SOARING Rx

BY DR. DANIEL L. JOHNSON

It *Felt* About Right!

On a perfect summer day, Mark pirouetted his glider all afternoon in thermals, sometimes near cloud base, sometimes lower. He liked to look downward along his inside wing, to watch it sweep backwards across the ground below. It felt as though he were riding a majestically spinning top. It was always a little surprising, later, to look at his GPS trace and see how very large the circles looked, that had felt so small.

Final glide back home left him a bit low entering the pattern. He didn't pay much attention to the instruments now; he paid attention to the field, and the pattern. Besides, he'd heard Tom Knauff talk about this situation. What was it he said? 'That Feels About Right?' Wait, maybe it was 'That Looks About Right.' Yeah, that's it, angles. 'How far can you spit?'

Let's see... The windsock is pointing away from me, so there's going to be a left crosswind on final... There might still be some thermal gusts – how will they change the direction and strength of the crosswind? He wasn't sure, looked again at the windsock. It all felt about right.

He turned base, announced the turn. Geez, that's quite a little tailwind! He quickly began turning final. Oops! Overshooting a bit! He felt fast, he felt low. The houses looked big. He had to cross a road and wires. Quick, jack it around! Slow down! Don't bank too much! Keeping the wings between him and his view of the ground felt comforting. Stall speed goes up in a steep bank, doesn't it?

He raised the nose to slow down, stepped on the inside rudder to swing the nose around. Suddenly, the ailerons disconnected! The stick wouldn't pull the nose up! What's happening here? Had he not safetied the control hookups? He felt stupid for skipping the positive control check. Abruptly, the nose dropped. He pulled hard on the stick, tried to level out, tried to keep the nose swinging around toward the runway.

The power lines suddenly came up from below. He hit them, took a violent bounce. Then a crack, then silence. His head hurt where it had banged on the canopy frame. He felt a trickle of wet running down one temple. The cockpit was tipped hard to one side; the nose was on the ground, the left wingtip crumpled on the ground, the right high in the wires. Bizarrely, he noticed that the traffic lights at the intersection to the left weren't working for some reason.

Mark eventually realized that he'd stalled and that he was lucky to be alive. He felt stupid and incompetent, embarrassed and ashamed. This shouldn't happen!

We've all heard that the stall-spin during the turn from base to final is a big cause of aircraft fatalities. Until that Uh-Oh moment, it had *felt* about right – and when it started to feel un-right, making it *feel* better had caused the crash.

Why?

One standard answer is that Mark is a Bad Pilot, having done Something Wrong, violated Proper Procedures. Unfortunately, this is a "what" answer, not a "why" answer. To understand 'why', we must understand two basic things: One is, of course, the hard physics: to *fly*, to be in the condition we call 'flight' the aircraft must remain within the boundaries of the 'flight envelope.' One important boundary is Vso, the stall speed. Below Vso, which varies with things like weight, bank angle, spoiler status, and density altitude, the airplane falls (more or less aerodynamically). We normally want to pass below Vso only while in controlled level flight about a foot off a smooth runway. Otherwise, the higher we are, the harder we bonk the ground, perhaps fatally.

The other answer is that Mark is a Human Being, and that his understanding of the status of the aircraft in the air depends completely on his *perception.* He has five senses and a few instruments, both of which are prone to error. Erroneous perception is called '*illusion*.'

The most important factor in spatial orientation is vision. This is supplemented – and sometimes betrayed – by input from the vestibular system ("inner ear": hearing, angular acceleration, linear acceleration). Many spatial illusions occur when vision and vestibulation conflict.

The turn from base to final is a situation, as others have pointed out, in which illusion operates steadily. In my experience, there are only two important instruments at this point: the first is the **airspeed indicator**. Our perception of speed at any altitude is absolutely unreliable. The only way to know whether we are above Vso is to repeatedly glance at the ASI. The only way. If you happen to need to make a turn, for example, at 100 ft AGL, the only way to do it safely is to be fast and the only way you can know *how* fast is to glance at the ASI. A glance is enough, because speed doesn't change abruptly, and our perception of *changed* speed is accurate even if our perception of *absolute* speed is wrong.

Second, and less important, is the **yaw string** or ball. I have a pretty vivid memory of once, mid-downwind, having a cu above me suddenly dump ballast. Surprise! I was now flying in a heavy rain shower. When it was time to turn base, I realized the yaw string was glued tight to the canopy by the water. I yearned to reach through the canopy and flick it off. At that moment, I first fully appreciated its importance to safe and precise flight. In addition, I abruptly realized, with embarrassment, that I had trained myself to ignore seat-of-the-pants gravity sensations in favor of the yaw string, and that this had been a mistake. Oh and there was heavy sink, and other glider traffic with the same dilemma heading onto the same runway – and I had to figure out how this was all going to work out. It's one thing to sit under the awning at the gliderport solving it in conversation with our buddies; it's another thing entirely to discover it, fresh and new, all by our lonesome, realizing that doing it wrong might hurt very bad.

It's my belief that the altimeter is not very important here, though we tend inadvertently to train pilots to depend on it by continually talking about altitude. Tom Knauff is absolutely right that it's the *angles* that are important in judging a safe approach, not the precise altitudes. (That I had Mark mixed up about this has nothing to do with Tom being correct.)

And we can actually see our glide slope, unless it's really shallow. As we glide in on final, nothing is more obvious than the point we'll strike if we do nothing. The fact that we *don't* hit that point is due to our good judgment in descending at about 1.3x Vso; we land beyond the point by spending that 0.3x of energy in ground effect, to decelerate enough for a soft touchdown.

Let's talk about illusions (again). Our perception of what's happening in the real world around us is *not* reality, nor is it very precise. It's a *cartoon* that is susceptible to predictable distortions. Accurate perception – and recognizing errors of perception – is important in judging the status of the aircraft in flight.

We refine our perceptions – make precise their cartoon of reality – by continually crosschecking the inputs. The most important one is vision's continually changing information; we supplement this with instruments like the ASI and yaw string that are sensitive to things outside our senses.

The illusions in the standard lists never appear in our lives as isolated, easily recognizable events. They are integrated seamlessly into our view of reality, and are the main cause of inaccuracy in our judgments about the status (speed, altitude, position) of our aircraft.

What standard illusions may contribute to awkward pilot judgment in the turn to final?

Shape and size constancy: Our memory of shape or size – the usual runway, usual buildings, typical cloud, and the usual hills – causes us to 'automagically' fit (the new runway, the new building, the unusual cloud, the novel location's hills) into the old shape, the old size. Something must "not fit" to jolt our perceptual mindset out of this rut.

Shape and size constancy, when combined with time, imply that illusions of speed constancy must occur, including illusions of rotational speed.

Accurate judgment is impossible when clear perception is masked. This is the sole reason that pilots become quickly disoriented (10-15 seconds) when deprived of visual cues in instrument meteorological conditions. In conditions that are officially VFR, visual cues can be severely degraded by smoke, haze, canopy dirt, glare from looking or being pointed toward the sun; or the wrong glasses, sun- or other. This degradation from various kinds of blur can create false sense for distance and angle, with false aerial perspective.

Autokinesis: When we fixate for more than 6-12 seconds on any point, it may seem to move, sometimes as rapidly as 20 degrees/second. This is most vivid when fixating on a dim small light at night, but may, of course, occur if fixated on anything, with degraded detail around it. This can be expected, when subtle, to remain unrecognized, and would create errors in stickhandling until the false perception is corrected, at least creating unexpected clumsiness.

False ambient cues. Other standard illusions that may cause perceptual error in the pattern include false planes or false horizon due to sloping terrain such as hillsides or mountaintops, or sloping clouds. Distant showers or haze can significantly lower the apparent horizon. The lean-on-the-sun illusion is the tendency, in haze, to bank the aircraft to make the sun higher on the canopy, more toward the zenith. (I guess we like to be level, perhaps a reason for not making a nice safe steep bank in the pattern.)

Vection illusion. This is a perception of false motion. Our car imperceptibly rolls backward downhill at a stoplight; we saw the adjacent car moving forward in our peripheral vision and think he's cheating on the green light. The "Star Wars" illusion is due to reflections of ground objects moving across the canopy, so named because this technique was used in those films to create a sense of motion. The point of this illusion is that when apparent motion of outside objects is ambiguous until verified with a "close look." This illusion is, I think, a main cause of incorrectly perceiving our speed, both at altitude (where outside objects fail to "move" because they're so far away) and when low (because we don't expect them to zoom past).

Oculogyral reflex. Eye fixation is guided by stimulation from the semicircular canals and the otolith apparatus. These acceleration detectors cause the eyes to 'lead' when our head tips or turns, reflexively helping to maintain visual fixation. This is good! However, curiously, our conscious perception also is 'led' by this reflex, so we see – subtly – false movement or false rotation until accurate visual fixation and spatial stability allow our brain to correct this. The effect is usually small and hard to measure experimentally, but surely contributes to a certain amount of pilot imprecision and awkwardness from time to time, especially when vision is degraded or (more likely) we're distracted by some event in the cockpit or on the panel. Crashes have occurred due the pilot turning and tipping his head while focusing full attention inside the cockpit during pattern turns.

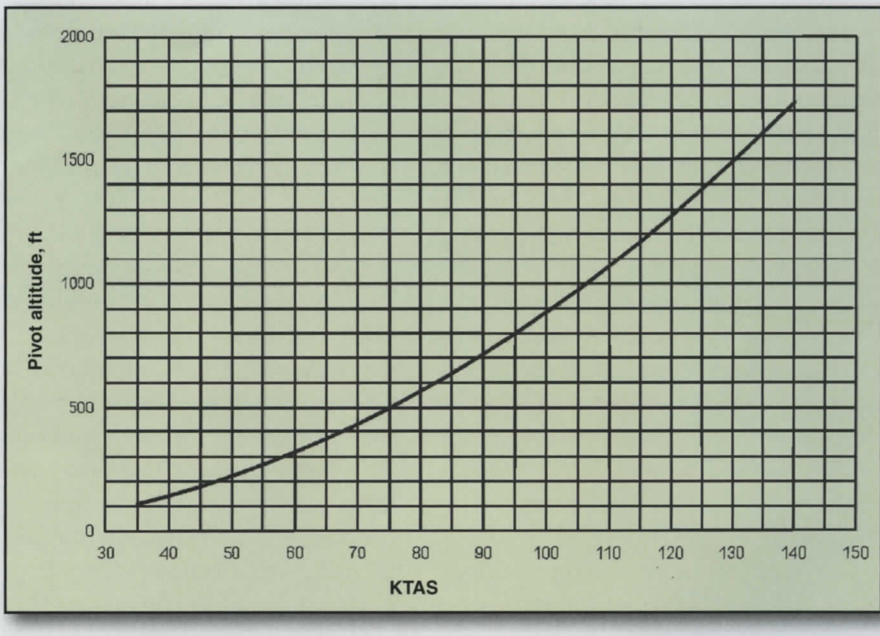
False sense of speed. I believe that an important contributor to turn-to-final stalls occurs when the turn is made below the pivot altitude (reversal height) of the aircraft. Above this altitude, the down wing moves backward against the ground in a turn, and the aircraft speed feels relatively slow. Below the pivot altitude, the wing moves *forward* against the ground (this is why it's called the reversal height) and the aircraft *feels* much faster – at the same airspeed! My experience is that it's essential to keep the ASI in one's scan when flying really low. In addition, I do feel that it's important to safety to deliberately train by sometimes flying a pattern deliberately low – with careful margins! – So that when we do this, it's familiar.

Reversal height is important!

I constructed a chart of speed versus pivot altitude. In studying this, don't use your aircraft's stall speed as your touchstone! – use at least 1.3 Vso. The left three columns show this relationship; the right three columns show how far you can glide, in feet, from the reversal height at three common glide ratios.

Title: **Reversal/Pivot Altitude vs. speed, Remaining Glide Distance**

Reference: Dr. John T. Lowry, *Pivotal altitude and reversal height* http://www.auf.asn.au/magazine/pivotal_altitude.html



Title: **Graph of Reversal/Pivot Altitude vs. Speed** (Dr. John T. Lowry)

TAS,mph	TAS,kt	Pivot att, ft.	Glide@10:1	@20:1	@30:1
35.0	30.4	**82**	819	1637	2456
40.0	34.8	**107**	1069	2138	3208
40.3	35.0	**108**	1084	2168	3252
46.0	40.0	**142**	1416	2832	4248
50.0	43.4	**167**	1671	3341	5012
51.8	45.0	**179**	1792	3584	5376
55.0	47.8	**202**	2021	4043	6064
57.5	50.0	**221**	2212	4425	6637
60.0	52.1	**241**	2406	4811	7217
63.3	55.0	**268**	2677	5354	8031
65.0	56.5	**282**	2823	5647	8470
69.0	60.0	**319**	3186	6372	9558
70.0	60.8	**327**	3274	6549	9823
74.8	65.0	**374**	3739	7478	11217
75.0	65.2	**376**	3759	7518	11277
80.0	69.5	**428**	4277	8554	12830
80.6	70.0	**434**	4336	8673	13009

Source: http://www.avweb.com/newspics/image18.gif in http://www.avweb.com/news/airman/182421-1.html

Conclusion:

Though the perceptual phenomena are complex, the resolution is simple: glances at airspeed, flying proper attitude, and eyes fixated outside the cockpit.

I hope you can see that Mark wasn't merely stupid or badly trained – more likely, he was simply functioning as a normal human being, who failed to successfully adapt to a series of false perceptions.

Happy and safe glidering