C4/1-13 The Gateway
Broadmeadows
Victoria Australia 3047
Phone: (03) 9359 1613
Fax: (03) 9359 9865

The Gliding Federation of Australia Inc.

Operations Advice Notice

No. 01/19

Is incipient spin training permitted in your aircraft?

Glider pilots must learn to recover from incipient and full spins and demonstrate recovery from these manoeuvres during flight reviews. A recent accident in the General Aviation environment suggests that in some cases, spin training is being performed in aircraft that are not approved for intentional spins. Depending on the aircraft type, the manufacturer may not have specified whether that restriction applies to an incipient spin or only a developed spin.

What happened

On 26 September 2017, an instructor and student conducted a training flight in a Diamond Aircraft Industries DA40 aircraft from Archerfield Airport, Queensland. The purpose of the flight was a simulated Recreational Pilot Licence flight test to prepare the student for an upcoming flight test. The aircraft entered a developed spin during manoeuvres consistent with advanced stall recovery training, which likely included incipient spins. The spin continued until the aircraft collided with terrain. The instructor and student were fatally injured, and the aircraft was destroyed. Read more about this ATSB investigation at this link: AO-2017-096.

Factors uncovered during the investigation

The ATSB identified concerns relating to the conduct of incipient spin training in aircraft types not approved for intentional spinning. The DA40 aircraft type is certified to recover from a one-turn spin or a three-second spin (whichever takes longer), and is not proven or certified to be recoverable from a longer spin. The aircraft's manuals state that intentional spins are prohibited. During the ATSB investigation, the aircraft manufacturer clarified that this limitation prohibits any action that is intended to induce a spin, even if the aircraft is immediately recovered. Aircraft types with similar limitations are currently in use throughout the world for flying training.

In Australia, the Gliding Federation of Australia requires the demonstration of recovery from both full and incipient spins during training and flight reviews. However, there is no clear and consistent definition of the point at which a manoeuvre becomes a spin (or incipient spin) for the purposes of flying training.

Crucially, the ATSB found that there can be varying interpretations of an 'incipient spin', and this has led to aircraft not approved for intentional spins being used for incipient spin training and assessment.

Glider certification

Most sailplanes on the Australian Register are built to the standards relevant to the time of certification. The former British Civil Airworthiness Requirements (BCAR) Section E was replaced by the Joint Airworthiness Requirements (JAR) 22 in 1980 and is now Certification Specification (CS) 22. The GFA also has amateur-built experimental gliders that are not certified.

Gliders certified to the EASA standard CS-22 must be able to be recovered from a spin in less than 1.5 additional turns regardless of configuration. If the aircraft is in a configuration approved for intentional spins, it must recover in one additional turn or less. Thus, all gliders designed to CS-22 must be recoverable.

However, not all CS-22 aircraft are certified for deliberate spins and, as stated earlier, not all gliders are certificated to CS-22. Furthermore, some certified aircraft may not be approved for spinning in certain configurations (e.g. with water ballast, at certain flap settings or cockpit loads, etc.).

There is also an increasing market for small, simple to operate gliders designated ‘Light Sport Aircraft’ that meet certain performance and weight requirements, without direct certification oversight by the countries respective National Aviation Authorities (NAA). The NAA does not review, test or approve the design, nor does it provide continued operational safety oversight of the design. The design holder is responsible for the review, testing and approval of the design under industry consensus standards (e.g. the American Society for Testing and Materials (ASTM) LSA), and is responsible for the continued operational safety oversight of their design under the standards. These standards are applicable to ‘simple to operate’ aircraft intended for ‘non-aerobatic’ and for ‘VFR day’ operations only.

Safety Advice

The primary reference for spin approval to certified standards, or spin limitations, is the approved Aircraft Flight Manual or Pilot Operating Handbook (and applicable supplements). Operating an aircraft within the stated limitations is essential to the safe conduct of a flight.

Training organisations are required to conduct both full and incipient spin recovery training that includes intentionally inducing a spin, and recovering before and after it fully develops. ***Organisations must not conduct this training in aircraft not approved for intentional spinning***. If the operator does not have a suitable type of aircraft for a particular kind of training, then GFA would expect the operator to make appropriate arrangements to acquire or loan a suitable aircraft.

Christopher Thorpe
Executive Manager, Operations
For the GFA Operations Panel

26 July 2019

What is a spin?

When an aircraft spins, a stall occurs together with yaw, and self-perpetuating rotating forces develop. These forces keep the aircraft in the spin until positive and correct control inputs from the pilot stop them.

In a fully developed spin, the aircraft follows a spiral flight path about an axis going straight down, pitching up as well as rolling and yawing towards the spin axis. Descent rates during a stable spin in gliders are typically between 300 to 800 feet per rotation (a rotation could take as little as 2½ seconds), depending on type.

All aircraft will spin, but not all aircraft can be recovered from a spin. Your aircraft's particular spin characteristics are listed in the Aircraft Flight Manual or Pilot Operating Handbook.

The aircraft may be approved for spins, but only under certain weight and balance, and centre of gravity restrictions.

Anatomy of a Spin

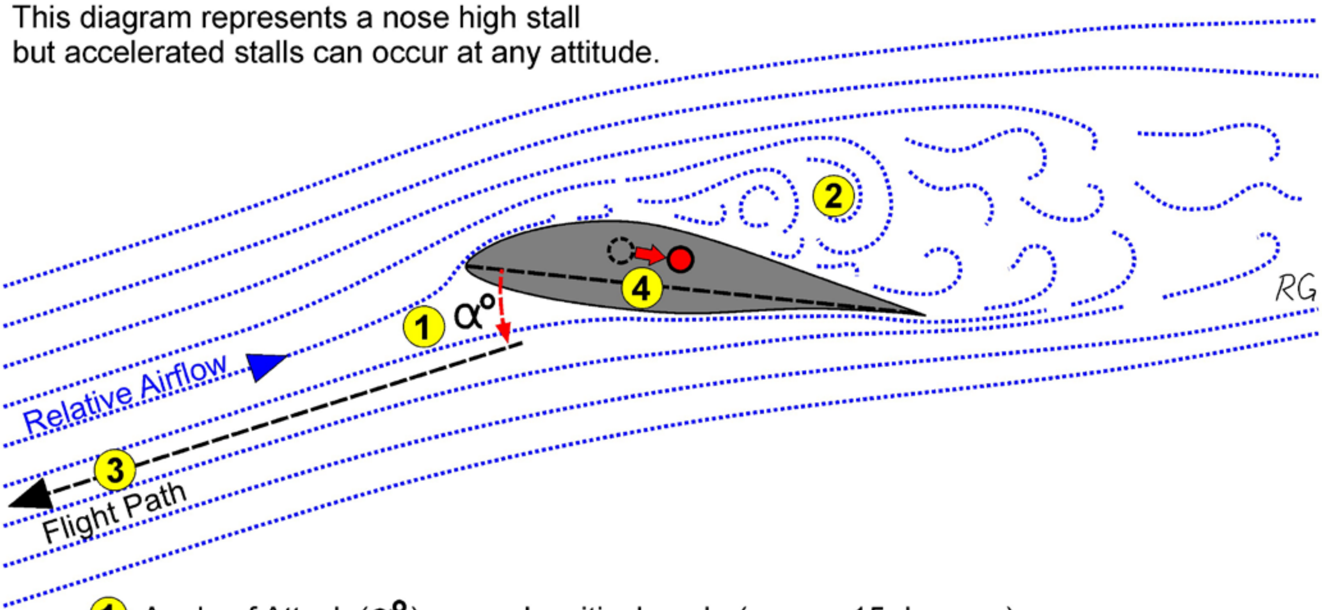
A spin will not exist without both stall and yaw.

Stall

The stall angle of attack is the critical angle which, when exceeded, will cause the normally streamlined flow of air that follows the curvature of the upper wing surface to separate from the wing and leave as turbulent air flow. At the stall angle of attack, lift reduces rapidly.

Airflow during a stall

This diagram represents a nose high stall
but accelerated stalls can occur at any attitude.



1. Angle of Attack (α°) exceeds critical angle (approx 15 degrees).
2. Turbulent airflow separation causes decreased Lift, increased Drag & airframe buffet.
3. Steep Flight Path = high descent rate (decreased Lift & increased Drag).
4. Rearward movement of Aerodynamic Centre causes uncommanded nose drop.

Pilots use a quoted indicated airspeed (for straight and level flight at a given weight and configuration) to correspond to this stall angle for each aircraft. But in reality, this speed varies depending on the weight the wing has to support. Airspeed is therefore only an indirect measure of an approaching stall.

The quoted stall speed really reflects the 1G straight-and-level speed at a nominal aircraft weight. Increase aircraft weight, and the stall speed will increase. Enter a turn, and the stall speed will increase. Open the airbrakes, and the stall speed will increase. Also, turbulence can cause a glider to stall at a significantly higher airspeed than in stable conditions.

A 60-degree banked steep turn at a constant altitude produces a 2G loading in all aircraft from gliders to jets. The stall speed will increase with the square root of that loading – e.g.$\sqrt{2}$ is 1.4 and thus a basic stall speed of 40 knots becomes a little more than 56 knots (40 x 1.4) in a 60 degree (2G) steep turn.

When evaluating how close an aircraft is to the stall, pilots should think angle of attack rather than airspeed. The elevator position (how far back the stick or control column is held), is actually a better indication of how close to the stall the aircraft is.

In a balanced, wings-level stall with the ball in the middle, both wings will remain at the same angle of attack. At the stall, aerodynamic forces may try to pitch the nose forward, but there should be no overall rolling or yawing.

Yaw

If the aircraft is yawed, a roll will develop in the direction of yaw because the outer wing has increased speed, which has increased its lift. The descending (inner) wing gains an increased angle of attack. If this wing is at or near the stall angle, its lift reduces. When one wing goes down, the other will rise, and exactly the opposite happens to the rising wing. The relative airflow now produces a reduction in angle of attack on the up-going wing, which may be below the stall angle (in effect it has become less stalled). The effect of these differences in lift will be to produce an accelerating roll rate in the direction of the initial yaw.

These changing angles of attack also affect drag. The down-going wing with an increased angle of attack suffers increasing drag. The up-going wing gets a drag reduction. The difference causes even more yaw towards the down-going wing.

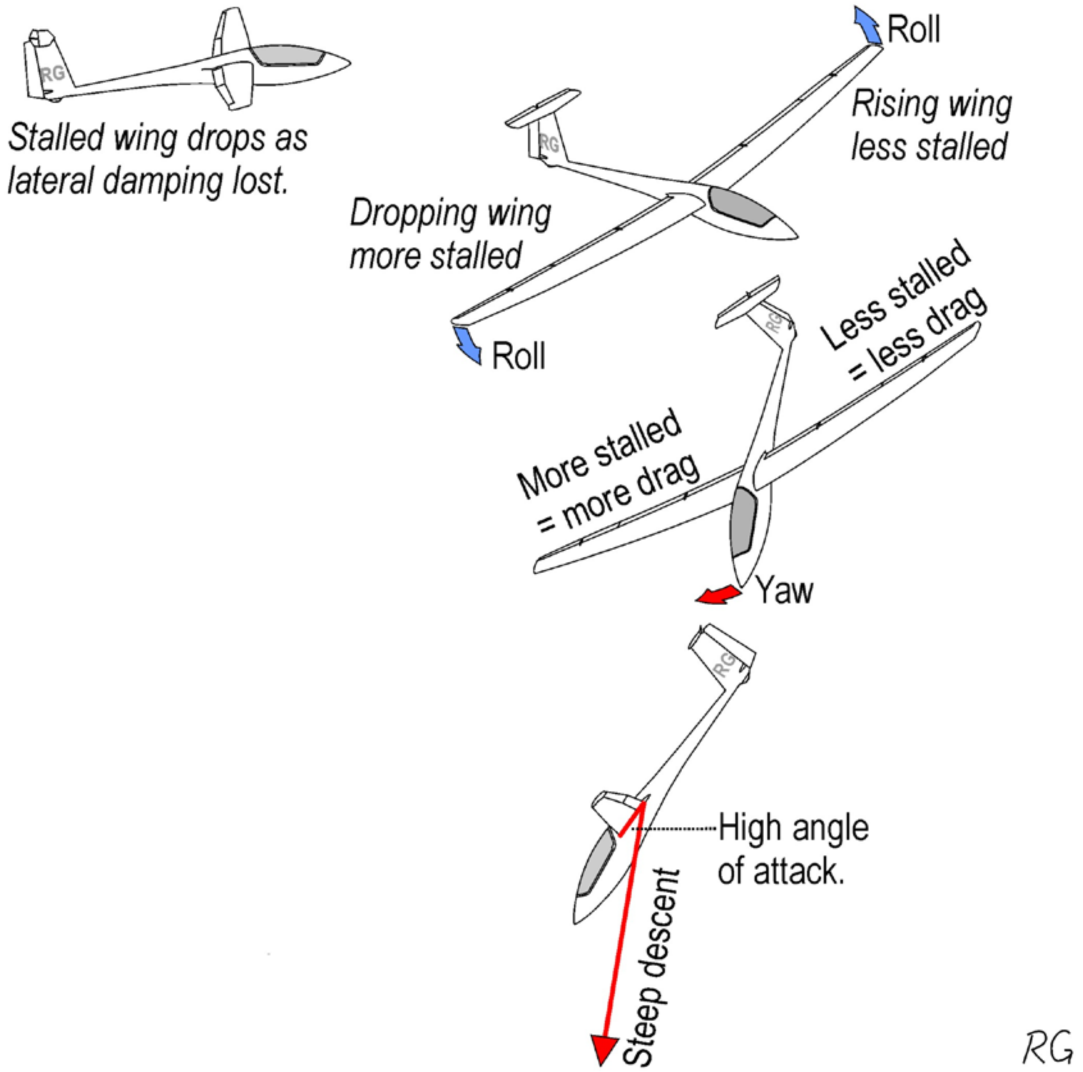
Autorotation

The yawed and stalled aircraft then starts to rotate. However, it not only rolls about the longitudinal axis due to the differences in lift from each wing, but also simultaneously rotates (yaws) about the vertical axis due to the differences in drag. The combination of these two movements gives us a new axis, the spin axis. The aircraft will continue in a self-perpetuating spin, or autorotation, about this axis until opposing forces come into play.

Causes of Yaw

- Out of balance flight caused by inducing (or not preventing) yaw with rudder.
- Wing drop at the stall, due to rigging or dimensional differences between wings.
- Application of aileron will cause aileron drag. On some aircraft when stalled, this will produce yaw.
- Gusts.

By far the most common cause of entry to an unintentional spin is the first of these – yaw at the stall caused by out-of-balance flight.



Spin Characteristics

The development and characteristics of a spin vary between glider types, but a glider will usually rotate a few times before it settles down into a state of spinning steadily. The spin stabilises once a complicated balance is reached between the various aerodynamic and inertial forces acting on the aircraft.

The pitch angle it finally adopts may be steep (60 degrees or more with the nose low) or flat (nose on the horizon).

The aircraft will lose altitude rapidly and descend along a vertical path about the spin axis. The rates of roll and yaw, and the pitch attitude, can all oscillate.

Not only do the spin characteristics vary depending on glider type, but even a given type of glider can have markedly changed spin characteristics depending on its weight, its centre of gravity, and how the controls (including engine power) are handled during the spin.

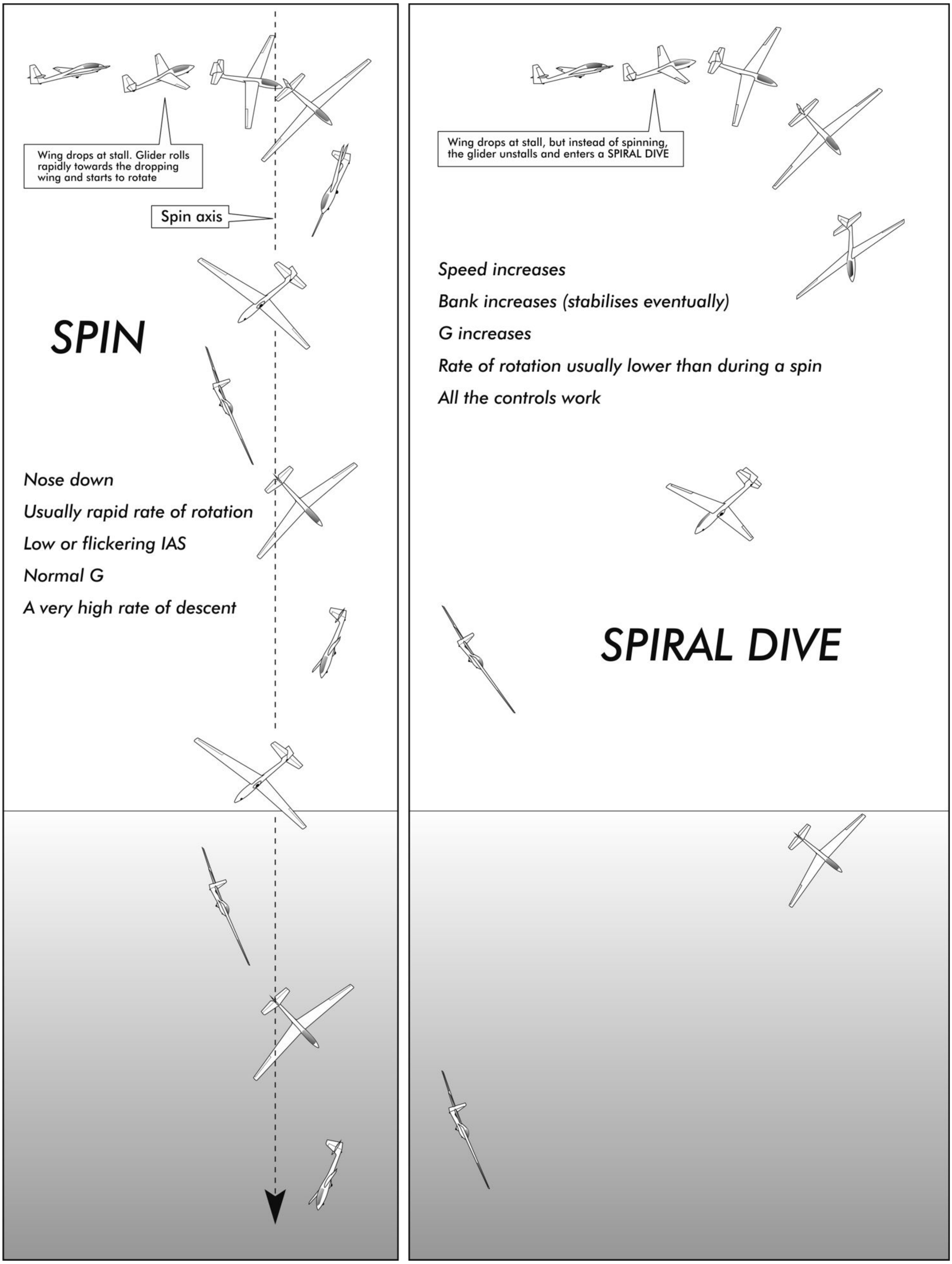


Image courtesy of the BGA

Spiral Dive

The spiral dive can be confused with the spin. Spirals are steep, descending turns that become progressively tighter over time. They occur at lower angles of attack (the wing is not stalled) and display the same over-banking tendency common to all steep turns. They are characterised by high or increasing airspeeds and G forces.

The fundamental problem of the spiral dive is too much bank. Spiral dives become tighter if nose-up elevator inputs alone are applied. Attempting to arrest the rate of descent with more ‘up’ elevator without other remedial inputs will aggravate the spiral dive.

To recover, close the throttle (if under power), use the ailerons to reduce the bank angle, and ease the aircraft out of the ensuing dive. The aircraft is likely to be at a high speed and will be very easily overstressed, so ease out of the dive using gentle back pressure and do not open the airbrakes.

Three Stages of Spin

Incipient Stage

This is the transitional stage, during which the aircraft progresses from a fully developed stall into autorotation. This progression may be very rapid and is sometimes described as a flick. It may last only one turn, during which time the rotation tends to accelerate towards the rate found in the developed stage. The final balancing of aerodynamic and inertial forces has yet to occur.

The incipient stage is generally driven by pilot inputs. As a very general rule, if pro-spin control inputs are removed in the incipient stage (the stick or control column is moved forward to unstall the wings, or the out-of-balance yaw is removed), then the aircraft will not continue to enter a stable spin.

Incipient spins that are not allowed to develop into a steady-state spin are the most commonly used manoeuvre in initial spin training and recovery techniques.

Developed Stage

In the developed stage, a state of equilibrium is reached, characterised by a low and constant airspeed. Rates of descent in unballasted gliders can be as high as 800 feet per rotation.

At this stage the spin will be self-perpetuating. If the pilot does nothing about it, the spin is likely to continue until the aircraft hits the ground. Positive anti-spin control inputs will be required to recover from the fully developed spin. Some gliders may not enter into the developed phase but could transition unexpectedly from the incipient phase into a spiral dive.

Recovery Stage

Spinning ceases only if and when opposing forces and moments overcome auto-rotation. Since yaw coupled with roll powers the spin, the pilot must forcibly uncouple them by applying full opposite rudder. This is followed by forward movement on the stick or control column.

During the recovery phase, the nose attitude typically steepens and the rate of rotation may momentarily accelerate as well, giving the impression that the spin is actually getting worse. It is not, and the anti-spin control inputs must be maintained until the spin stops.

Spin recovery is not instantaneous. It may take up to several turns for the anti-spin control inputs to finally overcome pro-spin forces. The longer an aircraft is in a spin, the more turns it may take to recover. Spins are recoverable only when the cumulative effects of the interacting variables favour recovery and there is enough altitude.

Human Factors

Disorientation

Pilots understand which way is up via three sensory mechanisms – proprioceptive (seat of the pants), visual (eyes) and vestibular (inner ears).

Proprioceptive inputs provide information about joint position and muscle tension, but generally play only a small part in the total picture. Visual sensation is the most reliable, whereas vestibular inputs are very powerful but frequently misrepresent the rotational motion of flight. Therefore the eyes, through the interpretation of instruments and outside references are important to orientation. Disorientation occurs when there is a conflict between the visual and vestibular sensations – your eyes tell you one thing, but your inner ear says something else.

Within the ear, three semicircular canals are structured perpendicular to each other, so that a canal lies in each of the three planes of the human body. Information from these semicircular canals affects visual tracking.

During the initial stages of a spin, the eye is able to remain oriented. However, in a spin that continues beyond about two turns, disorientation often occurs and it will be very difficult for the pilot to make the correct recovery inputs, unless properly trained and experienced in spinning.

After about five turns, the eye becomes out of synch with the aircraft's rotation. Vision will blur and the speed of rotation appears to increase. Now the pilot has difficulty in determining the number of turns in the spin, its direction, and the effectiveness of any actions taken to exit the spin.

Upon stopping a spin, the fluid within the semicircular canals continues to move in the same direction as the spin rotation.

The brain must contend with a conflict between this indication of turning one way and a visual indication of turning in the opposite direction, when there may be no actual rotation at all.

Startle / Surprise Response

Startle is an uncontrollable, automatic muscle reflex, raised heart rate, blood pressure, etc., elicited by exposure to a sudden, intense event that violates a pilot's expectations.

Surprise is an unexpected event that violates a pilot's expectations and can affect the mental processes used to respond to the event.

This human response to unexpected events has traditionally been underestimated or even ignored during flight training. The reality is that untrained pilots often experience a state of surprise or a startle response to an aircraft upset event. Startle may or may not lead to surprise.

Pilots can protect themselves against a debilitating surprise reaction or startle response through scenario-based training, and in such training, instructors can incorporate realistic distractions to help provoke startle or surprise.

Pilots need to understand that primary training cannot cover all possible contingencies that an aircraft or pilot may encounter, and therefore they should seek recurrent/additional training for their normal areas of operation, as well as to seek appropriate training that develops the aeronautical skill set beyond the requirements for initial certification.

The GFA Flight Review provides this recurrent training.

Avoiding Spins

Prevention is better than cure, and maintaining a safe speed when near the ground (i.e. below circuit height) provides a vital safety margin. The following situations can cause a spin.

Skidding Turn onto Final

Consider a late turn onto final approach, overturning the centre line, particularly on a glide or forced-landing approach, or in a crosswind. If any attempt is made to correct the situation by increasing rudder in the direction of the turn without increasing bank, this coupled with a reducing or low airspeed will result in a skidding turn, and will provide all the ingredients needed to start a spin. The low altitude will preclude the chance of recovery.

Low-speed Climbing Turns (powered sailplanes)

The aircraft is already vulnerable by being at low speed and in a nose-up attitude and therefore close to the stall. Low-energy, low-powered aircraft in this situation will suffer some performance loss during a turn. If this is not compensated for by lowering the nose, the speed will further diminish. Turning – or even the application of aileron – may give the required yaw to precipitate the spin.

False Visual Horizons

Flying in hilly terrain may distort the visual cues needed to ascertain both the pitch and roll attitudes of the aircraft. It is easy to allow airspeed to reduce further than anticipated. When combined with a turn, particularly in confined areas, this can produce stall and yaw, the two components needed for a spin.

Engine Failure After Take-off (powered sailplanes)

In a high nose-up attitude, with high power and low speed, the immediate priority is to lower the nose and preserve existing airspeed. In most cases, there is little option but to land ahead. Attempting a turn back to the runway or to a limited selection of landing areas will provide the G loading to increase the stall speed. Any yaw will now put the aircraft into the incipient spin situation.

The pull up and reversal turn from a high-speed, low run (competition finish) may produce the same result.

Attempting a turn back to land will increase G loading and stall speed.

Spin Recovery

To have a chance at recovery, the pilot must immediately recognise the spin, and its direction, know exactly what to do in the right order, and then execute the procedure correctly the first time. In most aircraft there is only about three seconds to do all this. The minimum altitude loss for a text-book recovery will be between 300 to 800 feet, depending on glider type.

Direction of Spin

A serious problem in perceiving spin direction occurs when the pilot’s attention is directed, perhaps unconsciously, to roll direction. The spin (yaw) direction will always be correctly indicated by the turn needle, as this reacts to rotation only in the yawing plane.

The ball cannot be trusted. It is likely to be centrifuged away from the centre of the aircraft and its reaction may depend on where it is mounted on the aircraft in relation to the centre of gravity.

Recovery Technique

Spin recovery does not follow a pilot's natural instincts.

Incipient Spin

Recovery from an incipient spin (a spin that has just started) requires instant recognition (critical at low level), an immediate check forward on the stick or control column (to unstall the wing) and sufficient opposite rudder to eliminate yaw and further wing drop. This must be instinctive. Be wary of pitching forward too much. Applying only sufficient forward stick or control column to unstall the wing ensures maximum lift is still being achieved and height loss is minimised. Similarly, only sufficient rudder to eliminate yaw should be used. Any more applied at high angles of attack may cause the aircraft to flick or spin the other way. With control now restored, aileron may be used to reduce bank angle.

Developed Spin

In a developed spin, full deflection of controls is required. The universal spin recovery technique in gliding is guaranteed to work for all gliders certified to EASA Standards CS-22. You should follow the procedures outlined in your aircraft's Flight Manual or Pilot Operating Handbook. The universal spin recovery technique in gliders is as follows:

Close the throttle

Powered sailplane pilots must check that the throttle is closed. This decreases forces from the propeller that might tend to hold the nose up, flattening the spin and possibly blanketing the elevator. It will also keep the engine from overspeeding during later stages of the recovery.

Full opposite rudder

Identifying which rudder is opposite to the direction of spin is critical.

- Change your field of vision by sighting straight down the nose of the aircraft. By doing so, you will see only the yaw component of the spin. Force yourself to look beyond the nose and observe the ground movement. The ground will appear to flow past the canopy – apply the rudder fully in the direction of this flow. In a left spin the ground moves in a blur to the right – use right rudder for the recovery.
- Look at the turn needle. It does not lie. Do not trust the ball. A turn coordinator will indicate the direction of yaw (and therefore spin) in an upright spin, but it may not indicate the right direction in an inverted spin.
- Sample the rudder pedals – feeling for the one that offers the most resistance. Press the heavier one all the way to the control stop. Unless you have a lot of experience in spinning a particular type of aircraft, this technique may be the most difficult of the three to implement during an unintentional spin. It is not uncommon to lock both feet on the rudder pedals during an unintentional spin. Consciously relaxing your feet improves your sense of feel and will also reduce your tendency to oppose the application of full opposite rudder.

Ensuring ailerons central…

Never use aileron in an attempt to roll out of a spin. The result could be a flatter, faster, steadier spin. The most appropriate aileron position for recovery from an unintentional spin in most gliders and standard light aircraft is central (neutral).

… move stick forward until spinning stops

Move the stick or control column progressively forward until the spin stops to reduce the angle of attack and unstall the aircraft.

Recover from dive

Once the spin stops, centralise rudder and aileron and ease gently out of the dive.