



Grant Benns performing a Half-Cuban in a Falco

# Aerobatic Turn Arounds

Most competition flying requires turn-around manoeuvres of some kind, often at speed or in a confined space. In this continuation of his aerobatics series of articles, Grant Benns describes the commonly utilised options:

A sporting competition invariably pitches competitors (individuals or teams) against each-other, either directly, such as in a running race or a rugby match, or indirectly, such as darts or gymnastics. In the case of the latter two examples, you may be judged or scored objectively by points awarded for accuracy (darts), or subjectively by a group of judges, against defined criteria - in this case the person who scores the highest points against that criteria becomes the winner.

## Reno

In the world of 'sport(ing) aviation', or perhaps aviation-sport, there are only a few examples of direct competition. Glider Grand Prix racing is one. Another well-known example is the National Air Racing at Reno, Nevada. Here we have pilots competing directly against each other, going fast (VERY fast) and VERY low around a pylon racecourse, with the winner being easily identifiable as the one to cross the finish line first. As you may be aware from the exploits of local pilot Graham Frew in his Yak 3, this is very exciting, addictive and not without a degree of risk. Putting a group of 70 year-old aircraft in close proximity to each other at

400+mph, less than 100 feet off the desert, whilst pulling 6g in near-constant turns is not for the faint hearted.

## Red Bull Air Race

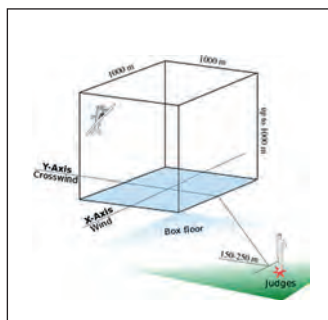
An outsider might view the Red Bull Air Race (RBAR) series similarly, however a key point of difference is that you never see the aircraft directly racing against each other, although, through clever technology and a big production budget, the television coverage will occasionally show the current race aircraft 'racing' against the ghost digital image of a previous competitor. There are also criteria that must be met, such as 'wings-level' through certain pylon-gates (judged externally), and certain speed or manoeuvre requirements, all of which attract time penalties for infractions. The winner is the pilot with the lowest time though the course.

## Competition Aerobatics

Unlike Reno or the RBAR, competition aerobatics is generally an untimed event. There are a group of judges on the ground assessing the pilot's ability to fly a series of prescribed manoeuvres, called a sequence, in accordance with a known criterion, to generate a score (from zero to 10) for each manoeuvre. The winner is found by being the competitor with the highest overall score. In this regard, competition aerobatics is much more like gymnastics, or even Dancing with the Stars. Some competition pilots would even like to consider themselves as sky-dancers, and most definitely 'stars'.

## The Arena

Common to Reno, RBAR, gymnastics and Dancing with the Stars is an arena in which to perform and/or display your talents. Keeping the competitors in sight is good from a spectator point-of-view but also very important from a judging perspective, when having to apply subjective scoring criteria.



For competition aerobatics our arena is the 'Aerobatic Box', also described in the rules as the 'performance zone' (where we 'perform'). The Box is 1000 m x 1000 m when viewed from above, and up to 3300 ft high, and is within which the competitor must contain their aerobatic sequence - no more wandering around the wild blue yonder. This creates a constrained arena enabling the ground-based judges to view the flight of the competitor with relative ease, although a little Pitts Special at 3300 ft on the far side of The Box can create challenges - 'was that a roll or a snap?'

The challenge for the competitor is containing their sequence within The Box, a problem made worse by winds aloft and airspeeds of 200 kts or more in the higher-performance aircraft. At 150 kts it takes just 12 seconds to fly from one side of The Box to the other, and there may be up to three manoeuvres to be flown across that distance.

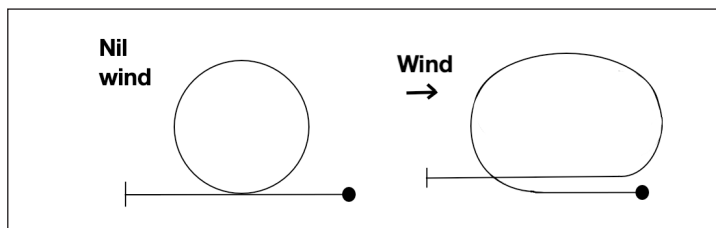
## Turns

To keep within the arena - The Box, in our case - requires making turns. The dancers and gymnasts have flourishes that achieve this, the Reno-racers bank-and-PULL, while competition aerobatic pilots generally carry out manoeuvres with funky names like stall-turns, rollers, Immelmans, half-Cubans, shark's-tooths, humpties and goldfish. Occasionally they will carry out a plain-Jane banked turn, albeit to strict criteria, or, even worse, a banking turn mixed with a continuous roll, called a rolling circle (a 'roller'). In previous articles I have described stall turns and rolling circles, so now let's consider these other oddly named manoeuvres.

## Part-Loops

These manoeuvres all require, at their initiation, a pull-up or push-down using the stick. Every time you pull back on the stick with wings level you are carrying out a part-loop. Some stop fractions of a second after you start, in which case you may have initiated a climb or arrested a descent. If you sustain it for longer your aircraft will prescribe a curving flightpath that may result in, for example, a vertical climb, a 180 degree direction change, or, ultimately, finishing you up in the same direction you started.

## The Perfectly Round Part-Loop



In competition aerobatics, the curving vertical flightpaths/partial loops must always have a constant radius, when viewed from the ground. This means as well as the pilot having to adjust the pitch inputs (using the elevator) for differing speeds throughout the looping segment, they must also take account of the effects of the wind component too. How hard can that be?!

With nil wind and practice it's not too hard. Understanding the interaction between speed, required g and stick position for your particular aircraft type will result in reasonably consistent results. Generally, most pilots new to aerobatics don't quite pull hard enough at the beginning and end of a complete loop, resulting in a tall, egg-shaped manoeuvre. Having established the correct entry g (at least 4g) the trick is to then hold the stick position constant whilst varying the stick pressure as the g changes throughout. Once that underlying technique is sorted you will have capacity to consider the effect of the wind - a loop into wind requires more 'pull' when the aircraft is flying the into-wind segments of the loop, and less 'pull' when flying the down-wind segments. See - told you it was easy!



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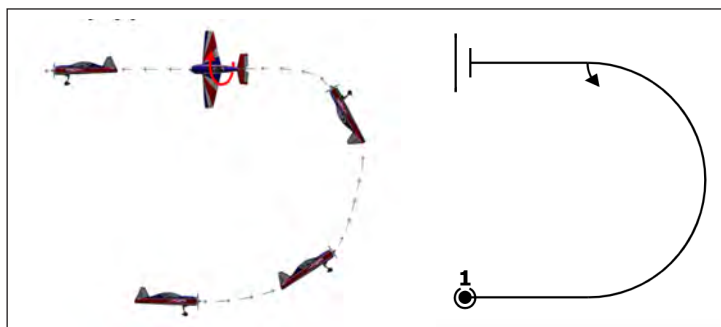
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## Immelmann Turn

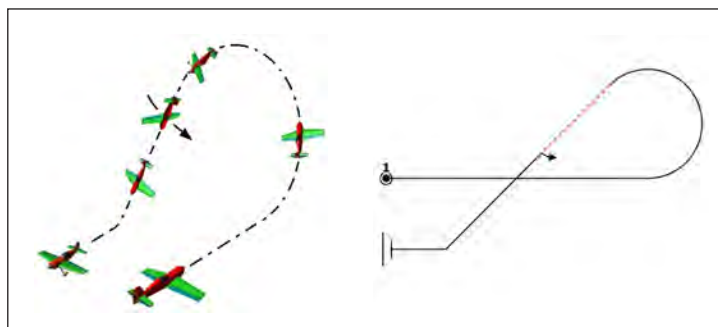


Also known as 'a roll off the top', this is probably the most basic and easy-to-visualise turn-around manoeuvre. If only it was that easy to fly!

A full loop has the aircraft pitching through 360 degrees and finishing in the same direction it started - it follows that a loop which is only half-completed will result in the aircraft flying in the opposite direction, albeit upside-down. In order to correct this uncomfortable turn of events, a half roll is skillfully inserted at the completion of the half-loop and thus the aircraft has returned to straight-and-level flight. You need at-least the normal looping entry speed for your aircraft to perform an Immelmann, but another 10-20 knots will make it easier and safer. Rookie mistakes? A poorly flown half-loop - not enough g at the start - will result in less speed at the top of the loop to fly the half-roll. Pulling back on the stick through the roll will pull the nose off-line, and possibly stall the wing. Pushing forward will have the same effect, but in a 'inverted' sense. Add to that poor rudder control whilst rolling and you have the recipe for a spin entry (but at least you should be up high). Not judging the correct time to commence the roll will result in either a climbing or descending flightpath out of the manoeuvre. All-in-all, plenty to go wrong and evidence that good dual instruction and plenty of practice at altitude is required for this seemingly simple manoeuvre.

In terms of keeping within The Box and changing EVERYTHING about the aircraft's velocity, the Immelmann is a winner - you have made a 180 degree direction change, plus climbed and slowed down dramatically, which would be great if your next manoeuvre was, for example, a spin. But what if you need plenty of speed for your next manoeuvre? The Half-Cuban Eight fits the bill nicely.

## The Half-Cuban Eight



Named for no other reason than it was first flown by an American barnstormer in front of the Cuban Airforce during the early 1930s, the Half-Cuban Eight is closely related to the Immelmann, and could even be seen to be a very poorly flown example of the Immelmann.

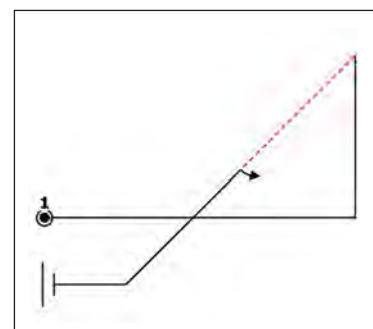
It contains two elements - a 5/8ths loop, and a half-roll on the 45 degree down-line that follows the looping segment.

Flying the Half-Cuban Eight commences from horizontal flight, at the appropriate looping speed (or higher) for your aircraft type. You pull back on the stick to perform the loop in your usual manner until such time as you perceive you are about to reach the 45 degree inverted attitude. You must now push the stick forward a tad to briefly maintain this attitude - cue momentarily 'hanging in your straps' and other engine/fuel/oil anomalies! A half-roll to upright - but still on the 45 degree down-line - is now commenced, and because the aircraft is pointing downhill and the airspeed is increasing this is relatively easy to complete. Just don't let the nose drop too much or use too much elevator and 'pull' the nose off line. Ideally, if you look over the spinner as you commence the roll, the spinner (and the plane following it) should neatly roll around a point on the ground.

Once the roll has been completed, a short pause is required, so that a 45 degree line of equal length to that at the completion of the 5/8th loop, but before the commencement of the roll, can be displayed for the judges. Typical errors seen by the judges are pinched/egg-shaped looping segments, incorrect 45 degree lines, 'pitching' rolls (that look like barrel rolls) and differing line-lengths before and/or after the roll.

## Shark's Tooth

They sound dangerous, but the family of Shark's Tooth manoeuvres are essentially a Half-Cuban Eight flown with a vertical line inserted within the looping segment. The arresti symbol shows this quite clearly, however it also shows what appear to be nigh-impossible sharp corners to fly.



Don't be fooled into thinking you have to pull your wings off to make your flight path match the symbol - the tightness of the corners is not the judging criteria for this manoeuvre as these are merely looping segments and must only be a constant radius, as mentioned above, and don't even have to be the same radius as each other within the manoeuvres. Apart from the usual errors made with constant radius looping segments, the 45 degree line and roll-centring, the most common error with this manoeuvre is pilots holding the vertical line for too long and running out of

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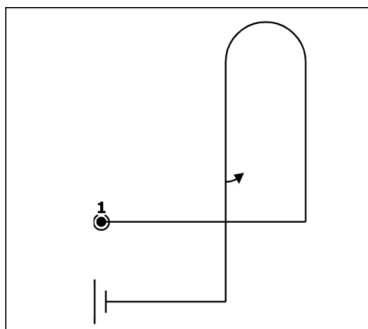
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energy/speed and thus elevator control to 'fly' the top looping segment - the top of the Sharks Tooth can look (and feel) like a fall or collapse back down to the 45 line.

### Humpty-Bump

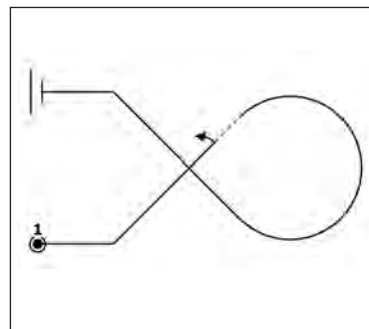
Don't ask me the origins of this name, however it is another manoeuvre that is not flown 'as-drawn' - you don't have to pull the wings off to make the corners square. A bit like how a poorly flown Immelmann becomes a Half-Cuban Eight, if you fly a loop really REALLY badly, i.e. with a vertical up and down line, you end up with a Humpty-Bump. To make it work in this conversation about turn-around manoeuvres, we must add to it a half-roll on the vertical down-line, which isn't particularly difficult with an increasing airspeed although it can use up a bit of altitude. Like the Sharks Tooth and Half-Cuban eight, you should finish this manoeuvre with plenty of speed.



### Goldfish

Closely related, the Goldfish (or Three-quarter Loop) is really just an extension of the Half-Cuban Eight, but instead leaves you high-and-slow, which may suit your energy needs for your next manoeuvre. In this example of the Goldfish, you must pitch up to the 45 degree line, complete the half-roll of that line, then hold the inverted line briefly (cough, splutter!) before 'pulling' through

the loop. A Half-Cuban flown in this manner works too, and is called a Reverse Half-Cuban. In both cases, this has the potential to go wrong if you don't pull up steeply enough before commencing the roll, or let the nose drop toward the horizon through/after the roll, or don't extend the inverted 45 degree line long enough, or don't pull hard enough approaching the bottom of the loop, or all of the above. Starting high and knowing your 'gates' is important - it would be wise to have an entry gate of 4000 ft and a 'pull over the top' gate of 4500 ft in the early days of practicing these potentially dangerous manoeuvres.



### Other variations

What has been described in this article are the basic foundations of each of these manoeuvres - there are many more variations which serve to reverse the entry and/or exit speed/ heights and thus the energy of the aircraft.

Getting to know the basic manoeuvres - their shape, what they should look like from the judge-line, what they will feel like from inside the cockpit, where to put your eyes/head at various times, and where they can go wrong - will give you with a large repertoire of potential turn-around manoeuvres to keep your show front-and-centre for your chosen audience.

Grant Benns



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