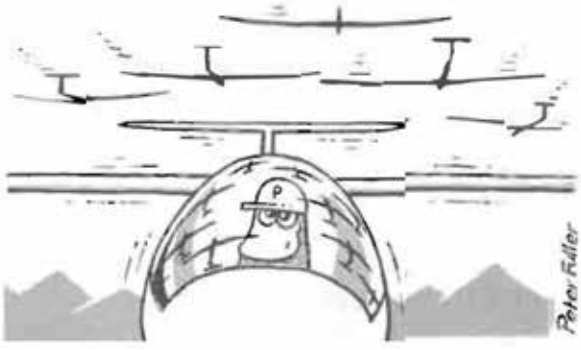
COLLISION RISKS

The BGA Safety Team describes how the risk of mid-air collision can be calculated



Back in 1992, the late Platypus observed: "I can image traffic lights or a Gendarme in a balloon to direct the flow of plastic along the Parcours des Combattants in August, especially on some sharp corners where you can't see a squadron of rock-polishers coming the other way until – aaaarrrgghhh!" (Peter Fuller)

GOODHART'S INTENTION WAS TO SHOW THAT COLLISION RISKS CAN BE CALCULATED, AND AIRSPACE DECISIONS BASED UPON QUANTITATIVE CRITERIA

SIXTY years ago, the future of gliding at Lasham was jeopardised by plans for a western extension of the London Control Zone, and overflight by aircraft bound for Farnborough [1]. The ensuing battle between Lasham and the Ministry prompted the BGA's Airways Committee chairman, Nick Goodhart, to undertake a mathematical analysis of the risk of a collision between an airliner and a glider [2-4]. His memorable conclusion was that 'if there was no controlled airspace anywhere except the South-East of England, if the last collision had been in Queen Elizabeth I's reign we would be keeping up to the average if the next one was about now, provided of course commercial and glider flying had been at the present level during the intervening period.'

Nick Goodhart was, by all accounts, a singular character [5,6]. A navy flier and test pilot, he invented the mirror deck landing system and rose to the rank of Rear Admiral. He was the first British glider pilot to gain all three Diamonds and the first to achieve a 500km goal; he won the nationals three times, was world two-seater champion, and held the UK absolute height record for over 40 years. Nick was a crusader who relished a challenge and, according to a fellow glider pilot and test pilot, "He could – and often did – argue you into the ground… and 90 per cent of the time he was absolutely right."

Collision probabilities

Goodhart's calculation followed a standard analysis from the kinetic theory of gases, whereby gas molecules are assumed to be randomly distributed rigid bodies whose collision rate depends upon their relative speed, average spacing and cross-section (the area around one body through which the centre of a second body must pass for a collision to occur). The fraction of space that this cross-section appears to sweep out, as viewed from the second body, equals the probability of collision.

Goodhart took the cross-section for collision between an airliner and a glider

to measure 140ft x 42ft and the relative speed to be 400ft/s. To estimate the effect of eliminating all airspace beyond the home counties, he reckoned that 3,000 hours per year of cross-country glider flight and 30 airliners at any time would be randomly distributed over 25,000 square miles of airspace up to 12,000ft; and he assumed that good lookout would prevent nine out of 10 collisions under visual flight conditions. He thus calculated that there would be an average of one mid-air collision between an airliner and a glider every 370 years.

Winch cables and parachutists

The numbers have changed, but Goodhart's method was valid, and we recently used it to compare the present-day risks of light aircraft collisions with glider winch cables and parachutists. With reasonable assumptions, they proved essentially the same [7]. If pilots did not route around drop zones and gliding sites, and launches and parachute drops were not suspended until airspace is clear, we might expect one light aircraft per year to collide with a parachutist, and another with a glider winch cable. Our analysis allows us to argue for clearer depiction of winch sites on charts and moving maps, and better publicity of the dangers of overflying them.

Such calculations also help us to push for a more balanced approach by regulators, who require a large temporary danger area to be established for trial of a drone (UAV) that, even if continuously aloft at light aircraft altitudes, would present only a fraction of the collision risk of glider winch cables.

Model limitations

Goodhart's calculations assumed that glider positions, headings and altitudes would be randomly distributed, and he persuasively argued the validity of this simplification, but there are other situations in which such assumptions are less accurate. The collision

rate depends upon the relative speeds of aircraft sharing the same airspace, which are lower if the aircraft are heading in similar directions. This is the principle behind maritime Traffic Separation Schemes, one reason for airfield circuit patterns and, for glider pilots, the reason for turning the same way around a thermal [8]. The reduced relative speed also gives more time to spot an aircraft and manoeuvre out of its way.

Semicircular rule for cruising flight

The same ideas lie behind the semicircular rule for instrument flight rules (IFR). By international convention, aircraft cruising with an easterly track component should adopt a flight level (FL) that, below FL290, is an odd number of thousands of feet, while those with a westerly component should fly at an even number. Grouping in this way by the direction of travel reduces the relative speed of aircraft cruising at the same altitude. (Until 2015, the UK quadrantal rule further divided flight levels so that aircraft tracking between E and S would be 500ft higher than those travelling between between N and E, etc.)

Unfortunately, as explained in a 1983 CAA-funded paper [9], concentrating aircraft at specific flight levels generally increases the collision probability despite the reduction in relative speed. Unless pilots are very imprecise in their height-keeping, the semicircular rule proves unlikely to reduce the collision risk; indeed, with autopilot precision, it can be doubled or worse.

The risk of flying together

For the same reason, the greatest collision risk is often between aircraft involved in similar activities: airfield circuits, military pair flying, and gliders sharing a thermal, ridge soaring, or flying the same competition task. It's hard to calculate numbers for such situations, because aircraft positions and velocities are neither randomly distributed nor uncorrelated, but accident records confirm the dangers.

Similar arguments could be made about flying in airways, which concentrate the aircraft laterally as well as vertically, but – happily for airline passengers – deliberate spacing under air traffic control allows this to be done safely. Goodhart's original point was that, while controlled airspace can be safer for aircraft within it, its expansion inevitably increases the concentration of aircraft outside it, as well as creating particular pinchpoints at its edges and corners. Opposing the introduction of the Lyneham control zone in 1967, he famously asked the government minister who should take responsibility for the consequent increase in collision risk: he received no satisfactory answer [10].

Collision risk today

It would be hard today to sustain Goodhart's suggestion that most UK airspace could be eliminated. Cross-country glider hours have increased tenfold, while public expectations of airline safety have risen. Gliders are, in any case, less of a collision risk than light aircraft, which accumulate a million flying hours per year. But Goodhart's intention was mainly to show that collision risks can be calculated, and that airspace decisions can thus be based upon quantitative criteria.

Goodhart's method reveals that, even if light aircraft and gliders flew randomly in the available UK airspace, we should expect several mid-air collisions per year amongst them; with bunching by weather etc, there would be still more. Disciplined soaring and circuit patterns and vigilant lookout reduce the actual rate, but until a few years ago there were still on average a couple of collisions per year involving UK gliders – 90 per cent of them with other gliders or aircraft involved in gliding activity. There have been no further glider-glider collisions since 2014, presumably thanks to the further barrier provided by FLARM. Indeed, our records show only one collision between gliders that were both equipped with serviceable FLARM devices. The collision hazard nonetheless remains.

Please therefore keep a keen lookout, follow the soaring protocol, and fit FLARM if you haven't yet done so. Please also report any dangerous overflights of winch sites [11]: we need the data.

Tim Freegarde and the BGA safety team

[1] W Kahn, *A Glider Pilot Bold*, 3rd edn (2011) *https://tinyurl.com/flyright2216*
[2] H C N Goodhart, *S&G* p4 (Feb 1963) *https://tinyurl.com/flyright2217*
[3] H C N Goodhart, *S&G* p96 (April 1963) *https://tinyurl.com/flyright2218*
[4] H C N Goodhart, *S&G* p3 (Feb 1964) *https://tinyurl.com/flyright2219*
[5] R Harris & B Williams, *Goodhart – the story of an exceptional man*, Woodfield Publishing (2012) *https://tinyurl.com/flyright2220*
[6] W Kahn, *S&G* p70 (June/July 2011) *https://tinyurl.com/flyright2221*
[7] T Freegarde, BGA website (2022) *https://tinyurl.com/flyright2222*
[8] BGA Soaring Protocol (2020) *https://tinyurl.com/flyright2223*
[9] R L Ford, J Nav **36**, 269 (1983) *https://tinyurl.com/flyright2224*
[10] P Wills, *Free as a Bird*, John Murray (1973)
[11] BGA Guidance re Overflight of Winch Launch Sites (2019) *https://tinyurl.com/flyright2225*

■ Clubs can obtain printed copies of Safety Briefings from the BGA Office.

PREVIOUS 'FLY RIGHT' ARTICLES

- *The perils of distraction* (Apr/May 19)
- *Keeping safe in thermals* (June/July 19)
- *Why it is good to think ahead* (Aug/Sep 19)
- *The effects of wind gradient* (Oct/Nov 19)
- *A fun but safe introduction* (Dec 19/Jan 20)
- *Stop the drop* (Feb/Mar 20)
- *Avoiding upset* (Apr/May 20)
- *Backroom boys* (June/July 20)
- *Cockpit muddle* (Aug/Sep 20)
- *Safe rotation* (Oct/Nov 20)
- *Cockpit remedies* (Dec 20/Jan 21)
- *Covid currency* (Feb/March 21)
- *Eroded margins* (April/May 21)
- *A good lookout* (June/July 21)
- *Trouble with turbos* (Aug/Sept 21)
- *'Hopefully' is not an option* (Oct/Nov 21)
- *Act when the launch fails* (Dec 21/Jan 22)
- *Time to solve a knotty problem* (Feb/Mar 22)
- *RTFM: Read the flight manual* (Apr/May 22)
- *Startling events* (June/July 22)