

# Formation aerobatics

...or an old dog learns a few new tricks: there's more to flying such manoeuvres in close company than you might think

By Bob Grimstead



Photo: Guy Westgate

**"B**e careful what you wish for..." In my teens I yearned to be an aerobatic airshow pilot. Now, after 100-plus displays, I can look back on the long, and surprisingly steep climb to achieving that ambition.

In the eighties, when I was 32, it took me 24 twenty-minute training sessions over a four-month period to reach formation display standard with the Tiger Club's Turbulent Team. I subsequently flew more than thirty shows with them, but with a growing family and a committed airline career I had to wait another 25 years to be where I really wanted.

On my eventual retirement from British Airways, I bought a Fournier RF4D to polish





**Main:** Matt looks out to check the display line while Bob fixes his entire attention on the lead aircraft  
**Below:** to echelon after looping line-abreast, turbulence distorting the trails from the team's smoke cannisters  
**Bottom:** Redhawks emulating the Red Arrows in their ironic version of the Twinkle Roll

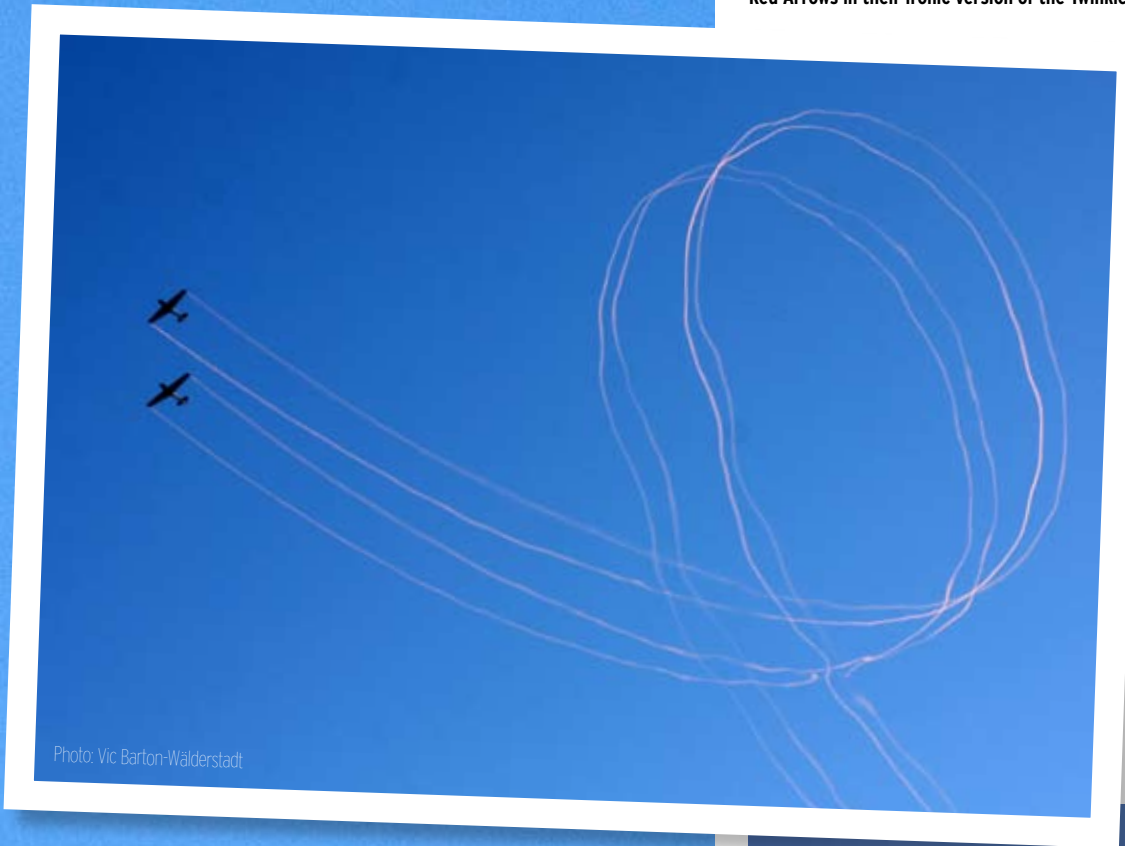


Photo: Vic Barton-Wäldestadt



Photo: Keith Park

Main photo: John Parkin

my aerobatics to airshow standard. Having flown simple loops and rolls for forty years, it took me a surprising 150 twenty-minute sorties over two further years to achieve reasonable competence. Thirty more aerobatic displays got me proficient enough for the next step.

My great buddy and highly experienced airshow performer Matthew Hill (right in photo) resurrected his identical Fournier and suggested we work up a two-ship act, so I jumped at the chance. After all, with thirty years of regular formation flying experience, plus a half-dozen more recently of serious aerobatics, how hard could that be?

Wrong, wrong, wrong! Little did I appreciate just how difficult it is to formate

in such low-power, low-drag, straight-winged aeroplanes through all three dimensions – it is even harder than hovering the trickiest helicopter I've flown. My respect for that legendary Fournier display duo/trio, the Skyhawks, has grown in Olympic leaps, so let me explain some of the challenges.

I formate on Matthew, because my ambition was learning that skill. Matt leads, something he hadn't previously done in Fourniers, despite being Skyhawk Three for a couple of years and leading the Crunchie/Utterly Butterly wing-walking Stearmans for a season or two. Fortunately Matt is a superb instructor – without his skill and patience I would never have got anywhere.

Formation pilots probably need empathy, rapport, a deep affinity – call it what you will, but I suspect we are actually telepathetic: often communicating without the complication of speech or hand signals, even finishing each other's sentences. My phone buzzes with Matt's incoming SMS just as I am texting him. Sometimes I worry we're turning into 'Red Jedward', or maybe Butch & Sundance – just don't ask "Which one's butch?" – or, considering our sizes, Tweedledee and Tweedledumb.

Our Fourniers weigh the same (290kg) and are identical aerodynamically, with similar (puny) power. I weigh 73 kilos, Matt's a little heavier – my sole advantage. I've tried over-filling his fuel tank and

Photo: Andrew Dennes



hiding sandbags behind his seat, but he keeps finding them. Because it's difficult holding station with such low power, Matt flies all his manoeuvres at cruise rpm, accepting our performance loss.

Let's put this power deficit into context. The average training aeroplane has from 120 to 160 horsepower. Full-blooded aerobatic machines boast 300hp or more, with constant-speed propellers converting this grunt into brute thrust. An Extra 300L produces nearly 100 pounds of thrust at idle. We struggle to generate that at full throttle!

All Fourniers have tiny, fixed-pitch wooden props and ancient Volkswagen Beetle car engines of nominal 39hp – at sea level and in ISA. But we start at 1,500 feet and mostly display on warm summer afternoons, so in reality it is quite a lot less. We weigh about half what an Edge, MX or Pitts does, so we have perhaps one fifth of their power-to-weight ratio. This does not give us much 'catch-up'. We also have very little drag for dropping back. Basically, we fly formation aerobatics on the power you use to taxi.

Yes, things would be much easier in jets or Extras, but we can't afford them. We would also improve more quickly if we could practise every day – or even every week. Regrettably our jobs make that impossible, so we grab opportunities whenever they arise. But first we had to establish which manoeuvres were even feasible.

Line-abreast is the most demanding formation position – and the degree of difficulty is multiplied by our wings'

considerable length. The slightest angular difference in roll or yaw shows up like a carbuncle on Keira Knightly. But, when done properly, line-abreast does look best.

Unfortunately, in Fourniers we have no choice. Echelon loops, although easier in most types, are impossible with such a tiny power margin. So we stick with line-abreast, and I have to cope through 4g manoeuvres with my upper body twisted at right-angles in my seat. My neck and shoulders ache and I have to fly with my upper straps loose, so my body shifts and my heart lurches whenever I push a bit of negative G or hit our wakes. It can't be helped, I must get used to it, and thank goodness for Sloan's Liniment and a helpful osteopath.

### Looping in precise position

With so little grunt, as Matt repeatedly emphasises, the solution to correct positioning lies in anticipation. Provided I stay in the right place, with the appropriate power, and fly a loop of the same radius as his, I should be OK. Precise positioning is paramount. I must be within one foot of Matt vertically and longitudinally (but forty feet laterally, of course).

If I am even slightly high on Matt, I shoot ahead because I'm flying a smaller circle. So, when I say, 'Correctly positioned', I really do mean to within twelve inches in both dimensions. We think of this as 'matching' rather than formatting. I fly an identical loop close beside Matt, making tiny adjustments to mirror him.

This means I must start in the right place: exactly level with Matt, perhaps two feet ahead of him, and one wing-span apart (so our four wing-tip smoke trails are equidistant) and stabilised with an identical power setting. Then I have to pull at precisely the same time he does (so he pauses imperceptibly after calling, "Now") and at the same pitch rate. I need to keep my wings exactly level with his using my ailerons, and I have to stay in balance accurately, otherwise the increased drag of even a slight sideslip makes me drop back.

And that's just the start. From the moment Matt begins diving, without even glancing at the slip ball I have to make a steadily and constantly-changing rudder input around the loop. First I need a squeeze of right ruder as we accelerate in the dive, then left rudder as we pull up, then lots of left rudder at low airspeed over the top, then less left rudder, and finally right rudder again as we bottom-out. Provided I do all that, I should have just enough surplus power to counter the increased drag of my repeated small aileron corrections.

Meanwhile I juggle the controls to keep my wings as nearly as possible aligned with his, while opening and shutting the throttle – with appropriate rudder adjustments, of course. If the slightest sideslip develops, I drop back and will be unable to catch up for one full manoeuvre. There are three vital ingredients for success: keeping the slip ball centred, not allowing any sideslip, and centring the ball.



Main photo: ??????????????????????

Main: Stepped down line astern – close, but not quite as close as the camera makes it seem (inset, above)  
Opposite: Eyes on the leader in formation takeoff

I have to stay in place, despite Matt's Fournier's lower half being obscured by my smoke pod, and once my wings bend up under increased G, I can only see his top third. Moving around relative to one another in the hurly-burly of atmospheric turbulence, slight lateral and longitudinal displacement and my inevitable over-controlling, his aeroplane almost disappears from time to time. I usually retain glimpses of his rudder, spinner or smoke trails but, like any formation pilot, if I become completely unsighted I must break off and roll assertively away, whatever our attitude. No-one survives even a 'gentle' mid-air coming-together.

Lateral spacing is not quite so important, since it changes from figure to figure (we separate more for stall turns and half-flicks in case they 'hang up' or over-rotate). Nevertheless, if I get my rudder a bit wrong, we will drift apart (or together). The consequences of getting it badly wrong don't bear thinking about! In an effort to improve my deteriorating reaction times I

have given up alcohol, and even ventured a resolution for more exercise. You may appreciate the enormity of those sacrifices!

*'No-one survives even a 'gentle' mid-air coming-together..'*

Initially, I committed that classic beginner's looping error of squeezing the stick towards my right shoulder rather than directly back to my navel. Having long ago corrected that failing solo, I presumably lapsed because of my awkward half-sideways seating position, exacerbated by having to concentrate on the outside picture rather than what was happening in my lap. So Matt's aeroplane apparently rolled away from me as we topped-out our loops, while pulling above me and ahead.

Once I straightened that rearward pull, I found not only were we staying equidistant and with our wings at similar angles, but that I was drawing ahead over the tops of loops and accelerating downhill. So, now my aeroplane was properly in balance I had enough spare power to modulate the throttle and stay in position. Flying formation loops is like any other hand/eye/brain coordination exercise. At first it seems impossible, but slowly, with enough practice, you get the knack.

I've since flown line-abreast loops in Pitts Specials, and believe me, they're simplicity by comparison. This would all have been so much easier aged 26 rather than 62, but my main consolation is that only six people in the whole world have ever been able to do this stuff in Fourniers.

### Echelon barrel rolls

Just as Fournier loops must be in line-abreast, barrel rolls have to be made in echelon. I often found myself dropping back in a loop's last quarter anyway, so



Above and right: for the signature Hamster Loop, the Redhawk's Fourniers chase each other in diametric opposition

sliding across and tucking in beside Matt was comparatively easy. Unfortunately, I then found it hard to become stabilised enough to get around the roll without dropping further behind; and catching up thereafter was my biggest problem. Moving forward again into line-abreast for the next turn-around seemed impossible. When RAF pilots get left behind despite having full power, they transmit, 'Buster'. Because Fournier pilots think I'm mad even attempting this stuff, I call, 'Bonkers!'

There was another totally unexpected aspect to our barrel rolls. I had presumed my biggest problem would be keeping up with Matt around a bigger rolling radius.

*'The speed loss is only a few knots... Seen through my eyes, he's reversing!'*

Not so – on our first attempt I discovered my main difficulty was not chewing into his trailing-edge during our initial pull-up.

Think for a moment and it's obvious. Like all Fournier manoeuvres, this starts with a dive for speed, then Matt calls, "Pulling now" and lifts his nose forty degrees above the horizon before rolling. As his Fournier rears up, it inevitably slows down. That speed loss is only a few knots, but because I'm several feet behind him, my airspeed dissipates later and more slowly. Seen through my suddenly-wide eyes, this looks like he's reversing into me!

As always, the solution is anticipation. Now I momentarily snap my throttle shut as he pulls, watching his near aileron very

carefully, and whack it fully open again (while simultaneously moving my stick to the left) as the aileron deflects. Done as mechanically as that, the rest of this evolution is a 'simple' matter of hanging on to Matt's wing-tip like a spider clinging to Vincent Simone's coat-tails while he dances the tarantella, and following him around that big, wide, positive-G roll as the earth curls up and over our heads.

Right from the start, I loved these barrel rolls. Line-abreast loops are exceptionally difficult, and I find myself concentrating so hard on holding exact station, keeping my wings parallel to and square with Matt's, and maintaining precise separation, I have no time to admire the world going upside-down behind him, as I had presumed I would. During our barrel rolls I find myself marvelling at the swinging, swirling, revolving scenery beyond Matt's Fournier as I swoop my way around the roll beside him – often smiling all the way around!

#### Quarter-clovers

These are a simple combination: first half barrel roll, second half loop, but they present two significant problems. First, as for the barrel roll I must drop back into echelon during the preceding stall turn, and then I must forge ahead into line-abreast during the second part of the manoeuvre for the next figure. Neither task is easy, but both eventually became feasible.

#### Line-abreast turn-arounds

In Fourniers, there is only one correct kick speed for the pivot and I am busy watching Matt, so he calls, "Rudder, now" for us to kick together. Our aeroplanes' rotation rates depend upon both the initiation speed and our propwash at the precise moment of that kick, so I have to snap my throttle to

an intermediate position when I hear Matt draw breath, to pirouette in unison.

The actual control inputs must be instinctive, because I need to whip my head and upper torso quickly from staring over one shoulder to looking past the other wing-tip for the revolution's second half. It is difficult to hold our wings precisely in the plane of rotation (the outer wing usually lifts, despite full opposite aileron) and we do not want to find ourselves getting any closer than necessary here.

#### Tootsie rolls

For our 'Tootsie Roll' Matt flies straight while I barrel-roll around his smoke trail. Once I've started, he throttles back, so he does not pull too far ahead while I fly a greater distance through the sky, spiralling around him.

At first I hadn't realised this would not be a normal barrel roll. If you think about it, a classic barrel roll puts the rolling aeroplane's wings vertical as it reaches its apogee above the leader, wings-level inverted on the way down past his wing-tip, in knife-edge again underneath him and wings level erect back alongside. But to see Matt and ensure safe separation, my canopy needs to be pointing towards him at all times. In other words, my aeroplane always has to be at right-angles to its natural attitude.

Surprisingly this comes naturally, although it does involve quite a lot of sideslipping and some negative G as I go over the top. Of course that makes the engine splutter and stop (the Fournier has no inverted systems – indeed, it has no systems at all) but this is not really a problem, because its low drag helps retain airspeed. Meanwhile, the prop windmills and the engine bursts back into life once it's upright again – or it has done so far.

Left: a half-flick – note air flow detaching from the starboard wing  
Below: looping, line abreast



Photo: John Parkin



Photo: Keith Park

### Twinkle rolls

This is a joke name for an easy manoeuvre. When they flew their original, fast-rolling Gnats, the Red Arrows' Twinkle Roll was a near-instantaneous roll made by all team members together, executed simultaneously in a big formation. Our Fourniers have a roll-rate timed more by calendar than stopwatch, but we emulate the Reds by synchronising our lazy tailchase ballistic roll.

### Looping breaks

Combining the first three-quarters of a line-abreast B-axis (going towards the crowd) loop with separating, opposite-direction quarter-rolls on the vertical down-line completes the aerobatic formation portion of our display. Having parted, Matt loops into-wind while I fly a half-Cuban to obtain the precise 164-metre separation required for our 'Hamster Loops'.

### Hamster loops

Our signature evolution was devised by Austrian Fournier pilot Christian Zok. Following one another around consecutive loops, each positioned diametrically opposite the other, we should look like two hamsters running around their exercise wheel. Spacing is my responsibility, and adjusted by looping either slightly wider or on a tighter radius than Matt.

If we're equidistant, I just track around his smoke trails as closely as I can, wrestling the wicked kicks and bumps from his wake. I must only make snapshot assessments of our separation when I'm at the very top or bottom of a loop, because on the climbing and descending arcs we are accelerating or decelerating, so any apparent closure is illusory.

People tell us our hamster loops look novel, and they are straightforward to fly

provided the leader has smoke for his wingman to follow. Without smoke, they are dangerous, because the climbing aeroplane can easily meet the descending one head-on!

### Roll off the top

We finish our hamster loops by rolling off the top of the last one away on to the B Axis. Again, this is not a true roll-off-the-top, but more a slewed, barreled half-Cuban. Whatever we call it, the idea is to continue our flowing motion, but now away from the crowd, to give us space for a rejoin – always the most difficult accomplishment, and made more so by our low power and narrow speed range.

### Barrel break

We used to make a simple fan break towards crowd centre, but we realised that, with lots of energy, we could amplify that climbing break into a rolling manoeuvre, giving us spacing for some opposition aerobatics. So that's what we now do, following the break with synchronised turn-arounds, opposition loops and a climbing crossover.

### Line-astern positioning

If we run out of height, if our positioning becomes doubtful, or if we have spare time, Matt calls me into line-astern and we position appropriately or throw an orbit. This formation enables us both to use full power and claw back energy, plus it gives me a bit of a breather (because line-astern is easier to fly). To stay nice and tight, I don't formate on Matt's rudder or tailwheel, but on his underwing centre-section inspection panels.

### Waving run

Many performers simply end their slot by flying away. But then the crowd cannot see

the pilots, so they might as well be model aeroplanes. We want to see our audience, and for them to view us, so we finish by flying low along the crowd line to wave goodbye. This allows the public to show their appreciation by holding aloft one or two fingers or perhaps a bunched fist.

### Developing the routine

2011's routine consisted almost entirely of formation aerobatics. We now had an act more like that of our idols the Skyhawks, but still finishing with our hamster loops and some simple low-level formation passes. Unfortunately line-abreast loops predominated because all that practice had made me rather a 'one-trick pony'.

For 2012 we should have a better balance, with a selection of echelon and line-abreast manoeuvres, followed by the hamster loops and then some opposition aerobatics before a few simpler and lower formation evolutions and our waving fly-past. We have already received enquiries for quotes from Farnborough, Southern France and Northern Italy.

I freely admit that learning this stuff has been bloody difficult – even harder than being married – and I'm still not where I want to be, but it's immensely satisfying when everything clicks. Our flying should look like an easy and graceful aerial ballet, although (like that serene swan paddling madly below the surface) anyone monitoring our R/T would hear a stream of instructions, reminders and entreaties passing between us as we perform our apparently effortless pas de deux.

Come and see us this summer, and we hope you will enjoy watching our graceful Fourniers. For our calendar, video footage and more photos, visit: [www.redhawkduo.co.uk](http://www.redhawkduo.co.uk).