VFR and IFR air traffic are controlled by different air traffic controllers on separate frequencies by APP control and control tower. Scattered clouds, estimated 25000 ft overcast, 6 mi visibility with haze. Controller of CESSNA not aware that FALCON was being vectored to traverse his airspace.

| **Date:** 9/25/1978 | **Aircraft 1:** BOEING 727-100<br>**Aircraft 2:** CESSNA 172 | **Country:** US | **Accident/Incident:** Mid-air |
|---|---|---|---|

**Description:** During a visual approach the BOEING collided with the CESSNA 172. The BOEING was on an IFR flight plan and had accepted a visual approach to rwy 27. The CESSNA was making a practice ILS app to RWY 09 and had abandoned the approach. It was instructed to climb to below 3500 ft on a 070 heading. Crew did not comply with maintain-visual-separation clearance.

| **Date:** 12/20/1984 | **Aircraft 1:** BOEING 747-100/200<br>**Aircraft 2:** Unknown | **Country:** US | **Accident/Incident:** Near Mid-air |
|---|---|---|---|

**Description:** During ILS app to New Orleans the B747 crew saw the other a/c coming head-on (2000 ft msl) and turned steeply to the right. The near collision occurred at the bottom of the TCA. VFR flight there was allowed.

| **Date:** 3/14/1993 | **Aircraft 1:** BOEING 727-200<br>**Aircraft 2:** CESSNA 206 | **Country:** Mexico | **Accident/Incident:** Mid-air |
|---|---|---|---|

**Description:** During a VFR approach to GUADALAHARA, MEXICO, both airplanes were intending to land on runway 28. On a two mile final approach the delta captain felt impact and noticed a flash on the side of the airplane. Passengers observed the Cessna pass below the airplane from right to left. The Cessna pilot, identity unknown, reported propeller stoppage and performed an off airport forced landing.

# 11. Appendix A

| **Date:** 6/8/1999 | **Aircraft 1:** AIRBUS A320<br>**Aircraft 2:** Socata TB-21 | **Country:** Germany | **Accident/Incident:** Near Mid-Air |
|---|---|---|---|
| **Description:** The incident involved a loss of separation between an airbus a-320 and a light a/c TB-21 in class D (CTR) airspace. The airbus was on an IFR flight and the TB-21 on a VFR flight at night. Both a/c were under control of different tower controllers. The shortest distance was 350 m in the same altitude between both A/C. The incident was caused by ignoring the atc instructions to shorten the downwind leg and keeping clear of departing traffic by the TB-21 pilot. | | | |

| **Date:** 10/17/2000 | **Aircraft 1:** BEECH 90 KING AIR<br>**Aircraft 2:** GULFSTREAM GIII | **Country:** US | **Accident/Incident:** Mid-air |
|---|---|---|---|
| **Description:** The Beech was on a straight in visual app with airspeed of 120 to 125 kt. Suddenly and unexpectedly, the pilot saw a shadow over his a/c and the nose of the gulfstream became visible in the top of his windshield. There was a loud 'bang,' and the a/c rocked violently. The gulfstream having sustained minor damage landed safely. The weather was clear, vis was unrestricted, and the sun angle was not a factor. | | | |

# Appendix B VFR traffic radar trajectories Geneva Airport

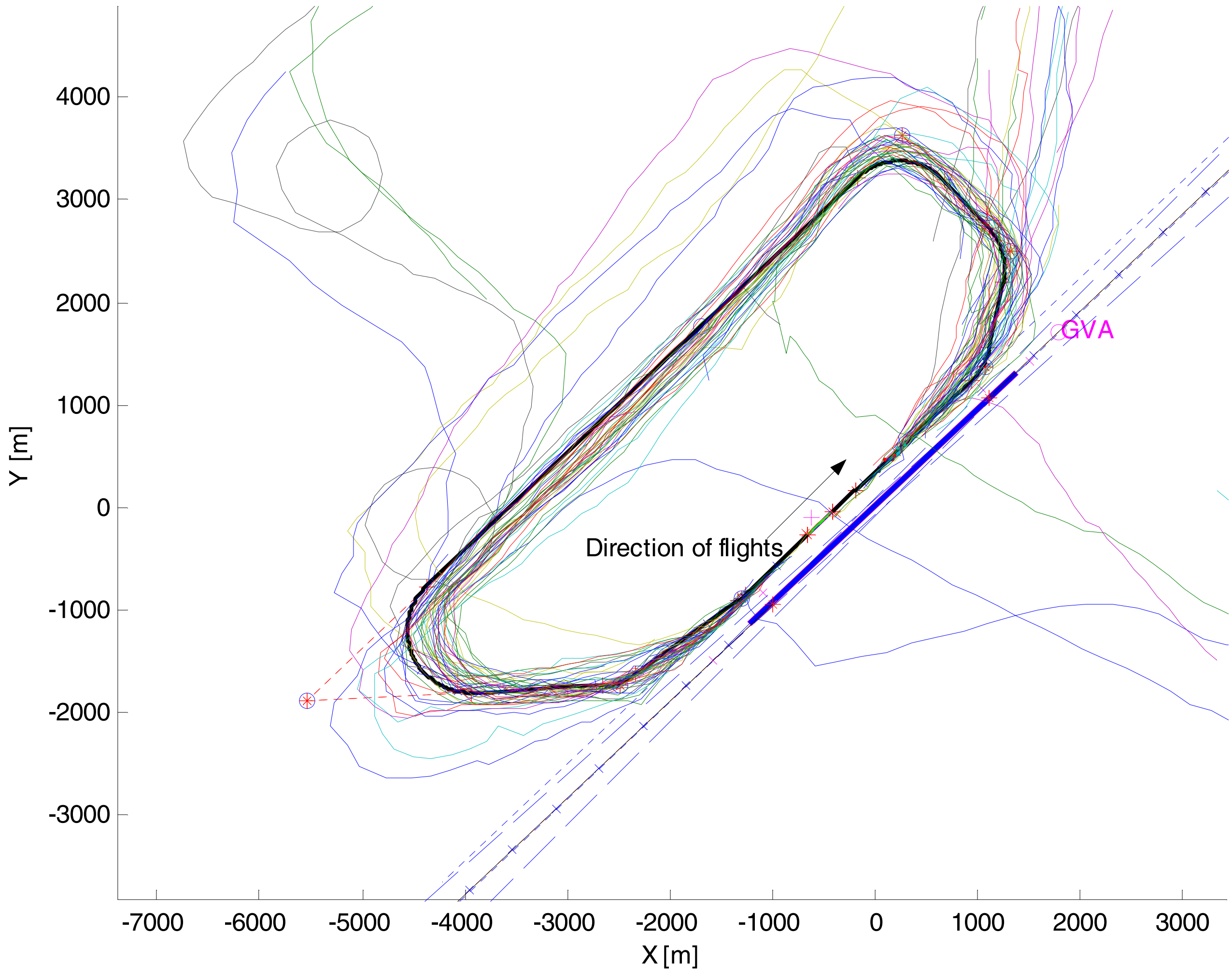


*Figure B-1 VFR traffic on grass runway 05, August 2004*

# 12. Appendix B

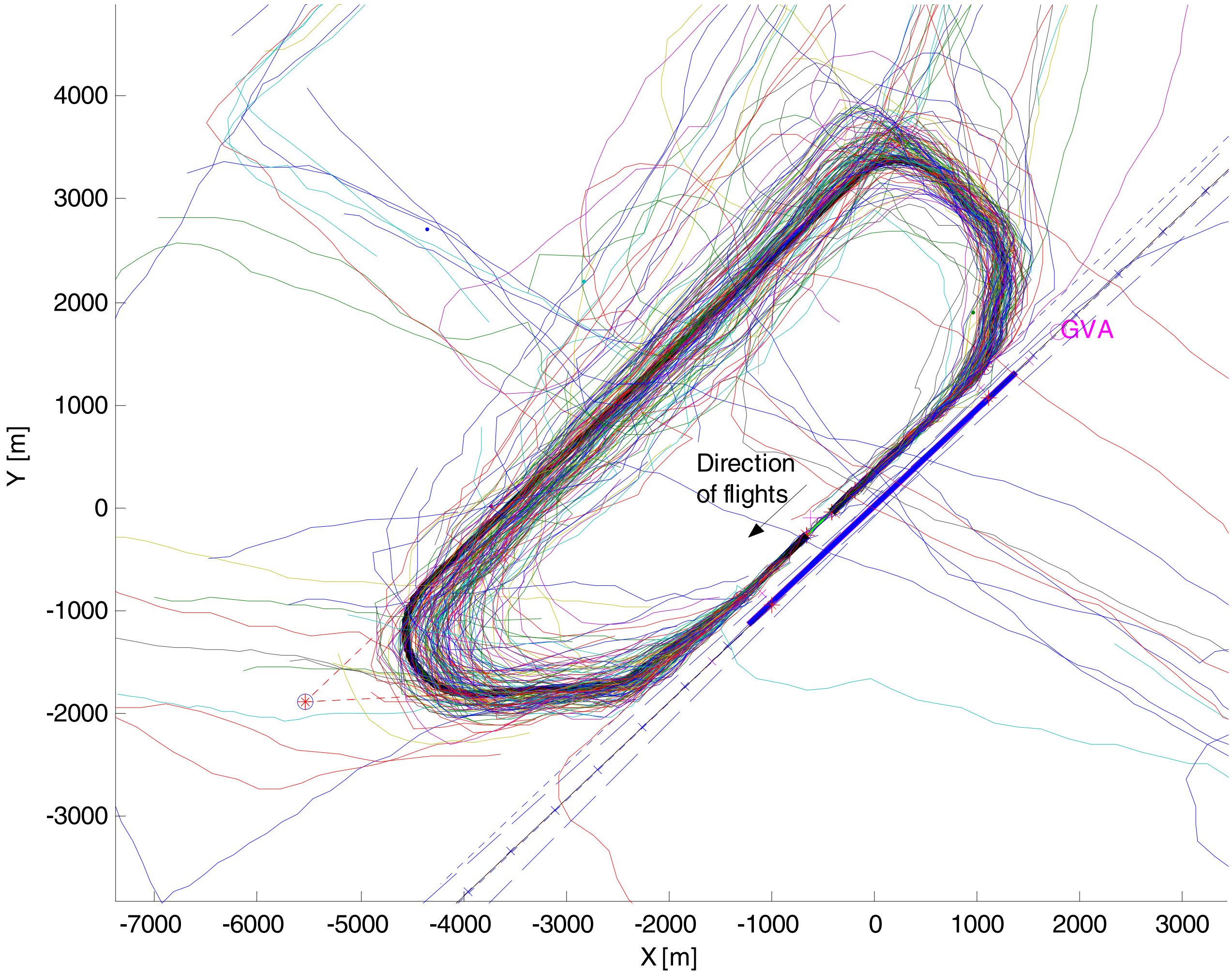


*Figure B-2 VFR traffic on grass runway 23, August 2004*

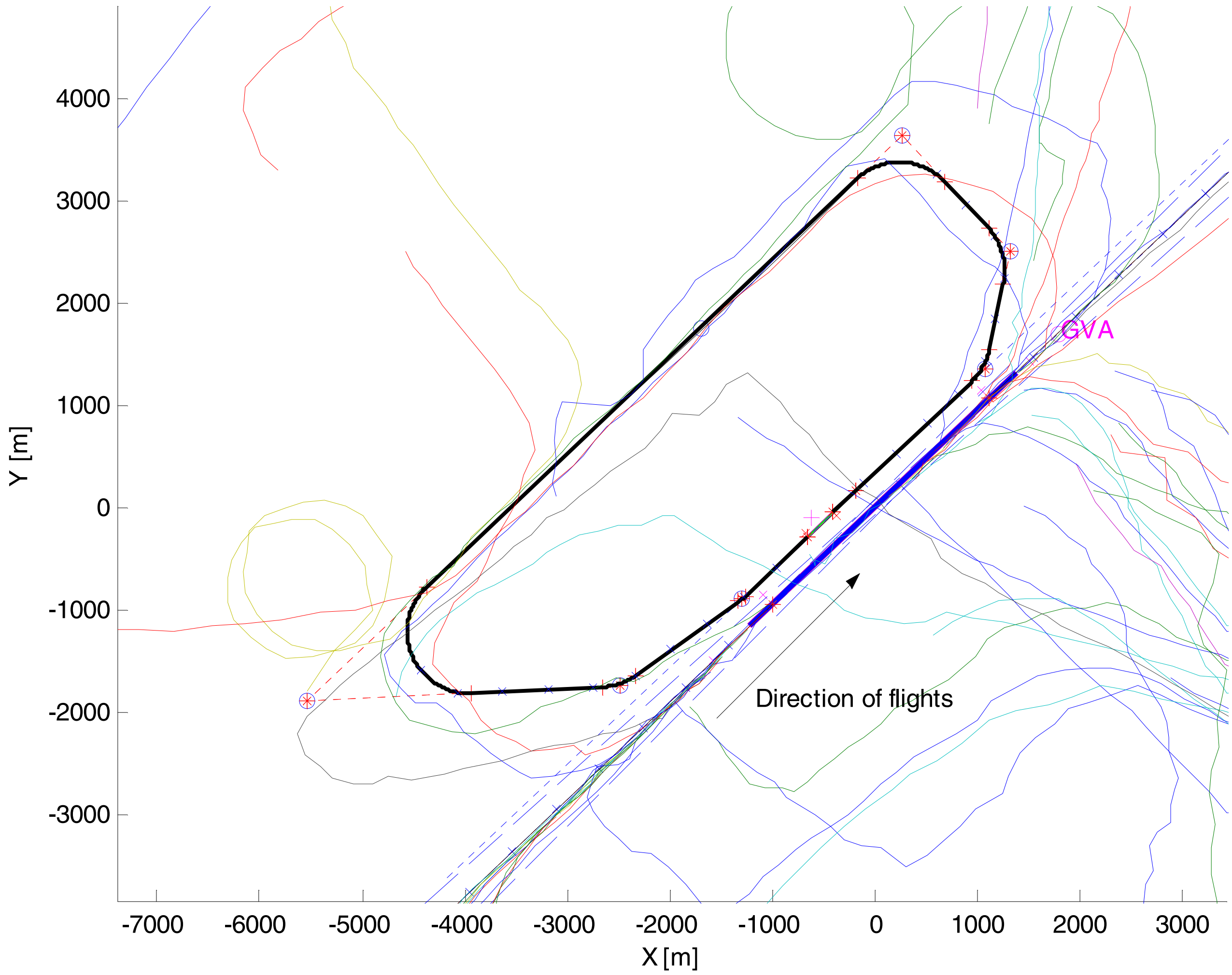


*Figure B-3 VFR traffic on concrete runway 05, August 2004*

12. Appendix B

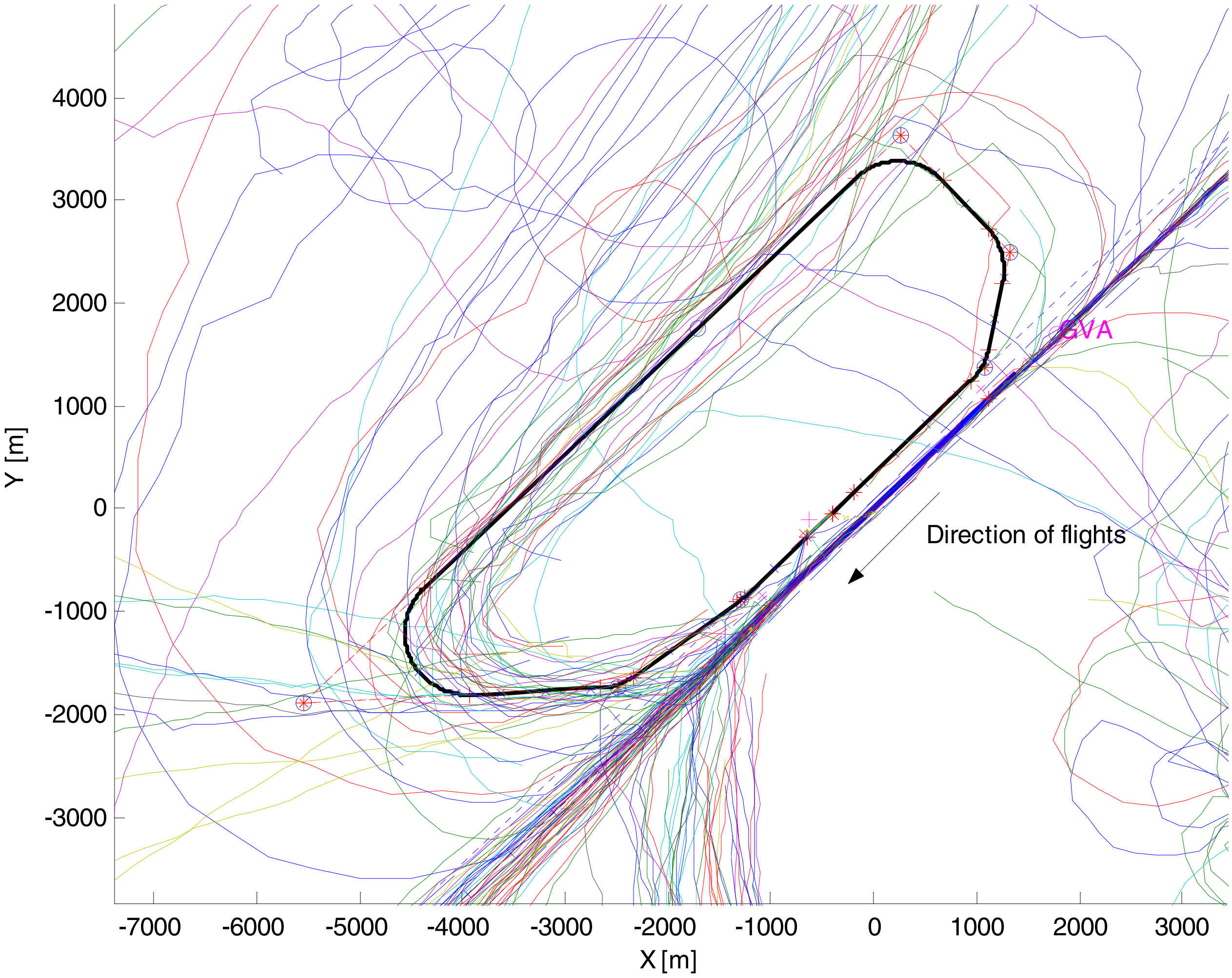


*Figure B-4 VFR traffic on concrete runway 23, August 2004*

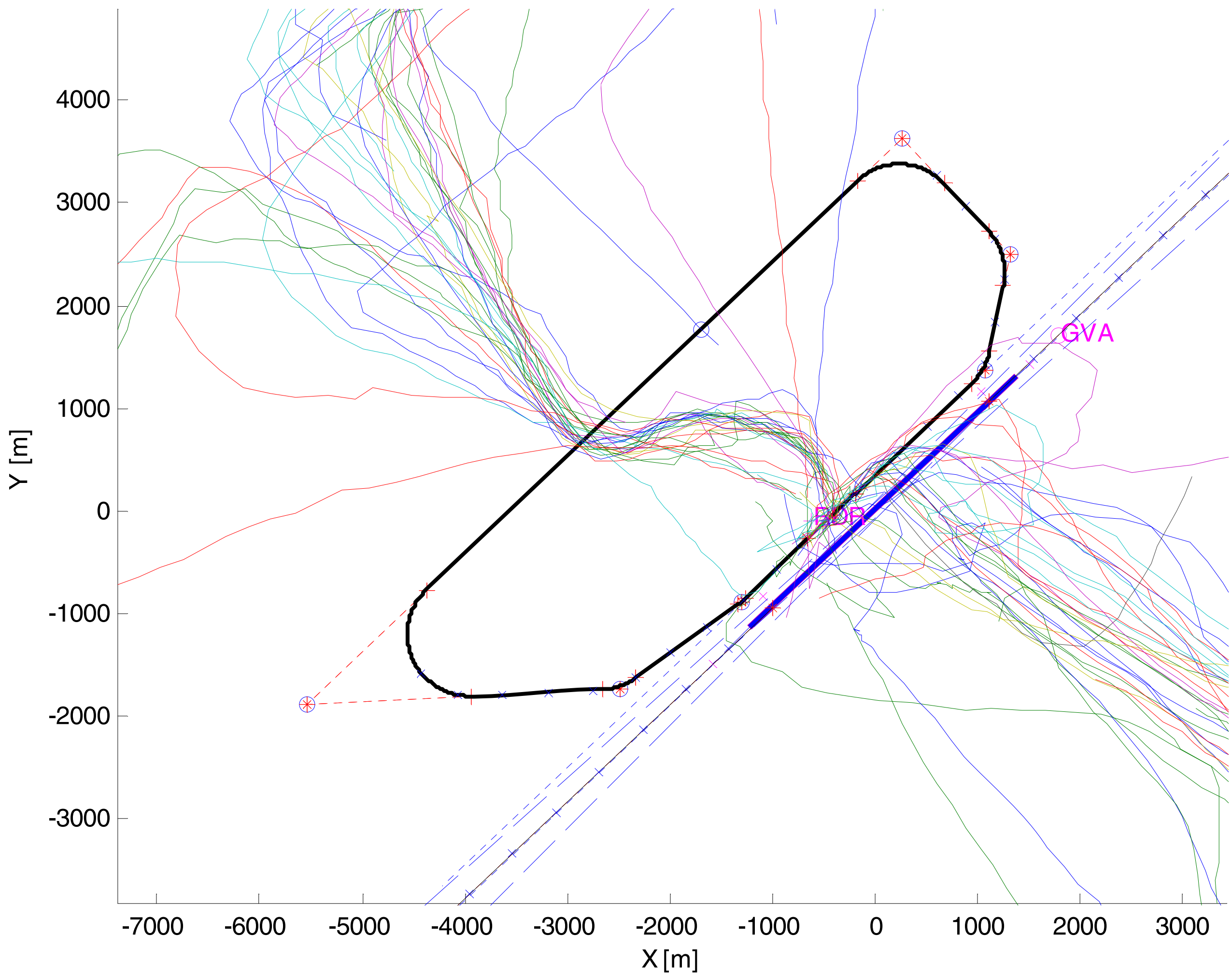


*Figure B-5 VFR Helicopter arrivals, August 2004*

12. Appendix B

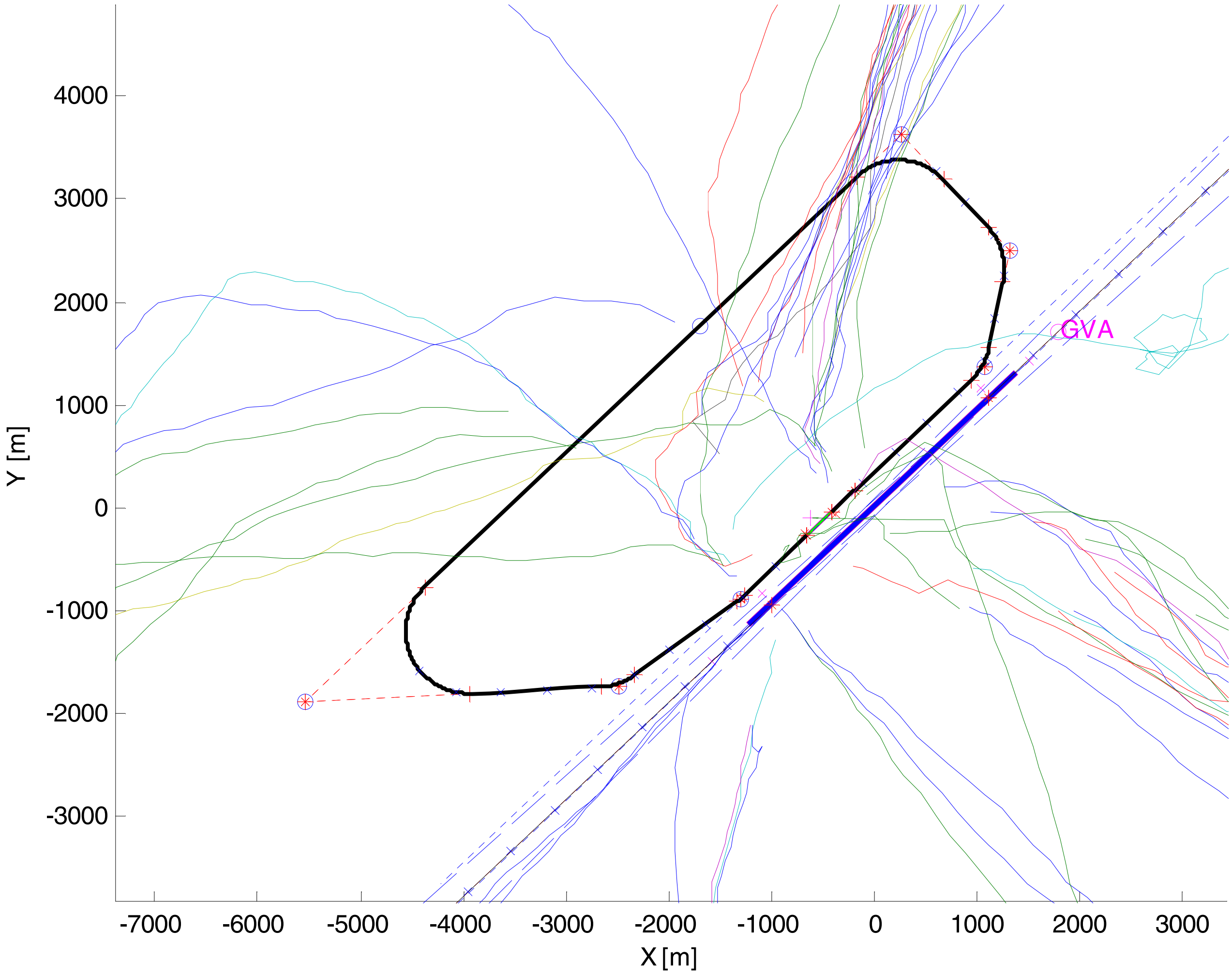


*Figure B-6 VFR Helicopter Departures, August 2004*

# 12. Appendix B

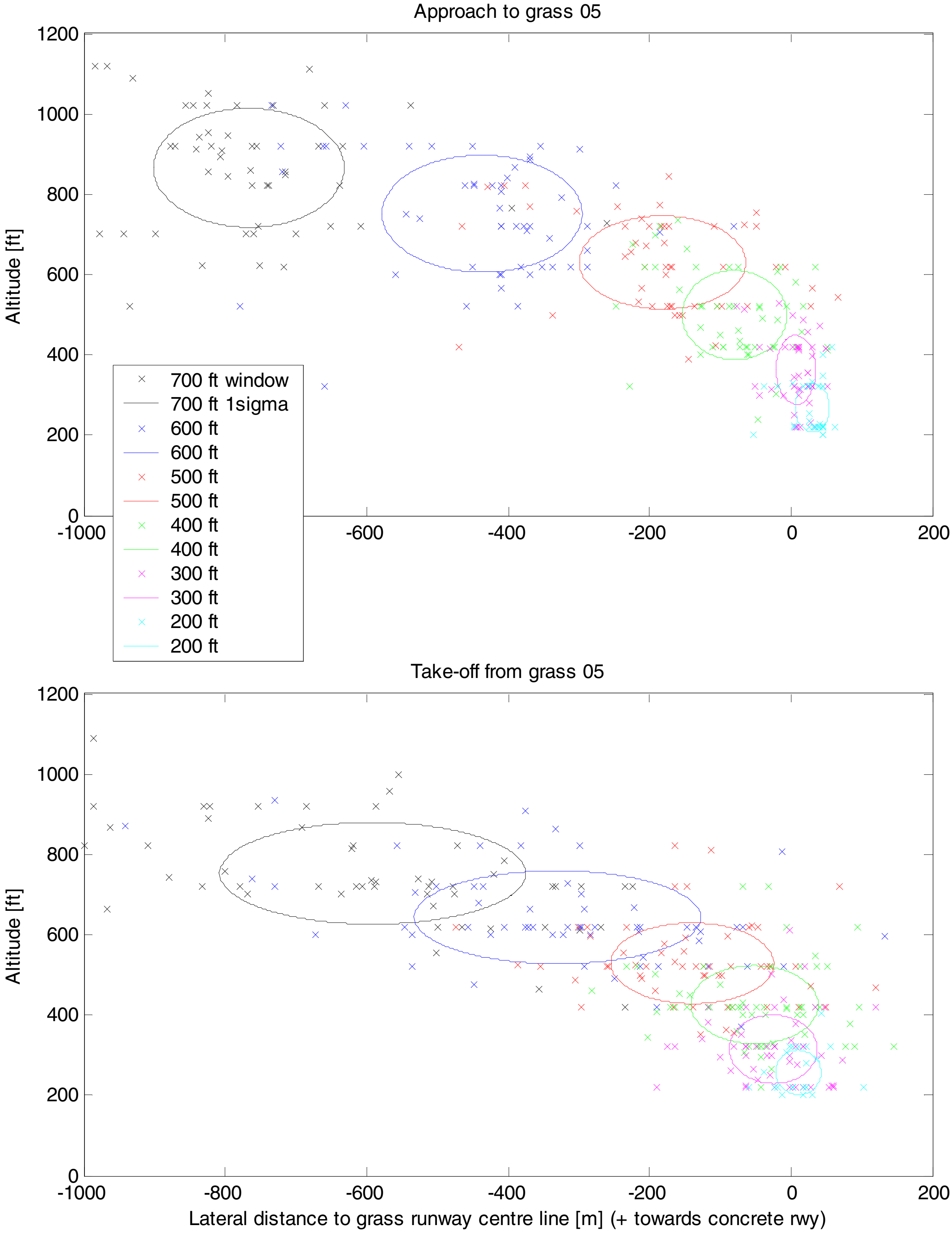


*Figure B-7 VFR traffic dispersion for operations on grass RWY 05, at six windows before threshold, August 2004*

# 12. Appendix B

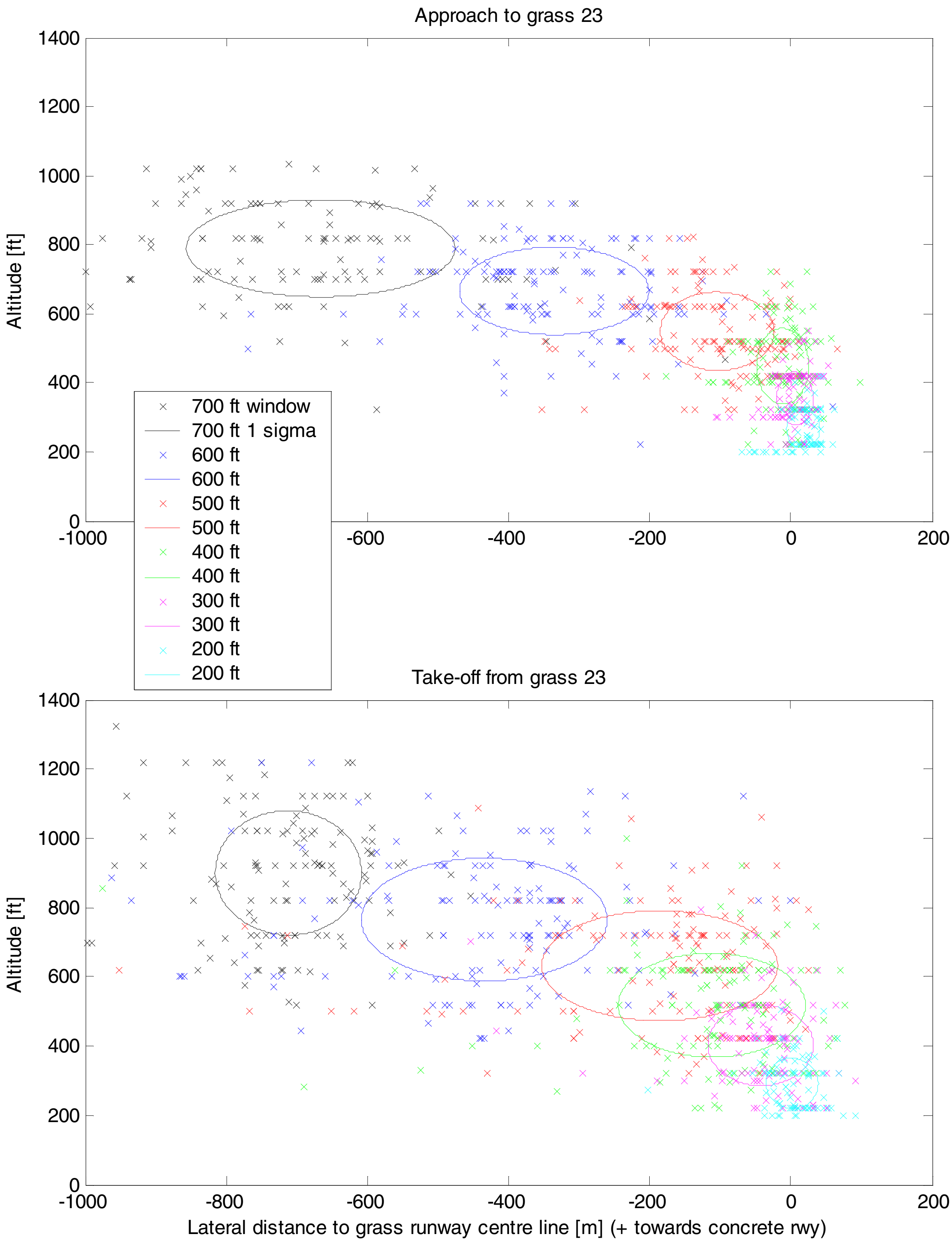


*Figure B-8 VFR traffic dispersion for operations on grass RWY 23, at six windows before threshold, August 2004*