

## CLIFF EDGE EFFECTS

Back when I was a young lad learning aerobatics in my Airtourer with Aub Coote I was firmly of the view that spinning must feel just the way it would feel if I drove my car over the edge of the cliff at 13<sup>th</sup> Beach. Much later in life I found myself working at NASA Langley (Virginia, USA) in the Spin Research Facility. At that time NASA was just finalising their general aviation spin research program and I was able to learn a lot from them firsthand. The sort of things they'd done as part of that program included dynamic model spin tunnel tests, rotary balance tests, radio control model tests and flight tests of a variety of types as diverse as the Cessna 172, AA-1 and Vari-Eze. I was there on a RAAF program and, of course, most of NASA's work was on US military projects. Their GA spin program was part of a broader NASA effort in support of GA – they'd even put whole aircraft in the wind-tunnel!

As it was my first visit to the States and being around the time of the Hogan commercials and our America Cup victory I thought I'd ensure that my skills with a boomerang were up to scratch – I got to a fair standard, even got involved in the World Boomerang Throwing Championships but that's another story. There was one day when we were unable to operate the spin tunnel so I invited the technical staff down to the banks of the James River for a demonstration. Ollie thought it was stupid of me to actually throw it out over the water but I was confident and tried to re-assure him – I'd promised to leave that boomerang with NASA and he was worried that I'd lose it. I threw it and we all watched as it spun out to the middle of the river. Ollie turned around and grimly muttered again that I was stupid. Jack, Randy and I continued to quietly watch the flight path until my nerve broke. "Duck, Ollie", I shouted in time for him to move before the boomerang whizzed by and landed just behind me. I must admit that was my best throw ever.

On our project we'd made a lot of design changes so we really found out about cliff edge effects – a technical term used by the spin research fellows to describe a situation where you make a series of significant changes with no change to the spin characteristics and then you make one very small change which has a large effect on the spin characteristics ie technically, we'd gone over a cliff in the graphical presentation of the solution. Cliff edge effects are particularly common in spinning as there are large, opposing forces and moments so what we are seeing is the difference between two large values – a small change in one makes a very large difference in the outcome. And, of course in spinning as in normal flight there are secondary effects – the difference is that a cliff edge effect resulting from a secondary effect gives exactly the opposite effect you'd expect from consideration of the primary effect. Just to illustrate that – in a normal steep, steady spin the motion is primarily rolling with some yaw with the aerodynamic forces and moments balanced by the gyroscopic and inertia forces and moments. Applying aileron, even in a spin, produces a rolling moment and we can call that the primary effect of the control as in normal flight. It also produces a secondary effect through a yawing moment caused by aileron drag etc (I rarely use "etc" but this would get to be a very long story otherwise). If the spin motion changes primarily through changes in rolling moment then the outcome is predictable. It rarely so simple – the change may have resulted from a change in sideslip (in a spin there is always sideslip, its not a "balanced turn") with a consequential change in fin side-force in which case one of the secondary effects of aileron deflection dominates with the opposite effect. Once the characteristics of a

particular type is known the effects become predictable and explained by reverse engineering ie we know what happened therefore we deduce which effect was dominant. Its dangerous to extrapolate that result to a totally different aircraft type. The message again is – before spinning a new type have a thorough briefing and dual check beforehand.

That was all much more technical than in normally good for pilots. Any pilots still with me? If so, just read on as its all downhill from here.

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I'm quite willing to accept that there is a limit of lateral unbalance beyond which it is not possible to recover the Cessna 150 from a spin with the standard recovery technique. My big question is whether that was the case with this incident or whether he had two problems – one being a lateral unbalance and the other not identified because they stopped looking, having found what they thought was the problem. I should explain my reason for questioning the report. Even with long range tanks the amount of lateral imbalance is about 25 kg at a moment arm of about 1000 mm from the aircraft centre-line ie about 25000 kg mm. Now consider solo flight by myself – also a lateral imbalance of about 25000 kg mm! If we were talking about wingtip tanks then lateral imbalance would undoubtedly be significant but note that even the straight gyroscopic moment from wingtip tanks would be more important than a small imbalance. Some time ago, in Planetalk I described another incident where there were difficulties in recovering from a spin in a Cessna 150. Back then I suggested that a possible explanation was “finger trouble”, perhaps aileron applied inadvertently during the entry. This incident was different in that the instructor followed my own recommended procedure for a failed recovery before trying that aileron snatch – so there was obviously some problem. Its not fun when you encounter problems like that.

Flyer magazine asked an interesting question at the end of the article: “What is a safe height to enter a spin?” In this case a four turn spin so, using my rule of thumb – 3000 ft AGL plus 700 ft plus three times 300 ft – that's 4600 ft. In that incident they entered the spin at 5000 ft and recovered at 1000 ft! So, there's the question for each of us – how much margin should we give ourself?