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EUROPEAN AIR
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SAFETY

Airspace Infringement Risk Analysis

Part III

Case Study Switzerland

EUROCONTROL

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EUROPEAN ORGANISATION
FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

Airspace Infringement Risk Analysis

Part III

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Abstract

In order to collect the in-depth information about the causal factors of airspace infringements, in 2006 EUROCONTROL commissioned Skysupport of Geneva, Switzerland to conduct a study of airspace infringements in Switzerland. The study was carried out with the support of Swiss Air Navigation Services Provider - Skyguide, the Swiss Aircraft Accident Investigation Bureau and the Swiss AIRPROX Board, who provided the incident data from 2004 for analysis. Of 1,046 events and occurrences, 123 were classified as airspace infringements.

In addition, two field discussions with Swiss GA pilots were held at Zurich-Kloten airport and at Yverdon-les-Bains aerodrome to gather information about the issues encountered by VFR pilots with regard to airspace infringement, and to obtain meaningful feedback on potential mitigation actions and safety improvement recommendations.

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Risk	Safety analysis	Safety initiative	Switzerland

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EXECUTIVE SUMMARY

In order to collect in-depth information about the causal factors of airspace infringements, in 2006 EUROCONTROL commissioned Skysupport of Geneva, Switzerland to conduct a study of airspace infringements in Switzerland. The study was carried out with the support of Swiss Air Navigation Services Provider - Skyguide, the Swiss Aircraft Accident Investigation Bureau and the Swiss AIRPROX Board, who provided the incident data from 2004 for analysis. Of 1,046 events and occurrences, 123 were classified as airspace infringements.

In addition, two field discussions with Swiss GA pilots were held at Zurich-Kloten airport and at Yverdon-les-Bains aerodrome to gather information about the issues encountered by the VFR pilots with regard to airspace infringement, and to obtain meaningful feedback on potential mitigation actions and safety improvement recommendations.

The case study focussed on airspace infringements of controlled airspace only, i.e. ICAO Class C and D airspace, excluding Class E airspace. The following major conclusions could be drawn as a result of the occurrence analysis:

Various types of airplanes are involved in airspace infringements. However, the majority of infringements (64 %) are committed by single and multi-engine piston airplanes registered in Switzerland and the adjacent countries. About 75% of the infringing aircraft were flying with their transponder switched on.

Terminal Control Areas (TMAs) are the most infringed airspace structure.

There was no radio contact between ATC and the infringer in over 60% of the reported infringements. In another 17% of cases, the pilot called ATC when already in controlled airspace.

In almost half of all occurrences ATC and pilots initiated either preventive or avoidance action to ensure separation during airspace infringement. Loss of ICAO separation minima or inadequate separation occurred in 17% of the reported airspace infringements. Severity assessment of the occurrences revealed that 2 incidents were classified as serious, 5 as major and 9 as significant.

In a few occurrences, ATC had a direct or indirect contribution to the airspace infringement. Inadequate coordination between ATC units was identified as the major causal factor for the ATC contribution.

Only a very small number of occurrence reports contained the explanations of the pilots involved in the airspace infringement. Therefore, field discussions with VFR pilots were carried out to obtain more detailed information about the causal factors and potential mitigation actions.

The field discussions confirmed that the root causes for airspace infringement can be found in human factors related issues (e.g. stress, inadequate preparation), airspace and procedural complexity, unintelligible aeronautical information and navigation failure.

Accordingly, the risk-mitigation measures should focus on improving pilots' navigation skills and pre-flight preparation, reducing the complexity of airspace and the procedures governing its use, as well as improving communication between pilots and controllers and their understanding of each other needs and limitations.

CHAPTER 1 – Introduction

1.1 The Airspace Infringement Safety Initiative

Unknown aircraft stray into some of the busiest areas of Europe's airspace at least once a day. This happens mostly in airport control zones or areas and in en-route airspace. In December 2005, the EUROCONTROL Safety Team approved the launch of an Airspace Infringement Safety Improvement Initiative, as proposed by the Safety Improvement Sub-Group (SISG).

Airspace infringements (AI) are not new. Despite efforts made in several European countries, these incidents continue to occur with a frequency which calls for an increased effort to develop preventive action. The causes of airspace infringements are various and, most of them, identified. However, effective remedies are not so simple to identify and put into practice.

Technology, both on the ground and in the air, has evolved rapidly in recent years. Equipment allowing improved situational awareness in the cockpit is now available and will become more and more so in the future - a basis for taking a fresh look at the airspace infringement issue.

While several countries (e.g. Denmark, the Netherlands, UK) have already identified major causes and implemented mitigating actions, it is recognised that more benefits could be drawn from a European initiative. Therefore, the ultimate goal of this safety initiative is to develop, agree and implement an industry-wide risk reduction action plan. The key success factor is the involvement and cooperation of all risk stakeholders, including national regulators, air navigation service providers, general aviation representatives, military authorities and professional organisations.

1.2 Scope of the AI Safety Initiative

The focus of this safety initiative will be the infringement of controlled airspace, which is a major point of concern for ATM service providers and regulators. Controlled airspace infringement can be defined as a flight into notified airspace made without prior approval from the designated controlling authority of that airspace in accordance with international and national regulations.

The controlled airspace referred to comprises ICAO airspace classes A to E. It is important to note that class E airspace includes the issue of "legal" encounters. Although no airspace infringements can occur, since no clearance to penetrate this type of airspace by VFR flights is required, serious incidents have occurred between IFR and VFR flights, mainly due to the inherent limitations of the see-and-avoid concept. The members of the EUROCONTROL Safety Improvement Sub-Group reached a common understanding and agreement that this important risk also needs to be addressed by the initiative.

Besides infringement of controlled airspace, flight into restricted airspace may pose a serious risk to the “infringer" and the operations being carried out in that airspace by the registered user. The generic term “restricted airspace” is used to designate Prohibited, Restricted and Dangerous Areas, Temporary Reserved Airspace or airspace subject to flying restrictions in accordance with national requirements.

All the above-mentioned types of airspace are regularly infringed. The causes and circumstances of these infringements are various and tend to repeat themselves, regardless of the type of airspace infringed.

1.3 Introduction to Case Study Switzerland

In order to capture more information about the causal factors regarding airspace infringements, the Eurocontrol Safety Enhancement Business Division commissioned several studies. Skysupport of Geneva, Switzerland, was contracted to conduct a study regarding airspace infringements in Switzerland. Skysupport is a consulting entity drawing on operational ATM experience spanning over more that 37 years in Switzerland and abroad. This includes practical handling of VFR flights in ATC as well as a view from the cockpit, conducting VFR flights.

This case study is focused on the areas surrounding Geneva and Zurich Airports, as sufficient data was available to conduct a meaningful study. These major airports were also an obvious choice, since the number of IFR movements is substantial. Furthermore, the majority of airspace infringements, including the serious ones, occurred within airspace controlled by Geneva and Zurich. However, airspace infringements also occur at the controlled regional airports in Switzerland.

For this case study, the year chosen was 2004, as full data from the following years was not available when the study was commenced.

While a substantial amount of data was available, the view of the pilot committing an airspace infringement was rarely available for investigation. Therefore, the "why?” question (causal factors), could not be answered directly for most of the occurrences analysed. In order to obtain more information on the reasons as to why airspace infringements occur, two brainstorming sessions were organised with Swiss VFR pilots.

Chapter 2 of this paper describes the data-gathering efforts, the origin of the data samples, the data preparation as well as the taxonomy established for this case study. Chapter 3 presents the results of the analysis, while Chapter 4 reports on the field discussions with VFR pilots. General conclusions as well as conclusions on the results are outlined in Chapter 5. Chapter 6 outlines the mitigation areas in the form of recommendations.

The overall objective of this case study is to analyse operational data, where the results will contribute to establish a risk reduction action plan.

CHAPTER 2 – Case Study Switzerland

2.1 Data gathering

To conduct this study, airspace Infringement (AI) data had to be collected. The search for data revealed that the latter is available to a certain extent, but mostly in absolute numbers (i.e. the Annual Summary Template, AST). However, these numbers provided little detail on the background to the occurrences. Indeed, to be in position to subsequently propose mitigation actions, more information is needed on the circumstances in which the incidents happened - and ideally, as to why an airspace infringement occurred.

The "why?" question is probably the most difficult to answer as there is, in most cases, one major 'actor' missing: the infringing pilot. Indeed, information on what happened in the cockpit could provide clues on the causes of an AI. In fact, it is deemed crucial to have his or her story as to why an AI occurred, in order to propose the appropriate risk-mitigation actions.

But information from the cockpit is hard to get since a large number of AI's are generated by 'unknown traffic'. For those which have been identified, but did not constitute a danger to other traffic, an in-depth investigation is rarely performed, i.e. the infringing pilot is usually not interviewed. At best, a written statement by the pilot is available.

More information can be obtained when an AI results in an AIRPROX and the infringing flight crew can be identified. Depending on the severity, an investigation is launched and pilots are then interviewed - thus more facts emerge on the causes that led to the airspace infringement.

For this study, data in sufficient detail, quantity and quality was available in Switzerland to conduct a meaningful analysis. Due to its geographical location, the airspace infringement issue is particularly acute in this country. At the crossroads of commercial traffic, VFR flights follow similar routes, but at lower altitudes. Furthermore, its main airports, Geneva and Zurich, are situated near national borders where TMAs extend laterally into foreign territory.

But Switzerland is no exception when it comes to AI's. Other countries in Europe suffer from similar phenomena.

The ideal situation would have been to obtain and analyse data from several countries to acquire a broader picture of the magnitude of the AI issue. However, this has proven to be

too lengthy within the scope of this study. Therefore, the case study for Switzerland has been limited to the airspace surrounding Geneva and Zurich airports.

2.2 Data samples

For this case study, it was decided to look into occurrences over one complete year. The choice was made for the year 2004, as sufficient meaningful data was available.

The data obtained in Switzerland were compiled from 3 main sources:

- Air Navigation Services Provider - ANSP, Skyguide
- Swiss Aircraft Accident Investigation Bureau, Swiss AAIB
- Swiss AIRPROX Board, chaired in 2004 by the Swiss AAIB

Note 1:

The sole objective of this airspace infringements data analysis was to obtain information on the AI issue. It is not an investigation into the Air Navigation Services Provider in Switzerland.

Note 2:

The aim of this analysis is not to obtain statistical evidence over the years on the evolution of the AI issue. It is rather an analysis of the types and frequency of occurrences over one year. The aim is to show the magnitude of the issue over a selected period in time.

2.2.1 Air Navigation Services Provider, Skyguide

The main provider of the data required for this study was Skyguide. The Air Navigation Services Provider (ANSP) of Switzerland provided the listings of all known events and incidents for the year 2004. Of 1,046 events and occurrences, 123 were identified as airspace infringements. It is important to mention that of the 1,046 events and occurrences, only a few were of a serious nature.

The above numbers exclude Class E airspace ‘legal’ encounters, which will be dealt with elsewhere within Eurocontrol’s Airspace Infringement Safety Initiative.

Skyguide also provided the internal files of the incidents that were, because of their low risk severity, neither investigated by the Swiss AAIB, nor by the Swiss AIRPROX Board. Special thanks go to Skyguide for providing the data as well as their confidence that the latter would be used in a de-identified way. The de-identification has been consistently applied, except for the information contained in the Swiss AAIB reports, which are public and published on the Internet.

2.2.2 Swiss Aircraft Accident Investigation Bureau (AAIB)

The final reports of the AAIB are public and published on the Internet. These include aircraft accidents as well as serious incidents. Since 1998, serious ATM incidents (AIRPROX) have also been investigated. Over 105 investigations have been conducted since 1998. Several concern airspace infringements. By nature, the AAIB reports are the most informative, since those investigations are in-depth and, in general, more information is available from the infringing pilot.

2.2.3 Swiss AIRPROX Board

The reports from the Swiss AIPROX Board were made available through the Swiss AAIB. In 2004, the AIRROX Board was managed and chaired by the Swiss AAIB. This board is a Stakeholder entity where ATM incidents are discussed, rated and, if applicable, recommendations are made.

2.3 Data preparation

As outlined in Chapter 2.2, the data for this study was compiled from three sources. Depending on the depth of the investigation, the data available ranged from scarce to detailed. Particular attention was paid to availability and consistency. Where data was not available, or its consistency could not be crosschecked, the data-field was labelled “Not enough information”. In other words, no assumptions were made. Therefore, the results of the data analysis are based on facts. They are presented in Chapter 3 of this report: Results of the Case Study Switzerland.

The database programme used for this study is FileMakerPro Version 8.5, a relational database that works seamlessly on Windows and Macintosh platforms.

2.4 Data taxonomy

The database established for this study contains a total of 161 searchable fields. The following sub-chapters contain a series of tables, which explain the data taxonomy. However, only the data fields needed for an understanding of the results are listed here. Although different, each table features the Database search criteria in the last (right-hand) column. These criteria were used to conduct the analysis.

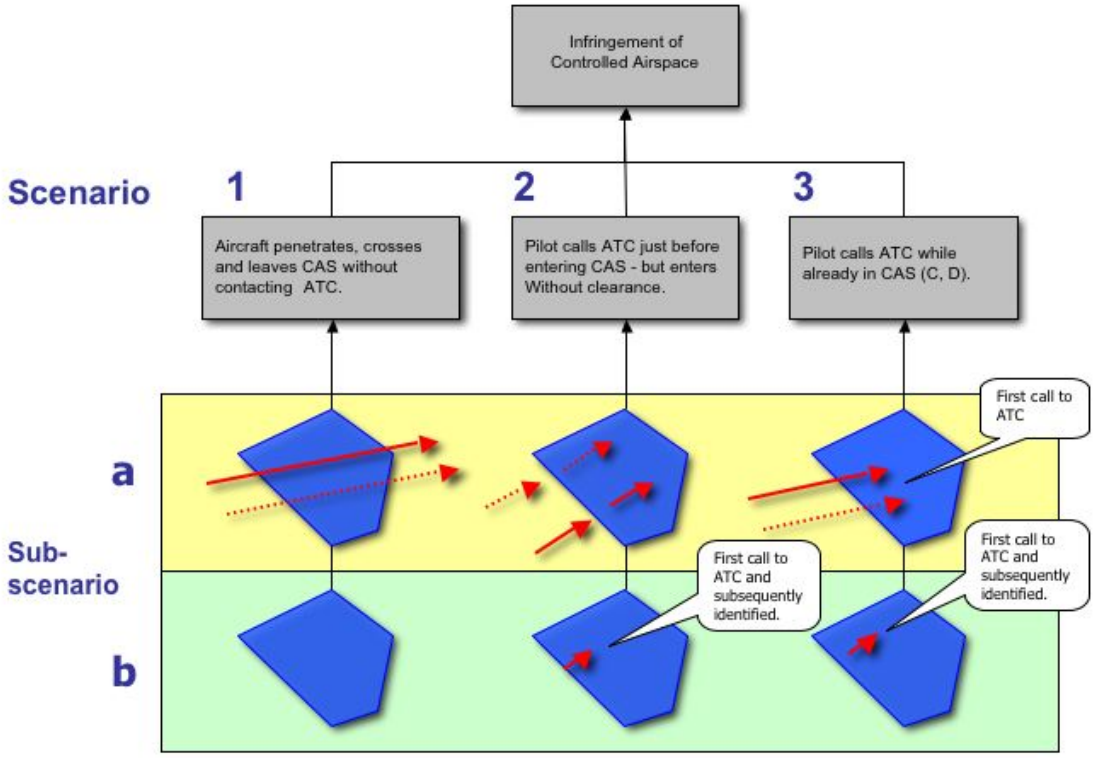
2.4.1 Airspace infringement scenarios

As this constitutes the main issue, the first part of this case study initially focuses on Airspace Infringement (AI) of controlled airspace, i.e. ICAO Class C and D airspace. As mentioned in Chapter 2.2.1, Class E airspace encounters will be dealt with elsewhere within the Airspace Infringement Safety Initiative.

Three basic AI scenarios were identified and were subsequently used to structure the data. These scenarios are generic, but should cover most of the cases encountered.

The figure below explains three (3) basic scenarios along with their sub-scenarios. They are:

1. Aircraft penetrates, crosses and leaves controlled airspace without contacting ATC.
2. Pilot calls ATC just before entering controlled airspace – but enters without clearance.
3. Pilot calls ATC while already in controlled airspace.



The three scenarios each contain two sub-scenarios as depicted above in row a (yellow), and b (green).

The main difference between a and b are the detection possibilities by the ATCO.

a 'implies' that the infringing aircraft was visible, or could be observed on the radar screen of the ATCO, either in the form of a primary radar return (dotted red line), or a Secondary Surveillance Radar (SSR) return emanating from an interrogated transponder (full red line).

Whereas b is the situation where the flight could not be detected or observed by means of radar and therefore was not visible to the Air Traffic Controller (ATCO) beforehand. The flight appears on the radar screen once the pilot turns on his transponder and selects the attributed code (Scenario b 2 and b3), or a primary radar return is strong enough to become visible.

The following table presents an overview of the three main scenarios as defined above. In addition, the effects on ATC as well as some possible causes are shown. The last column contains the search criteria used for the data analysis.

Scenario		Effects on ATC	Possible causes	Database search criteria
1	**Penetrates, crosses and leaves controlled airspace without contacting ATC.**	▪ May go undetected by ATC ▪ May create a conflict with aircraft using same airspace	▪ Is not aware of position ▪ Is not aware of airspace structure ▪ Is convinced that has clearance from previous unit ▪ Diversion due to prevailing WX conditions ▪ Not familiar with local procedures ▪ Penetrates intentionally, intending to look out and separate itself from other traffic.	▪ No contact
2	**Calls ATC just before entering controlled airspace - but enters without clearance.**	▪ *Fait-acompli* situation, where ATC is dealing with an enforced situation	▪ Awaiting clearance and expects to obtain it in time ▪ Is convinced that since he is talking to ATC (be it the previous unit or the actual/receiving unit) – there is a clearance to continue.	▪ Call before entering CA
3	**Calls ATC while already in Controlled Airspace (C, D)**	▪ *Fait-acompli* situation, where ATC is dealing with an enforced situation	▪ Is not aware of position. ▪ Is not aware of airspace structure. ▪ Is convinced that has clearance from previous unit.	▪ First call already in CA
				▪ Not enough information

2.4.2 Data on ATC detection & identification means

The detection by ATC of infringing traffic is an important element when analysing the airspace infringement issue. There are various scenarios ranging from a 'blind' ATCO (nothing is seen on the Radar screen) to a positive monitoring of a squawking transponder.

However, a squawking transponder or a primary Radar return does not necessarily mean that the aircraft has been identified, or monitored by ATC. In other words, the aircraft might have been visible but not noticed by the ATCO.

The table below outlines the different means of detection as well as its limitations.

Means by ATC to detect / identify aircraft	Definition	Limitations	Database search criteria
SSR Radar (Transponder)	▪ The transponder code selected by the pilot is visible on the Radar screen.	▪ If a/c squawks Mode A only – no altitude is shown. Information is of limited use to ATCO. ▪ If a/c squawks Mode A/C – altitude is shown and ATCO can exploit information to some extent (i.e. a/c intentions are not known).	SSR Radar target
Primary Radar	▪ Aircraft appears as a primary 'blip' on the Radar screen.	▪ Size of aircraft and/or its altitude determines whether it may become a usable 'blip' for the ATCO to 'work' with. ▪ However, no altitude is shown.	Primary Radar target

Reported by another pilot	▪ Pilot reports observing an aircraft.	▪ In some cases, pilots can identify type and/or colour of aircraft. ▪ Distance and vertical separation is difficult for pilot to estimate. ▪ Limited use to ATCO for traffic separation purposes.	Reported by a pilot
			Not enough information

2.4.3 Data on separation provided by ATC & pilots

Fortunately, the majority of airspace infringements do not result in a loss of ICAO standard separation. However, during several airspace infringements, ATC or the IFR pilot intervened to provide separation with the intruder, either in a preventive (separation assurance) or positive (collision avoidance) manner.

The table below outlines the different situations and search criteria that have been identified with regard to separation assurance.

Maintaining Separation	Definition	Actions	Database search criteria
Separation maintained by ATC *preventive*	ATCO provided separation between infringing aircraft and IFR traffic during AI.	▪ Preventive vectoring ▪ Preventive altitude restrictions ▪ Traffic information	Separation provided by ATC
Separation maintained by pilot *preventive*	Pilot provided separation between infringing aircraft and IFR traffic during AI.	▪ Preventive track change ▪ Preventive level-off ▪ Maintaining visual contact	Separation provided by pilot
Traffic information provided by ATC	ATC issued traffic information as no other action was necessary **or** it was too late to provide separation assistance.	▪ Traffic information	Traffic information provided by ATC
Avoidance by ATC *positive*	Avoiding action by ATC required to prevent collision	▪ Positive vectoring ▪ Altitude restriction ▪ Essential traffic information	Avoidance by ATC
Avoidance by pilot *positive*	Avoiding action necessary by pilot to prevent collision	▪ Positive avoiding action	Avoidance by pilot
No effect on other traffic	Flight has infringed controlled airspace without affecting other traffic.	▪ None	No effect on other traffic

2.4.4 Data on impact on ICAO separation minima

Loss of separation may occur during an airspace infringement. If this is the case, the closest point of approach (CPA) is compared with the required ICAO separation minima or, where no minima are specified, where the separation was inadequate.

Loss of separation or inadequate separation during an AI has in most cases triggered an investigation (AIRPROX).

Loss of Separation	Definition	Database search criteria
Separation infringed	The standard ICAO separation of 3/5NM and/or 1,000ft has been infringed.	Separation infringed
Separation inadequate	Where no separation criteria are specified (i.e. CTR, ICAO Class E-airspace), but aircraft were perceived to pass too close to each other for pilots to ensure safe separation.	Separation inadequate
No loss of separation		No loss of separation
		Not enough information

2.4.5 Data on ATC Coordination

ATC coordination plays an important role during the different airspace infringement scenarios. In general, procedures are established to handle VFR traffic movements in, and about to enter, controlled airspace. These are published within the relevant procedure manuals for the ATCO but also in some AIPs.

The table below outlines the different coordination scenarios identified in the context of airspace infringement.

Coordination	Definition	Effects on ATC	Possible reasons	Database search criteria
Prior coordination by adjacent unit (external)	▪ An adjacent ATC unit coordinates flight before it enters controlled airspace.	▪ Receiving unit is prepared to manage incoming flight	▪ Procedures exist and are applied.	Prior by adjacent
Prior coordination by adjacent unit (internal)	▪ An internal adjacent ATC unit (i.e. FIC) coordinates flight before it enters controlled airspace.	▪ Receiving unit is prepared to manage incoming flight	▪ Procedures exist and are applied	Prior by internal
No prior coordination by adjacent unit (external).	▪ An external ATC unit does not coordinate flight.	▪ Receiving unit is not prepared to manage incoming flight ▪ Data needs to be gathered 'on the spot' by ATCO.	▪ Letter of Agreement (LoA) does exist – but procedure is not applied by ATCO ▪ Lack of time to do so due to proximity	No by adjacent

Coordination	Definition	Effects on ATC	Possible reasons	Database search criteria
		▪ Time-consuming process. ▪ Effect on ATCO workload	of airspace. ▪ Lack of appropriate procedures.	
No prior coordination by adjacent unit (internal).	▪ An internal ATC unit does not coordinate flight.	▪ Receiving unit is not prepared to manage incoming flight ▪ Data needs to be gathered 'on the spot' by ATCO. ▪ Time-consuming process. ▪ Effect on ATCO workload.	▪ Internal procedures exist – but are not applied by ATCO. ▪ Aircraft is immediately sent to sector – no time to co-ordinate.	No by internal
No coordination	▪ No coordination procedures are specified for this specific case.			Not applicable
				Not enough information

CHAPTER 3 – Results

3.1 Scope of analysis

Although the data provided covered the occurrences in Switzerland for the year 2004, the analysis focused on the incidents that occurred around the major airports Geneva and Zurich, as more detailed data was available for these two areas.

3.2 Data analysed

In general the data analysed was factual in the sense that the majority of the reports only contained data on what actually happened. In other words, these reports contained no analysis or conclusions. More information as to why the occurrence happened was available from 3 Swiss AAIB reports where airspace infringement was a factor. These in-depth investigations provided enough background to draw informed conclusion on the cause. However, this information represents only a fraction (3 of 123) of the total factual information that was available for the study.

This confirms earlier statements that data on the “why?” factor will need to be gathered from other sources. Nevertheless, the analysis of the factual data confirms certain perceptions - for example that airspace infringements are a real issue and that problem areas need to be identified by their frequency of occurrence.

The results for each criterion analysed are presented in graphical form in the following chapters. This includes a description and, where applicable, a comment. Data from Geneva and Zurich are shown in a combined way on the same graph, with the exception of the first graph showing the results for airspace infringements versus other occurrences.

The following criteria were analysed:

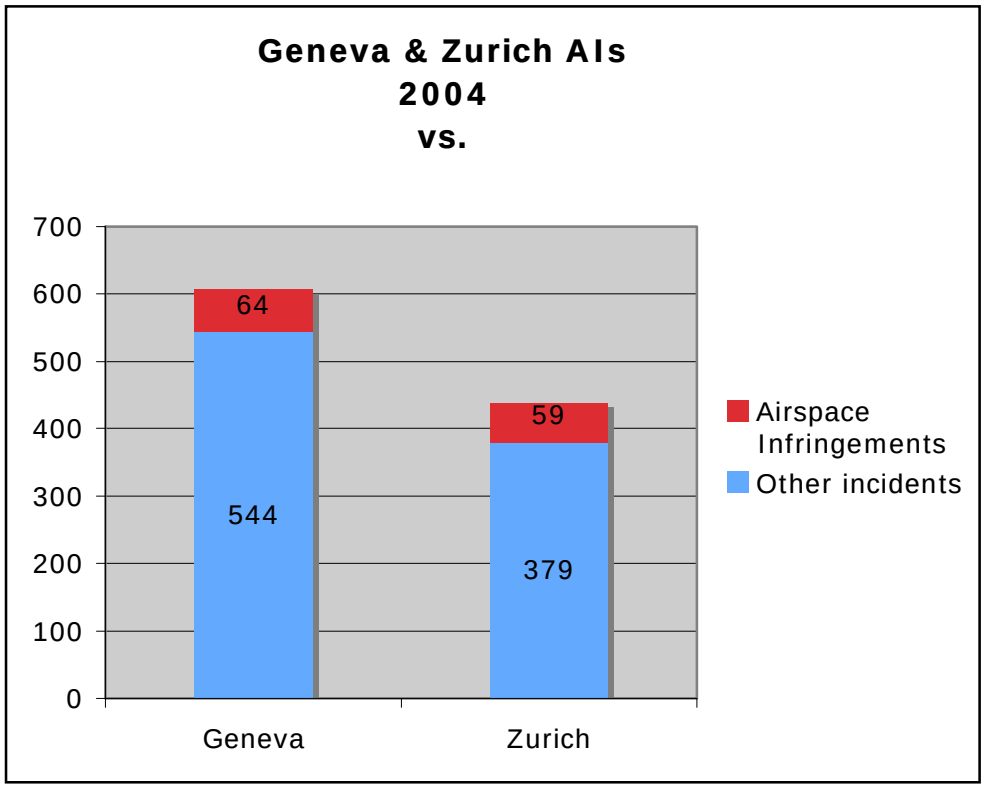
- Number of airspace infringements for 2004
- Category of aircraft involved
- Country of registration
- Class of airspace infringed

- Vertical distribution
- Airspace Infringement scenarios
- ATC detection & identification means
- Separation assurance by ATC & pilots
- Impact on ICAO separation minima
- Separation achieved during incident
- ATC contribution
- ATC coordination
- Severity assessment
- Primary causal factors

3.3 Analysis results

3.3.1 Number of airspace infringements in 2004

The graph below shows the number of airspace infringements around the airports of Geneva and Zurich compared to other incidents that occurred within the area of operation of these two units. Within these units, airspace infringements concern mainly Tower, Approach and Flight Information positions.



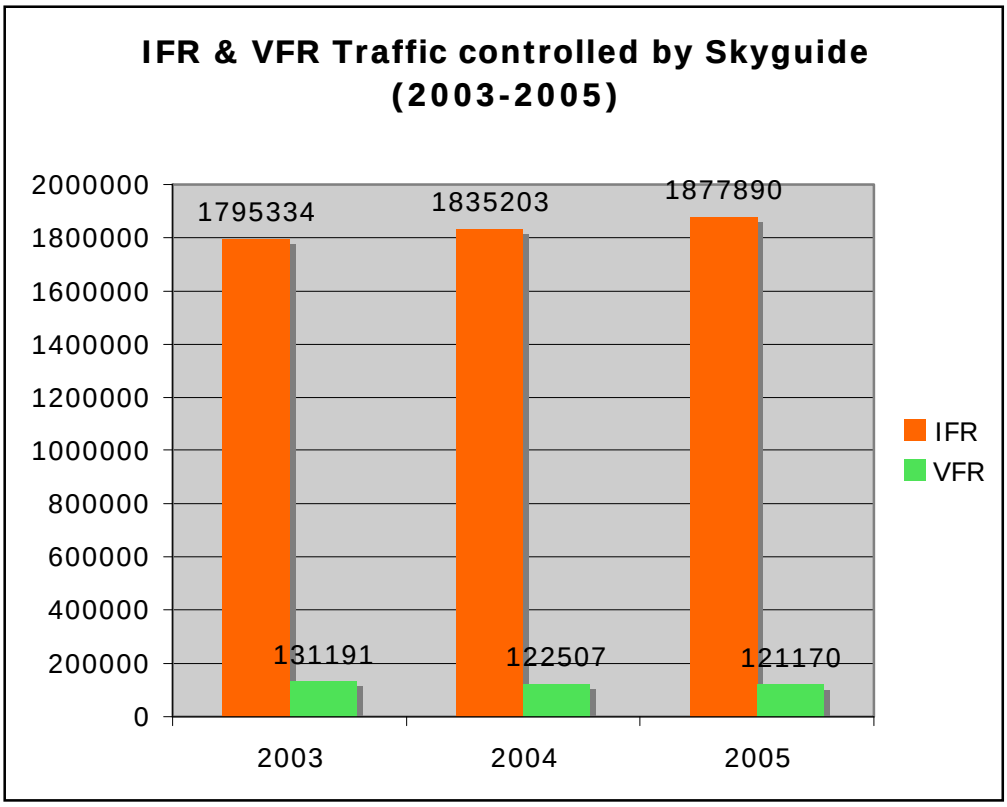
Comments:

The numbers presented above are absolute and show only the relationship between reported general incidents and those which were identified as airspace infringements during the year 2004. The most striking finding is that a similar number of AI's occurred in Geneva and Zurich during the year 2004, despite the difference in numbers of total occurrences. For Geneva, airspace infringements account for 11% of the total, while for Zurich the figure is 13%. It should be noted that this study deals only with reported airspace infringements. The

real number is most probably higher, although it would be pure speculation to try to put a figure on this.

3.3.1.1 IFR and VFR traffic statistics

The following graph shows the total yearly IFR & VFR movements controlled and monitored by Skyguide at its units. According to these figures, VFR traffic represents between 6% and 7% of total traffic in the period from 2003 to 2005.

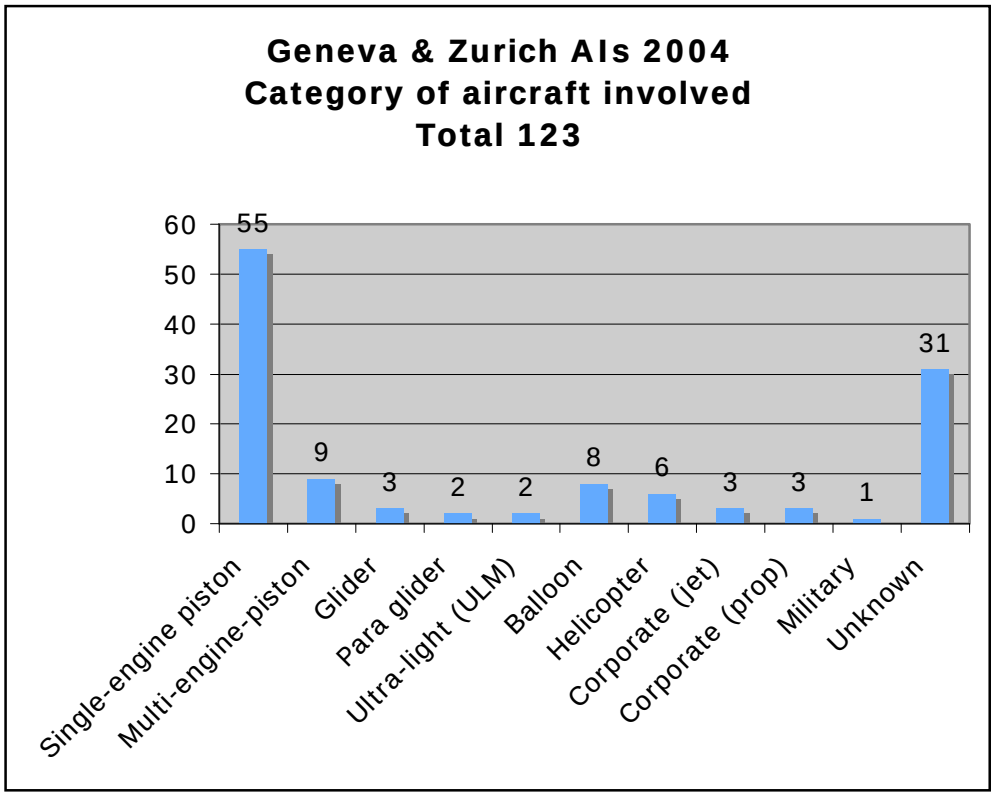


Comments:

As elsewhere in Europe, IFR traffic continued to grow between 2003 and 2005, while VFR movements tend to decrease. Rising fuel cost, insurance cost, new regulatory requirements, etc., have probably contributed to the reduction of VFR movements.

3.3.2 Category of aircraft involved

A wide variety of aircraft 'participate' in airspace infringements. However, the single-engine piston category stands out, with a relatively substantial number. Unknown means that the category of aircraft could not be determined.



Comments:

Single-engine and multi-engine piston aircraft account for the majority of infringing aircraft, and it can be reasonably assumed that a large number of the unknown category is of the same proportion.

Although glider activity is substantial in the area around Geneva and Zurich, comparatively few incidents were reported. This could be attributed to the major information campaign launched in 2003 when, along with other airspaces, there was a reorganisation of the glider areas around both airports.

Relatively new airspace users are the para-gliders. The performance of this equipment has improved over the years, allowing the pilots to use updrafts to reach altitudes high enough to penetrate controlled airspace. Two encounters with commercial traffic (airliners) have occurred near Geneva.

It should also be noted that infringements involving gliders and para-gliders may be underreported due to lack of SSR response (for gliders - SSR transponder not switched on or not fitted).

Ultra-light aircraft are prohibited in Switzerland, but not in the neighbouring countries. Two airspace infringements have been registered within Geneva CTR. The geographical limits of this airspace extend across the national boundaries of France and Switzerland.

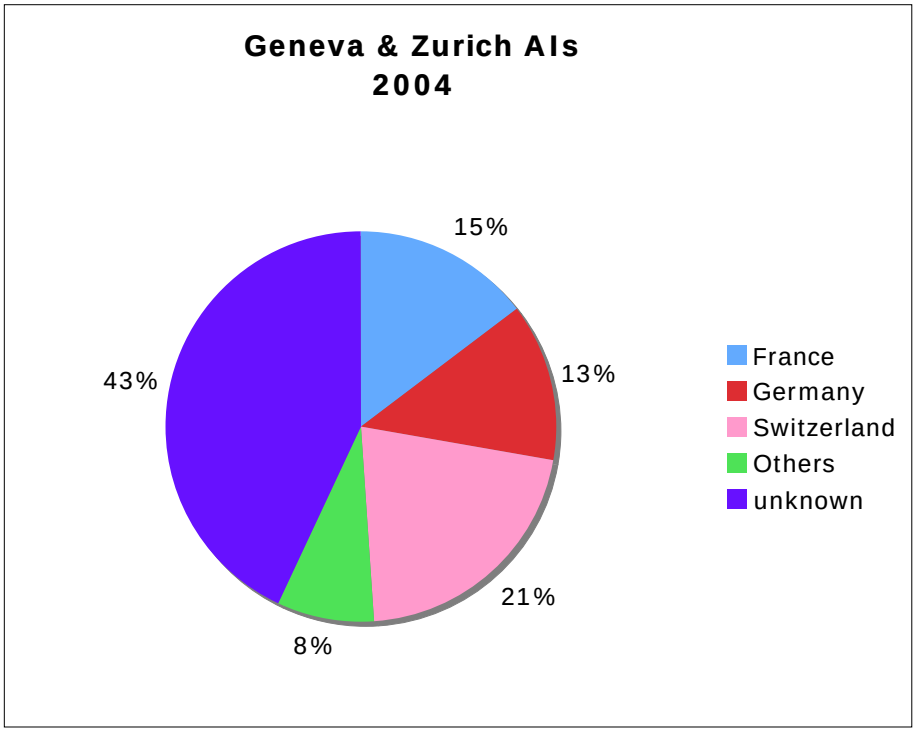
Ballooning is popular in Switzerland. Balloons, both gas and hot-air, are spotted relatively easily due to their size. However, they do present a danger, as they are virtually stationary in the air. Furthermore, their ability to fly high has repercussions on safety. Of the 8 airspace infringements registered by balloons in 2004, 5 were cruising between 9,500 ft and 15,000 ft. In 3 cases, separation with the balloon was assured by the pilot, and in one incident ATC maintained separation.

Comparatively there were few airspace infringements where corporate jets and corporate turboprop aircraft were involved. However, since their performance is similar to that of airliners, lead-time is often limited for ATC to take appropriate actions. In 4 out of 6 cases the aircraft infringed an airway (Class C airspace), while the remaining 2 cases infringed TMAs. The majority of airspace infringements occurred while these aircraft were on a joining, or

leaving, IFR Flight plan. Climbing into controlled airspace in order to maintain visual meteorological conditions was also a causal factor cited.

3.3.3 Country of registration

The country of registration provides some indication as to where the infringing aircraft come from. However, almost half (43%) of them could not be identified, which leaves a question mark as to which country of registration they belong to.



Comments:

Of the known intruders, Swiss registered aircraft produced the most airspace infringements (21%), followed by French registered aircraft (15%), and German aircraft (13%). The majority of airspace infringements by French registered aircraft occurred in the region of Geneva, while the German aircraft were mainly involved in infringements in the region of Zurich. Likewise, the majority of the known intruders are registered in adjacent countries (44%).

The category 'others' concerned 8% of the non-adjacent countries, like US, Luxembourg, UK, etc.

Looking at the ratio between known and unknown intruders, it can be reasonably assumed that the unknowns are more likely to be originating from Switzerland as well as from the adjacent countries.

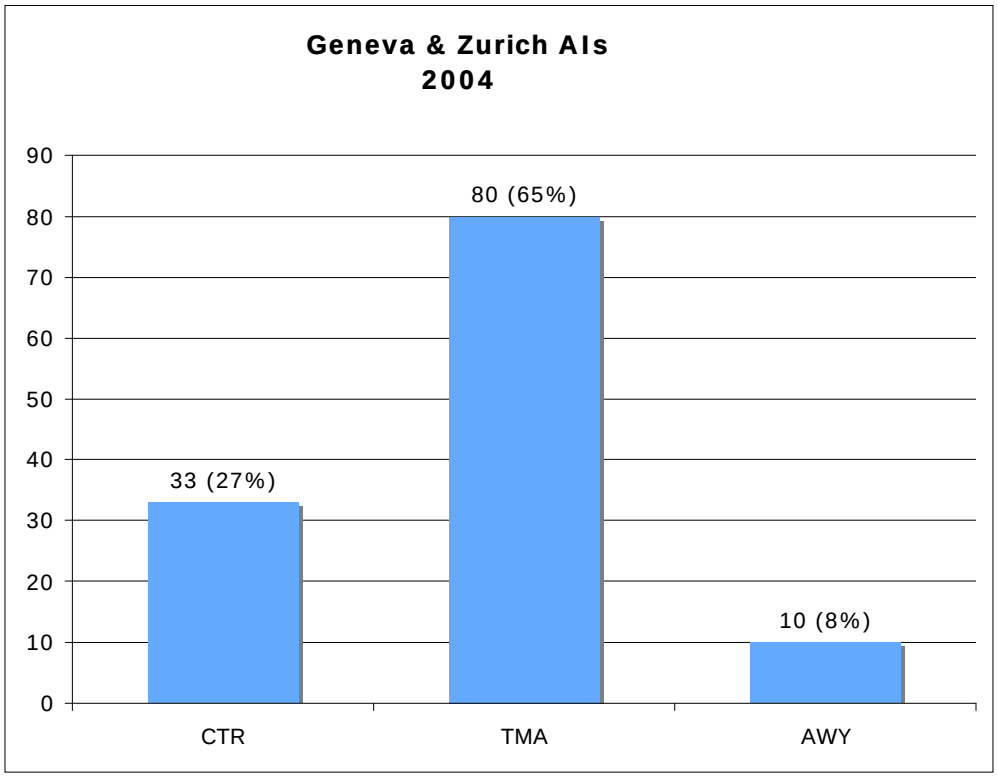
In general, it can be noted that mitigation action (awareness campaigns) should not only concentrate on informing Swiss pilots, but should also include pilots from the adjacent countries (France and Germany).

3.3.4 Class of airspace infringed

Three airspace classes are concerned: Control Zone (CTR), Terminal Control Area (TMA) and Airways (AWY). Within these airspaces, ICAO Class C and D services are provided. Both classes are controlled airspace and therefore an entry clearance is required. Class E airspace is not shown on this graph despite being controlled airspace, as no entry clearance is required. Again, Class E airspace encounters, will be dealt with elsewhere within the

Eurocontrol Airspace Infringement Safety Initiative.

The graph below shows the airspace infringements in absolute numbers as well as in percentage terms.



Comments:

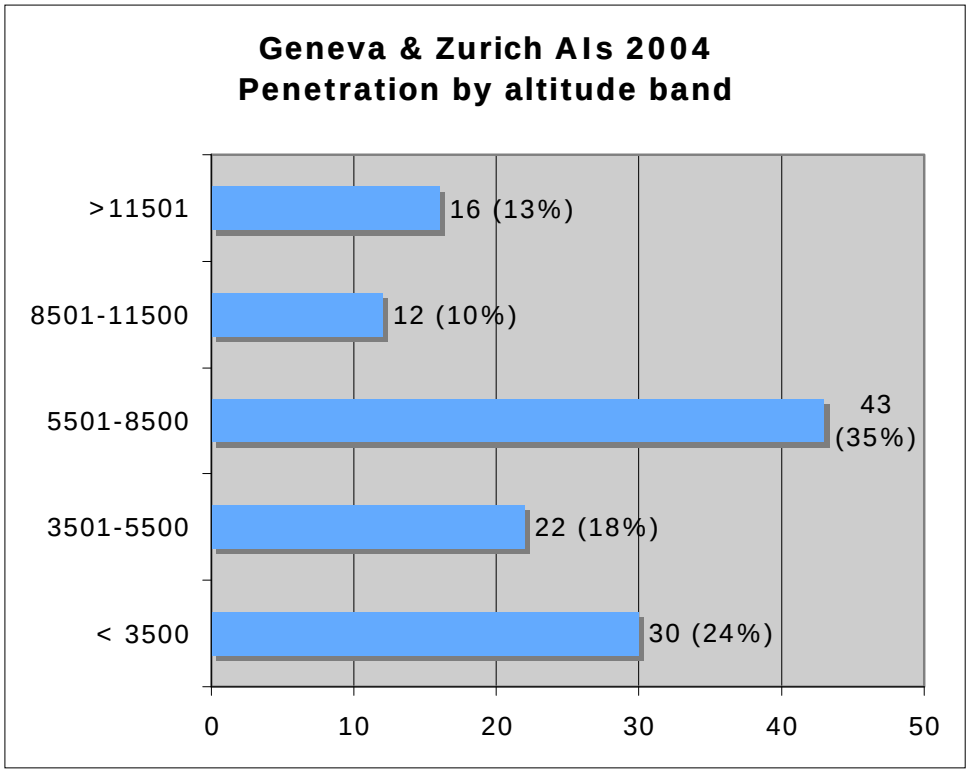
The majority (65%) of infringements occurred in terminal airspace (TMA), while 27% of the airspace violations occurred in CTRs.

In a few occurrences, both TMA & CTR airspace were infringed by the same flight. In this case, the occurrence was counted only once - the first airspace that was infringed without clearance.

3.3.5 Vertical distribution

The presentation of the 123 occurrences in altitude bands provides some information as to at which altitude airspace was infringed. The bandwidth was chosen to reflect roughly the vertical airspace structure around Geneva and Zurich Airports. Most of the airspace infringements below 3,500 ft (30) were within CTR. Indeed, there was a total of 33 CTR infringements. The airport elevation for Geneva and Zurich are 1,411 ft AMSL and 1,416 ft AMSL respectively.

42% of the airspace infringements occurred below 5,500ft, while 35% occurred between 5,501 ft and 8,500 ft, 23% occurred above 8,501 ft and the highest infringement was within an AWY at 17,000 ft (FL170).



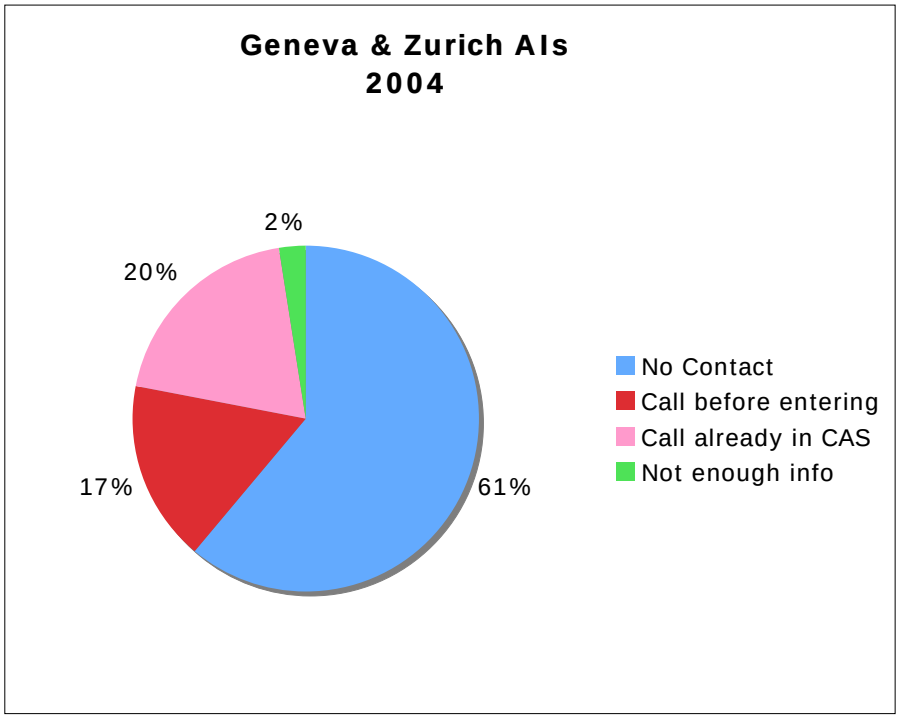
Comments:

The figures reveal that 77% of the airspace infringements occurred at or below 8,500 ft. This confirms the perception that the majority of AIs happen at lower altitudes.

3.3.6 Airspace infringement scenarios

The infringement scenarios are described in chapter 2.6. The graph below shows that 61% (75) of the infringing pilots did not, or could not, contact ATC to obtain an entry clearance into controlled airspace (CAS).

17% (21) of the pilots contacted ATC, but penetrated anyway, while 20% (24) called when already in CAS, whether in a CTR, TMA or AWY.



Comments:

The reasons for penetrating controlled airspace without calling ATC are various and one can only speculate as to why it may have occurred, since there is little or no explanation available from the pilot.

The scenario “call before entering and already in CAS” can narrow down the choice of causes. Late requests by pilots or delayed clearance by ATC are frequent causes of the call before entering scenario, while the already in CAS scenario, reveals causes like: not aware of position and/or airspace structure, or the pilot is convinced that he has the clearance to enter from the previous unit. Penetration due to the prevailing weather conditions has also been a cause in the last two scenarios.

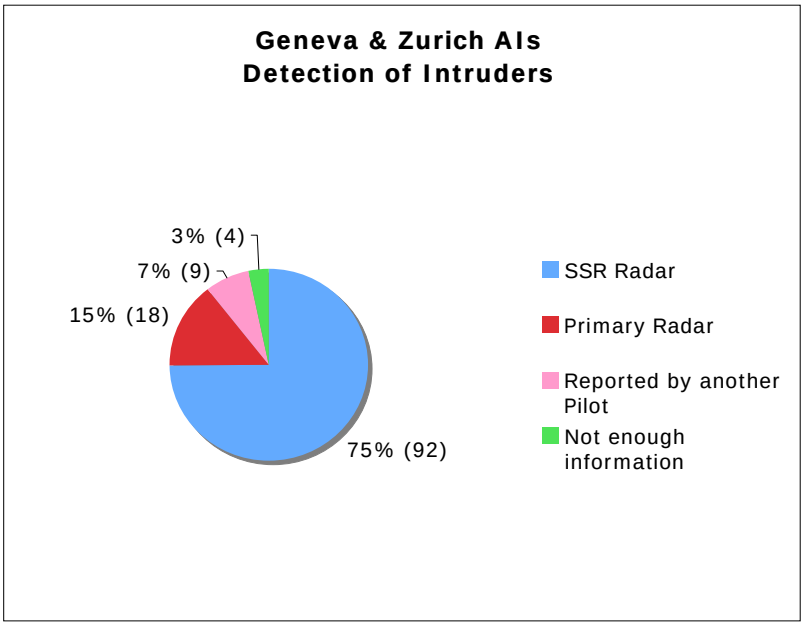
However, of the 123 occurrences analysed, 3 incidents were investigated by the Swiss AAIB and 5 by the Swiss AIRPROX Board. As a reminder, the mandate of the Swiss AAIB is to investigate serious accidents and incidents.

3.3.7 ATC detection & identification means

Detection and identification of intruders into controlled airspace is an important factor in the airspace infringement issue. Several means help ATC, such as Secondary Surveillance Radar (SSR) and Primary Radar (PR), with the detection of intruders. However, there are limitations as, for example altitude reporting - Mode C readout - is not always available. Primary Radar targets are difficult to detect as the return depends on the size and position of the aircraft in relation to the antennae.

However, the fact that a SSR or primary plot is visible on the controller’s Radar screen does not necessarily mean that the controller could see, or could work with this information. In 9 occurrences, it was the infringed pilot who reported the intruder.

Of the 92 intruders that switched their transponder to ‘ON’, a little fewer than half (44) contacted an ATC unit. The remaining 48 infringed controlled airspace without calling ATC.



Comments:

The study revealed that 75% (92) of the infringing aircraft were flying with their transponder ‘ON’. What does that mean? Does it mean: I am here, please separate me from other traffic? Or, I have a code from the previous unit, and I assume ATC coordinated my entry into the next airspace? Or, I will separate myself from other traffic. Or, I think that I am in un-controlled airspace, etc.

Many other causes may apply to that scenario. As previously mentioned, few explanations

are available on the rationale as to why 48 pilots turned their transponder on, but did not contact ATC.

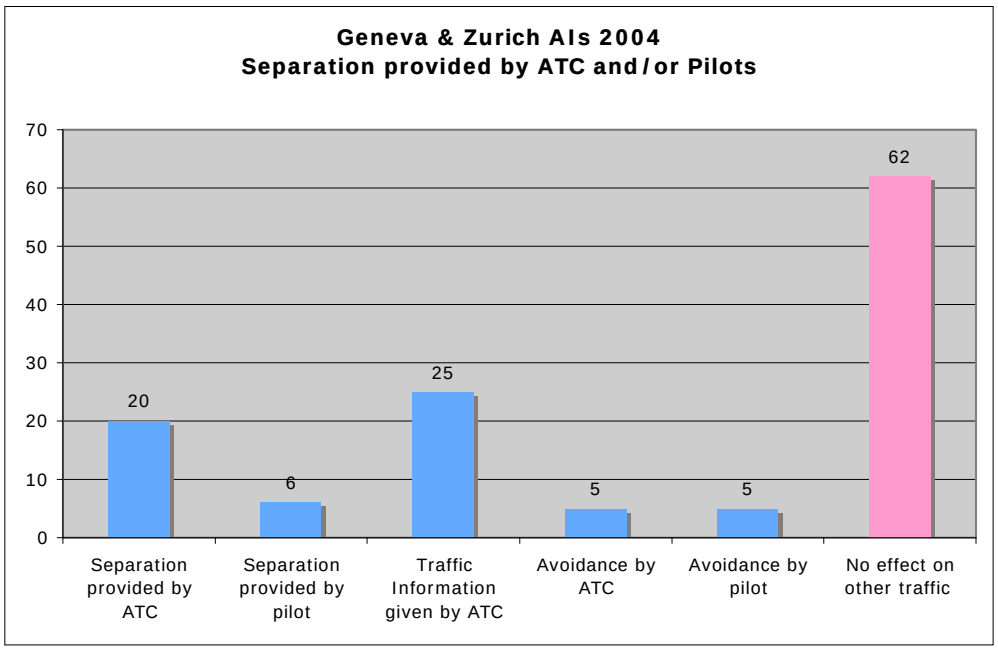
3.3.8 Separation provided by ATC and pilots

The definition separation provided by ATC and/or pilots was created for this study to illustrate the different actions undertaken by ATC or by the 'infringed' pilot to avoid collision. These range from preventive to avoiding actions. The details of these specific actions are outlined in Chapter 2.8.

In 20 incidents, ATC provided separation either by vectoring and/or altitude restrictions. In 6 occurrences, the pilot provided his own separation with the infringing aircraft.

During 25 occurrences, traffic information was issued by ATC - either because no other action was necessary or because it was too late to provide separation assistance to the respective pilots.

Avoiding action had to be taken in 5 cases by ATC and in 5 cases by the pilots to prevent collision. The remaining 62 infringements did not have any effect on other traffic.



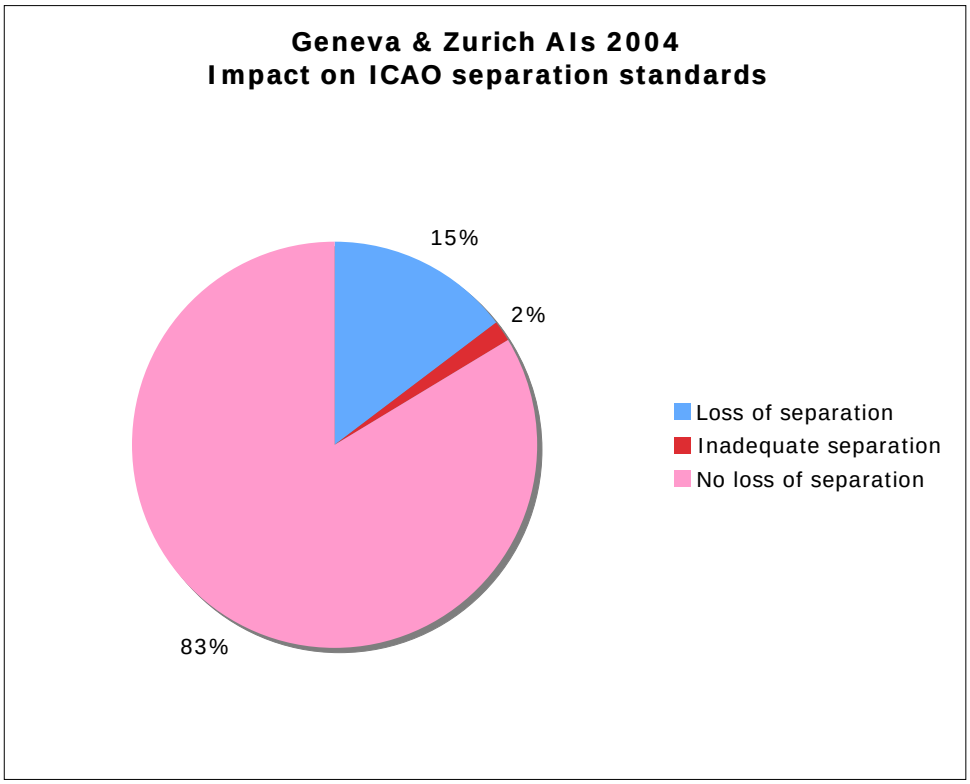
Comments:

Of the 123 occurrences in this study, 61 required one of the above-mentioned actions by ATC or the infringed pilots. This constitutes almost half of all airspace infringements recorded for Geneva and Zurich during the year 2004. This fact reveals a significant safety issue.

While in 43 occurrences loss of separation was avoided by actions engaged by ATC or pilots, 18 resulted in separation infringement or inadequate separation. These 18 occurrences are discussed in the following chapters.

3.3.9 Impact on ICAO separation minima

Loss of ICAO minima separation - 3/5NM and/or 1,000 ft – occurred in 18 cases (15%), while 2 incidents (2%) were classified as inadequate separation . No loss of separation occurred in 103 cases (83%).



Comments:

What could seem a comparatively small number of losses of separation as well as inadequate separation does in fact highlight a real safety issue.

Despite the intervention of ATC or the infringed pilots, 18 occurrences experienced a loss of separation whereas 2 occurrences belong to the inadequate separation category. Of the 18 cases where a loss of separation occurred, 5 were given avoidance action by ATC and 5 pilots took avoidance action to prevent collision.

For the remaining 8 cases, ATC gave traffic information, as it was too late, or inappropriate, to provide assistance to prevent separation infringement.

The 18 AIRPROX cases, where loss of separation or an inadequate separation occurred, are detailed within the next Chapter (3.3.9.1).

3.3.10 Achieved separation during incident

The table below compares the required separation versus the achieved separation for the 18 cases that experienced a loss of separation, as presented in the previous chapter. It should be noted that in 14 incidents the intruder was not in contact with the ATC unit concerned.

Likewise, in 14 of the 18 incidents, the intruder was visible on SSR Radar, while 2 were observed on Primary Radar. In 2 incidents, the infringed pilot reported the intruders.

Regarding separation assurance, 5 actions were initiated by ATC to avoid collision. In 8 instances, traffic Information was provided by ATC, while during 5 incidents, the infringed pilot initiated avoiding action.

These losses of separation generated various intensities on the severity scale. Two AIRPROX were considered serious – risk A and were investigated by the Swiss AAIB (Report No. 1889 and 1897). The Swiss AIRPROX Board investigated 14 incidents, while the ANSP Skyguide investigated the remaining 2 internally.

Code	Required separation (NM)	Required separation (ft)	Achieved separation (NM)	Achieved separation (ft)	Infringement scenario	Identification means	Separation assurance	Investigation by:
006	3	1000	**2.0**	**0**	Call already in CA	SSR Radar	Avoidance by ATC	AIRPROX Board
012	3	1000	**1.2**	**300**	No contact	SSR Radar	Traffic Information given by ATC	ANSP Internal
016	3	1000	**2.3**	**500**	No contact	SSR Radar	Traffic Information given by ATC	AIRPROX Board
023	5	1000	**4.8**	**400**	No contact	SSR Radar	Traffic Information given by ATC	ANSP Internal
033	3	1000	**2.5**	**0**	No contact	SSR Radar	Traffic Information given by ATC	AIRPROX Board
034	3	1000	**1.2**	**0**	No contact	SSR Radar	Traffic Information given by ATC	AIRPROX Board
038	3	1000	**1.1**	**100**	Call before entering	SSR Radar	Avoidance by ATC	Swiss AAIB No.1897
045	3	1000	**2.1**	**600**	Call already in CA	SSR Radar	Traffic Information given by ATC	AIRPROX Board
061	3	1000	**1.0**	**0**	No contact	Primary Radar	Avoidance by pilot	AIRPROX Board
072	3	1000	**0.4**	**500**	No contact	SSR Radar	Avoidance by pilot	Swiss AAIB No. 1889
074	3	1000	**0.7**	**300**	No contact	Primary Radar	Avoidance by pilot	AIRPROX Board
078	5	1000	**0.2**	**0**	No contact	Reported by pilot	Avoidance by pilot	AIRPROX Board
080	3	1000	**0.0**	**500**	No contact	Reported by pilot	Avoidance by pilot	AIRPROX Board
088	5	1000	**0.3**	**500**	No contact	SSR Radar	Traffic Information given by ATC	AIRPROX Board

Code	Required separation (NM)	Required separation (ft)	Achieved separation (NM)	Achieved separation (ft)	Infringement scenario	Identification means	Separation assurance	Investigation by:
093	3	1000	**1.4**	**500**	No contact	SSR Radar	Avoidance by ATC	AIRPROX Board
114	3	1000	**1.1**	**500**	No contact	SSR Radar	Traffic Information given by ATC	AIRPROX Board
115	3	1000	**2.2**	**400**	No contact	SSR Radar	Avoidance by ATC	AIRPROX Board
118	3	1000	**2.4**	**300**	Call already in CA	SSR Radar	Avoidance by ATC	AIRPROX Board

3.3.11 ATC contribution

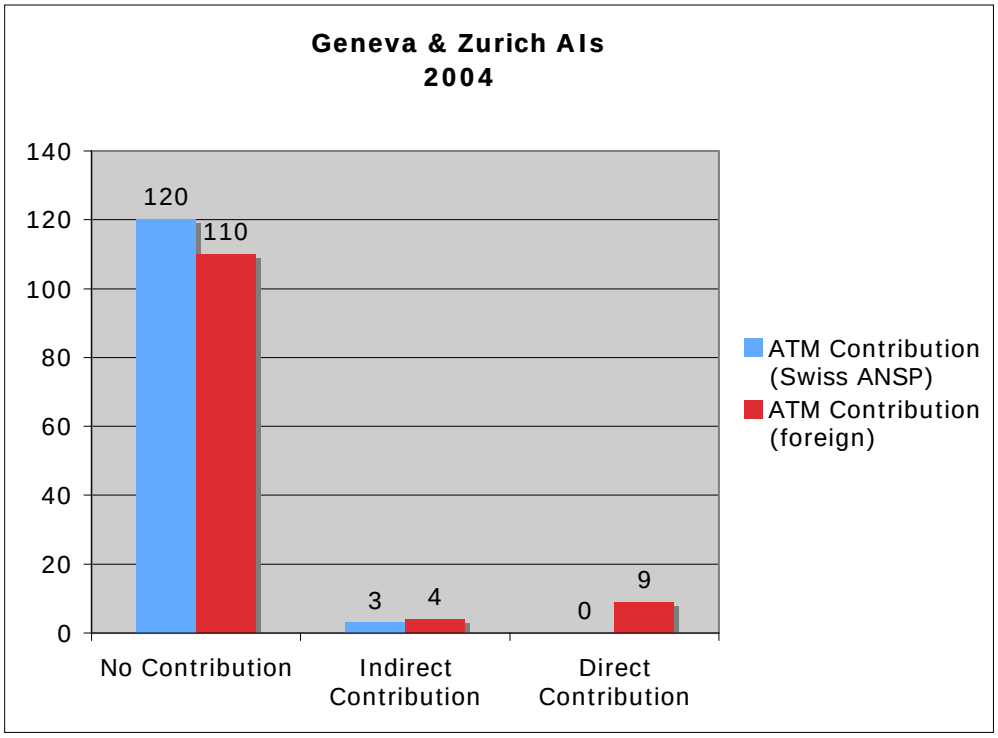
In rare cases, Air Traffic Control may directly, or indirectly contribute to an airspace infringement. The main reasons are absence of coordination or late coordination by the adjacent unit, or a sector within a unit. Another issue might be inadequate procedures or the absence of procedures to coordinate VFR traffic between units. The classification in this study was made according to the Eurocontrol HEIDI definitions:

ATM direct contribution

Where at least one ATM event or item was judged to be DIRECTLY in the chain of events leading to an accident or incident. Without that ATM event, it is considered that the occurrence would not have happened.

ATM indirect contribution

Where no ATM event or item was judged to be DIRECTLY in the causal chain of events leading to an accident or incident, but where at least one ATM event potentially increased the level of risk or played a role in the emergence of the occurrence encountered by the aircraft. Without such ATM event, it is considered that the accident or incident might still have happened.



Comments:

For each incident, ATM contribution was assessed regarding the Swiss ANSP as well as the foreign (adjacent) ANSP. For Geneva, this concerns the ANSP in France, while for Zurich the adjacent country is Germany. For the Swiss ANSP, 3 of 123 incidents were classified as indirect contribution, while no direct contribution was registered. Foreign ANSPs were indirectly involved in 4 incidents and directly in 9.

3.3.12 ATC coordination

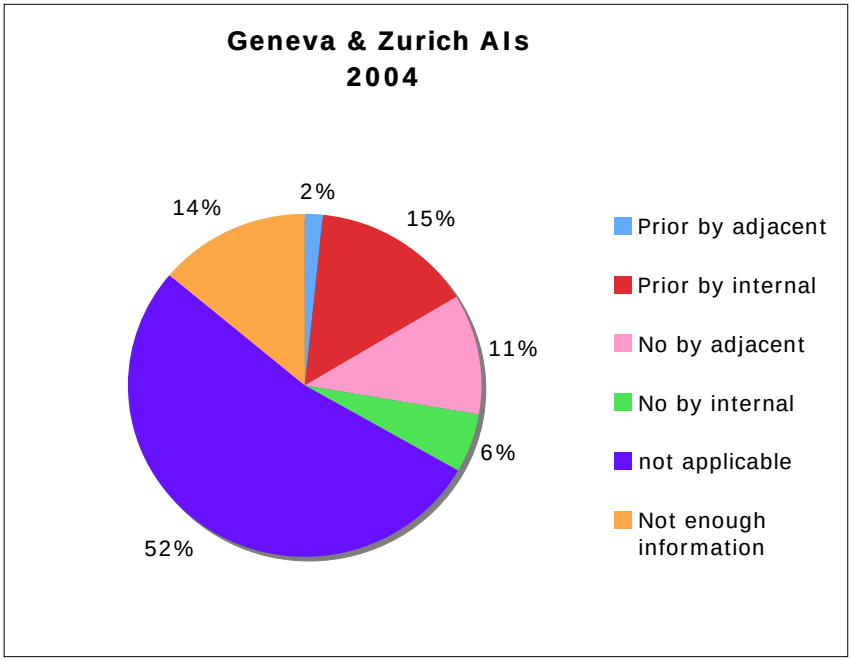
As mentioned in the previous chapter, ATC coordination has been a factor in some airspace infringement occurrences. For this study, a distinction is made between an accomplished coordination and that which has been omitted, despite the fact that one would have been required, as prescribed by (internal) ATC procedures (i.e. Prior by adjacent or No by internal as shown in the graph below).

The required coordination is one which has been omitted by either an adjacent unit (i.e. another ANSP) or an internal unit (adjacent sector). The detailed definitions regarding ATC coordination are outlined in Chapter 2.11 of this report. Late coordination, be it by an adjacent has also been included into this category.

The other categories are labelled not applicable and not enough information. The first means that in this occurrence, no coordination was required by ATC. The second is self-explanatory.

Of 123 incidents studied, the adjacent or the internal units conducted 17% of the required coordination, while in 17% of the incidents the required coordination was omitted.

In 52% of the occurrences, airspace infringement occurred under circumstances where no coordination was required (not applicable).



Comments:

Although low in numbers, lack of coordination contributed to airspace infringement and, in some cases, with an ensuing loss of separation. The issue is harmonisation of airspace classification and the way different countries handle VFR traffic.

For example, in an AIPROX Report (Swiss AAIB No. 1897), the investigation concluded that one of the factors playing a part in the incident was the lack of coordination of the adjacent Chambéry Approach unit.

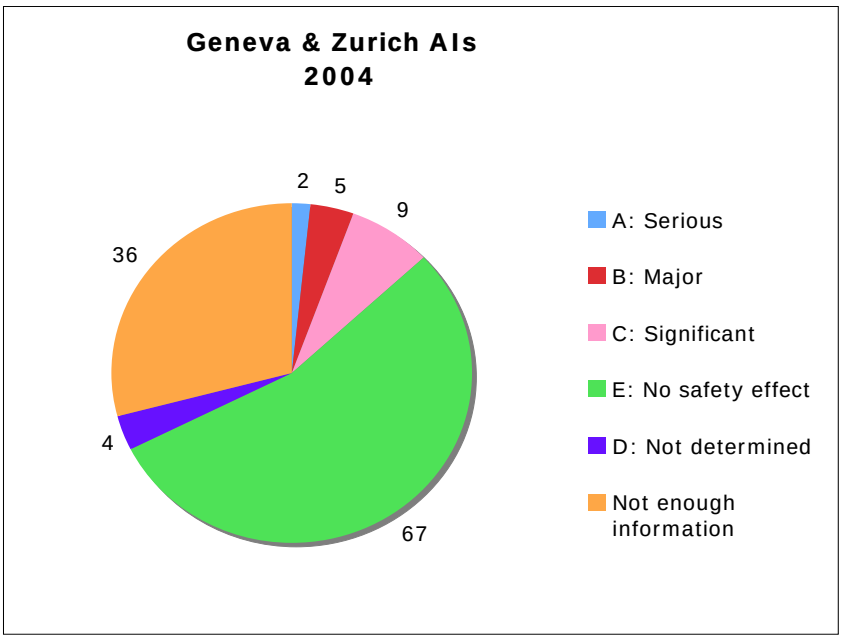
In another incident (Swiss AAIB No. 1889), the investigation concluded that the factor affecting the development of the incident was the absence of an exchange of information on an essential traffic between Chambéry Approach and Geneva Approach.

3.3.13 Severity assessment

The severity assessment figures were those determined by ANSP Skyguide according to their evaluation of the occurrence. They are classified according to the Eurocontrol ESARR2 Guidelines EAM2 /GUI5 Annex.

Of the 123 occurrences analysed, 2 were classified as Serious (A), 5 as Major (B) and 9 as Significant (C), whereas:

- Of the 2 classified as severity A, one was investigated by the Swiss AAIB and 1 by the Swiss AIRPROX Board.
- Of the 5 classified as severity B, one was investigated by the Swiss AAIB and 2 by the Swiss AIRPROX Board.
- Of the 9 classified as severity C, the Swiss AIRPROX Board investigated one.



Comments:

Over 50% (67) of the airspace infringements were classified No safety effect (E); while in 4 cases, the severity could not be determined (D). Severity D is normally attributed when no sufficient or reliable information is available. However, the 36 incidents termed as Not enough information stem from the fact that the information was missing on the data-sample provided. Indeed, some occurrences were not assessed, most probably due to their low severity.

3.3.14 Airspace infringement primary causal factors

To conclude the chapter on results, the 123 occurrences analysed for Geneva and Zurich in 2004 were mapped onto the list of the proposed primary causal factors defined by Eurocontrol airspace infringement causal factor model [Eurocontrol 2007]. Applying the same approach as throughout the study, the mapping is based on factual data only. Where no explicit causes were available, the causal factor was attributed to “Pilot did not request ATC clearance”, which is a fact, but does not explain why he or she did not request it.

Primary causal factor	No of occurrences
Aircraft control problem	1
Airspace structure identification error (issues)	3
ATC gives late ATC clearance for entering the airspace	1
Communication failure	2
Inadequate ATC coordination	9
Misunderstanding of ATC instructions/clearances	3
Navigation error (issues) (if above details are not known)	3
Non-compliance with ATC clearance limits	5
Pilot did not obtain ATC clearance	3
Pilot did not request ATC clearance	83
Position awareness error (issues)	3
R/T communication not established (in time)	2
Weather avoidance	5
Total occurrences	123

CHAPTER 4 – Field discussions with VFR pilots

4.1 Introduction

In order to obtain more information on the stakeholders' point of view regarding airspace infringements, field discussions were conducted with VFR pilots at two locations in Switzerland.

The objectives were:

- to gather information from the 'front' on the real issues encountered by VFR pilots on the issue of airspace infringements;
- to verify whether the field discussions provide enough meaningful feedback to be exploited for implementing mitigation actions and recommendations.

The field discussions were conducted at Zurich-Kloten Airport on 15 August 2006 and at Yverdon-les-Bains Aerodrome on 22 August 2006. The meeting in Zurich was conducted in Swiss German, whereas the meeting in Yverdon-les-Bains was conducted in French. The first meeting was organised by Philippe Hauser, CEO AOPA Switzerland, and the second by Jean-Pierre Besson, Flight Instructor. Both were evening sessions that took place on a Tuesday between 19:00 and 22:00. An average of 17 pilots attended each meeting. Pilots with a broad range of flying experience were invited in order to obtain the widest possible feedback.

The first part of the meeting consisted in providing an overview of the issue as well as some background information on ATC issues, usually not known to the VFR pilot. To introduce the subject, the Eurocontrol Airspace Infringement Safety Initiative was explained.

The support for this part was the first Safety Letter dealing with the airspace infringement initiative and a Eurocontrol DAP/SAF presentation. To describe the complexity of the issue, the Final Report of an AIRPROX that occurred on 25 May 2004 between an IFR flight BVR101 and VFR flight F-GSIX was presented. This report (No.1897) is published by the Swiss AAIB and is available on their Web-page under:

http://www.bfu.admin.ch/en/html/berichte.html

The second part of the meeting was dedicated to a brainstorming session that gave the floor to the participating pilots. This session was conducted in two parts. During the first, the

participants were asked to name the possible causes of AI's while the second was dedicated to the possible solutions. For the possible causes session, the following categories were proposed in relation to Airspace Infringements:

- Human factors
- Airspace structure
- Procedures/regulation
- Navigation

4.2 Brainstorming session

The following is a summary of the possible causes and mitigation actions identified by the pilots attending the above-mentioned meetings. Where the remarks and suggestions made at the two events were the same, they are only listed once.

4.2.1 Human factors

- Pilot stress when faced with the, sometimes arrogant, behaviour of the air traffic controller. The ATCO is often perceived as the police!
- There is an impression that VFR pilots are perceived as dangerous by ATCOs.
- There is general agreement that flight preparation, or a lack thereof, may be a major cause for AI's.
- Lack of refresher training regarding the specific subject of dealing with ATC and its airspace structure.
- As with professional pilots, task distribution should be performed when two pilots are on board a VFR flight.
- Lack of precision, especially regarding altitude and heading, was often cited as a cause for AI's.
- Lack of consideration of prevailing winds – drifting without noticing.
- One major aspect, which was mentioned several times, is the complexity of procedures that poses a real problem to such (non-professional) pilots.
- Overconfidence of the pilot when conducting a VFR flight.
- Lack of airmanship.
- Being tired and / or under the influence of alcohol.

4.2.2 Airspace structure

- Airspace complexity was probably the number one subject during the two sessions. Without wanting to interfere, the moderator mentioned that some airspace structure complexity probably arises as a result of the many stakeholders all wanting their share of airspace, including the various VFR activities (i.e. gliding near major airports). Although aware of this, the participants maintained that airspace complexity poses a real problem to the airspace users.
- One aspect mentioned was the fact that, especially around airports, VFR traffic is kept close to the ground.
- Availability of airspace has decreased over the years for VFR activity. Hence the increase of AI's. Some feel that there is a direct relationship.
- Although published on charts, transposing airspace structure into reality is no easy matter.

- The readability of charts is not easy as there is more information displayed as airspace complexity increases.
- The identification of waypoints is difficult, as they are not necessarily positioned at a distinct landmark.
- The pilots asked, in relation to compliance with airspace boundaries, which priority to apply when encountering marginal weather conditions?
- One of the causes for AIs is the continuous change of airspace structure. This has been especially acute for the Zurich TMA. A campaign had been launched to inform pilots, which was welcomed. However, the participants felt that it is difficult for non-professionals to follow and keep up-to-date with all the changes.
- Generally it was agreed that flying in ICAO class E airspace is dangerous. Some pilots believe that the see-and-avoid concept is not compatible with today's traffic densities.
- Although it is published (AIP) that the possibility exists, there seems to be a systematic refusal to requests to transit the Geneva TMA. This forces them to fly low or deliberately infringe airspace!

4.2.3 Procedures / regulation

- The pilot should be able (i.e. be allowed) to use the knowledge acquired during training. Pilots feel that the training received is not exploited when flying VFR.
- Acronyms should be displayed in full on each page when used.
- NOTAMS are difficult to decode (too many acronyms).
- Too many changes create insecurity.
- Intentional AI when ATC is busy (A pilot admitted infringing "reasonably" He meant flying just at the boundary inside controlled airsapce, be it vertical or horizontally).
- ATC overloads crew by asking for too many estimates (i.e. Italy).
- GPS programming / handling.
- Multilingual ATC diminishes traffic awareness.
- Complicated procedures.

4.2.4 Navigation

- Uncertainty regarding position.
- Lack of attention regarding wind influence.
- Lack of precision regarding altitude and/or HDG.
- Disorientation after GPS failure.
- The use of outdated charts.
- During marginal MET conditions - ATC should 'facilitate' the pilot to continue his flight.
- Limited 'Voice' knowledge.
- Complex ATC instructions.

4.2.5 Possible solutions / mitigation actions

- Coordinate IFR & VFR flights. The pilots suggested that instead of refusing (sometimes systematically) VFR flights into C-airspace, ATC should make an effort to accommodate both IFR and VFR flights needs.

- Better utilisation of pilot's capabilities (competencies). Pilots perceived that sometimes ATC disregards or underestimates their skills to fly in controlled airspace.
- Reduce complexity of the VFR flights' operational environment.
- Simplify NOTAMS
- All communications should be made in English.
- Provide 'tunnelling' for VFR flights.
- Provide free and easily accessible MET information.
- Implement confidential reporting.
- Improve relations between ATC and VFR pilots

4.3 Conclusions on the brainstorming sessions

The discussions were open and surprisingly self-critical. It was also felt that pilots were eager to learn how to fly in a complex environment.

During the brainstorming sessions, it became apparent that there is an important gap of understanding between the VFR pilot and ATC. The main issues are lack of information, communication and perception of ATC by the pilot and vice versa.

It was generally appreciated that these sessions were organised and that the pilots had a possibility to discuss these issues. Some of the participants said that it was the first time they had been able express their views and welcomed such an initiative – certainly something to repeat in the future.

CHAPTER 5 – Conclusions

5.1 General

The case study focussed on airspace infringements of controlled airspace only, i.e. ICAO Class C and D airspace, except Class E airspace.

Airspace infringements do happen at such a rate and magnitude that mitigation actions are required.

Inadequate ATC coordination and procedures have, in some incidents, been contributing factors during airspace infringements.

Some incidents involved infringement of separation. Therefore, airspace infringements constitute a real safety issue.

It is rare that the view of the pilot committing an airspace infringement is available for investigation. Therefore, the “why?” question (causal factors), could not be directly answered for most of the occurrences analysed.

Direct discussions with VFR pilots gave hints as to where future mitigation actions should be focused.

5.2 Results - Geneva / Zurich case study

- Various categories of aircraft are involved in airspace infringements. However, the single and multi-engine piston category constituted the majority of infringing aircraft.
- Aircraft registered in Switzerland and adjacent countries accounted for the majority of infringing aircraft.
- Terminal Control Areas (TMAs) were the most infringed airspaces.
- The majority of airspace infringements occurred below 8,500 ft AMSL.
- No contact was established with ATC in over 60% of the occurrences, while 20% of the flights called before entering, and 17% called when already in controlled airspace.
- 75% of the infringing aircraft were flying with their transponder squawking a code.

- ATC and pilots alike initiated either preventive or avoiding actions to ensure separation during airspace infringement in almost half of all occurrences recorded for Geneva and Zurich in 2004.
- Loss of ICAO separation minima or inadequate separation occurred in 17% of the airspace infringements.
- ATC was a direct or indirect contributor to the airspace infringement in few occurrences. Omitting required coordination between units was identified as a causal factor in at least two incidents.
- Severity assessment of the occurrences revealed that 2 incidents were classified as serious, 5 as major and 9 as significant.

CHAPTER 6 – Recommendations

Based on the analysis of the results and the discussions held with the pilots during the brainstorming sessions, possible mitigation areas were identified and formulated here as recommendations, grouped into several categories. Wherever appropriate, text in italics introduces the recommendations.

6.1 Human factors

- Improve the controller-pilot relationship, mainly regarding the respective understanding of each other's constraints and expectations.
- Stress the importance of flying with precision (altitude/heading), especially in controlled airspace, and of taking prevailing winds into consideration.
- Reduce the complexity of procedures, bearing in mind that most pilots flying under visual flight rules are not professional pilots.
- Discuss the subject of overconfidence, airmanship and priorities in the context of conducting VFR flights.
- The use of GPS equipment presents some advantages, but also some limitations. Discuss the use of GPS in relation to ATC.

6.2 Airspace structure

- Tackle the airspace complexity issue together with all concerned stakeholders. This should comprise harmonisation efforts throughout Europe.
- Study the relationship between the airspace changes concerning VFR flights and the number of airspace infringements reported.
- Facilitate the identification of airspace boundaries in flight by aligning them along easy-to-identify landmarks.
- Airspace complexity decreases the readability of aeronautical charts. Apply different scales or dedicated charts for specific areas in order to enhance the identification of

airspace boundaries and thus reduce airspace infringements.

- ANSPs are sometimes not too clear about the availability of their airspace for VFR flights. Although procedures exist – quasi-systematic refusal is applied within certain airspaces. Clearly communicate the availability of airspace for VFR flights.

6.3 Procedures / regulation

- Pilots feel that special training on ATC procedures are not exploited to their full extent by ANSPs during daily operation. Exploit the knowledge acquired during training.
- Acronyms used on aeronautical charts and NOTAMs should be spelt out in clear text to facilitate the reading of these documents. In the same vein, pilots mentioned that too many changes create insecurity.
- Bear in mind that asking for too many estimates overloads the pilot of a VFR flight.

6.4 Navigation

- The issues regarding navigation under visual flight rules can mainly be traced back to the preparation of the flight, i.e. flight planning. Address the practical aspects regarding flight planning with all concerned stakeholders.

6.5 Training of VFR pilots

- Basic and refresher training should include ATC subjects, focussed on airspace structure, services provided, etc.
- Address, and maybe include, a module on the subject of Crew Resource Management (CRM) in the basic training syllabus. This would also serve the controller-pilot relationship.

6.6 General recommendations

- Information campaigns should be targeted at the entire range of airspace users, giving priority to the category that produces the most airspace infringements.
- Field discussions with VFR pilots have generated a substantial interest and understanding of the airspace infringement issue. This approach is probably one of the better ways to convey the message. Pursue the field-discussions approach as a way of raising awareness and understanding on the airspace infringement safety issue.

ANNEX 1 – List of analysed airspace infringements

The following three lists contain the 123 airspace infringements that have been analysed in this study. The first list contains the 33 CTR, the second the 80 TMA and the third 10 AWY infringements.

The occurrences have been de-identified and given a code for the traceability with the original database (left column). The Short description is an edited version (de-identification) of the reports provided. The Remarks, where available, are also taken from the report. All identifiable items have been left out or replaced by xxxx.

Airspace infringement in CTR (33 occurrences)

Code	Short description	Remarks
011	SEP enters CTR without clearance	Pilot is sure he did not enter. Pilot later admitted flying into the CTR due to snow showers.
022	SEP entering CTR class D without prior permission.	
024	Unknown primary blip appears near ILS and gets close to two airliners.	
025	Traffic info given to corporate jet about unknown traffic southbound at 4,700 ft.	
030	Unknown traffic crossing CTR. Its flight path crosses the ILS. Traffic information is given to corporate jet who sees the traffic and estimates its altitude at around 3,500 ft.	
036	An A7000 enters CTR without clearance at 3,600 ft.	
041	Penetration of CTR by a traffic squawking A7000.	

047	SEP following river VFR enters CTR, apologises afterwards.	Pilot subsequently calls ATC and cites problems with his radio.
049	SEP enters a small part of the CTR at unknown altitude, no problem.	Pilot calls ATC and later explains in a letter that he was flying in marginal weather and did not realise that he had penetrated the CTR.
060	Unknown VFR traffic crosses ILS at about 7.5NM at 2, 600 ft, entering CTR without permission. Airliner has visual contact.	
062	A separation minima infringement occurred between an IFR traffic established on ILS and a VFR traffic arriving at the same airport.	Pilot realises that he entered the CTR and that the next time he would call earlier or wait outside (the CTR).
063	Unauthorised penetration of CTR in conflict with two airliners on ILS.	The VFR traffic is seen going towards a nearby aerodrome. Registration is asked by phone.
065	SEP enters xxx CTR without clearance	After coordination with FIC, the aircraft should have contacted the TWR. The pilot never did so and entered CTR without clearance from ATC.
067	VFR in contact with FIC does not respond and penetrates CTR without clearance. Departing traffic has to be stopped due to uncertainty of the intentions of the pilot	According to the FIC LOG, pilot was making his first international flight after license.
076	TWR observes a primary blip and with binoculars it appears to be a ULM. the latter is in conflict with a VFR inbound xxxx.	
083	An unknown ULM squawking A7000 crosses the CTR without clearance.	Traffic has been seen as an ULM by the PIC of a SEP. Its altitude was estimated between 1,800 and 2,200 ft.
084	Unauthorised penetration of the CTR by an unknown aircraft without transponder, which makes two orbits and continues its flight and subsequently leaves the CTR. A/C in conflict with 3 arriving IFR, estimated altitude is 500ft above the lake.	
085	SEP enters the CTR at 2700 ft	That traffic finally called FIC when leaving the CTR and was identified.
087	Airliner on the ILS crosses hang-glider at same altitude.	Several other traffic on the ILS report the hang-glider
088	Airliner crosses unknown traffic opposite on ILS - 8 NM final.	
090	Penetration of TMA2 and CTR	VFR was told not to enter TMA. He descends to 3,000 ft. To avoid entering CTR, headings were given by ATC. Despite being warned, VFR enters CTR. After entering he requested headings.
096	Unknown traffic crosses the ILS at 1,700 ft indicated (Mode C) while an airliner is on final.	
105	Unknown traffic in CTR, observed on primary radar, flying around for 10 minutes.	

Airspace infringement in TMA (80 occurrences)

Code	Text from report	Remarks
1	A helicopter calls FIC inside TMA at FL85 without clearance (nor FPL).	The helicopter was on A/C 7000
3	A7000 observed heading 100 - 110 and climbing FL85.	A/C could not be identified by ATC
5	Squawk A7740 enters TMA at 4 500 ft. Climbs up to 5600ft. airliner has to stop descent at FL70.	Registration obtained from destination airfield.
6	SEP comes close to airliner on ILS. Despite FIC instruction, a/c entered TMA.	Pilot tried to avoid ATC report by negotiating on FRQ! Says had engine problems and missed calls!
8	Two airliners report seeing balloons at FL150.	Neither of the crews was able to estimate with accuracy the distance between them and the balloons as they reported their presence to ATC.
9	SEP contacted FIC to cross the area. Given a TXPDR-Code, he is invited to contact the Arrival sector. After crossing, Arrival released the aircraft. Thereafter the pilot climbed into C-airspace without contacting ATC.	
10	Hot air balloon A7000 enters TMA at FL 95 descending 6,500 ft without permission.	
12	Unknown traffic SE squawking 7675 overtakes IFR traffic to the left by 2NM.	Occurred at night. Could be a MIL traffic according to the pilot.
13	IFR is cancelled, the pilot is advised to leave the AWY FL130 or below due to MIL activity. But he enters Class D airspace at FL150.	
14	Pilot reports 4,000ft before entering TMA without clearance.	PIC gave navigation problems as cause. Was looking for a nearby aerodrome.
15	The pilot enters TMA without clearance.	Pilot called FIC beforehand, but eventually entered controlled airspace.
16	Airliner on arrival from the East, an unknown VFR crossing TMA LSZH from the West without clearance.	A separation infringement occurred with an airliner opposite. The minimum distance was 2.3NM and 500 ft.
17	ATCO initiates avoiding action for airliner on base-leg due to an A7000 in TMA without contact.	
18	An unknown traffic squawking A7000 flies around in the TMA at 5,000 ft, and crosses the ILS several times.	
19	Unknown traffic squawking A/C6310 crosses ILS without contact and at position of an IFR traffic	
20	An A7376 enters TMA without clearance at FL110.	After contacting the adjacent (foreign) unit, the ATCO is told that the traffic is now avoiding.
21	Helicopter on a MEDEVAC squawking A0020 enters TMA by 1-2 NM parallel to the northern boundary.	Observed by ATC at 3,900 ft, while the pilot says that he was always below 3,000 ft.
26	Hot air balloon A7000 enters airspace C without	

	clearance	
29	SEP enters TMA. Preventive avoiding action issued to airliner on a standard departure route. Flight calls FIC at FL85 within TMA and is told to descend and avoid departure axis.	The adjacent unit, which had the traffic in contact, omitted to coordinate to prevent the illegal penetration.
31	An unknown VFR A7000 enters TMA without clearance and without radio contact. Descent of an airliner has to be stopped at 6,000 ft. The altitude of the intruder varied between 4,500 ft and 5,500 ft.	
32	SEP enters TMA at FL85 without clearance. A/C later called ATC.	
33	Unknown VFR crosses TMA without clearance and without being on a radio frequency. Avoiding action needed due to approaching airliner.	Loss of separation occurred with a minimum distance of 2.4 NM / 0 ft.
34	While intercepting the ILS localiser, two airliners reported an unknown VFR approaching from their left at 6,000 ft. Aircraft squawking A0022 without mode C readout. According to pilots - on same altitude.	The crew of both aircraft estimated the same altitude and rated the encounter as close.
35	The pilot reports on first call within the TMA maintaining 7,500 ft. The controller on FIC Position co-ordinates immediately with the concerned sector and informs the pilot about his airspace infringement. He was then allowed to continue his flight, maintaining 7,500 ft.	
37	Airliner reports glider 1,000 ft below, within TMA.	
38	FGSIX pops up ahead of BVR101 at the same altitude, opposite. CBY sent it to FIC even though in Class C airspace. FGSIX then does not hold at GE and comes close to flight BBO003.	Data not de-identified as Final BFU Report is published.
39	Airliner was on downwind and cleared to descend to 7,000 ft when an A4220 appeared within the TMA at 7,000 ft. The airliner was re-cleared to climb back to 8,000 ft to ensure vertical separation. Other aircraft had also to be guided around the intruder.	
40	The pilot enters TMA without clearance and contacts FIC. ATCO informs the pilot that he has infringed Class C airspace.	
42	SEP calls on FIC frequency at 5,900 ft within TMA. Controller informs pilot that he is flying within Class C airspace without clearance. Controller co-ordinates immediately with IFR sector and tells the pilot to descend to 4,500 ft or below.	
43	Unknown VFR traffic squawking mode A/ C FL127 is penetrating controlled airspace without clearance heading north. Controllers of 3 IFR sectors had to stop or circumnavigate IFR traffic around this unknown VFR traffic. The flight later switches off TXPDR.	
44	SEP reports getting into clouds and requests vectors. FIC controller sends him immediately to a control frequency. The ATCO vectors the pilot he can climb to 4,500 ft. After passing 3,500 ft, he gets on top of clouds. After passing TMA, the ATCO clears the SEP direction xxx VOR with max climb up to 5,500 ft. Near xxxxx the pilot climbs up to 6,000 ft without a clearance. The controller informs the pilot to descend	

	immediately to 5,500 ft.	
45	SEP VFR is at 5,500ft very close to CTR and crosses airliner established on ILS just behind.	SEP called already in controlled airspace. Little chance for ATC to take avoiding action. Traffic information given to airliner. The minimum distance between both traffic was 2.1 NM / 600 ft.
46	SEP flies with activated ELT (without knowledge of pilot). Controller tries to explain this to pilot, but radio is very bad. Then the SEP starts to climb without clearance into Class C airspace. The controller informs pilot immediately to descend to 3,000 ft or below.	
48	Twin-piston slightly enters Class C airspace when descending. Info from FIC comes late.	
50	SEP calls IFR sector for a VFR transit and was informed to stay clear of Class C airspace and contact FIC, which it does at 6,500 ft in Class C airspace.	Did the pilot assume that he would receive a clearance from FIC?
51	Airliner turning onto the axis of runway observes a VFR intruder at 4,300 ft, same altitude, crossing close from left to right with primary only. Airspace infringement occurred.	ATC observes a primary Radar return and SEP could be identified later.
52	Corporate turbo-prop slightly enters Class C airspace in TMA at FL 081 before joining IFR (1 NM)	
53	Unauthorized penetration of Class C airspace of unknown VFR. Comes close to airliner on ILS (traffic visual). The VFR traffic squawking A7000 was observed by TMA at 6,000 ft, tracking North.	Airliner crossed the intruder twice, first on downwind - visual contact was established- then again on ILS, visual contact as well.
54	SEP climbed to 6,000ft into TMA Class C airspace between without clearance; PIC in contact with adjacent unit.	

55	Pilot flies into Class C airspace without clearance.	Controller on FIC RADAR observes a squawk A4535 at FL130 flying from xxxx direction xxxx entering Class C airspace without a clearance. The IFR controller asks by telephone whether FIC controller knows this traffic, which FIC denies. After passing xxxx aircraft changes squawk to A7000 and descends to FL100. Overhead xxxx pilot calls on FIC frequency. Controller instructs the pilot to change squawk to A4250. After landing, pilot apologizes by phone call.
56	Unauthorised penetration of Class C airspace by unknown VFR.	He crossed TMA at FL147 indicated between 17:24 and 17:33 UTC. Avoiding action had to be taken by ATC, but none of the pilots passing near the unknown traffic had him in sight.
57	Pilot enters Class C airspace without clearance	The adjacent unit did send the VFR traffic on to FIC Frequency at FL110. Controller of FIC gave squawk A4251 immediately to the pilot to identify the traffic. When the position was identified, the FIC controller co-coordinated with sector. Thereafter FIC informed the pilot about unauthorised penetration of Class C airspace but allowed him to maintain FL110. The pilot did continue climb up to FL115 without authorisation.
58	Unauthorized penetration of Class C airspace at FL85 by SEP VFR. Pilot calls FIC while already in controlled	Receiving ATCO remarks that this happens

	airspace. The aircraft was squawking a TXPDR Code from the previous unit. The latter does not co-ordinate the flight with the receiving unit.	often, despite existing Letter of Agreement.
59	A7000 enters TMA from the NW at FL 085	Aircraft climbs to FL090 but creates no conflict
61	Airliner at 11 DME on final RWYxx observes intruder primary 2 NM 9 o'clock, reported 300 ft below.	The traffic was visible to the ATCO on primary Radar only. This disables STCA as well as TCAS.
64	SEP flies through TMA without clearance and without being in radio contact.	SEP was opposite to airliner being vectored to ILS. ATCO gave traffic information and avoidance heading to ensure separation.
68	SEP enters TMA without clearance.	Pilot called FIC before entering and ATCO informed the pilot in advance to avoid the TMA.
69	SEP squawking A0022 passes through ILS localiser at 4,000 ft without clearance.	Aircraft altitude requires ATC to limit inbound traffic at 5,000ft and provide traffic information to airliners. No separation infringement occurred.

70	Aircraft enters TMA without clearance.	Squawk A7000 was observed descending through TMA as well as the squawk change when entering the adjacent unit's airspace. Identity of aircraft was subsequently obtained
71	Unknown traffic crosses the ILS at 6,000 ft indicated. airliner has to maintain 7,000 ft.	Airliner is visual on the traffic.
72	An AIRPROX occurs between an approaching Lear Jet and a SEP crossing the ILS. According to the radar recordings, the minimum distance between the two aircraft was laterally 0.4 NM and, according to the statements of the pilot of aircraft LX-DSL, an altitude difference of 500 ft.	Intrusion into Class C airspace as well as navigation issues was cited as the cause. Coordination issues between two ATC units affected the development of the incident. Report published by the Swiss AAIB No.1889
73	SEP enters TMA at FL90 without clearance. Airliner on downwind has to level off at FL100 in order to maintain separation.	
74	A target is observed Primary Radar crossing ILS14. No altitude info, pilot of an airliner reports this traffic 800ft below	
75	SEP enters TMA at FL105 without clearance.	Serious coordination issues between ATC units reported by ATCO.
77	A multi-engine a/c enters TMA at FL80 without clearance.	PIC said he was cleared by adjacent ATC-unit to FL150.
78	Airliner on left hand down wind at FL80 crosses a glider within Class C airspace. Minimum distance reported by the pilot 0.2 NM lateral and 0 ft vertical.	No avoiding action necessary by the crew.
79	SEP enters TMA without prior clearance. Subsequently the pilot obtains the latter, but leaves cleared route to enter CTR without clearance.	
80	An unknown VFR entered the TMA without clearance and without being on any Air Traffic Control frequency. The pilot of an airliner informs the controller of a glider flying right underneath them, at a distance of approximately 500 ft.	There was no secondary or primary blip visible on the controller's radar screen.

85	Twin-engine piston a/c navigation approximate and therefore enters TMA. Some IFR traffic stopped their descent.	
88	An unknown aircraft squawking A7000 appears on the right of an IFR traffic at FL090. The IFR receives traffic information and reports the unknown traffic in sight, crossing from right to left. Unknown traffic continues its climb in the TMA, passing at 0 NM/500ft of the IFR traffic.	The pilot of the unknown traffic turned on his TXPDR when passing FL069.
91	Airliner encounters hot air balloon near ZUE at FL 95, balloon is at FL 103, 7NM.	
92	An unknown traffic, squawking A0022 with an altitude reporting of FL080 appears over xxxx and crosses xxxx TMA for more than 30 minutes.	
93	Two airliners are inbound to xxxx. Both are on vectors for runway xx when they detect an opposite traffic. The traffic is an unknown VFR, which was unauthorized in the xxx TMA at 6,300 ft (lower limit of TMA is 4500ft). Both pilots receive a traffic information and resolution advisories. One airliner is vectored to ensure separation.	
94	Unidentified aircraft with squawk A0021 is flying westbound and enters TMA near xxxx at about 3,500 ft climbing to 3,700 ft. ATCO then gives traffic information to an IFR traffic, which is on ILS14 5,000 ft descending.	
96	On a flight from Spain to France, a SEP penetrates TMA without clearance at FL 105.	
97	Helicopter flies Northwest and crosses Class C airspace of xxxx TMA squawking A7000 and climbs. When passing 8,500ft, abeam North of xxxx, helicopter enters in contact with xxx FIC. After coordination IFR sector, FIC advises the pilot to descend rapidly below TMA. Pilot seems not to understand and is not collaborating. The helicopter is then sent to IFR sector. The PIC finally follows instructions.	
99	SEP in contact with FIC penetrates TMA without clearance.	
100	SEP enters several TMA segments without clearance.	The aircraft is observed to land later on at a German airfield and is identified.
101	SEP VFR below TMA xxxx slightly climbs into TMA xxxx to 5,100 ft.	Pilot cited turbulence as the reason for deviation.
102	Unknown VFR appears 0.5 NM south of active glider area xxxx at 3,700 ft, flying direction xxx and climbs to 4,100 ft. Leaves TMA direction north. Traffic info was given to airliner.	
103	HBCJB, VFR flight from Perpignan to Grenchen (Switzerland) crashes near Dent de Jaman. Airspace infringement, as aircraft already in controlled airspace on first call.	Full report No.1919 published by Swiss AAIB.
107	Hot air balloon enters TMA at 7,000ft without clearance. 3 a/c report him in sight.	Identified visually by one of the passing crew.
111	SEP enters TMA Class C airspace without clearance	

	and became a conflict for IFR departures.	
112	An unknown VFR enters the TMA without being in radio contact and without clearance. An arriving aircraft has to be turned away.	The unknown aircraft is seen landing at a nearby airfield and is identified as a motor-glider.
114	Unknown VFR enters TMA without clearance. Loss of separation occurs between an airliner on ILS approach and the SEP intruder. Traffic information is provided and pilot reports traffic in sight. Minimum separation 1.1 NM/500ft.	The unknown VFR flight squawking A0021 was later monitored by the ATCO to its destination xxxxx and was identified. The pilot reports that he has misinterpreted the TMA airspace structure.
115	Airliner on heading 100° for vectoring ILS runway xx, descending from 6,000 ft to 5,000 ft, encounters a VFR intruder at 4,400 ft at 11 o'clock, moving southbound, range 5 NM to 2.2 NM.	The report mentioned that the boundary between the two concerned TMAs does not feature any specific landmarks to identify the boundary visually.
116	Unlawful penetration of TMA, 7 NM South of xxxx by A7000 which climbs FL120, makes a 180° turn & descends.	
118	Airliner was inbound to xxxxx. Suddenly an unknown traffic appears about 10nm southwest of xxx at 5,300 ft while the airliner is on downwind for runway xx. When the airliner is on base, the unknown VFR, which is meanwhile identified by FIC, crosses the ILS – a loss of separation occurs. Minimum distance 2.4 NM/300ft	
119	SEP, en-route to xxxx at FL85, enters TMA C without clearance. The pilot contacts FIC & reports that he is unable to descend due to cloud layer 1,500 ft below.	PIC argues that he has the right to fly in Class C airspace!
120	The hot air balloon was cruising at FL135 in Class C airspace. No contact with ATC and no TXPDR return was visible on Radar. Airliners avoid the balloon by maintaining visual contact, and are able to identify the flight.	Pilot later stated that he had set his TXPDR to A7000, but no explanation was provided as to why he penetrated controlled airspace and why he did not contact ATC.

Airspace infringement in AWY (10 occurrences)

Code	Report text	Remarks
2	SEP does not call back on FIC frequency after he crossed TMA xxxx as instructed; he continues his flight to the south, turns left back north and enters Class C airspace (A9) north of the "Alps-Mittelland-Line"	
4	A business jet is on a flight from xxxx to xxxxxxxx. 13NM west of PITAR, one minute to the Swiss Boarder, pilot calls on FIC frequency at FL155. Controller gives squawk A4252. Meanwhile the a/c has entered Swiss airspace. In that region FL155 is in Class D airspace, and the flight has no clearance yet to enter it. Therefore it is an unauthorised penetration of airspace.	
7	Business jet takes off in xxxxxxxx and climbs to FL160, entering Class D airspace without any clearance. When he calls for the first time on FIC frequency 124.700MHz, he is in the region of xxxx and already at FL160.	
23	Airliner at FL 154 outbound LSZH encounters unknown VFR A7000 at FL 150 near xxxx.	Later identified as PARA-dropping flight from xxxxxx.
27	Business jet calls on the FIC Frequency. FIC takes all the details and in order to cross TMA xxxx sends the traffic on the xxxx Tower frequency. After crossing the TMA, the a/c does not call again on the FIC Frequency. But it still keeps the squawk given by FIC. The controller observes the BJ in the region of xxxxx climbing. The controller tries to call the flight several times. After some calls the pilot answers already at FL140. The pilot says he had to climb in order to stay in VFR VMC conditions, but at no point did he ask for a clearance to enter airspace C.	
28	Two military fighters identify a glider at position xxxx at FL140. The glider is nowhere on the frequency and does not get a clearance to enter Class C airspace (unauthorized penetration of Class C airspace).	NOTE: REQ from a GLD 50' before was not granted due to no TXPDR
66	Corporate a/c crossed AWY and climbed up to 13,500 ft without permission. Class C airspace.	

REFERENCES

EUROCONTROL (2007) Airspace infringement causal factors modelling study

ABBREVIATIONS

AAIB	Aircraft accident investigation bureau
AI	Airspace infringement
AIP	Aeronautical information and publication
AIRPROX	Serious loss of separation
AIS	Aeronautical information services
AMSL	Above mean sea level
ANSP	Air navigation service provider
AOPA	Aircraft owners and pilots association
ATC	Air traffic control
ATCO	Air traffic controller
ATM	Air traffic management
ATS	Air traffic services
AST	Annual Summary Template
AWY	Airway
CAS	Controlled airspace
CPA	Closest point of approach
CPL	Commercial pilot licence
CTR	Control area
FIC	Flight information centre
FIS	Flight information services
GA	General aviation
GPS	Global positioning system
HDG	Heading
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
MET	Meteorological information
NOTAM	Notice to airmen
PPL	Private pilot licence
PR	Primary radar
TMA	Terminal control area
SISG	EUROCONTROL safety improvement sub-group
SSR	Secondary surveillance radar
VFR	Visual flight rules

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