The h⬤le story

You'll know the 'Swiss Cheese theory' about accidents or incidents, and now in-depth research is exposing any 'safety barriers' issues in Airprox

You might think the term 'safety barriers' sounds like something that gets in the way of safety, and while it's perhaps understandable to think that, nothing could be further from the truth – 'safety barriers' are in fact quite the reverse.

Look at it this way; you probably know the Swiss cheese theory that when all the holes in a series of cheese slices line up an incident can happen, but if something stops the holes lining up you then have a 'safety barrier' that prevents the incident.

Back in 2017 we started to look at Airprox from the perspective of 'safety barriers' in addition to the traditional cause and risk assessment. This was to try to move away from a simple review of 'what' happened in individual cases, to a more informative and systemic assessment of

One of the best sources of situational awareness about other aircraft is ATC – if you talk to them

'why' the incident happened and where the safety barriers might be improved. So Airprox Board reports now include an assessment of the barriers for each incident, together with short statements for why we graded the key barriers as we did. Although it's still early days at present, this process is rapidly maturing to the extent that we can now see useful results from the aggregate of these assessments that give an indication of the strongest and weakest barriers in Airprox terms.

There are nine recognised barriers to mid-air-collisions (MAC) grouped into four ATC (ground) barriers and five Flight Crew (airborne) ones as follows:

ATC/ANSP
- *Regulations, Processes, Procedures and Compliance*
- *Manning & Equipment*
- *Situational Awareness & Action*
- *Warning System Operation and Compliance*

Flight Crew
- *Regulations, Processes, Procedures and Compliance*
- *Tactical Planning and Execution*
- *Situational Awareness of the Conflicting Aircraft & Action*
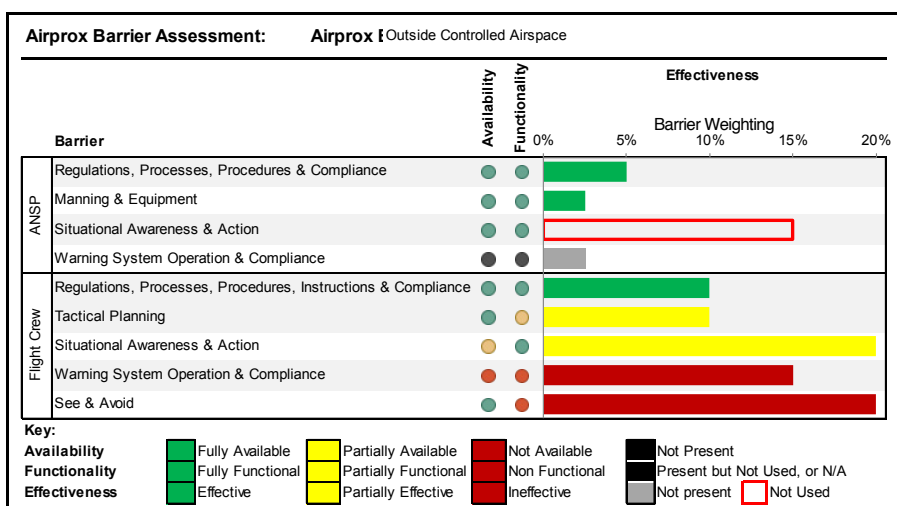- *Warning System Operation and Compliance*
- *See & Avoid*

Although they all have relevance to a greater or lesser extent, some are more relevant than others and so we apply a weighting to each barrier to reflect that.

For a typical Airprox in uncontrolled Class G airspace, the chart shows how the barriers are weighted for importance (their length represents their part of a theoretical 100% for all the barriers added up).

For example, Flight Crew see-and-avoid and situational awareness are both seen as being 20% of the solution in Class G, while ATC regulations are only seen as being 5%. There's no mathematical formula behind these weightings, it was purely the output from a panel of pilots and controllers who were asked to grade the relative importance of each barrier for us. But they do give an idea of what's important and what's not so important. These percentages don't change from Airprox to Airprox in Class G, they simply allow us to quickly identify which are the most important barriers. That being said,
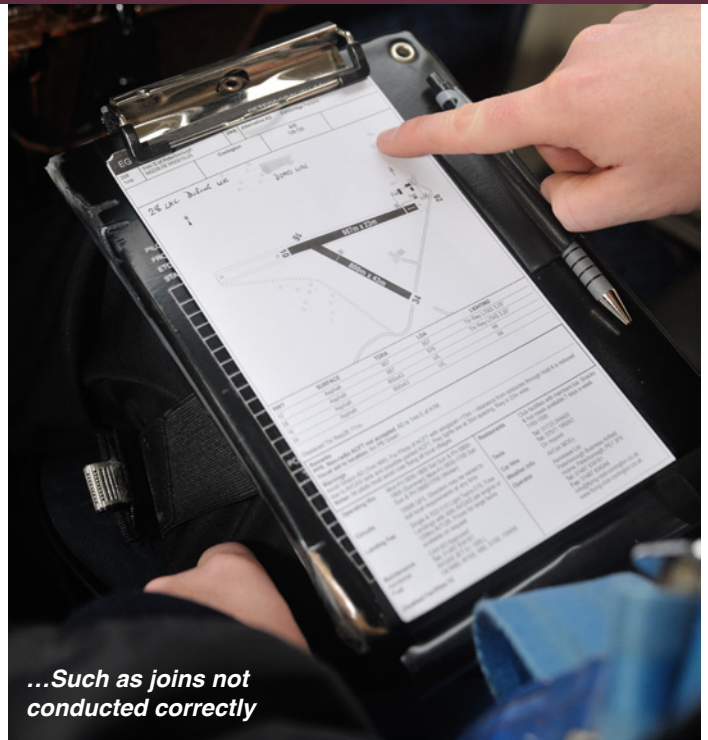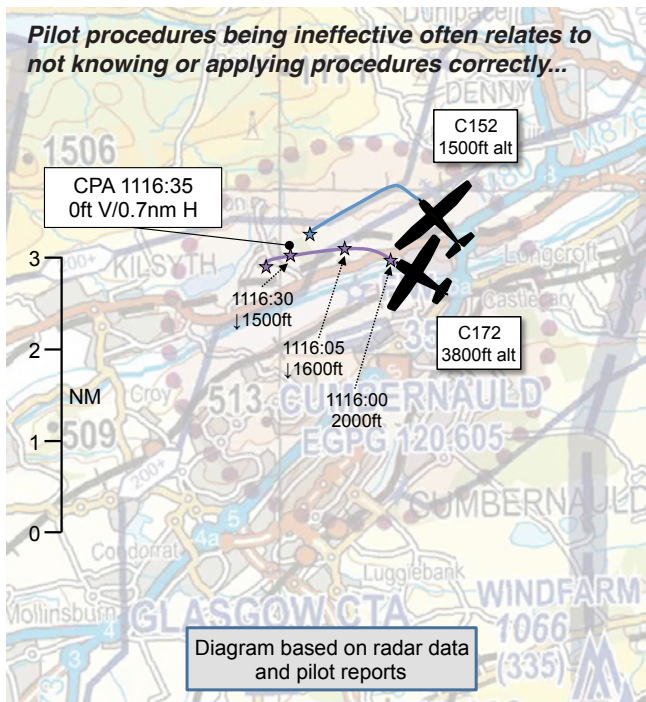

See-and-avoid remains the mainstay of preventing collisions

Airprox Barrier Assessment: **Airprox** Outside Controlled Airspace

Barrier	Availability	Functionality	Effectiveness / Barrier Weighting
ANSP — Regulations, Processes, Procedures & Compliance	green	green	green bar (~5%)
ANSP — Manning & Equipment	green	green	green bar (~3%)
ANSP — Situational Awareness & Action	green	green	red-outline (Not Used) bar (~15%)
ANSP — Warning System Operation & Compliance	black	black	grey bar (~2%)
Flight Crew — Regulations, Processes, Procedures, Instructions & Compliance	green	green	green bar (~10%)
Flight Crew — Tactical Planning	green	amber	yellow bar (~10%)
Flight Crew — Situational Awareness & Action	amber	green	yellow bar (~18%)
Flight Crew — Warning System Operation & Compliance	red	red	red bar (~14%)
Flight Crew — See & Avoid	green	amber	red bar (~20%)

Key:

Availability	Fully Available (green)	Partially Available (yellow)	Not Available (red)	Not Present (black)	
Functionality	Fully Functional (green)	Partially Functional (yellow)	Non Functional (red)	Present but Not Used, or N/A (black)	
Effectiveness	Effective (green)	Partially Effective (yellow)	Ineffective (red)	Not present (grey)	Not Used (red outline)

Barrier Assessment:	Effectiveness Percentage Count					Effectiveness Numerical Count					Check Sum Total Incidents
	Absent	Ineff	Partly Eff	Fully Eff	Not Used	Absent	Ineff	Partly Eff	Fully Eff	Not Used	
ATC Regs, Processes, Procedures & Compliance	17%	6%	11%	66%	0%	27	10	18	107	0	162
ATC Manning & Equipment	22%	2%	5%	72%	0%	35	3	8	116	0	162
ATC Situational Awareness & Action	26%	21%	17%	25%	12%	42	34	27	40	19	162
ATC Warning System & Compliance	90%	3%	1%	5%	1%	146	5	1	8	2	162
Pilot Regs, Processes, Procedures & Compliance	1%	19%	17%	64%	0%	1	30	27	104	0	162
Pilot Tactical Planning	0%	12%	35%	52%	0%	0	20	57	85	0	162
Pilot Situational Awareness & Action	0%	41%	38%	21%	0%	0	66	62	34	0	162
Warning System Operation & Compliance	33%	28%	12%	25%	2%	53	45	20	41	3	162
See & Avoid	0%	14%	42%	39%	6%	0	22	68	63	9	162

Antennae mountings can be an issue in the effectiveness of traffic warning systems

Pilot procedures being ineffective often relates to not knowing or applying procedures correctly...

CPA 1116:35
0ft V/0.7nm H

C152
1500ft alt

C172
3800ft alt

1116:30
↓1500ft

1116:05
↓1600ft

1116:00
2000ft

NM

Diagram based on radar data and pilot reports

...Such as joins not conducted correctly

the percentages are different for incidents in controlled airspace where we apply different weightings to take more account of the importance of ATC versus see-and-avoid.

What does change from Airprox to Airprox is how each barrier performed during different incidents. We colour-code each barrier according to how we assessed its effectiveness for each incident (colour-coded as: Red – barrier ineffective; Yellow – barrier partially effective; Green – barrier fully effective; Grey – barrier absent; and Open Red – barrier not used).

The first three colours are self-explanatory. 'Absent' refers to incidents where the barrier wasn't present (for example, ATC is not present in much of UK airspace), and 'Not used' applies to incidents where the barrier was present but was not employed (for example, ATC may have been available but the pilot chose not to talk to them).

So, for the fictional example shown, see-and-avoid and warning systems were both ineffective, thereby removing 35% of barrier protection, but ATC procedures, ATC manning and Flight Crew procedures were fully effective (giving 17.5% of full protection) and Flight Crew tactical planning and situational awareness were both partially effective (giving another 30% of partial protection).

So in other words, 17.5% of the total protection that might have been available was fully effective, 30% was partially effective and another 15% of protection might have been available if ATC had been used but it wasn't (as indicated by the ATC situational awareness being an open red box).

While all of that is interesting for each Airprox, it's when the aggregate analysis is done that real value can be gained. The next chart shows the combined outcomes for the 162 incidents assessed in 2017, and the pie charts show the key outcomes for the six highest weighted barriers. So, here are some things to think about.

- *ATC was not present for 26% of Airprox in 2017. Not much that can be done about that other than to think about it in another way: ATC was present for 74% of Airprox but was not always fully effective. ATC situational awareness and action being 'ineffective' often derives from Airprox where the other aircraft was not displayed on radar at all (due to terrain, radar coverage, or lack of radar cross-section, perhaps) or lack of secondary surveillance radar meaning that the controller did not know the height of the aircraft. This was in the days before it was mandatory to switch on transponders with all modes showing and so reflects that*

factor. But it also reflects situations where one of the pilots might not have been talking to ATC and so they had limited or no situational awareness with which to give traffic information to the other pilot. ATC situational awareness 'partially-effective' derives from Airprox where a controller might not have provided timely traffic information due to other priorities, had only generic information about the other aircraft (probably a primary return only), or ATC only partially resolved the conflict (often due to late 'pop-up' traffic on their radar display). The deduction is clear – if ATC is present then talk to them for both your benefit and to increase their situational awareness to the benefit of others.

- *Pilot procedures being 'Ineffective' or 'Partially-Effective' often relates to pilots not knowing or applying procedures appropriately (for example, overhead joins not conducted correctly, or other examples of failing to integrate in the visual circuit), or not avoiding ATZs and glider sites sufficiently, or not calling ATC as they transit through an airfield's feathers for example. A figure of 64% fully effective compliance with procedures is good to see, but we can work on those 36% of incidents where pilots didn't perform so well due to lack of knowledge.*

- *Forty-seven percent of incidents saw ineffective or only partially effective pilot tactical planning. This includes pre-flight planning, in-flight re-planning, and execution of the plan. 'Ineffective'*

'See-and-avoid is the mainstay of collision avoidance in Class G but it was only fully effective in 39% of Airprox incidents in 2017'
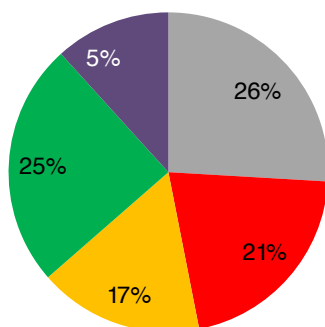
tactical planning often concerns a lack of any proper planning (not reviewing NOTAM, weather, airfield details etc), while 'Partially-effective' often concerns a failure to modify the plan when confronted with changed circumstances in the air (no 'plan B' when things go wrong, for example).
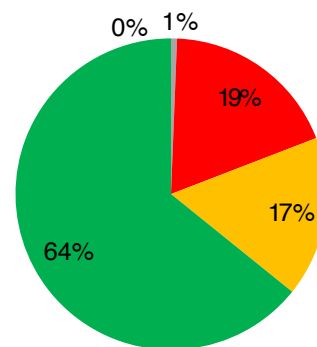
• Pilot situational awareness was fully effective for only a disappointing 21% of incidents. Pilot Situational Awareness 'Ineffective' (41%) generally applies to situations where the pilots had no knowledge that the other aircraft was present. 'Partially-effective' (38%) often applies to situations where pilots did not act sufficiently on information they had, or situations where they had only generic information that there might be other aircraft in their vicinity (e.g. knowing that there was a gliding site nearby and therefore expecting that there might be gliders around, for example). The best sources of situational awareness about other aircraft for a pilot are: ATC (did I mention that it's a good idea to talk to ATC if you can?); on-board collision warning systems (see the next bullet); and thorough pre-flight planning (as mentioned in the previous bullet).

• Collison warning systems are becoming increasingly affordable and available. It's not for me to promote any system in particular, but there are several available and system-to-system compatibility is key. In the pie charts, 'absent' refers to situations where neither aircraft was fitted with such a system; 'ineffective' refers to situations where one aircraft was fitted with a system, but the other aircraft did not have compatible equipment; and 'partially-effective' refers to situations where the aircraft did have compatible systems but the warnings were late or only partially acted upon. It's not just a matter of buying such a system though, think carefully about how it is mounted in the cockpit (especially the aerial). Antenna performance is greatly affected by masking and orientation of the antenna so don't expect it all to work if the antenna is pointing at an odd angle or buried beneath a metal computer tablet that's also resting on the coaming. There's a really good article about this from the LAA which is reproduced on our website airproxboard.org.uk under Topical Articles of Interest.
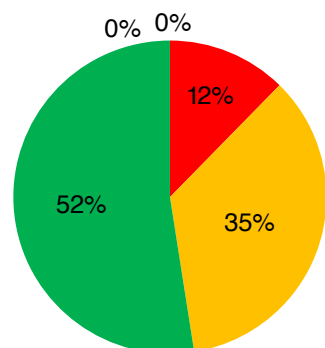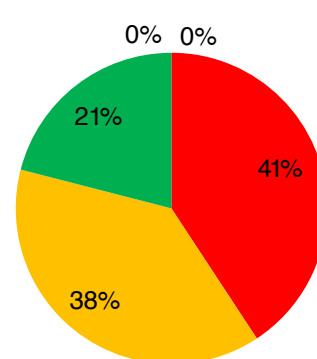
ATC SA & Action

26% ABSENT
21% INEFF
17% PARTLY EFF
25% FULLY EFF
5% NOT USED

Pilot Regs, Processess, Procedures & Compliance

0%
1%
19% INEFF
17% PARTLY EFF
64% FULLY EFF

Pilot Tactical Planning

0% 0%
12% INEFF
35% PARTLY EFF
52% FULLY EFF

Pilot SA & Action

0% 0%
41% INEFF
38% PARTLY EFF
21% FULLY EFF

Collision Warning Systems

2% NOT USED
33% ABSENT
28% INEFF
12% PARTLY EFF
25% FULLY EFF

See & Avoid

0%
6% NOT USED
14% INEFF
42% PARTLY EFF
39% FULLY EFF
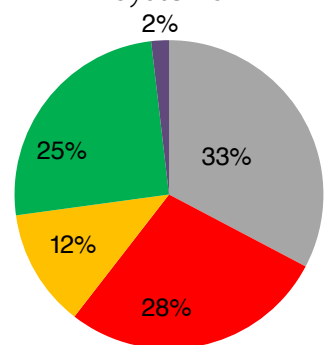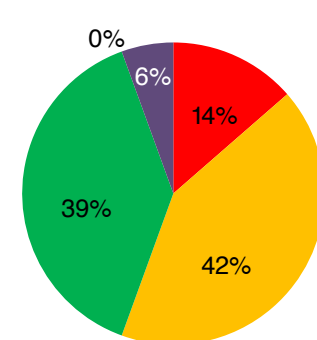
| ABSENT | INEFF | PARTLY EFF | FULLY EFF | NOT USED |

• See-and-avoid is the mainstay of collision avoidance in Class G airspace but it was only fully effective in 39% of Airprox incidents in 2017. 'Ineffective' (14%) refers to situations where neither pilot saw each other (non-sightings), while 'partially-effective' (42%) refers to situations where late sightings meant that often only one of the pilots was able to take emergency avoiding action. So that's why we talk a lot about lookout 'effectiveness' and scan patterns. As pointed out in the magazine's article on Lookout, it's very important to try to spend 80% of your time looking out and only 20% looking in – and that 20% should be done in small bursts of activity for two to three seconds interspersed with lots of looking out again. Lookout is probably one of the most important parts of 'Aviate' in the 'Aviate-Navigate-Communicate' mantra. ■