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# SAFETY NOTICE 00115 REV 1

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# *AN AEROBATIC EPISTLE*

Author: Dick VanGrunsven

Your RV is a high-performance airplane capable of meeting many flying needs. Our testing, both on the ground and in the air, shows that the airplane, flown properly, is capable of many missions: it is an excellent cross-country cruiser, and a fine airplane for efficient just-for-fun flying. It is also capable of very good sport aerobatics.

Properly approached, aerobatic flight can be very enjoyable and can help a pilot hone and expand his flying skills. However, a careless approach to aerobatics can result in disaster. The following are suggestions and guidelines, based on our 50 + years' experience, which are offered to assist you in flying your RV safely in all flight regimes including, if you choose, aerobatics.

Now is a good time to plant firmly in your brain the concept that, although the RV is a sturdy airframe, it is NOT indestructible. In aerobatic flight, the pilot is almost always the limiting factor. This statement conjures visions of a completely reckless hot rod pilot – not someone like *you.* While this type of pilot is definitely an accident looking for a place to happen, bad things can also happen to "regular pilots" for offenses no worse than acting on assumptions and ignoring cautions. Let's look at some of the reasons this is so.

## *A MATTER OF GRAVITY*

When Isaac Newton defined the attraction between objects and called it GRAVITY, he could just as well have defined the force as "the enemy of flight." In airplanes, we can counteract gravity for short periods, if we have a suitable aerodynamic shape, sufficient energy to move the suitable aerodynamic shape through the air and create lift, and control of both. If we lose the shape, the energy or the control, the airplane will fall toward the center of the earth.

GRAVITY is what causes an airplane's SPEED to increase, perhaps beyond safe limits,

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when its ATTITUDE (nose) is pointed down.

GRAVITY (plus aerodynamic drag) also causes an airplane's SPEED to decrease, perhaps to below stall speed, when its ATTITUDE (nose) is pointed up.

In most flying, it is easy to forget that gravity is still at work. Normal flight attitudes prevent gravity from getting the upper hand. But when we begin flying aerobatics and start pointing the airplane both directly toward and directly away from the center of the Earth, the effects of gravity become vastly more dramatic.

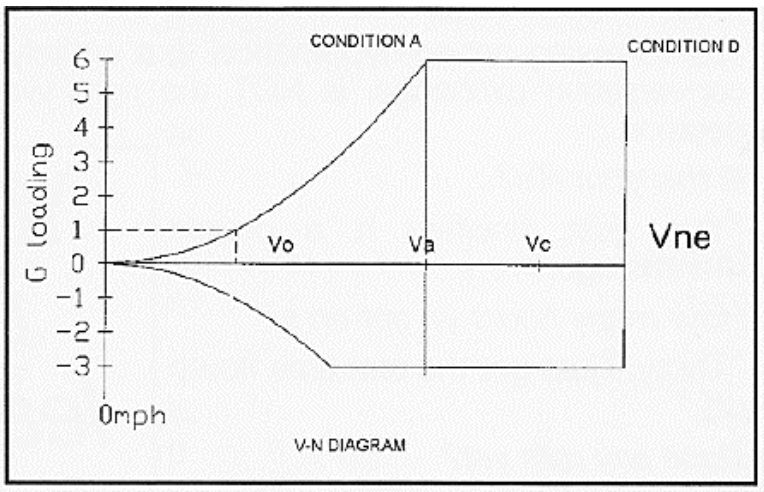
Some very simple mathematics should help us understand why:

In level flight an RV requires about 225 lbs. of propeller thrust to produce a speed of 200 mph. Pointed straight down, GRAVITY (or weight) becomes the same as thrust. Now we have the weight – say 1500 lbs. – plus the thrust of 225 lbs. acting to produce speed. With 1725 lbs. of thrust rather than just 225 lbs., how long do you imagine it will take to reach a destructively high speed?

OK, let's not be so bold and only lower the nose to a 30°-down attitude. Now the thrust component contributed by gravity is 750 lbs., bringing the total thrust to "only" 925 lbs. In other words, lowering the nose 30° quadruples the force pulling the airplane!

With all this extra energy, especially in an aerodynamically clean airplane like the RV, you will be going very fast before you know it. By our quick calculations, a full power 30° dive would yield a top speed of 370-380 mph.

Why is this a problem? Because at speeds well above Vne (redline), aerodynamic flutter and other forms of aeroelasticity can destroy an airplane. Also, as speeds increase above maneuvering speed (Va), the possibility of pilot-induced "G" overload increases.




Let's have a quick review of airspeed vs. G load potential (lift). At stall speed a wing can produce only enough lift to support the weight of the aircraft, or 1G. As speed increases, the lift potential increases in proportion to the square of the speed. Thus, at twice stall speed the lift potential will be 2 squared or 4Gs. At 3 times the stall speed it is 9Gs, etc. Maneuvering speed is calculated by multiplying the square root of the design limit (in the case of the RVs, 6Gs) times the 1G stall speed. This works out to between 132 and 142 mph for various RVs operating at the

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aerobatic gross weight of 1375 to 1550 lbs. At any speed greater than maneuvering, and at its maximum lift angle of attack, the wing will produce lift in excess of 6 times the aircraft weight, or more than 6Gs. Thus, at any speed above maneuvering, the pilot must ***NOT*** use full control movement lest he overload (overstress) the wing. At Vne (red line) speed of 210-230 mph (depending on the model) an RV is capable of producing almost 16Gs if you pull hard enough. It should be very obvious that YOU as the pilot must CONTROL your stick force inputs to keep G loads within design limits. To graphically illustrate this concept, we have provided the above graph, or more specifically, a V-N load diagram. The sloped curve represents the maximum lift that can be produced by elevator pressure at a given speed. The dotted line extending above maneuvering speed (Va) shows the speed range in which pilot induced structural overload can occur.

## *THE KEY TO SURVIVAL*

In one word, the key to safe flight, particularly safe aerobatic flight, is CONTROL. Flying your RV safely under any condition involves only one essential: maintaining CONTROL. In level flight, maintaining control is not normally difficult. We spend our lives right-side-up and are familiar and comfortable there. When we decide to turn ourselves upside down, everything becomes unfamiliar and it is easy to become confused and lose CONTROL.

This section was intended to contain a few catchy slogans which could be easily remembered to keep you under CONTROL and out of trouble. The trouble is, despite several inspired starts, I can't reduce all of the intricacies of safe flying within a few buzzwords. Words like Altitude control, Airspeed control, Acceleration (G) control, energy management, situational awareness, and velocity vectors are all appropriate. But they can have different meanings, or no meaning at all, to different pilots. Simply memorizing slogans doesn't ensure that control will be maintained and survival will be assured.

As I was pondering the selection of the perfect buzz words, I happened to be reading a book about Charles Lindbergh written by his daughter Reeve. In one chapter she described a childhood flight with her father in a rented Aeronca. When a sudden engine failure necessitated a dead stick landing in an impossibly small Connecticut farm field, she commented that Lindbergh wasn't flying the airplane, he was "being the airplane." While this may sound like nothing more than metaphoric prose, I feel those three words are a beautifully simple summarization of the theme I am trying to convey. The most skilled pilot is one who knows flying, and the airplane he is flying, so well that he is essentially an integral and indispensable part of that airplane.

The pilot who is "being the airplane" knows instinctively that he must balance CONTROL of attitude, altitude, airspeed, and acceleration so that GRAVITY does not win.

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## *AEROBATICS: TO DO OR NOT TO DO*

While your RV has been designed and tested for sport aerobatics, you may not feel the need or desire to perform them – you may find more than enough satisfaction from flying that does not include aerobatics, G-forces, or extreme attitudes. This is fine; aerobatics are an *option*. Certainly, a pilot can greatly enhance his overall flying skills through learning and practicing aerobatics. However, he can also enhance his skills through practice of non-aerobatic maneuvers. Aerobatic flying almost always presents an increased risk. When undertaken with careful training and planning the risk is small. When approached any other way aerobatics can be deadly. If you choose not to pursue aerobatics, that could well be a sign of superior judgement rather than lack of courage.

The following not-so-hypothetical (but entirely possible) airport conversation exchange is NOT the right way to make your decision.

> *Is this your RV?*
>
> "Yup, just finished it a couple months ago."
>
> *How many hours ya got on it?*
>
> "Thirty. I just got the test time flown off."
>
> *Done any rolls yet?*
>
> "No, I haven't had any aerobatic training yet. There isn't a flight school around here that teaches it."
>
> *Awww..you don't need that. My friend Louie over to Spudsville, he's got an RV-4. He never had no aerobatic trainin' and he does 'em all the time. He sez all ya gotta do is yank the stick back a bit, slam in a bunch of aileron and rudder and it's around before ya know it.*
>
> "That does sound really easy. Tell me again how it's done? Maybe I'll try one next time I'm up."

If you do choose to do aerobatics in your RV, make sure it is your decision, and that you are comfortable with it.

## *WHAT CONSTITUTES AEROBATICS?*

According to FAR 91.303, "Aerobatic flight" means "an intentional maneuver involving an abrupt change in an aircraft's attitude, an abnormal attitude, or abnormal

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acceleration, not necessary for normal flight."

FAR 91.307 states that unless each occupant of the aircraft is wearing an approved parachute, no pilot of a civil aircraft carrying any person (other than a crew member) may execute any intentional maneuver that exceeds:

- a bank of 60° relative to the horizon, or
- a nose-up or nose-down attitude of 30° relative to the horizon.

Note that "aerobatics" is not defined by bank or pitch angle. These specifics only apply to wearing parachutes. Any abrupt attitude change, abnormal attitude, or excessive acceleration can be construed as aerobatics.

## *SOME THOUGHTS ABOUT ABNORMAL ATTITUDES AND AEROBATICS*

For the sake of this discussion, I will refer to common sport aerobatic maneuvers that the RV does well. These include rolls, loops, hammerhead turns, spins, and various combination rolling and looping maneuvers such as horizontal 8s and Immelman turns. Properly flown, these maneuvers can be accomplished without exceeding about 4 G's positive, and well within the airspeed limits.

Here are some suggestions and guidelines to help you maintain control while flying your RV. These are based on my 5000 hours of accident-free RV flight time, and the hundreds of thousands of hours of other successful RV pilots. Unfortunately, they are also based on the misadventures of others that have not been as successful.

First, I want to impress upon you that any aerobatics which you might choose to perform in your RV should be viewed as a completely new and different endeavor than all of the "normal" flying which you have done. Although the FARs don't define aerobatic flight specifically as exceeding 30° pitch and 60° bank, let's use those numbers for the sake of the following: The difficulty or risk of a maneuver does not necessarily vary in direct proportion to the angle of flight. In reality, a 60° pitch angle poses much more than twice the challenge and risk of control loss than does a 30° pitch angle. A 120° pitch angle (inverted steep climb) poses an infinitely greater risk than a 30° pitch angle, not just 4 times as much. The same applies to bank angles.

Once you get the aircraft into an inverted position, a completely new and much more demanding realm of flight begins. You should not undertake any form of aerobatic flight casually. You might ask: "A roll only takes a few seconds; how can I possibly get into much trouble in that short time?" "What can possibly be so difficult if it is over so fast?" If you have had aerobatic training, you already know the answer to this. If not, take some aerobatic dual and you will soon learn. But never, ever try to teach yourself! You took instruction when you learned to fly right side up. Get instruction if you want to learn to fly

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upside down!

Our goal is to approach intentional aerobatics in a manner that will minimize the possibility of loss of control, and to practice and plan procedures for safely regaining control in the event it becomes necessary.

Contrary to the fatalistic examples above, loss of control need not be permanent – it can be corrected and safe flight resumed. Ability to recognize impending loss of control can lead to immediate corrective action and retention of control. Knowledge of procedures for regaining control can minimize out-of-control excursions.

EXAMPLE: Recognition of pre-stall buffet can alert the pilot to add power and/or lower the nose, thus avoiding a stall. If this signal is missed and a stall occurs, stall recovery procedures can be applied before significant loss of altitude or attitude control occurs. If this is not done, a spin could ensue, and even then, corrective action can be taken. However, you must be able to recognize danger signals, assess corrective action required, and take this action, instinctively and without delay, from unusual and uncomfortable attitudes.

Therein lies the challenge.

When a loss of control occurs at abnormal attitudes that are commonplace in aerobatics, the pilot may have more trouble regaining control due to being disoriented by the unusual attitude. Often a pilot can remedy this problem by thinking in terms of finding the "quickest way back to normal," or the shortest route back to wings level. This should be a part of formal aerobatic training and should also be a part of the planning for any aerobatic maneuver attempted: "What should I do if_____?"

## *PRE-AEROBATIC RV FAMILIARIZATION*

Flying an RV can be intoxicating. The exhilarating performance, the light, responsive, harmonized flight controls; it's an easy airplane to love. It's also an easy airplane to master, or perhaps it's easy to feel that you are its master. However, to the unwary it can offer surprises, as suggested in the forgoing loss of control scenarios. To help avoid these pitfalls, before attempting unusual attitudes that can lead to loss of control you should become thoroughly familiar with all "usual" and "semi-usual" attitudes. Below is a list of suggestions for training and familiarization maneuvers.

**SLOW FLIGHT:** Practice flying slow, at power off and minimum level-flight power. You should be able to hold the IAS within 5-10 mph above stall for several minutes, or until the engine overheats. You should be able to roll into and out of turns up to 30° bank angles within this speed range. This will teach you to recognize control feel as speed decay, regardless of attitude.

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**STALLS:** Stalls of every conceivable variety: power off, minimum level-flight power, full power, wings level, banked turns, accelerated – all combinations of these. Because of the unusual attitudes that will be commonplace during aerobatics, you must be prepared to recognize and recover from stalls encountered at any attitude. While stalls should not occur during properly executed aerobatics, you must be prepared for anything that can happen. Progress from gentle power-off and low-power stalls to stalls in full-power climb attitudes. These will definitely be uncomfortable, but if you can't handle them you're not ready for aerobatics.

**STEEP TURNS:** A good way to become familiar with unusual bank angles is by practicing steep turns. Practice stopping the roll at precise bank angle and at a pitch angle to maintain altitude. A steep-turn attitude also provides an opportunity to experience the elevator stick forces needed to produce G loads.

**LAZY EIGHTS:** This is an excellent training maneuver, often overlooked in private pilot flight training programs. It teaches control coordination and attitude control over a wide range of airspeeds. It provides an easy and progressive introduction to unusual attitudes. Performed correctly, it is very demanding because the airplane is constantly moving about all three control axes, as are the cockpit flight controls. It is a good avenue to humility.

**SPINS:** A thorough knowledge of spin recognition and recovery is an absolutely essential pre-requisite for aerobatics. Spins are a classic example of control loss, and they can accidentally occur at very unusual attitudes when you are doing aerobatics. You must be able to recognize signs of impending spins and make corrections before the spin can fully develop. Once fully-developed in a spin, the "quickest way back to normal" becomes more distant.

**SMOOTH FLYING:** Some pilots fly airplanes as if they were being controlled by short-circuited robots; they sort of jerk the airplane around the sky. Others fly the plane as if it were flowing through the air on a precisely programmed track. The difference could be a matter of preference, or more probably is a matter of training and finesse.

To gain a better understanding of smooth yet assertive flying, define two terms: control RATE and control ACCELERATION. RATE is the change in position per unit time. Most often we hear of roll rates, in degrees per second. For instance, it may require 15° of up aileron to produce a steady roll rate of 90° per second. Pitch rates are also important because in combination with forward speed they have a definite relation to G loads, but we rarely see pitch rate figures published.

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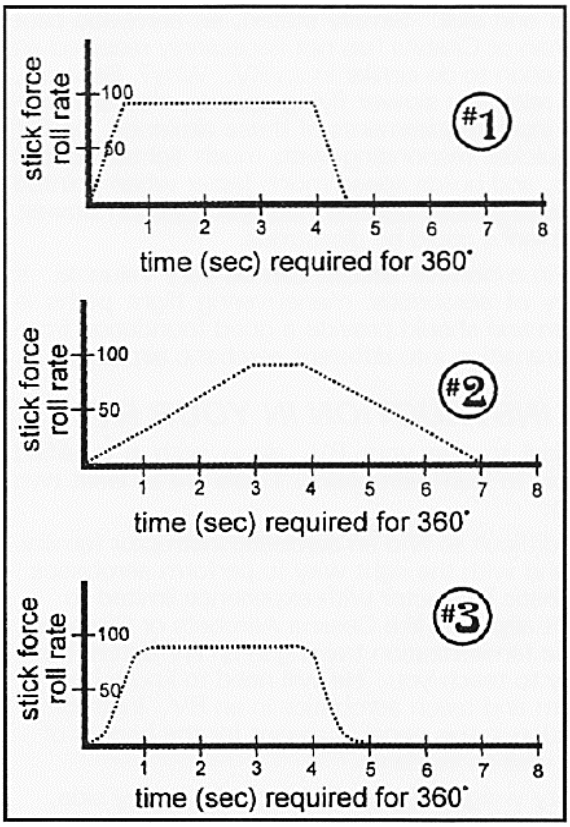
ACCELERATION is the rate change per unit time. We rarely hear this term, but it refers to the rate at which an airplane responds to control application. For the sake of this discussion, we will limit its use to define the rate at which the pilot applies control forces: How much time it takes to move the stick from neutral to the 15° up aileron position that will produce a desired roll rate of perhaps 90° per second. The difference between smooth and jerky flying is primarily a matter of control acceleration. Does the pilot apply control abruptly with rapid acceleration, or gradually, with a lower acceleration? These graphs represent an attempt to illustrate the difference through a plot of control application.




Plot #1 shows the fastest way to complete a roll, whether it be a 360° roll or just the rolling needed to establish a 45° bank. The steep ramp of the plot indicates abrupt control application to produce a large control deflection and achieve the target roll rate in a minimum time. It would be an effective procedure to execute a crisp air show roll, but would not be the most desirable way to establish a 45° bank with a load of passengers on board, or even to perform an enjoyable recreational aerobatic roll.

The shallow slope of Plot #2 shows very gentle control deflection and the resultant much longer time to achieve the desired roll rate and the total degrees of rotation desired. This would be practical for establishing a 45° bank but would not be desirable for doing aerobatic rolls.

Plot #3 depicts the technique that smooth pilots use, though they may not be aware of it. The curved lines show how the pilot eases into and out of a high roll rate. This is achieved through the use of a quick, yet smooth, control application. The overall time to complete the roll is only slightly increased but the jerkiness is completely eliminated.

Fly your RV enough to become thoroughly familiar with its performance, controllability, and limits before attempting formal aerobatic flight. What measure of "thorough" is sufficient? 10 hours, 50 hours, or 100 hours? It's impossible to say. The amount of time

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will vary widely, from practically nothing to infinity.

If you are not comfortable with any of the above training pre-requisites, extreme stalls, unusual attitudes, etc., then you're probably not ready – or even suited – for aerobatics.

Your own judgement – and that of your aerobatics instructor – are needed to make this determination.

## *AEROBATIC PRE-FLIGHT PLANNING*

"Visualization," a technique used by many performers and athletes, can also be a useful tool for the aerobatic pilot. This consists of mentally putting yourself in the airplane and imagining what you will see and feel during a maneuver. Repeatedly forming the "picture in your head," even though you are sitting in your Barcalounger, will make the actual event seem familiar and less disorienting.

A pilot can also learn a lot by using a small handheld model airplane. He can twist and turn this model through the anticipated flight path of any aerobatic maneuver. He can try to put his mind and his eyes in the cockpit of that model plane to visualize the sight picture he might expect throughout the maneuver, particularly at certain key points in the maneuver.

## *FORMAL AEROBATIC TRAINING*

We feel that it is essential to have formal aerobatic training before attempting aerobatics in your high-performance RV. Performing aerobatics in any qualified light airplane is both similar to – and yet very different than – other aircraft. Similar because the basic control requirements and maneuvering flight path are the same, and different because aircraft configuration, horsepower, speed capabilities, control force input requirements, reaction time, control harmony, etc. can demand a widely differing piloting experience and skill. Simply stated, an aerobatic pilot trained in a Stearman or Citabria has not necessarily received an adequate indoctrination to do similar in an RV. Why? Because in contrast to the relatively slower flying speeds, slower reacting, higher control input requirements of these airplanes, the RV is much faster, quicker responding with much lighter control input requirements, and builds speed much faster when pointed down. An attempt to directly transfer habits acquired in slower, less responsive airplanes could be disastrous.

Aerobatic training in a non-RV aircraft can be very valuable. It teaches the theory of aerobatics, maneuvering flight paths & kinetics, etc. It can and should provide a good foundation from which a pilot can transition into different aerobatic airplanes.

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## *AEROBATIC INSTRUCTION IN YOUR RV*

It would seem ideal to use your RV, along with a qualified aerobatic instructor, to learn aerobatics. There are at least two possible limitations:

1. It may be difficult to find an aerobatic instructor familiar with the RV and with the right way to perform aerobatics in it. An aerobatic instructor with experience limited to vastly different airplanes like Cessna Aerobats or Citabrias will need some familiarization training in an RV before they are ready to teach you. They will need to know how best to perform and teach aerobatics in an RV. The instructional information in this paper is meant for the benefit of instructors as well as students.

2. If the empty weight of your RV is on the heavy side, you may not be able to add the combined weight of yourself, an instructor, two parachutes, plus sufficient fuel and remain within aerobatic gross weight and C.G. limits. This can be a real dilemma. An overweight RV is a single place aerobatic airplane. It's as simple as that.

## *A FEW BASIC DIRECTIONS*

*CAUTION: These instructions are presented only as a supplement to the instruction you must receive from a qualified aerobatic instructor. They are not intended as a sole source of aerobatic instruction.*

### *ROLLS:*

I feel that rolls are good entry level aerobatic maneuvers for an RV pilot. They can be done with minimum control inputs and without imposing high G loads on the airframe. A roll performed in an RV can be simple and safe, or it can be very dangerous. It can be accomplished at barely over 1G or it can result in destructive 6G+ loads. These vast differences are due to variations in pilot skills, judgement, training, preparation, and execution.

There are a number of variations of rolling an airplane; these are covered in good aerobatic training textbooks, training videos, and aerobatic flight training curriculums. The following is a description of a method of performing rolls in an RV. It is meant to supplement the written and practical knowledge you have already gained, by introducing information specific to the RV. It is not meant to be a textbook-perfect method. Rather, it is a method that we have found effective for beginners. The primary intent is to guide the pilot through successful completion of the roll maneuver with the least pilot effort and the least chance of loss of control. This basic roll procedure also presupposes that the RV is not equipped with inverted fuel and oil systems, and as such is tailored for positive-G execution.

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***HOW TO ROLL:***

1. Climb to at least 3000' AGL, tighten your seat belts and harnesses, and secure loose objects in the cockpit.
2. Achieve 170 mph IAS.
3. Nose up 20°-30° above the horizon.
4. Neutralize elevator control.
5. Take feet off rudder pedals.
6. Firm aileron input; half stick deflection or more.
7. Hold uniform aileron pressure throughout at least 300° of roll.
8. Reverse aileron just prior to wings level. Arrest roll rate at wings level.
9. Elevator (usually up) as required to return to level flight.

***COMMON ERRORS:***

1. The roll is completed but the nose is far below the horizon. Speed has increased and is rising rapidly. Usually this means that the nose was not high enough at the start of the roll. Most straight-and-level pilots will raise the nose 10° and think that it is 30°. Ten degrees is not enough.

*Correction: (and training aid): Place a strip of tape on the side of the canopy to align with the horizon when a 30° deck angle is attained Practice a pull up to 30°, then pause and note the nose/horizon position, level out, start over. This way, you can learn to recognize a 30° attitude to be sure that it is right before attempting your first roll in your RV.*

2. Failure to neutralize elevator pressure. Holding back pressure will result in a higher than necessary G load and result in a barrel roll, and usually an excessive loss of attitude and altitude.

*Correction: Set the trim for 160-170 mph. Practice pull up to 30° and neutralize elevator stick pressure. Watch as the attitude remains relatively constant for a second or two.*

3. Not applying enough aileron. Non-acro pilots are unaccustomed to high roll rates and as such are hesitant to apply hard aileron and initiate a high roll rate. The sight of the horizon spinning in front of them is intimidating and they ease off the stick pressure. Often the pilot will start with a high roll rate and then subconsciously ease off as the roll progresses. This will cause the roll to take longer, and thus more time for the nose to drop, altitude to be lost, and speed to become excessive.

*Correction: Practice rolling from 45° to 45° bank at high rates. Become accustomed to fast roll rates. Concentrate on maintaining the rate, despite the unaccustomed visual*

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*rush. Though the world may be upside down and whirling around, that's what it is SUPPOSED to do. Don't panic--hold that aileron pressure.*

4. Getting confused and trying to recover with up elevator. A slow roll rate, particularly when combined with insufficient nose up entry attitude, can result in an inverted dive at the mid-point of the roll. PANIC, CONFUSION, AND OVERLOAD can set in. The natural response when the nose is below the horizon is to apply up elevator. This is a conditioned reaction the pilot has learned from normal flight, but is WRONG when inverted. This will result in lowering the nose even further below the horizon and the beginning of a high-speed split-S maneuver. Particularly if the throttle is left open, you will almost certainly greatly exceed red line speed and could even exceed design and ultimate G load limits. Herein lies the greatest opportunity for loss of control and danger in performing rolls.

*Correction: If you let the nose drop below the horizon before the mid-point of the roll, simply reduce power, roll wings level in the nearest direction with firm aileron, and return to level flight. Never pull up elevator when inverted (between 90°and 270° bank) (remember, up is down, down is up). Better that you push forward and cause fuel flow interruption (engine sputters and quits temporarily), and then complete the roll in a more level attitude. With this in mind, you can see the benefit of keeping the elevator neutral throughout the roll.*

***MOVING FORWARD:***

Once you have mastered the basic roll – meaning you can do it consistently and are comfortable and cognizant throughout – you can experiment with variations. You can increase or decrease the rate of roll and the entry angle. If you wish to do a very slow roll, you will need a steep entry angle because the nose will drop a lot during the greater duration of the roll. Conversely, with a high roll rate a lesser pitch angle will suffice. All that I have tried to cover here is a simple, safe, and technically imperfect method for performing a basic roll. There is much, much more to learn about performing rolls more precisely as well as other variations of rolls. The foregoing is meant only to supplement what you will learn from your aerobatic instructor: techniques peculiar to the RV, which need be blended with your prior general aerobatic knowledge.

***ADDING SOME POLISH:***

Now, on to better things: Remember how in our initial discussion of rolls, there was a complete lack of instruction about the use of rudder? I intentionally omitted any mention of the rudder because RVs have so little aileron induced yaw that acceptable, safe rolls are possible without it. To avoid sensory overload, I didn't

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mention it. Now that you can comfortably perform safe, albeit slightly uncoordinated rolls, it's time to perfect them. A textbook perfect aileron roll is one in which the flight path describes a straight, level line through the sky. To do this, several control inputs and reversals are necessary. It goes something like this:

The roll begins, like a turn, with coordinated aileron and rudder with slight back pressure to maintain altitude. The elevator pressure is gradually decreased to zero at the 90° roll point. As the roll progresses to a 90° bank, opposite rudder is gradually applied to help hold the nose up when on edge. The elevator is now vertical, like a rudder, and must be pushed forward to prevent turning. As the roll progresses from 90° to 180°, forward/down elevator is increased so the nose is high enough to maintain level flight when inverted. Opposite rudder is gradually released and reversed, to assist the ailerons in rolling by the time the 180° point is reached. Then, "into the turn" rudder is increased to help hold the nose up as knife-edge flight is approached at the 270° point, and the forward elevator pressure is relaxed to near neutral. As we pass the 270° point of the roll, top rudder is diminished as we approach wings level. Up elevator is gradually applied to maintain a level flight path.

If you agree that the above procedure sounds like a lot to do in 3-5 seconds, then you can better appreciate why I suggested the imperfect, aileron pressure only roll as a beginning point. With an RV, we are fortunate that such an uncomplicated procedure will produce an acceptable, safe roll; a starting point upon which to build.

A true aileron roll – one in which the aircraft is held on a straight, level line – is difficult to do without a full inverted fuel and oil system. A gravity fuel system will quit feeding fuel to the engine at about the 90° point and the ensuing lack of power will reduce the effectiveness of the elevator and rudder and cause a rapid loss of speed. Since the engine is still windmilling, oil will be pumped out the engine breather tube to lubricate the outside of the airplane rather than the inside of the engine. With luck, the engine will restart after returning to level flight. This is not a fun way to do rolls. However, we don't have to perform textbook-perfect rolls when flying just for fun. We can redefine the perfect roll to be one in which we maintain the straightest possible line of flight without starving the engine.

How do we progress from the simple roll to the perfect aileron roll? One step at a time. Start with the roll we practiced until we are at ease with it and can think ahead of what is happening. Then we can introduce, one at a time, other control inputs needed. Let's try a little top rudder. As we approach and pass through the 90° point, we apply some opposite or top rudder. Note how the nose hangs on the horizon longer than before. Then as we approach and pass through the 270° point, we apply top rudder, which is now "into-the-roll," and note how the nose again stays higher than before. After the roll is completed, note that the nose is probably higher on the horizon than before; maybe even above it.

We can also do a simple roll and add nothing but forward pressure during the

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inverted phase. Even a gravity fuel system will operate at partial pressure; maybe as low as 1/2 G. That won't keep the airplane level when inverted but will help to limit the altitude (or attitude) loss. Be advised that you should carefully ease the stick forward, not shove it forward. We don't want to starve the engine. This is a good example of why we recommend flying your RV a lot before attempting aerobatics. If you have become very familiar with control pressures and reactions, you will be better able to apply a "just right" amount of control force in a sensitive maneuvering position like the inverted phase of a positive-G roll.

With top rudder and nose up elevator applied at optimum times, we find that we are losing much less altitude, so we can enter rolls with less nose up attitude. We are now able to think and react faster with all elements of control needed to roll so we can increase aileron deflection and roll rate. This also means less attitude change and therefore a more nearly level roll.

By Jove, we're catching on! Really now, if the object is to limit altitude variation by keeping the nose up, then all we need to do is apply the control inputs which hold the nose up, in whatever attitude we find ourselves at that split second. When the wings are level, the elevator holds the nose up. When on edge, the rudder does it. With practice, these inputs become subconscious and you're on your way to becoming another Sean Tucker or  Patty Wagstaff. (Well, we can dream, can't we?)

***HESITATION ROLLS:***

Now, let's try a hesitation roll. This can be described as a rapid series of rolls, the rotational sum of which is 360 degrees. In a hesitation roll, say 4 points, we are doing 4 consecutive 90° rolls rather than one continuous 360° roll. Because of the hesitation required in a 4 -point roll, completion will require a greater elapse time and will typically require more entry speed and entry pitch-up angle. It will also require that the roll segments be started and stopped more abruptly to conserve time.

First, try a single hesitation at the 180° (inverted) point. Begin with extra speed and pitch up angle. Then at the inverted position, pause just enough to see if you are approximately level with the horizon. Then re-initiate the roll to upright position. Practice this until you are comfortable and can perform it with a minimum pitch-up entry and a minimum attitude and altitude change. Then try hesitating only at the 90° position. Here it will be desirable to apply and hold "top rudder" which we discussed earlier. You will apply opposite aileron and rudder to stop the roll. Just as the wings stop in the vertical position, neutralize the aileron, but hold and increase the opposite rudder. Hold the vertical position just long enough to check that the wings are vertical and that the nose is being held up (somewhat). Then apply aileron and rudder into the roll and complete the remaining 270° back to upright. By practicing each point individually, you will have more time to concentrate on that point than if you were trying to stop at all three intermediate points. Once you have mastered each point, gather a bunch of speed, get the nose way up, and do your first complete 4-point hesitation roll.

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## *LOOPS:*

Because of the broad performance range of your RV, there are different ways in which loops can successfully be performed. I will start by explaining what I feel to be the easiest and safest means of performing entry level loops.

1. Apply full throttle. (with constant speed prop, set rpm at 2600-2700 rpm)

2. Attain 170-180 mph IAS. Lower nose to hasten speed build up if desired.

3. Apply pitch control, (smoothly pull back stick) to attain 3Gs.

4. Maintain 3G load until passing through 90° nose up, then begin releasing back pressure so that at 180° (top of loop) not more than 1G is experienced. I must explain that "releasing back pressure" on the upper portion of a loop does not mean moving the stick forward. If you hold the stick firmly in position, back pressure will automatically diminish as the speed is dramatically dropping. When you are going straight up, or beyond vertical, speed decays much faster than you are accustomed to in all other normal flight attitudes. It will be necessary to pull the stick even further back (but not back to the control stop) to maintain a positive G load and to avoid excessive speed loss.

As you pass horizontal, inverted, at the apex of the loop, airspeed should be between 70 and 90 mph. Speeds as low as 50 mph are OK, but begin to feel uncomfortable because the airplane tends to fall inverted, control pressures become very light, and you start to float off the seat. This results from not maintaining enough inertia to "fly" around the top of the loop. After a bit of practice, you will be able to feel the correct speed more accurately than trying to fly it on the ASI. All comments I have about checking indicated airspeeds and G readings are meant to be quick references only. You should keep your eyes outside the cockpit at all times other than very brief instrument cross checks.

5. As the horizon appears in the windshield, reduce power to idle and increase back pressure to prevent excessive speed build up during the recovery phase.

6. When level flight attitude is attained, neutralize controls and apply cruise power setting.

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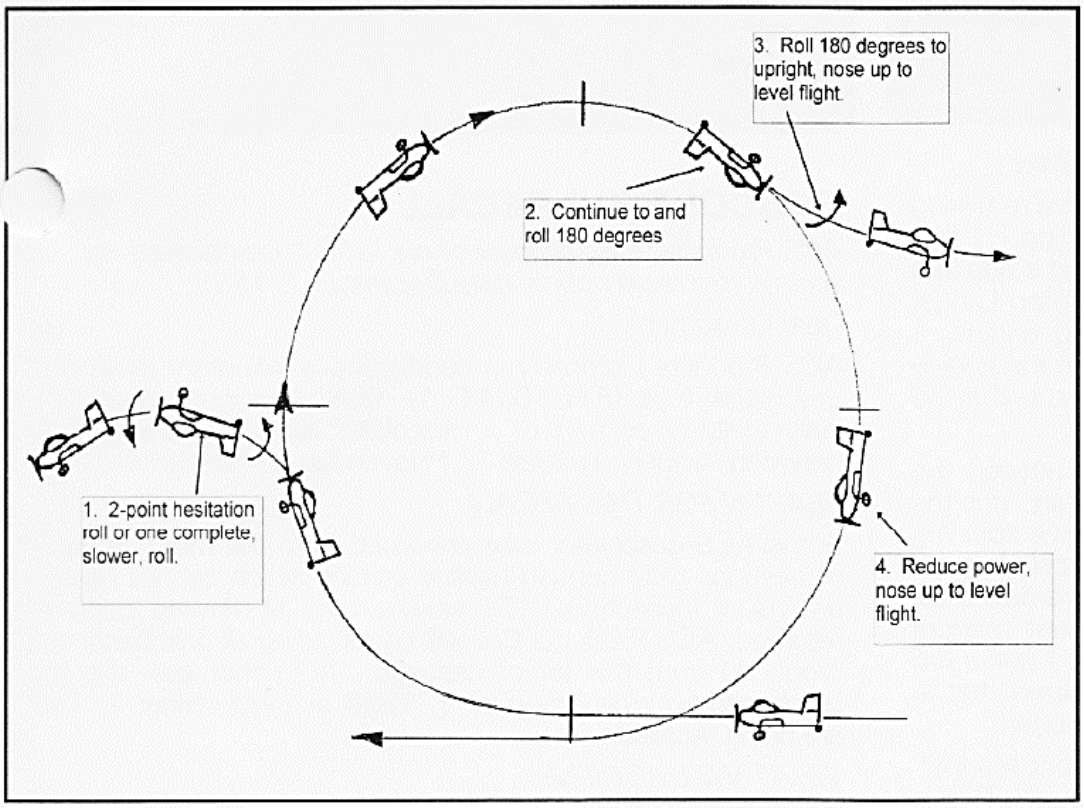


***POSSIBLE PROBLEMS:***

1. Maintaining too much back pressure nearing the top of the loop. As speed decreases, an accelerated stall can occur, just as it can when doing a too tight turn at low speed, or when recovering too abruptly from a stall. Correction is easy; just release enough stick pressure to cause the stall buffet to stop, then continue the loop.

2. Failure to correct by breaking the stall could result in:

   a) Continuing through inverted until the nose lowers enough to gain speed to break the stall.
   b) While inverted and stall buffeting, misuse of rudder could cause spin entry. Oops!

3. Too little backpressure approaching or on the top of the loop: the airplane will lose speed and begin to fall inverted. Adding back pressure at that time will be too late because there is insufficient speed to command elevator (pitch) authority. The airplane will have to fall, at close to zero G, until the nose lowers and speed is gained for the resumption of elevator control. During this phase, elevator and rudder pressures are important because excessive use could cause a spin.

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4. Too little back pressure on the back side (down side) of the loop: Can cause speed build-up, particularly if the throttle is left open. When an RV is pointed downward, whether upright or inverted, it is going to gain speed quickly. That's what clean airplanes do best! On the backside of a loop, it is necessary to apply back-pressure sufficient to produce a G force about equivalent to the entry G's.

Because of the wide speed range, low wing loading, and cleanliness of an RV, there is more than one right way to perform a loop. The engine HP, type of prop and pitch, and weight of your RV, all affect what might define the correct way to do a loop. For instance, I have performed loops with entry speeds ranging from 100 to 210 mph. The more I attempt to define specifics, the greater the opportunity for you to take me to task for correctness. Overall, it exemplifies a point I've tried to make before: You must have dual instruction. All that I can hope to do here is to point out a few techniques that are helpful when performing loops in an RV. Quite possibly this technique is different than that for the aircraft used in your basic aerobatic training. Thus, the textbook procedures must be tailored to the qualities, capabilities, and limitations of your airplane.

***EASIEST WAY BACK TO LEVEL:***

As with any aerobatic maneuver, it is possible to screw up loops in a wide variety of ways. Recovering gracefully from some attitude/airspeed situations you may find yourself in requires having an escape plan in mind. Thinking through a plan of escape can get you out of an awkward or even dangerous flight condition. The loop-escape drawing presented here shows a few possibilities where the RVs excellent roll performance can provide the "quickest way out." This drawing presupposes that the pilot has a mastery of basic rolling technique.

Should you decide to abort the loop when well into the first quadrant, a series of two 180° rolls, or one easy 360° roll, will get you back to normal flight. A "normal" tendency would be to simply lower the nose back toward level flight. With an inverted fuel system this would be OK. With just a gravity carburetor, you'd starve the engine almost immediately and this sudden loss of power at an extreme nose high attitude would result in a deep stall, a stopped prop, maybe even a tail slide, and a potential spin. The rolling technique maintains a positive G force to keep the engine running and promote easier energy management.

If things are not going right when you enter the third quadrant of a loop, particularly if you're too near the ground, a simple 180° roll will return you to level with a minimum altitude loss.

In the fourth quadrant of a loop, your options are limited. Rolling won't help. The quickest way back to normal is to reduce power to prevent excessive speed build up, and apply elevator to return to level flight with a minimum altitude loss and without

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exceeding G limits.

## *AEROBATICS WITH PASSENGERS*

So, you now have an airplane capable of playing in the wonderful world of aerobatic flight; perhaps your first such aircraft. Flying aerobatics with a passenger in back should be about the same as with an instructor. If you took a short-cut and taught yourself aerobatics, there are some real surprises in store when you chose to take a passenger along. First, you may have had an idiot for an instructor and thus be poorly trained. Second, the weight of the passenger, particularly in a tandem seat RV, will significantly alter the C.G. and the pitch control forces will become much lighter. The added weight will reduce the aircraft's capabilities and increase the skill requirements. The bottom line is that there will be a much greater possibility of losing control and inadvertently overstressing the airplane.

Assuming you have done everything right in the training department and have unquestionable control over the aircraft for the intended maneuvers, there is another factor to consider. Many years ago, a good friend stated it concisely, "Just when you think you're sharing a mind-expanding experience, your passenger suddenly throws up." Don't get carried away. There are probably better ways to impress your friends than with your aerobatic prowess.

## *AEROBATICS BY PASSENGERS*

Almost 20 years ago when I first started flying the prototype RV-4, the first 2-seat RV, I was overjoyed by the handling qualities, particularly the ease with which rolls could be performed. I anticipated that a part of every introductory flight would be letting the passenger do a roll. It was so easy I reasoned that even a non-pilot could do it. "Imagine how impressed he will be when he can do a roll so easily on his first attempt," I thought.

Well, I soon received a baptism into the real world. I would explain to the rear seat passenger how the roll was done, and I would demonstrate one or two. Sometimes I'd even fly with the stick between my knees and my hands on my head, just to show how simple it was. When the passenger tried his hand, the results were dramatically different, usually frightening. Why? Because I was very familiar with the handling qualities of the RV-4, and I was skilled at aerobatics. The newcomer wasn't. It was as simple as that. I had conditioned reflexes acquired through many hours of practice; the passenger didn't. Even when the passenger had an aerobatic background, the results were sometimes bad. One of the worst rolls I remember included a 5G recovery—and he was a Pitts pilot. Another roll with a 3.5G recovery was at the hands of an aerobatic instructor with Decathalon experience. Does this mean that Pitts and Decathalon pilots are inferior? Does it mean that the RV is more difficult to fly? Not necessarily, on either count. It simply indicates that the RV is different. It also reinforces my point: you need to become very familiar with normal

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flight handling qualities before attempting abnormal flight.

I strongly discourage turning the controls of your RV over to anyone for the purpose of aerobatics. If you feel strongly motivated to do so, first assure yourself that this person has become thoroughly familiar with the handling and control response of the RV. Thoroughly discuss what he is expected to do, and exactly how to do it. Then, be ready and able to take over at a split-second notice. I know that this sounds overly dramatic; but trust me, the average pilot not experienced with aerobatics and with the RV will mess up the simplest of aerobatic maneuvers.

Aerobatics are supposed to be fun and exciting. Carefully plan your aerobatics so that they don't become TOO exciting.

## *OTHER AEROBATIC MANEUVERS*

There are many other aerobatic maneuvers which an experienced pilot can perform in an RV, many of which require inverted fuel and oil system. These include Immelman turns, horizontal eights, hammerhead stalls, vertical rolls, bunts, etc. One maneuver conspicuously absent from the above list is the Snap Roll. This is a maneuver I feel that the RVs are not well suited for because high G forces are needed to produce a brisk snap roll. The low stall speed, and thus low maneuvering speed, of the RVs limit the speed range in which snap rolls can be performed. The good stall characteristics of the RV's rectangular wing planform are not compatible with the asymmetric stall requirements of snap rolls. Our advice is to ignore snap rolls unless you have the counsel of a really great aerobatic instructor who is also very familiar with RVs. A careless approach to snap rolls can overstress the airframe and cause structural failure.

Please do not conclude from our emphasis that aerobatic flight is the only realm in which loss of control could occur. We all know better than that; landing approaches being a classic example. However, it is in the more aggressive forms of flight where loss of control becomes more probable. Another hazardous playing field is that of low flying and buzzing. Diving low passes and sharp pull-ups, while they may not be considered aerobatic in the same sense as titled aerobatic maneuvers such as rolls and loops, can involve a much higher element of risk because of their spontaneous, unplanned nature and the close proximity of the ground. When we analyze activities like these against the precepts of CONTROL and GRAVITY, we can easily see how the margins of safety become much, much narrower.

## *SUMMARY*

Aerobatics are supposed to be fun and exciting. They can also be deadly. The information here is not intended to provide you with a complete "aerobatics in five easy lessons" guidebook. It is intended to provide some guidelines, to cause you to

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think and carefully consider your approach to this more demanding level of flight.

We strongly urge you to include this article with your permanent aircraft papers, Operators Handbook, and/or Operating Limitations, so any other pilot who may own or fly the airplane can have it available for his or her benefit.

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Make a logbook entry indicating compliance with this service document per the requirements of the controlling authority/agency.

Place a copy of this notification in the back of the maintenance manual for your aircraft. Add the name and date of the service information to the Addendum Documents List at the front of the Maintenance Manual.

If you are no longer in possession of this aircraft, please forward this information to the present owner/operator and immediately notify Van's Aircraft, Inc. via email at registrations@vansaircraft.com. Please include the new owner's contact information and date the aircraft ownership transferred.

Information regarding establishing/transferring aircraft ownership, registration and licensing is available at: https://www.vansaircraft.com/gr/transfer-of-ownership/