

**Reno Air Racing**  
Pylon Racing School-Basics

By: C. J. Stephens

**Forward**

Pylon racing, Reno Style, involves flying an airplane at about 50 feet above the ground, passing and being passed by other airplanes while flying at maximum speed on an exact course in front of 100,000 spectators. The experience is both exhilarating and challenging with an opportunity to exhibit exemplary flying skills to a large audience.

Though the sport itself, by its very nature, holds risk I believe that with sound training, practical experience, keen focus, and good equipment the risks can be minimized.

There were many years of racing at Reno before the idea of offering a school came into being. PRS was developed to improve training and issue a license in an effort to maintain a high quality of the participants and improve safety for the spectators.

## The Challenge

The flight, except for the race itself, is fairly repetitive. The taxiing and ground procedures are always well briefed and very similar to each previous time. The flight always takes off in sequence, turns left and joins up in a right echelon formation. The flight, made up of 8 racers plus the pace plane, climbs, turns a short base leg, levels off and gets ready for the start of the race. As the anticipation builds within the racers and the crowd, this large formation turns toward the race course entry point with a shallow downhill run for the start of the race.

As the pace plane announces the start of the race the flight then transitions from formation flying to racing. The speed differences, as they proceed to the first turn, naturally causes the flight to start separation into a racing string. The need for care and attention is the greatest during this transition from a downhill flight of eight planes to a turning race at low altitude. Once around the first start pylon the flight will further string out since the airplanes flying on the outside of the turn have a slightly greater distance to fly. After that the race will rapidly develop. Once established on the racecourse it is a matter of flying precisely your desired path and passing on the right side anyone that you come upon that may be flying slower than you are. After 8 laps of the prescribed course and the leader passing the checkered flag, the race is over and each plane pulls up and off of the course to cool down engine and pilot prior to landing. There is some regimentation but each pilot is expected to be able to take care of his own problems and make important decisions with little help from anyone outside of the plane.

Since each race sequence is very much like the previous one the difficulty is the greatest for those that have

little experience. That is where the concept of Pylon Racing School becomes important. It allows each participant to get an exposure to what racing is like in a controlled situation with experienced instructors and none of the confusion and distractions of the Big Crowd.

### **Basic Formation Flying**

By the time that you arrive at PRS you should already be proficient in the mechanics of flying formation. The school is not prepared, and there is little time, to teach those required skills. This must be learned before arriving.

You should also practice formation with more than two airplanes prior to PRS. The Race flights will have as many as nine airplanes in echelon formation all moving in harmony. You will not want to be the one that is causing anxiety within other race pilots. So, get plenty of practice ahead of time.

By paying close attention to quickly detect any movement out of your ideal position, you then make an input only large enough to stop the movement. Early detection of movement up and down as well as fore and aft is important to formation flying. The input needs to be positive and large enough to make the correction but be ready to take out the input that you just put in so the airplane will not go right through the proper position and beyond. Of course this concept is working in all three axis at once.

When flying next to a good flight lead, as in the #2 position, it is not too difficult to get the hang of solid formation, since you really only have to consider the relative motion of your own airplane. However, as the number of airplanes increases in the flight you may be farther from lead with a lot more airplanes between you and the lead. A big secret in this is to take your

place in the formation and fly your position off of the lead allowing the proper lateral spacing between you and the adjacent airplane. This is good for the entire formation since it tends to dampen out the apparent motion of the flight rather than amplify it. While doing this you need to primarily focus on the leader but keep a constant vigilance on the adjacent airplane so that if it abruptly moves out you will be able to compensate and avoid any contact. Your position also needs to be as solid as possible since there will very likely be someone just outside of your position attempting to do the same as you are doing.

It is important to be able to fly a good multi-ship echelon turn smoothly without making abrupt movements. You need to be able to plan the power required during turns so that you don't fall behind at the beginning, or get spit out the front of the formation upon roll out due to the speed that you gained by flying on the outside of the turn.

### **Race Preparation**

This is *RACING* so it stands to reason that your competitors will not wait for you. Therefore, it is incumbent upon you to have your plane fully prepared to fly with the fuel necessary, preflight complete and all of those details well in advance. Any last minute excuses such as "the fuel truck broke so I could not make the start", will only be met with joy from your competitors since you then would not be a threat to their success.

Be mentally prepared. Know your cockpit setup for racing, like mixture settings and all of those little things that you will want a certain way. Race day has a lot of distractions so a checklist may be in order to help on this. If you use a pit radio perhaps a checklist called from your pit may work so you won't

have your head down during a large formation race start.

Try to keep your mind free. Have someone else handle the hotel, food and ground transportation details so you are not distracted. Mentally go over every detail of the flight so that it is very clear in detail and sequence. Review emergencies. Have the plane out on the ramp and ready to go well before start time. Be ready to taxi in order as briefed. Make the radio calls sound sharp. A flight that sounds good on the radio will do better in flight. Above all stay heads up and alert to changing situations.

### **Radios**

A radio is required for flight so we don't need to review hand signals in this text. It is required that during flight the pilot monitor race control frequencies so if you plan on communicating with your pit, or spotter, then it will require a second radio.

A great amount of information comes over the radio that may not be directed to you but is useful in forming a picture of what is going on with the situation around you. Don't miss the opportunity to use this information. There are calls such as "no visual contact" or " I am overshooting" or calls that affect others but may also affect you. So listen to all calls. This information should all be taken in and considered for own situation to be used for total awareness.

### **The Join Up**

The flight join up seems to be one of the more difficult things that is required at the Reno Air Races. The difficulty stems from many pilots not

understanding and using the advantages of 'cut-off' for turning rejoins. If 'cut-off' is used properly it makes a difficult maneuver (the join up) work very well. If it is not used well things start to go wrong quickly. It not only makes it difficult for the pilot who is not effectively using cut-off but it multiplies the problem to all of those airplanes who are in the flight behind the offender. Unfortunately, we tend to have most of our practice join-ups as two ship flights. They usually get done quickly and seldom with large distances between the flight lead and the joining airplane so the true test is never brought out as well as it will be with the full race formation of nine airplanes.

So, I will be very purposeful here and talk specifically about the nine-ship rejoin, as it needs to be done at Reno. All join-ups are done in a left climbing turn. The flight members will pass behind and below the flight as each join to the outside in right echelon formation. Normally the flight has rolled out of the turn and is leveling off when the last of the flight gets joined up. Departures from runway 08 are a flatter climb than departures from runway 26. The Runway 26 departure starts with a 90-degree right turn followed by a slow 180-degree turn. There are other options for departures but the two mentioned occur nearly all of the time.

The ground movement details are usually well briefed and easily understood so I will not use this text to review them. We will pick up the join up from the start of roll by the pace plane. Each flight member needs to minimize the spacing at brake release. It may not seem too important as #3 or #4 but if you are sitting in #8 position the total spacing that you will need to cover to get aboard the flight can get excessive. So each flight member needs to start take off roll as soon as it is feasible. Know how many airplanes are ahead of you and attempt to keep all of

them in sight. That is another good reason to minimize spacing. The pace plane will go straight for a distance to allow each racer to have a chance to use cut off for join-up. As soon as the pace plane starts the left turn (usually with a radio call) all flight member needs to start a turn also. This will be very soon after lifting off for the later airplanes. Do not spend excessive time with cockpit duties since the more important responsibilities are with a safe join up. As you maneuver your airplane to get established on the 7:30 (o'clock) position of the pace plane you need to visually pick up all flight members ahead of you. This is challenging but important. Most important are the one or two that are just ahead but all are important. Allow your airplane to accelerate to 20 kts above the briefed join-up airspeed if possible. If you can't get that much airspeed just do the best that you can.

Most important is to get on and stay on the 7:30 line. I will refer to being 'cold' if you allow your relative position to be too much toward the 6 O'clock line, and 'hot' if you are too far toward the 9 O'clock line. Once on that imaginary 7:30 line your bank angle will be about the same as the pace and if your airspeed is about right you will slide right up the line toward the formation. The problem arises when you get off of the line either too 'hot' or too 'cold'.

If you are too 'cold' then it will take amazing amount of power, speed and time to join up. Your fellow racers will then want to pass you by and be waiting in the formation when you arrive there later on. So it pays to not get cold which is especially true if you can't get the desired amount of indicated airspeed. What to do about it? Let's say you got airborne as #8 and have all in sight ahead of you but see that you are about in the 6:30 position of the pace plane. Here is what you need to do. Keep your speed up to desired or higher. Increase your bank and increase your turn rate so that your nose position is well ahead of the pace.

You are effectively taking a short cut across the circle. Keep monitoring all of those ahead of your position and any that may be to the left of you. Monitor the clock position of the pace. When you have changed to the 7:30 line allow your heading to be closer to that of pace. If it looks like you are getting toward the 8:00 O'clock line then reduce your bank and you will slip over toward the 7:30 line again. Continue this logic until you close to near maneuvering range and finish the join up.

Too 'hot'? The other problem of being too hot can also exist. First if you are too hot you will be joining up quickly and most of the other flight members are going to be hard to see since they will be level to you, under your nose, and joining up slower than you are. So some danger exists in 'hot' join ups. If you are too 'hot' as exhibited by looking right down the pace planes wing line (by being in his 9:00 O'clock position) you need to fix the problem. While you keep the other flight members in sight roll out momentarily. The change happens fast but you will change from 9 to 8:30 to 8:00 to 7:30 line pretty quickly. As you approach the 7:30 line increase your bank angle more than pace planes bank angle to get your nose out in front of his. This turn needs to aggressively put your nose ahead of the pace plane. If done insufficiently then you will rapidly move to a 'cold' position and have to deal with that side of the problem.

I have included a few photos of what it looks like from the different perspectives of being on line during the join up and what it looks like when things aren't going just right also.

Too hot!





About right



Too cold



Way too cold!

Take note of the relative position of the right wing tip with the rudder. This is the best way to detect the relative bearing you are from the pace plane.

When you first discover that you are too 'hot' you will have the feeling that you want to reduce some power to slow things down. You are better off to maintain good power and the proper airspeed since when you get arrive on the 7:30 line (assuming that you fix the problem) you will need the proper airspeed.

In the "perfect" join up it looks like a string with all of the airplanes just sliding up the 7:30 line toward the pace plane. As each plane approaches the pace, it slides just behind and below the entire flight and takes up its rightful position in right echelon.

As you close to about a hundred plus feet behind (and still to the inside of the Pace plane) maintain an indicated airspeed about 10 Kts greater than the pace plane, it is time to cross to the outside of the formation. This is done absolutely behind and slightly below all flight members. If you arrive at this point with an excessive airspeed NEVER be even tempted to throw a wing up and try to stop on the inside. Instead

turn slightly right and slide below and behind all airplanes. As you pass to the outside your extra airspeed will *apparently* dissipate since the flight is still inside of your turn. Continue moving toward the outside until your forward motion stops and your airplane is stable with respect to the flight. Then you may carefully move into your assigned flight position. If you were to attempt to stop in your slot directly, instead of going clear outside of everyone, you would be belly up and blind to the outside flight member which will seriously threaten the safety and success of the join up. That sort of flying will bring great admonishment upon you from everyone.

If you arrive after a member with a higher flight position (i.e. you are #6 and #7 arrived before you) the other racers are supposed to leave you a space. Once you have stabilized you may maneuver into your assigned position. If insufficient space is available a radio call may be necessary to sort it out

Very likely, the last few airplanes will be joining up after the pace plane has rolled out of the big left turn leaving no choice but a straight ahead join up. These are done with airspeed advantage, which is hard to gain in the climb. If this happens to you it may be a good idea to remain in a flatter climb for greater airspeed until getting nearer the flight, then climb to reduce airspeed and join up. Maintaining control of speed in a straight-ahead join-up is the important thing. Your initial airspeed needs to be high, like 20-40 knots greater than pace, but as your range diminishes the speed advantage needs to be reduced so that you are able to stop without overrunning the flight. Be especially vigilant and look all around during a straight-ahead join-up since you may not be the only one doing this and the other guy may not be looking.

Always stabilize your airplane with matched airspeed and heading before attempting to finally join up. Sometimes closure is deceptive and speeding right through the formation is just not allowed and quite dangerous. So, what do you do if you arrive at the flight with a lot of extra airspeed and there is any doubt that you will be able to stop your forward motion? The answer is just move off to the right of EVERYONE and pass level but wide enough to keep everyone in sight. You need to slow and stabilize your plane, then slowly move back to a line abreast position still maintaining visual contact with everyone from your wide right position. Then, only when you are clear of others who are joining up and provided a space is left open for you, it is OK to move into your assigned flight position.

### **Echelon Formation**

By definition all wing-men are on the same side of an echelon formation. All turns will be made away from the echelon. The greater the number in the flight the more deliberate the roll in and roll out becomes. All flight members 'stack level'. To stack level means that everyone's helmet or windscreen, if you can't see the helmet, will be on the horizon. Now if there are mountains this means where the horizon would be if you were over an ocean. The Echelon formation can be flown from line abreast to the wing-men back up to 10 degrees. The preferred lateral spacing depends on your comfort level, which depends on several things such as experience, aircraft stability, and turbulence. We are not in the formation show business so a very tight position is not required. You have many cockpit duties in getting ready for a race so 3-4 wingspans out is good spacing. While performing cockpit checks deliberately do one item at a time paying most of your attention to the formation.

During the turns there is a tendency to want to fly a higher position. Avoid this tendency. If that was to be done the outside airplane already at a speed disadvantage would have to climb a great deal and when the flight rolled out it would be quite difficult to descend, slow down and maintain position. As the echelon turn starts each plane matches the bank of the pace and maintains the lateral spacing while adjusting the power to maintain fore and aft position.

Avoid abrupt movements especially in pitch. Remember there is someone just outside of you that will have to move right with you. Any rapid movement in bank or pitch will startle that pilot and cause a chain of jerking movements that will ripple clear out to the last wing-man. It is important to focus on formation and avoid doing any cockpit checks during echelon turns.

### The Nine Ship Turn

Usually about the time the last racer joins up it is time to make a 90-degree turn for the base leg to the racecourse. This will be followed by a second 90-degree turn for the final heading to the racecourse. These turns can be challenging depending on how much experience you have in such things. Usually there is considerable turbulence given the proximity to the high mountains with the normal desert winds.

The biggest difficulty with a nine-ship turn is due to the need of the airplanes on the outside of the turn going farther in the same amount of time. This means that they must fly faster. Then upon rolling out of the turn the outside planes have too much speed. Of course the wider the formation is spread out the more this becomes magnified.

The pace plane usually gives a 20-second warning prior to the turn. At this time you should add some power.

This should be done aggressively since airplanes don't exactly jump forward when power is added. How much power? That depends on how far you are out from the pace plane. His turn will be entered slowly and the bank will be shallow. The airplanes farthest outside will need to add a lot of power.

Keep the lateral spacing the same as it was during level flight. If you use less bank than the pace it will falsely appear that you are doing fine, but you are actually getting wider and steadily farther back. This becomes apparent as the flight rolls out and you see that you are way behind.

A 10-second warning to roll out is sometimes given but you can see the desired heading as it approaches. By judging the amount of airspeed that you had to gain upon entering this turn you will have a pretty good clue to how much you need to loose at roll out. Be aggressive about these speed changes so as not to get too far forward or lag behind.



Note the varied bank angles but good spacing

### **Down the 'Chute'**

As the second 90-degree turn is nearing its completion the pace plane will announce a speed increase. This actually helps the outside racers since they are still

dealing with the increased speed left over from the turn. There is a slight drop in the nose attitude and the flight will begin to accelerate to the release airspeed, which is briefed each day. The flight then slowly moves up to a line abreast formation, which will be held until the race is released for the start. Here it is important to continue to maintain a level stacked formation. The photo below shows a good formation just prior to release.



Note the line abreast alignment and level stack

The pace plane occasionally makes comments to individual flight members to dress up the flight for safety and fair start issues. If someone was having trouble maintaining formation that might jeopardize a safe and fair start then he will be directed to drop 500 feet behind the flight and remain there until the start.

### **Wake Turbulence**

There are two types of turbulence that will effect your flights. By the nature of the location on the Western desert there is considerable turbulence. On hot days there is the plain old thermal type. The winds also seem to consistently blow and cause moderate turbulence especially around the mountains during the route to the race course. This becomes quite noticeable with a large formation but the motion of the entire flight bounces together. This does require close attention to

maintain proper formation. Once on the course there is the additional factor of turbulence created by other planes. In the sport class this turbulence is manageable but it helps if you don't fly directly behind another plane; instead fly slightly high of the flight path.

### **Formation to Race Course**

Those famous words: "Gentlemen you have a race" along with the abrupt pull up of the pace plane are the signals that you have a start of the race. This is time for caution though. It would get pretty hairy if every racer looked straight ahead and went for the start pylon. It would get equally hairy if some racers pushed over to gain airspeed in a run for the start pylon. So certain procedures must be followed to get a safe start.

The formation that was just released by the pace plane must keep flying formation. The pilot of the pole airplane looks straight ahead and becomes the flight lead of the group. Each racer keeps flying formation during the short flight to the start pylon. The speed differential of the various airplanes will start to string out the formation. Looking around to pick up all that are around you is an important thing. It is possible that an airplane on your right has moved out ahead of you and is angling in toward the start pylon, therefore, it is also important to look to both sides of your flight path not just to the left.

As you approach the start pylon there will very likely be 3 or 4 airplanes still without safe nose tail separation so the turn needs to be flown as a formation with the person on the left being the lead even though he may be slightly behind. After the turn the group will continue to string out and become a race. It is not impossible that several turns will be made before

you will be clear of the ones that you were with at the start.

### **Flying the pylon course**

Be predictable!! It is important to do what others are expecting you to do. Everyone will be looking for you on the course passing close to the pylons. So don't get inventive if you encounter a situation that is unusual. Let's say that you are going very slow, for example, and you are concerned about the others that are coming up behind you at great speed. Just keep flying your normal position on the pylons; low and tight. Your being there is no problem. The overtaking airplanes will just whiz past you, on your right, and that will have little effect on their lap time. But if you were to try to fly wide or high, it throws off everyone. You are hard to see and they still have to go around you on the outside. So just do the predictable thing and fly the course. The passing planes will be looking for you in your normal predictable location.

If you make a bad turn and get off of the course, be very careful about coming back to the course. Once you are away from the normal line you are no longer predictable and will likely not be seen by airplanes that are coming up behind you on the course. If you get excessively wide or badly cut a pylon and figure out that you are no longer in the course confines you need to consider leaving the course and rejoin in the normal fashion. If you were to reenter the course from your present position do an extremely good visual clearing for any approaching traffic.

### **Cooling down**

At race end (that is the first time you cross the home pylon after the winning airplane crosses) you should pull up and turn left into a cool down orbit located over the racecourse. It is best to follow the airplane



that was just ahead of you on the course, unless of course if you were first. The orbit is an area for serious potential danger. Not everyone manages to fly the same orbit and that can lead to conflicting flight paths. Keep a sharp look out for all traffic; it can come at you from about any direction. The rules and procedures pretty well cover the methods and options for recovery so I will not belabor it here.

### **Emergencies**

Emergencies, due their nature, are probably one of the biggest concerns of the Reno Race Pilot. This text is not nearly large enough to go over all that can happen during a race. It is up to the pilot to know his airplane, be able to operate under stress, and make intelligent decisions and operate the airplane well. One of the most talked about emergency is an engine failure. It happens with regularity. You must be able to deal with it at any point on the course. Since the flight path is very predictable you can pre-plan your maneuver at any point on the course should you loose power. I recommend that you mentally review your emergency landing options every time you fly on the course until it becomes second nature.

One thing that is universally reported by all that experience a serious emergency on the racecourse is denial. The thought 'this can't be happening to me' is very common. This loses valuable time in solving the problem. You need to have it clearly in your mind what your first several steps will be at the first sign of an emergency. Then act on them and don't waste that 'denial time'. The energy that you had at the time you started losing power is all that you are going to have. It should be sufficient to get you to an altitude from which a safe landing can be made. However, if you waste just a few seconds trying to deny or analyze the problem rather than just going for altitude and landing, your chance of success diminishes rapidly.

Your forward speed is your friend and if it is reduced during indecisive delays, you will not get the altitude needed to make a successful emergency landing on one of the many runways available.

Therefore, if you feel an abnormal rumble, shudder, backfire, wobble, nibble or anything unusual immediately go into your "Mayday" mode. That should be something like this: 1. Pull sharply up and turn left. 2. Start to plan which runway you may want to use and fly to intercept a flight path to land on that runway. 3. Declare a Mayday. 4. Depending on the nature of the problem you might switch tanks; push mixture; turn on boost pump; check magnetos are still on; 5. Push on the throttle to see if the engine is still making any power at all. Use it if you need power. 6. Pull the propeller back if engine is dead. 7. Expect it to not glide as far as you thought. 8. Gear and maybe flaps if you want that drag. 9. Try to clear the runway if you landed on one (but clearing is just optional).

Don't get locked into attempting to land on the runway that you took off on. At the speeds that you will be flying you may not be able to make it to that runway and you may not be able to get to a runway into the wind. So find a smooth flat surface that you can make and go land on it. It will be the better option.

*Fly fast, turn left!*



#### **About the Author**

C. J. Stephens raced a Hawker Sea Fury in the unlimited division for 14 years at the Reno, Denver, Phoenix, and Kansas City Air Races. He currently flies a P-51 as safety pilot during Unlimited practice at Reno and is the

Pace/Starter/Safety pilot for the Sport Class Division. He has been a primary instructor with the Pylon Racing School since its inception. His fighter pilot career included 3,000 hours in an F-4 Phantom for the USAF until he retired at the rank of Lt. Col. in 1980. During his Air Force career he served two tours of duty in Viet Nam where he completed 232 combat missions. He is the Test Pilot for C.A.F.E. Foundation Inc. and in that capacity flew numerous flight tests on Experimental Aircraft. The reports of those test flights were published in Sport Aviation Magazine issues from 1990 through 2002 and can also be viewed @ [cafefoundation.org](http://cafefoundation.org). He is an ATP, CFI, with an All Types Piston Power Single and Multi. rating to go with his 12,000 hours flying experience. C.J. built and presently owns a Glasair III.