Air Traffic Control Events and Risk Analysis

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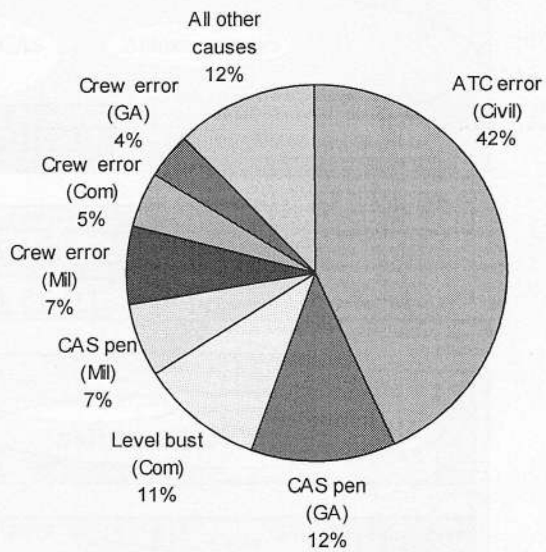
Introduction

The ultimate safety objective of an Air Traffic Control authority is to manage air traffic and ensure safe separation between aircraft. Failure to maintain separation results in an Airprox incident. This is defined as a situation where, in the opinion of a pilot or a controller, the distance between aircraft (as well as their relative positions and speed) was such that the safety of the aircraft was, or may have been, compromised. In the UK all Airprox events are reported to, and investigated by, the UK Airprox Board.

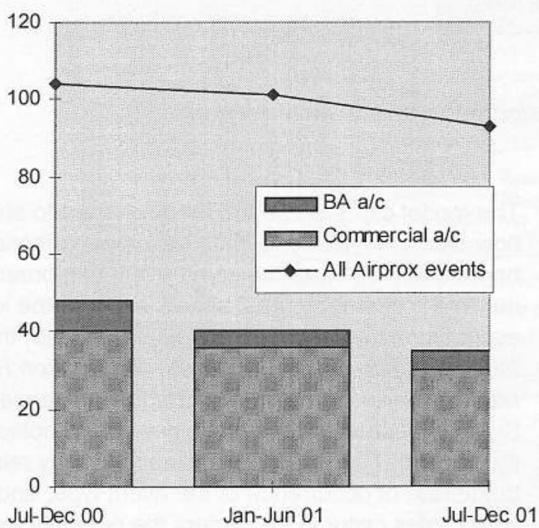
Causes of UK Airprox events



UK Airprox event trend

The UK Airprox Board reports on a six monthly basis. The trend of UK Airprox reports over the 18 month period from July 2000 is down overall and also for Commercial fixed wing aircraft. The number of events involving British Airways aircraft has remained approximately constant (at 14% of commercial aircraft events) with eight, four and five events respectively for the three reports in the period.

UK Airprox trend



The causes of Airprox events remained relatively constant across the period, with 42% attributed to a civil air traffic controller error. Unauthorised penetration of Controlled Airspace (CAS) by General Aviation (GA) pilots was the next biggest cause at 12%, followed by level busts by commercial aircraft at 11%.

Airspace risk model

Looking at the trend of Airprox events alone provides a very coarse measure of the safety of Air Traffic Management. It focuses on events in which the end result is an Airprox rather than events which have the potential to cause an Airprox. The risk methodology employed by the UK Airprox Board is based only on what happened and not the potential consequences so, for example, an incident resolved by the last back up protection of TCAS is classified as C risk (No risk of collision). Such a methodology fails to recognise the risk associated with the individual failures on the overall safety of the airspace.

To better understand and manage this risk, British Airways Safety Services have started to develop an **airspace risk model**. This model seeks to allow analysis of ATC type events in the context of their maintain safe separation. The three main ways that this barrier can be breached are through a horizontal error in the safe trajectory of the aircraft, a vertical error in the safe trajectory of the aircraft or through the design of the airspace leading to a loss of separation without positive control. Should this barrier be breached the next level of defence is ATC conflict resolution, which may fail because the conflict is not identified by ATC or because the resolution applied is ineffective. The final defence is the airborne collision avoidance function of both TCAS and the "see & avoid" principle.

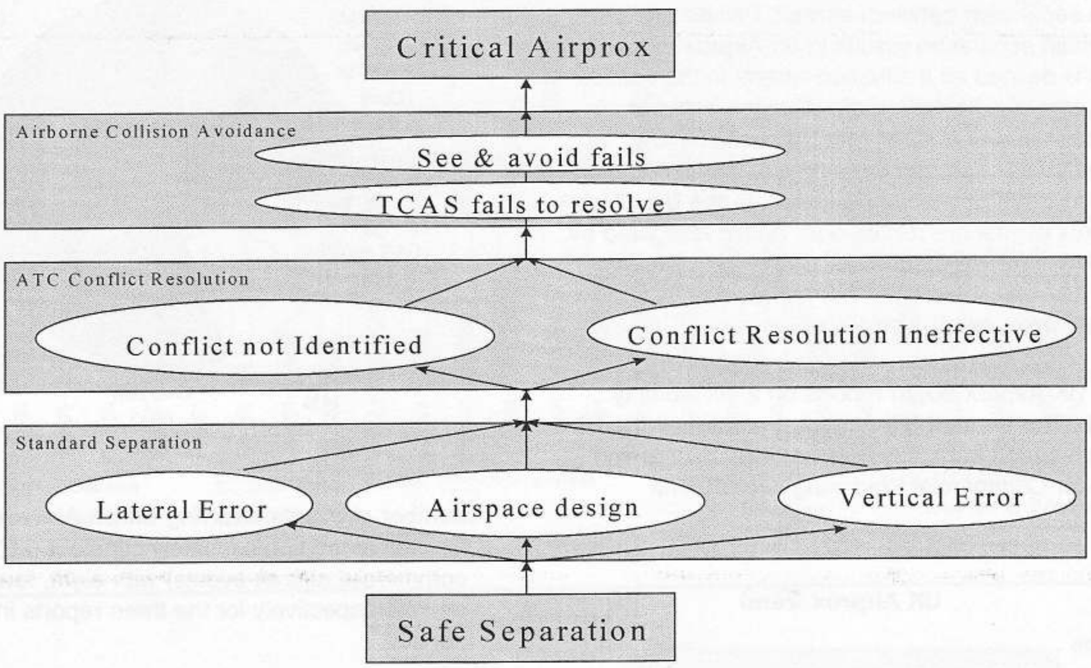


Figure 1 - Barriers between Safe Separation and Critical Airprox

potential to break through the barriers which exist between safe separation and a critical Airprox event. The model provides a visual indication of the significance of different event types and how they affect the overall level of safety for air traffic management.

The model is based around three main barriers between safe separation and a critical Airprox event, as shown in Figure 1.

This shows how, as a first level defence, ATC apply standard separation rules and practices to

The model can then be further developed to show how different types of events may breach these barriers and whether the same event can breach multiple barriers. Figure 2 shows some of the key event types that have the potential to breach these barriers. By relating the model to the *Reason Risk Model*, where each barrier is imagined as a piece of Swiss cheese and the event types as the holes in the cheese. The size of the holes is directly related to the rate of occurrence of the event type, and when holes occur in all barriers the potential exists for a critical Airprox event to occur.

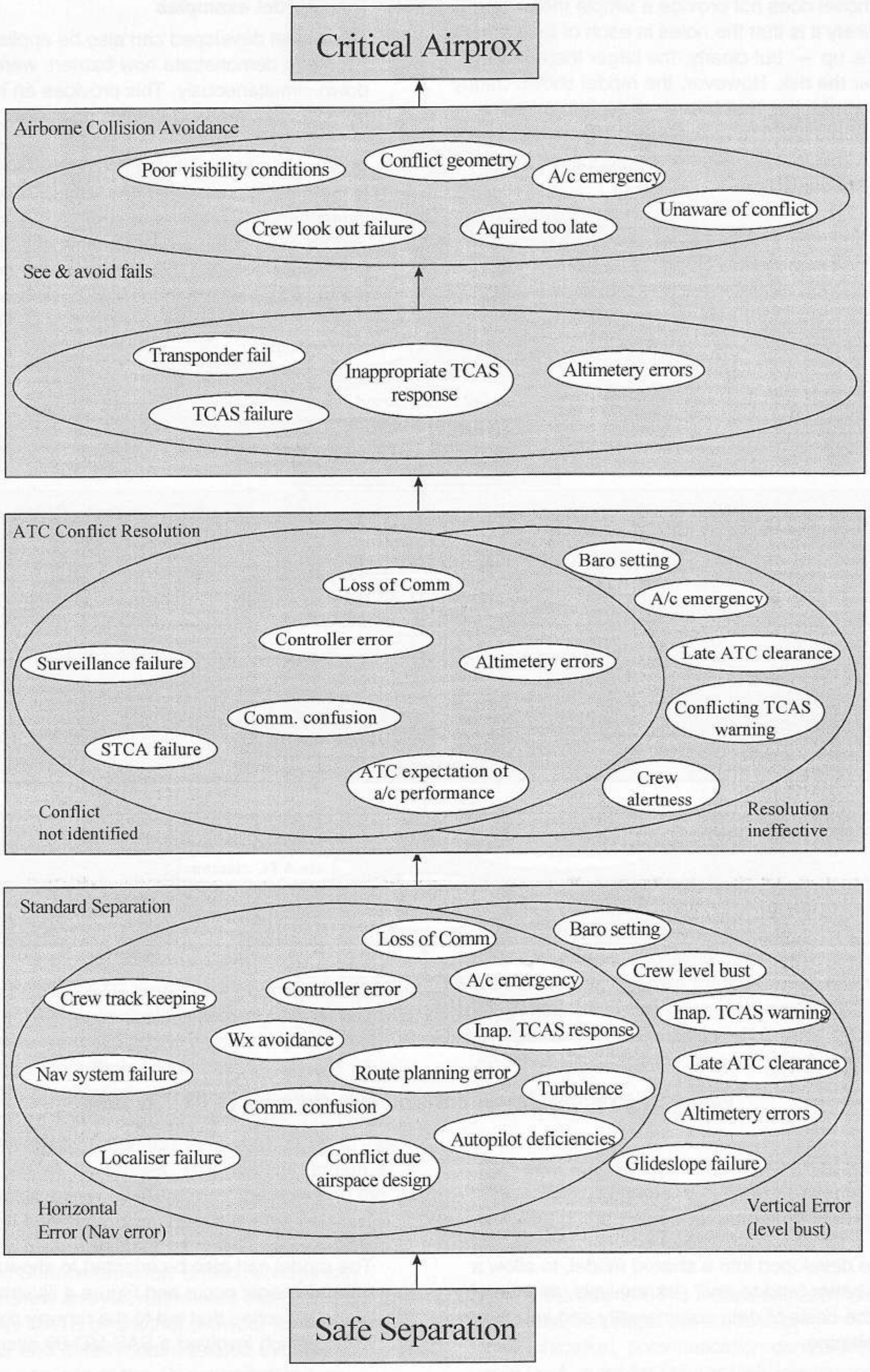


Figure 2 - Key events type

The model does not provide a simple measure of how likely it is that the holes in each of the barriers will line up — but clearly, the larger the holes the greater the risk. However, the model shows clearly how event types that breach multiple barriers carry significant risk. This is not only because they breach multiple barriers but also because they do so at the same time.

This model is in early stages of development, but British Airways Safety Services intend to work together with air traffic service providers to see if it can be developed into a shared model, to allow a much better "end to end" risk analysis, and thereby form the basis of data commonality and improved data sharing.

Risk model examples

The model developed can also be applied to past events to demonstrate how barriers were broken down simultaneously. This provides an indication of potential risk areas in today's operation.

The tragic midair collision in Germany in July 2002 is the most recent event and although the investigation is ongoing, a number of initial findings can be used in the model to show how the barriers fail. Figure 3 shows this event and the breaches of the barriers that are thought to have occurred.

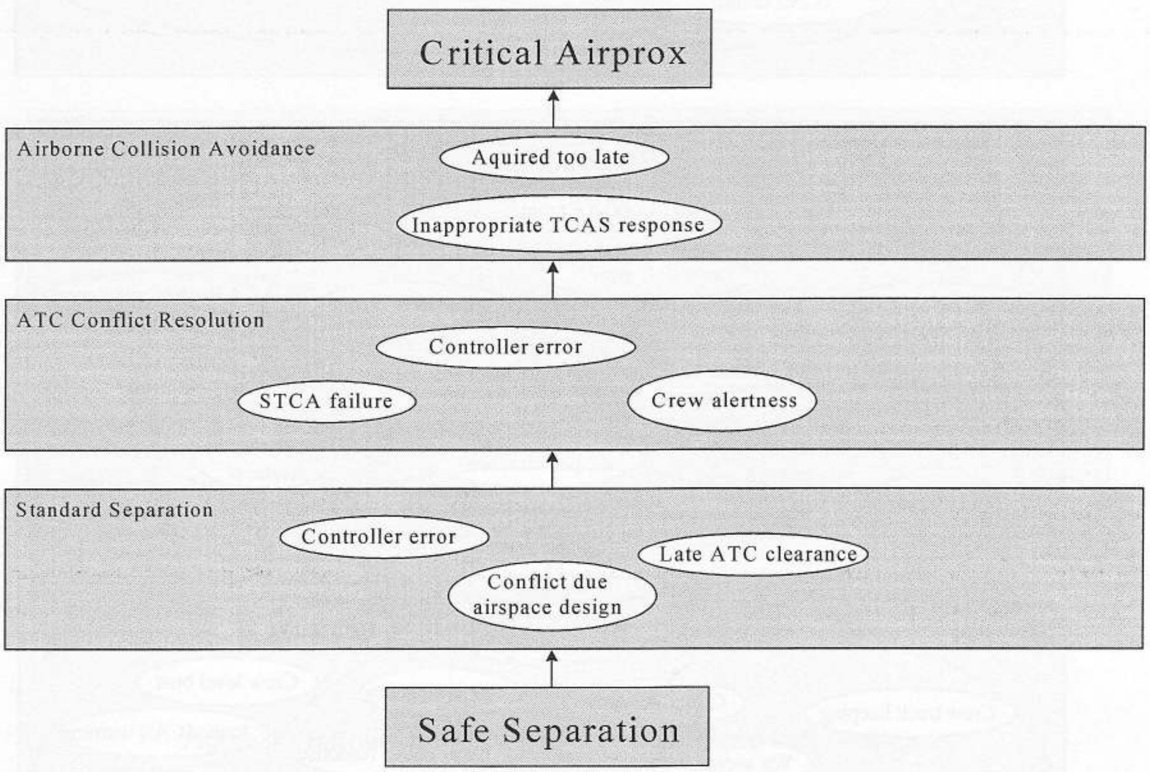


Figure 3 - Example: Midair collision over Germandy - 08 July 2002

The model can also be adapted to show how ATC ground events occur and Figure 4 illustrates some of the breaches that led to the runway collision in Milan, which involved a SAS MD-80 aircraft.

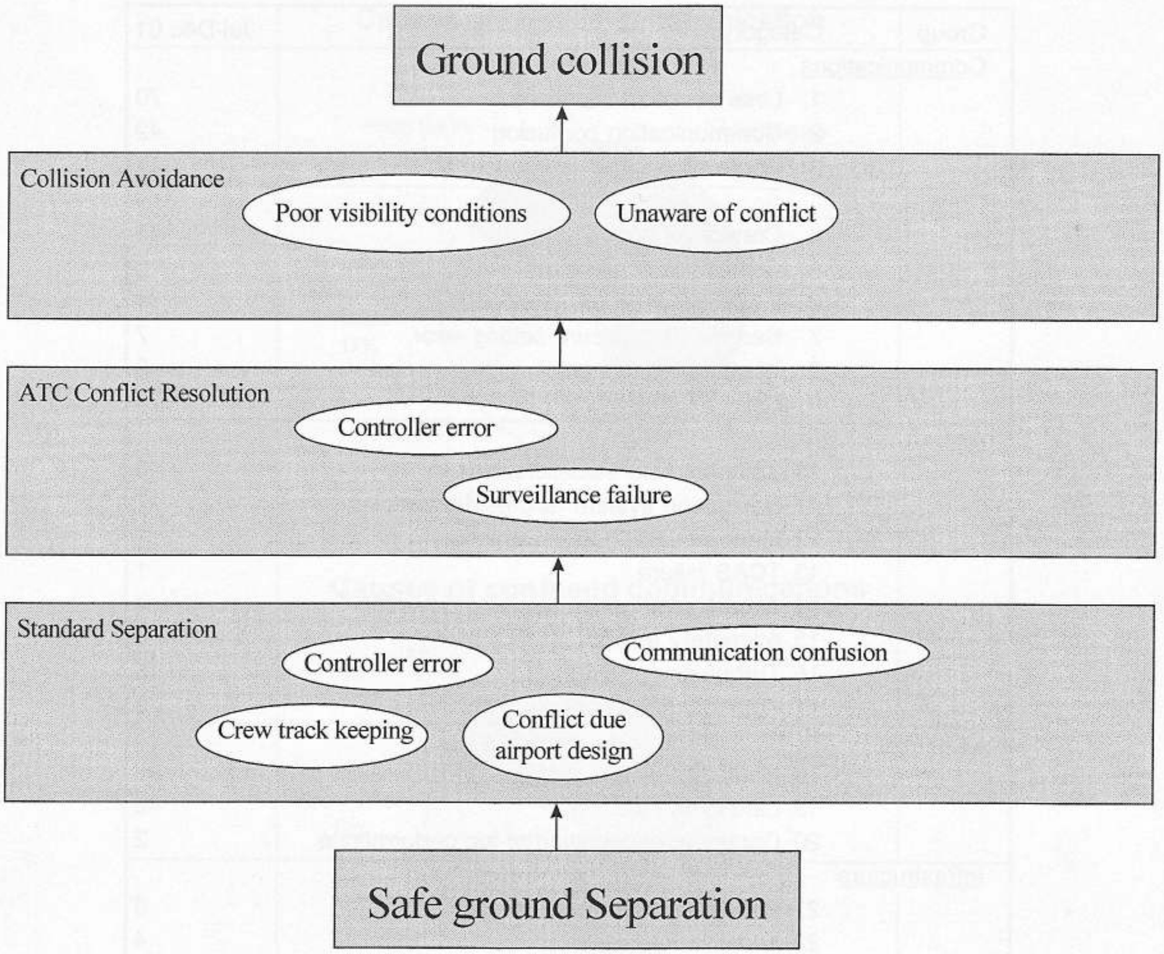


Figure 4 - Example: Runway collision Milan - 08 October 2002

Relating the model to event trend data

Applying existing ATC type event trend data to the model involves an analysis of existing events and categorisation into 25 cause categories, each of which relates to a "hole in the cheese". These 25 causes are grouped into six areas to enable high-level analysis and evaluation. Within each of the 25 categories there can be further sub-divisions to look more deeply at the causes. This can be done on a priority basis driven by the size of the hole and the number of barriers it breaches. It is an area that shows the real importance of collaboration with an Air Traffic Service provider. British Airways can look into *Crew* and *Aircraft* related categories but it would take NATS or another provider to look at the *Controller* and *Infrastructure* related events. Moreover analysis of the *Communication* type events requires close cooperation between both parties.

The application of existing data to the model is at an early stage but data for the period July to December 2001 has been analysed and categorised to fit the model. 413 were categorised and their distribution shown in table 1.

Identifying key risk areas

With data applied to the model, key risk areas can be identified by both the number of events and by factoring of the number of barriers that the category penetrates.

Taking the July 2001 to December 2001 data, the key areas that stand out are *loss of communication*, *communication confusion*, *crew level bust*, *autopilot failures/deficiencies*, *controller error* and *late ATC clearances.*

Group	Category	Jul-Dec 01
Communications		
	1 Loss of communications	70
	2 Communication confusion	42
	3 Route planning discrepancy	11
Crew		
	4 Crew level bust	35
	5 Crew track keeping	8
	6 Inappropriate TCAS response	1
	7 Barometric pressure setting error	7
	8 Weather avoidance	3
	9 Crew alertness	4
Aircraft		
	10 Autopilot failures/deficiencies	46
	11 Navigation system failures/deficiencies	7
	12 Inappropriate TCAS warnings	1
	13 TCAS failure	1
	14 Aircraft emergency requiring deviation	4
	15 Altimetery errors	0
	16 Turbulence	15
	17 Transponder failures	0
Controller		
	18 Controller error	97
	19 Late clearance	42
	20 Controller expectation of a/c performance	2
Infrastructure		
	21 Conflict due airspace design	9
	22 Localiser failure	4
	23 Glideslope failure	1
	24 Surveillance failure	3
	25 Short Term Conflict Alerting (STCA) failure	0

Table 1 - Event categorisation (July to December 2001)

ATC errors is the largest category and this correlates with the data from the UK Airprox Board. Obviously *ATC errors* would break down into a number of sub-categories, but such more detailed analysis could only be done by the air traffic service providers involved.

Loss of communications is the next largest category and this, along with *communication confusion*, is a major area of concern as it has the potential to break through two of the barriers to a critical Airprox.

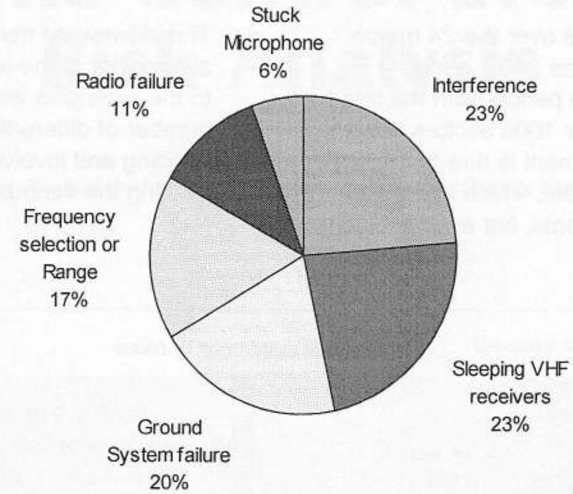
Autopilot deficiencies, crew level busts, turbulence and *late ATC clearances* are all major causes of level busts and these show a high rate of occurrence in the table.

Communication events

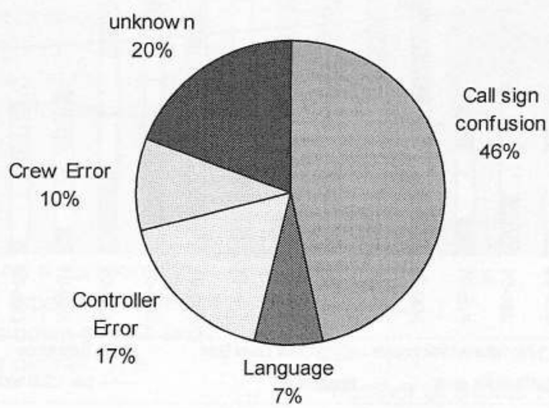
Further analysis of the causes of *communication* events reveals the following distribution of causes:

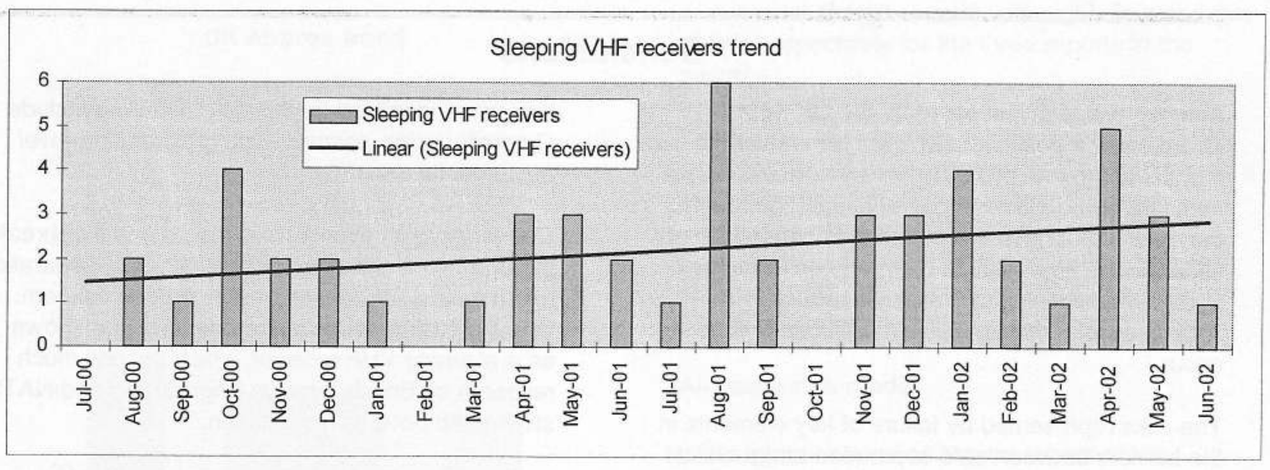
Loss of communication due to "sleeping VHF receivers" is a major area of concern and, despite significant activity by both British Airways Engineering and UK NATS, there is still no obvious explanation. Although in all cases communication can be re-established by the crew making a transmission, the high event rate in the busy terminal area creates a risk of an aircraft not receiving an avoidance manoeuvre instruction or missing an important clearance — leading to loss of separation. The trend of *sleeping receiver* events is increasing, partly due to its raised profile both with crew and controllers, and this is an area that requires continued attention.

Causes of Loss of Communication



Causes of confused communications



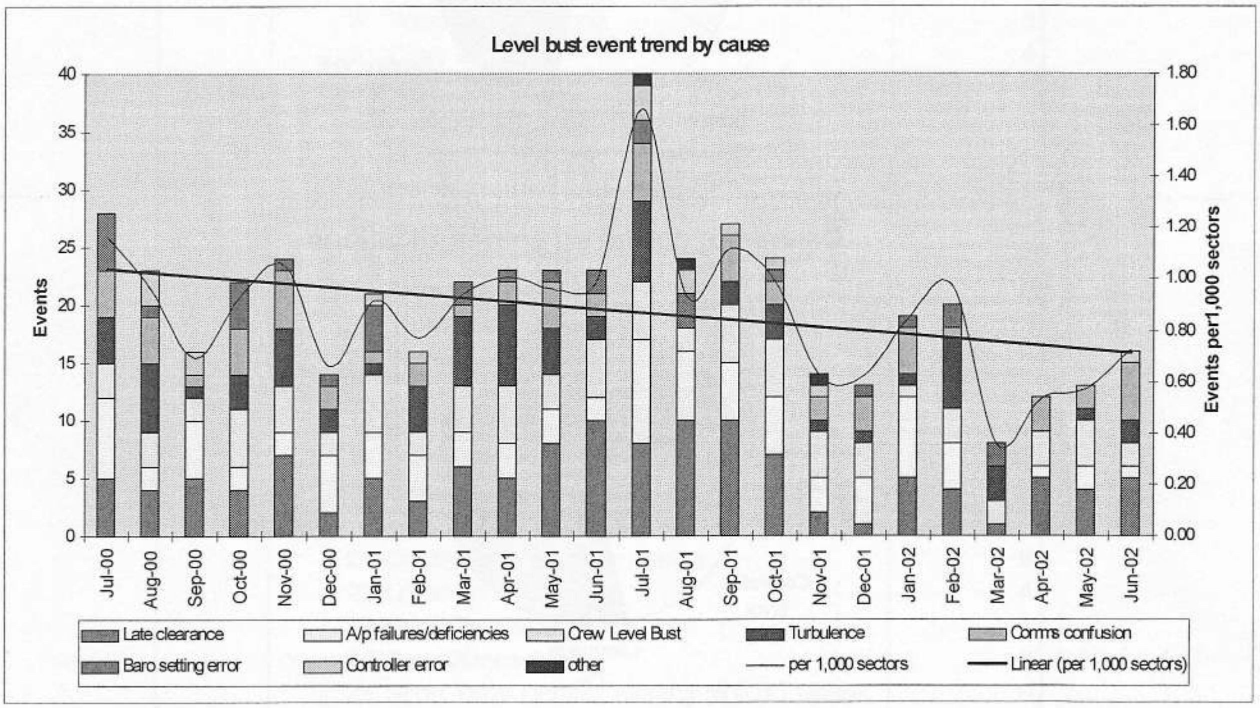


The profile of the subject continues to be raised, by Engineering with the VHF transceiver manufacturers, and by NATS with other airlines. It appears that the problem is not confined to British Airways or to one type of VHF transceiver but further data is being gathered by NATS and the CAA to determine the extent of the problem.

Level Bust events

Analysis of *level bust* events over the 24 month period from July 2000 to June 2002, shows a reduction in events over the period, with the trend reducing from one event per 1000 sectors down to 0.72. Some of this improvement is due to the retirement of the 747-200 fleet, which had a high level of *autopilot related* events, but even excluding the 747-200 there is still a marked downward trend.

This downward trend may be due to the increased awareness of the level bust issue, particularly due to the extensive work by UK NATS involving a number of different airlines. These activities are ongoing and involve a number of working groups tackling the various causes of level busts.



Conclusions

Airprox, events investigated by the UK Airprox Board show a positive downward trend over the 18 months to the end of 2001. However, this is only a measure of the ultimate loss of separation and not the events that have the potential to cause loss of separation. The events in Germany on 08 July 2002 demonstrate that, despite a reduction in Airprox events, midair collisions still can and do occur.

The risks represented by failure of key elements in the barriers between safe separation and a critical Airprox need to be better understood and ways to do this are being developed. By applying event data to an airspace risk model, key areas of risk can be identified and addressed accordingly, even when the incidents do not lead to a loss of separation.

Key areas identified by this risk modelling include *Controller error*, *communication failure* and *level bust* events.

Communication events have the potential to break through two of the barriers between safe separation and a critical Airprox, and are a serious concern. One increasing cause is the phenomenon known as a *sleeping VHF receiver*, which despite much research by British Airways Engineering and NATS still has no obvious explanation.

Level busts is an area that NATS and UK airlines have concentrated on for a number of years and the reducing trend of events is a good sign that this focus may be taking effect.

Efforts continue with various working groups tackling individual causes of events.