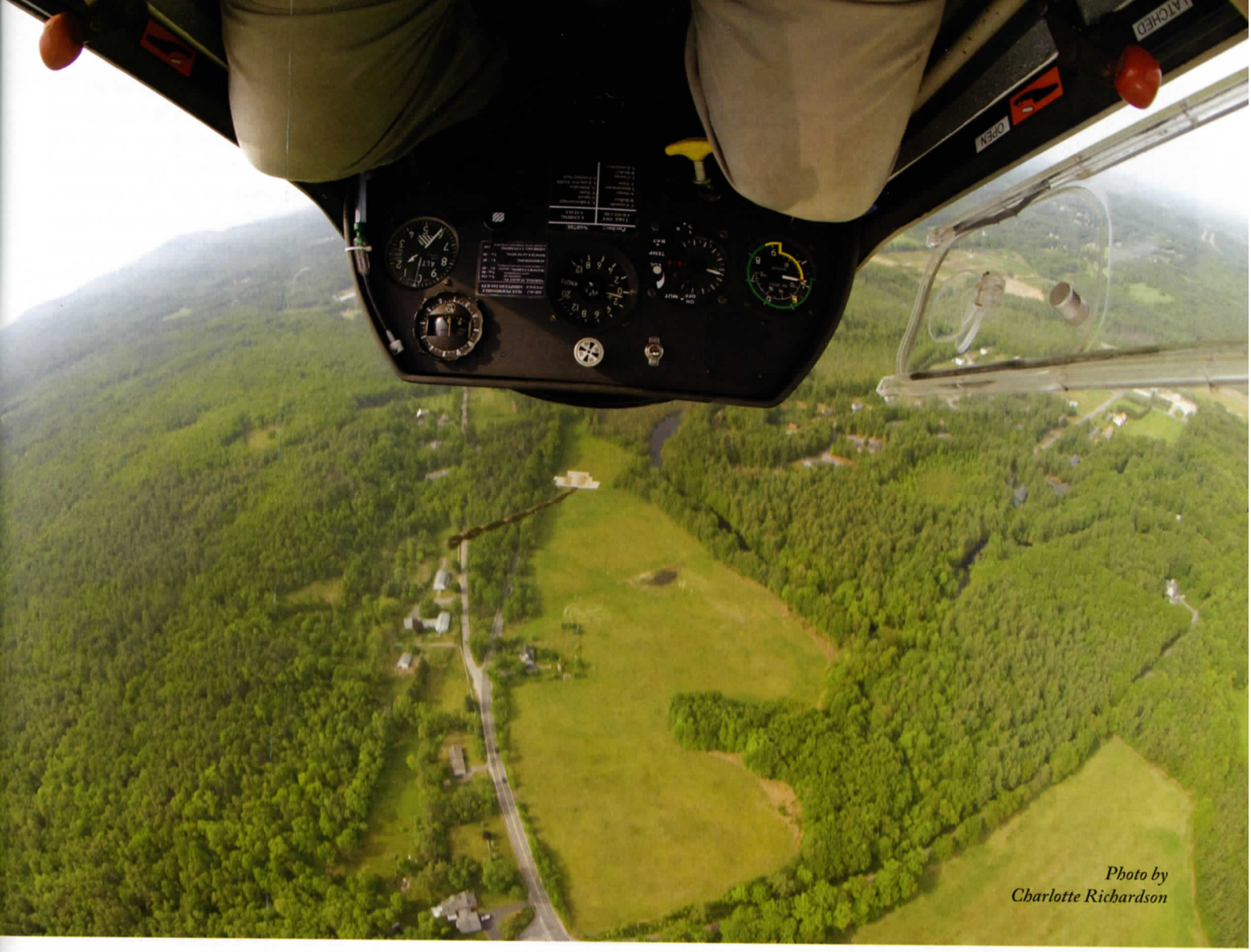

*Photo by Charlotte Richardson*

## SOARING Rx

BY DR. DANIEL L. JOHNSON

# Aerobatics – *Dangerous?*

*Clearly, at some point someone had to teach themselves aerobatics, but in those distant days - when aviation was bright and new - a high fatality rate was quite romantic. Not any longer.*

– British Gliding Association Instructor Manual, 2011

A recent, thought-provoking note from a CFIG asked (paraphrasing to keep the issue general), *"While overseas, I was very active in glider aerobatics. Now that I'm back in the U.S., I would like to teach aerobatics. However, my club rules specifically prohibit aerobatic maneuvers. There are several issues being cheerfully debated, including, Who should not do high-G maneuvers?"*

Right at the top, we must say that aerobatic flight, when performed properly, should be safe as well as exciting. At the same time, this monthly essay is dedicated to the principle that intelligent, educated, responsible, well-trained people sometimes are seen doing things that appear incredibly dumb. Some of which get us killed. So we should review this.

It's important to discern the difference between risk and danger. Normally, we use "risk" to describe a decision weighed in view of known hazards and importance or benefit. We tend to use "danger" to describe factors of risk that are out of our control or are somewhat unpredictable – or that are present. The waterfall nearby is a danger; risk is related to how close we walk, how slippery is the ground, how strong the wind, whether we cross the railing, and so on.

Risk may be managed; danger avoided.

My judgment is that the dangers of aerobatics are analogous. It is obviously possible to fly all types of aerobatic maneuvers safely. However, there are many risks, the greatest of which lie in ourselves: complacency, indiscipline, inadequate training, and lack of careful practice.

I reviewed many fatal aerobatics crashes, and thought about all the many components of risk. G-loads get most of the

press, but many other factors are more important. Just a month before this column was written, a local friend, an important cog in our airport's life, died giving an air-show performance. While G-forces may have been a contributing factor (he did a sharp pullout from a dive into a zoom), he had performed this many times, knew what to do, and lost control in less time than the 5-6 seconds of positive G that are cited as required for loss of consciousness.

In his accident, he unintentionally snap-rolled just as he began the zoom – watching the video, it seems obvious that he pulled hard, induced an accelerated stall, and lost control. As his mentor and show partner remarked later, "Then it doesn't take much to snap it." A small burble of thermal turbulence causing differential flow across the wings, a light push on a rudder pedal, etc.

A search of the NTSB accident database shows that every year brings several aerobatic accidents, mostly at air shows, with several fatalities. Yet most aerobatic training and performances are completed without incident, so success is expected, leading to an air of surprise in the comments of accident witnesses.

> … aerobatic flight, when performed properly, should be safe as well as exciting.

**What could go wrong?**

Let's keep this simple: There are only three candidates:

**1. Turbulence.**

The air is invisible. Air shows are mostly on sunny afternoons, when thermal activity is maximal. Aerobatic practice is least expensive, in gliders, when thermals permit cheap altitude recovery.

One day, a crop-duster pilot came into my office with a snapshot of a huge ball of bent metal tubing lying in a bean field. "What is that?" I asked.

"My helicopter," he said.

"What happened?"

"I flew into a dust devil." He was somewhat bruised, and lucky to be alive.

Some aerobatic maneuvers involve approaching a stall. Near a stall, small differences in relative airspeed between the two wings may spin or invert the aircraft. Sufficient windspeed differences are consistently present in any self-respecting thermal or wind-shear turbulence. I would guess that this is an important reason, when the air is bumpy, not to do aerobatic maneuvers near the deck that may involve a stall or accelerated stall.

It's impossible to know how much invisible atmospheric burbles have contributed to each year's list of aerobatic crashes, but I cannot believe it's zero.

**2. The aircraft.**

The Czech aircraft manufacturer, Let Kunovice, took the Blanik L-13 out of the air in June, 2010, after a metal-fatigue aerobatic accident. In March, 2013, a Schleicher Ka7 broke a wing, and the pilot and a young boy were killed (NTSB case CEN13FA213).

Years ago, in my state, a renowned and beloved aerobatic instructor and his student were killed doing a loop when the wooden spar of his old Citabria broke due to undiscovered dry rot.

A friend lost his airshow partner when on a season's first flight the elevator hinge, which had acquired new corrosion during the winter, became jammed in the up-elevator position on takeoff.

I'm sure that most of my readers can make their own lists of similar incidents.

**Aircraft qualification.**

It should be obvious, but apparently is not (given the Ka7 accident above), that aircraft not certified for aerobatic flight should not be flown aerobatically. (Me!? Read the manual!? Loops and rolls don't stress the airframe!)

**Aircraft Inspection.**

There are obviously three key tasks we face regarding the safety of the airframe.

A. The unknown:

- Detection of previous overstress to airframe. (Do we know whether placid, trustworthy fellow pilot Walter Mitty has been playing for thrills when alone in the sky?)
- Detection of airframe or controls deterioration. (Rust, fraying, dry rot, corrosion, etc.)

B. The known: Inspection for possible overstress requires a g-meter, I think, to be aware it's happened.

C. The design: What uses, and what stresses is the aircraft designed for?

*Has the aircraft had a properly annual?*

I am all too familiar with the cursory annual, followed by an either an incident or by a careful annual at which long-standing materials defects are discovered. (There is another type of bad annual, in which many false issues are discovered and remedied for the income generated, a standing policy at some FBOs I've known.) We all can tell stories about both bad flavors.

What is needed is an inspection by an AI who is familiar with the model and knows something about its design and about aircraft-materials engineering. It's worth the expense.

**3. The pilot.**

Pilots are not invisible, and we don't actually rust. Our failure modes are

much more complex. Tom Knauff"s letter in the March, 2014, issue of *Soaring*, **Developing Discipline**, eloquently described this central key to safety. We are safest when we meticulously fly within well-understood boundaries. Obsessive compulsiveness is a healthy feature of airmen who survive to old age. It's a disorder only when it *hinders* function!

I've twice worked with a little glider club. One consistency has been that every time an operational detail was skipped, there was a related risk of an incident. Pertinent to this, every incident I can recall has entailed missing one or more points. Whether we call the necessary meticulous attention to detail discipline or perfectionism or caution, each flight can be thought of as a (sometimes rapid-fire) sequence of items, requiring either attention or action, none of which can be ignored without risk.

**What are the features of safety in glider aerobatics?**

**Our organizations.**

Our clubs and associations do take responsibility for enhancing safety. Organizations can only function through rules and procedures. These define expectations. The easy way to limit auto accidents is to take away the keys. We do this, in clubs, regarding aerobatics, because the occasional foolish pilot does exist, and because higher-risk flight modes require careful preparation of aircraft and pilots that are often beyond club resources.

Insurance companies have long experience with rogue pilots performing aerobatics, often causing big payouts. They are in business to compensate for loss, but they will not stay in business unless losses are limited to a number comfortably less than premiums minus operating expenses. The policy your club has signed may have taken away the keys. Read your policy before you start an aerobatic program.

**Training**

We are not going to give tips today on proper aerobatic training. For one thing, this is outside our arena of competence (though that doesn't always keep us quiet). The salient point here is that proper training is the most important feature of safety, and training requires proper, diligent, frequent practice. We're not "done" at signoff, we've begun.

**Rules**

Most rules in aviation, as in medicine, are written in blood. This is worth remembering when we chafe at a rule that seems ill-considered. It's important to ask ourselves, "Why might this rule have been created?" Yes, there are dumb rules (not well thought out), but rules are written to reduce risk.

The intent of most rules is pretty obvious. Understanding the intent of the rule allows us to go beyond the rule in reducing risk by following the principles when they conflict with the precept. The clear rules of aerobatic flight are not to be stretched: approved airspace, hard deck, aerobatic-certified glider, parachutes, proper preparation.

With aerobatic flight, we have many regulatory and legal requirements regarding all aspects of flight (e.g., hard deck, passengers, etc.) that are created by every level of authority (club, airfield, government).

For example, if you want to do aerobatics near an airfield, you must file a formal request of the FAA to have a practice box. This is an excellent idea – we created one at our local airfield – because a good runway is close by if a quick landing is needed. However, it does inconvenience other traffic. For example, no instrument approaches or departures will be permitted by ATC during the hours that the practice box is open.

But it's safer for many reasons, not the least of which is that the aerobatics is done in a well-advertised, clearly-communicated area, which seems safer than doing it over a pasture in a random direction a few miles away.

**Flight preparation and planning**

Weight and balance, and equipment requirements, weather, traffic, etc., are obvious factors which, on reading accident reports, are sometimes left aside. This is complacency and indiscipline. These are bases that have to be touched, if only to reflect on what may have changed since last we reviewed them thoroughly.

Aircraft preparation. What is on the

floor and under the seats that will fly into your eyes and mouth when you go negative. Should the cockpit be vacuumed?

**Physiological factors**

Two things are uniquely important to aerobatic flight, both related to the fact that no activity is safe unless our brain functions well.

The first of these is ***spatial orientation***.

Awareness of our position and velocity in 3-dimensional space is crucial. Part of training involves learning techniques to do this during unusual attitudes. Maintaining spatial orientation is physiologically complex. Not everyone has the same ability to do this. Our orientation systems have limits and failure modes that are well understood, and are described in books of aviation physiology. Read up (see references, below).

The most interesting perceptual phenomenon of aerobatic flight is one called "the wobblies." After a flight involving many changes in orientation and g-load, the pilot may have trouble walking. A torrent of perceptual data and the need to analyze it rapidly has somehow created a state in which the pilot's system can no longer function.

If you want to study this, search for "G-induced vestibular dysfunction," cited at the foot. It is common and not much discussed. The instability involved may last for weeks (during which the pilot should stand down), though usually for a few hours. It is commonest after pulling more than -4Gs (not much done in gliders, eh?) or when pulling +Gs after a negative-G maneuver. It usually includes vertigo (a nauseating sense of rotation).

The wobblies are more common if anything is wrong with the middle ear or the spatial-orientation system: allergy, colds, medications, aging changes, spinal disease, etc.

The second important physical factor is ***G-tolerance.***

As you know, all perception, planning, and action occur in the brain, which does not function without a steady inflow of glucose and oxygen. This depends on a pump and resilient, complex plumbing.

A pump requires some inflow pressure, good valves, and a strong motor to push blood flow against resistance.

We have a G-tolerance detector, *vision.* The retina – part of the brain, actually – is highly active metabolically, so any loss of glucose/oxygen/pressure instantly reduces vision. Tunnel vision and grey-out are signs that we're on the edge of the G cliff.

**Limits of G tolerance.**

There's a lot of variation, between individuals and between situations, in what G forces can be managed. Brief exposures to what are essentially hard knocks ( +12, -10 G) can be managed with training. Untrained individuals in adverse situations may be incapacitated by +2 or -1 G (yes, this *could* be you, on the wrong day).

Read *Human Response to Acceleration* (cited at foot) if you want to learn the fine points.

First, the standard work on G tolerance was done with young, healthy, fit males, during WWII, in a centrifuge. This creates a useful guide, but doesn't apply precisely outside those conditions.

Awareness of our position and velocity in 3-dimensional space is crucial.

An important factor is **the push-pull effect.**

Negative G causes the heart to slow, veins and arteries to dilate, and diminishes the strength of the heart muscle's contraction. This decreases the heart's capacity to pump high volumes of blood to the brain.

This has some momentum of its own, and does not revert just because you decide to roll from an outside loop to inside. Recovery can take at least 8-10 seconds, depending on magnitude and duration of negative G. This causes very low blood pressure when transitioning from negative to positive G, greatly reducing tolerance.

The brain can function for 4-6 seconds without good blood flow. Pilots can typically endure -2 to -3 G, and +3 to +4 G, but when the pilot goes back and forth between only -1.0 G and +2.25 G, the blood pressure may fall to zero when G changes from negative to positive. This affects perception and performance at best, and loss of consciousness at worst.

***Medication versus G-force***

Many pilots take medication of various types. Some of these are prescribed to reduce blood pressure, a scourge of western society. Others affect blood pressure as a side effect. For example, the drugs prescribed to men to improve flow or to increase the turgidity of the faucet are actually blood-pressure medications.

Diuretics not only reduce blood pressure, but also reduce blood volume, as does dehydration, whether from sweating, diarrhea, vomiting, or simply failure to drink adequately.

A useful way to use the Internet to explore your own medications is to search for "postural hypotension" preceded (one at a time) by the name of each medication. You'll get a lot of hits, but if your medication isn't named in the first page displayed, don't bother reading further.

If any medication *is* sometimes a cause of postural hypotension, your G-tolerance will be reduced. I personally would not do anything more strenuous than a wingover or a stall if on diuretics or medications affecting blood pressure.

***Disease and Deterioration***

Most pilots are beyond our youthful bloom. Years ago, when I first started presenting on the effects of aging in pilots, many studies were sponsored by the military, where over 40 is rather elderly. In our 40s, the slight loss of physical capacity is overshadowed by experience. However, over 70 is very definitely elderly (physiologically), and in case you haven't noticed personally, the resilient parts have become stiff and the elastic parts floppy. This reduces G tolerance.

A normal health condition for some pilots is pregnancy. The most important changes in blood volume and blood pressure occur during the third trimester. I think that good rules of thumb are that if you don't look pregnant and are comfortable, the pregnancy isn't yet a risk; if you are starting to feel big, it is a risk for reduced G tolerance. Ultimately, the uterus takes 20% of blood flow and will pop fatally if whacked, such as by big G forces.

The commonest diseases of the elderly in the West are cardiovascular disease and diabetes. Both the diseases and their treatment cause cardiovascular and blood-volume changes that decrease G tolerance in several ways.

Heart disease affects the strength and competence of the pump itself. Atherosclerosis decreases the resilience of arteries and may cause significant unsuspected strictures, including the arteries to and within the brain.

The brain itself shrinks with age, making it more liable to flop around within the skull, creating risk for brain injury and concussion from jerks and whaps.

### *The Wrong Stuff*

Even when we are healthy, not all of us have the physical gifts that permit safe aerobatic flight. Some of us are better off to realize that we have the wrong stuff for it, and are better spectators than participants at the sport. This is a hard self-assessment, yet an important one. We are all different from one another.

### Responsibility and Judgment

Not everyone has the same ability to exercise judgment. This ability is not inborn, but is learned through our upbringing and formative experiences. We do not show better judgment when playing in airplanes than in our social or work life.

A person's attitude toward rules, and whether their rule-breaking is considered or impulsive, is important in judging whether we can trust them to be prudent when out of sight.

A person who habitually takes others' concerns seriously is generally someone we can trust to respect equipment and procedures.

A person who comes to the field prepared and doesn't skip over details is also someone who can be trusted to take care of training details and practice for aerobatics.

A person who seems cranky and fussy, though often annoying, is characteristically someone who can be trusted with details, if not with club diplomacy. Contrariwise, the gregarious and convivial club member, full of enthusiasm and optimism, is not typically the sort of detail-driven person who does well in charge of an operation.

### Summary

We've taken a broad view of the risks that may be associated with aerobatics, which go far beyond G-tolerance, and the human-factors risks are more behavioral than physiologic, something that is normally less thought about. Obviously, most such risks are not at all unique to aerobatic flight, and need to be part of our checklist in creating such an operation.

My point is not to discourage you from learning and performing aerobatics – unless you think that the checklist this column represents is unimportant. Every detail counts.

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In memory of Bill Cowden, a dynamic, talented, and skilled man.