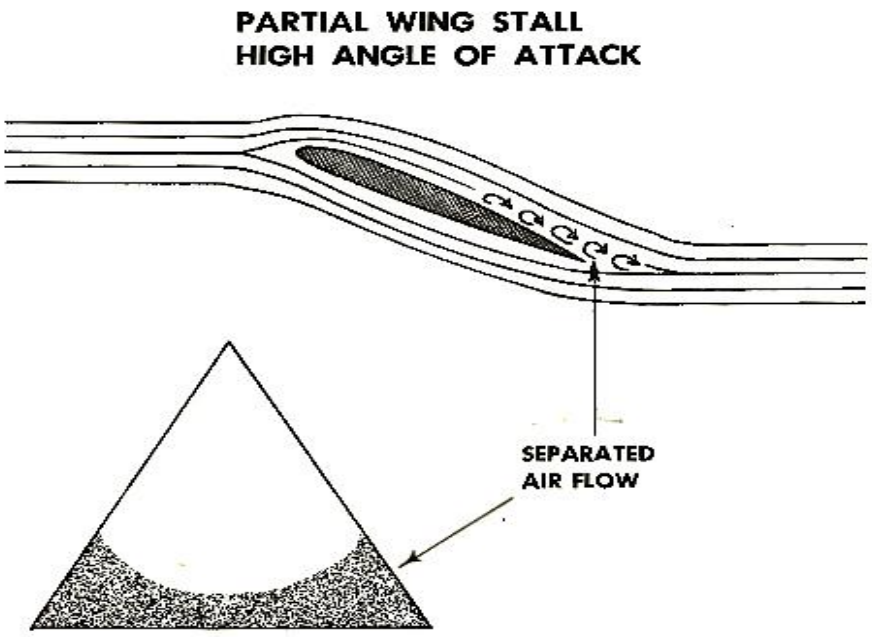
By Roger G. Crewse Headquarters ADC/SEY

Since taking over as Chief of ADC's Safety Education and Analysis Division in 1959, Mr. Roger G. Crewse has presented his knowledge, expertise, and 15 years of 'fighter pilot experience to our operational units in a unique and highly informative way. Roger has a way of dispensing with the "frills" and getting down to the "nitty gritty" in terms that his fellow fighter pilots readily understand. Most "Deuce" jocks vividly remember his treatise on "F-102 Compressor Stalls," and there are few F -101 crews who will not forget "the Crewse approach" to pitchup. More recently, Mr. Crewse has traveled to the F-106 squadrons to discuss "Control Loss" with aircrews. Numerous "Six Jocks" have since reported using Roger's words to great advantage in the ACT program, and one pilot who recovered from a spin admits using the instructions he remembered from the "F -106 Control Loss" briefing.

If you happened to miss Roger when he came by your squadron or would like to refresh yourself on this critical subject, we present this "typical Roger Crewse briefing with frills trimmed off" in his own inimitable style. Maybe the next time you've got the "pointy end" going sideways, you'll recall what he has said here and be able to "save your bird."

F-106 out-of-control maneuvers have definitely reduced in frequency during the past year, but they continue to occur. We have pretty well established that the recovery procedures now listed for post-stall gyrations/spins work as advertised. This is good, of course, and because the procedures do work, we have prevented two and possibly three major accidents in the last fourteen months. The basic problem, however, the one that really needs attention, is how to avoid the out-of-control condition in the first place. This article will discuss situations where control losses have occurred and can occur with little or no warning; and the symptoms which may precede the control losses under conditions of max maneuvering.



The F-106 does not have *one* symptom that can always be counted upon to telegraph to the pilot that a loss of control is imminent. If this were true, the job of knowing when enough is about to be too much would be much
easier.

Through the examination of some forty control losses, we have noted aircraft actions which will usually be present to some degree depending on the maneuver and which will presage an impending loss of control. Some of these symptoms are quite subtle. Some are much more noticeable, and, unfortunately, under certain conditions, they combine. The trick is to expect the specific one for the maneuver you have entered and then notice it when it occurs. This must be done even though you may be in the kill, kill, kill mode, with the adrenalin glands in the full-go configuration. Most of our control losses have occurred right when the "lossee" is in the position for the kill, whether it be in ACT or with the dot buried, pressing on, or he is in a stalemate and decides a double shunt is called for.

The first control loss entry we will discuss, and perhaps the simplest of them all, is one entered from coordinated flight. The aircraft can be in any attitude, e.g., steep turn, high climb angle, inverted ... makes no difference. But the aircraft is essentially in coordinated flight, not rolling, and *at a high angle of attack*. The first symptom, of course, the classic one, is an increasing buffet level. Now light - moderate - heavy buffet is a very subjective judgment. What may be a light buffet to one pilot may be quite heavy to another, but regardless of how it feels, as the buffet increases, so does the angle of attack. Buffet is a sure indicator that separation of the air flow is occurring on the wing. In other words, part of the wing is stalling.

The buffet level may increase to a point, then start to decrease. Don't rely on this symptom since it has never been reported by any of our aircrews who have lost control; but its cure, if you do experience it, is to go forward with the stick. At this point, the center of lift is moving forward. Much of the wing is stalled inboard from the tips, and stick forces may actually be lightening since the aircraft has a tendency to pitch up. The G forces will be decreasing with a constant back pressure because total lift production is decreasing. If you intend to hold a G level or even increase it at this point, a rather interesting ride will follow - almost immediately.

A good way to get into a serious situation, wings level, high altitude, low airspeed, is to move the stick briskly aft. Chances are, even if you stop stick action and reverse it, an overshoot will occur, which will take you flat beyond the stall level.

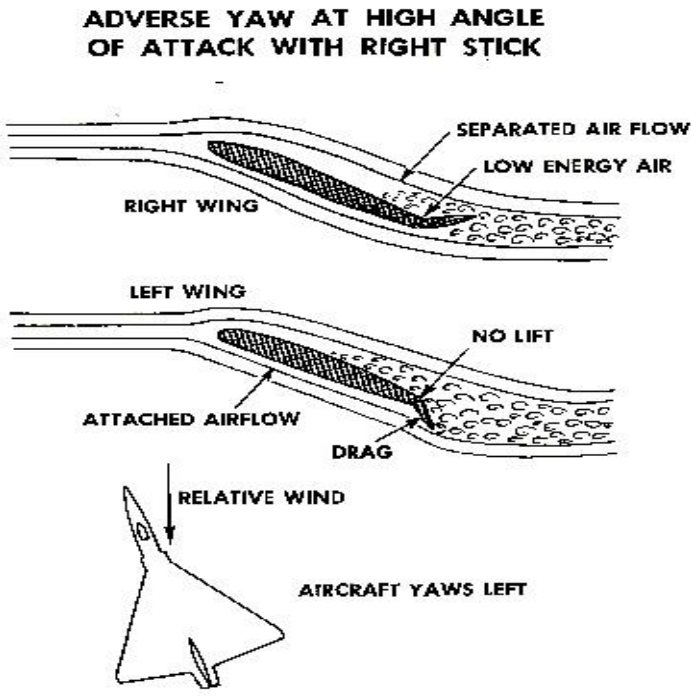
Going back to our unaccelerated stall, along with the decrease in buffet level, as you increase the angle of attack, a yawing motion will begin. It will be minor at first but gradually increases in intensity. Finally, the yaw will cause a rolling motion to begin. The reason the aircraft is starting to yaw is because vertical stabilizer effectiveness has been reduced to practically nil. Separation of the air flow in the aft portion of the wing, the large downwash angle over the wing, with low energy air in the vicinity of the rudder, causes the vertical stabilizer to be blanked out as a stabilizing device.

The rolling motion is caused by the yaw. As the wing is yawed into the relative wind, a roll, of course, results very much as if you had applied rudder.

The next step, if the angle of attack continues to increase, will be a roll off against the direction of a steady bank; or, if wings are level (either inverted or right side up), an increase in yaw rate with an accompanying roll. Right at this point, you have probably 'been "had." If any control inputs other than forward stick are introduced, the aircraft will pitch up rapidly, yaw violently, and the name of the game is to recover. Those control losses which have occurred here are primarily the result of the pilot's attempting to fight the roll or yaw with aileron or rudder. What was really needed was forward stick while holding all other controls neutral. These pilots were far beyond the max maneuvering capabilities of the aircraft and were not aware of it.

Here are actual examples where the control loss entry was from situations such as those described above:

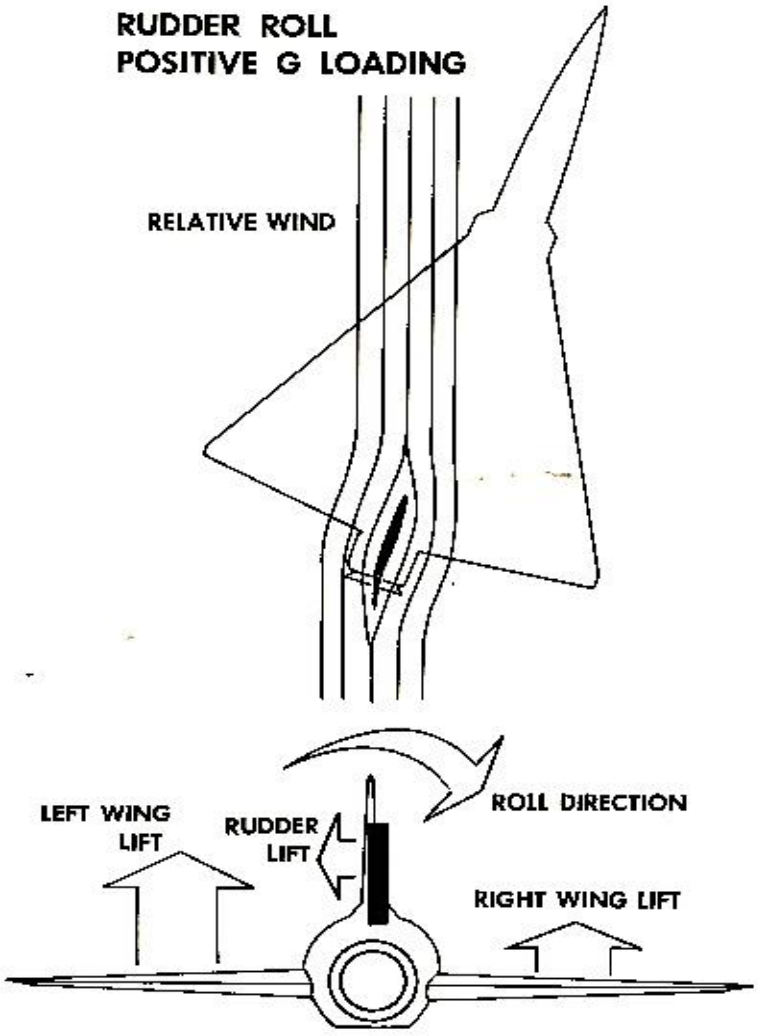
- The pilot was committed on a front intercept at 37,000 feet against a target at 40,000. Speed was .93M. Contact was at 33 miles, followed by lockon at 28. The pilot forgot to select armament. He was also flying in auto. This was the first auto attack the



pilot had ever flown in the F-106. He became engrossed in the scope presentations and did not watch his airspeed or adjust his throttle. When the countdown did not occur, the pilot began to realize that something was wrong. At five miles from the target, he decided it was time to get out of there. He depressed the momentary interrupt and applied left aileron. The aircraft yawed violently to the right and entered a spin at 39,000 feet. Recovery was made at 15,000, and a much wiser pilot flew home.

- This pilot was on a high-altitude front attack against a target at flight level 490. He got a contact at 25 miles and locked on at 19. He was slightly left of the course to intercept. He corrected right to center the dot. The radar broke lock at 16 miles, and he locked on again at 10 miles. He pulled up to center the dot, and at about five seconds to fire, the dot went to the right. He used rudder to center it as he felt the aircraft was very near a stall. He was in what he described as a moderate to heavy buffet. The nose continued to yaw left and right, and the pilot continued to use rudder to keep it centered. At approximately 47,000 feet, at fire time, he saw he had 140 knots, but the airspeed was decreasing rapidly. The aircraft yawed, rolled rapidly to a 90 degree left bank, shuddered, and the pilot noted zero airspeed. Recovery was made between 25 and 30,000 feet.

The next control loss situation concerns those which occur when the aircraft is being rolled at a high angle of attack. A rudder reversal (during which the majority of control losses have occurred) with a loaded aircraft from, say, 90 degrees right bank to 90 degrees left bank is typical. The control loss usually occurs as the aircraft approaches the wings level position, whether the roll is over or under.



In the first place, this maneuver is performed because the aircraft is at a high angle of attack, and adverse yaw would occur if ailerons were used for the maneuvering. High G loadings are usually present so that the aircraft will roll at a high rate. Lots of Gs are not necessary, however, for a high angle of attack to be

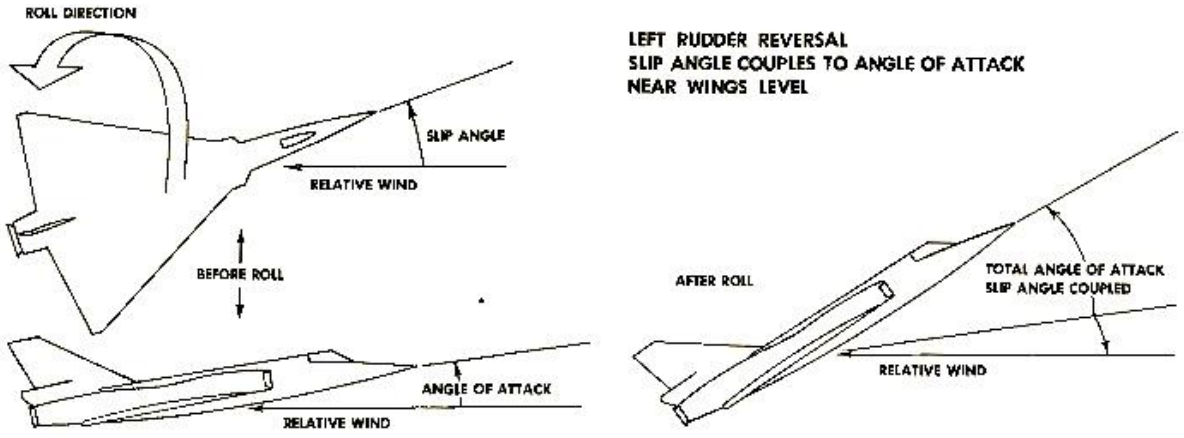
present. If the airspeed is low, of course, the angle of attack can be extremely high with only one G. Adverse yaw would certainly occur if ailerons were used.

The roll usually starts as advertised with mild or moderate buffet present. As the wings near the level attitude (right side up or inverted), aerodynamic coupling will occur. The slip angle you introduce to start the roll couples aerodynamically, in part, to the already high angle of attack, which made this method of maneuver necessary in the first place. Here the symptoms are very subtle. A sudden increase in buffet will occur, but it is not of a magnitude that will really get your attention unless you are waiting for it. If you are, then you will feel it. Chances are, if you are at a high enough altitude, the airspeed will be decreasing at the same time. If you maintain the same G level by the "old feel," you also will be increasing the angle of attack yourself. If some back pressure is not released at this point, the aircraft will suddenly snap into the direction of the roll. When this snap roll occurs, you have just had your control loss. The snap roll occurs because the downgoing wing has stalled. The upgoing wing has not. The tremendous lift differential between the downgoing wing, which is stalled, and the upgoing wing, which is still flying, will result in an increased roll rate. So fast is this roll that one we saw on scope film couldn't be measured - just estimated. It even watered the eyes of those of us looking at the film.

A good procedure during high angle of attack rudder reversals for pilots who are in the learning phase is to unload the aircraft slightly as the wings level attitude is approached. This procedure will neutralize the effects of aerodynamic coupling. Then, after you have gone beyond wings level about 10 or 15 degrees, bring it back in. The undesirable aspect of this procedure will be that the roll rate will reduce slightly as you unload the aircraft. But the procedure will avoid that extremely rapid roll rate produced by a snap roll. It will also give you some room for error while you are getting the feel of your bird under these unfamiliar flight conditions.

Mechanical rudder reversals, where the aircraft is loaded up while in a bank, and then full rudder is introduced with all controls held steady until reversal is complete, may change your way of life so fast you will scarcely recognize it. Mechanical rudder reversal should be avoided. Fly the airplane. Don't let it fly you.

We spoke earlier of control losses which specifically occurred during rudder reversals, but they have also occurred during normal high angle of attack rudder maneuvering. If the aircraft is rolled fast



enough, at a high enough angle of attack, the downgoing wing, which is having its stall angle of attack reduced by the side slip necessary to start the roll, is also having the angle of attack increased because of the rate of roll. If the increase in the angle of attack is sufficient, or if the initial angle of attack was high enough, the downgoing wing may start to stall. This, of course, causes it to lose lift. The pilot will note the phenomenon by a tendency for the aircraft to increase its roll rate, although there has been no increase in control inputs or the aircraft may tend to keep rolling after the rudder is taken out. In either condition, a snap roll is very near.

Once again, these are quite subtle symptoms, and if the pilot is not expecting them, he may not notice them. If this tendency for auto-roll is present and the pilot attempts to combat it by opposite aileron or even opposite rudder, which would seem reasonable under the circumstances, all sorts of exciting things may happen. If aileron is used to combat it, a yaw increase into the roll will occur, caused by the aileron deflection. The stall angle of attack of the downgoing wing will decrease further, and the roll rate will increase due to the increased side slip angle. The net result may be a snap roll because the downgoing wing suddenly gives up and stalls. The avoidance of this maneuver is simple: forward stick with all other controls neutral.

But you must be sensitive to the symptoms when they do occur and expect them to occur when the maneuver may border on the limits. Examples of control losses associated with rudder rolls are as follows:

- The student pilot was in one aircraft with an instructor pilot in the other. The instructor demonstrated a rudder roll. The student pilot then attempted one. He was in an approximate 90 degree bank. He loaded the aircraft up to moderate buffet and introduced full left rudder. As the wings neared level, a snap roll resulted, followed immediately by a post-stall gyration. Normal recovery was initiated. The instructor pilot advised the student pilot that he had used aileron, which had caused his problem, and to try the roll again. The student pilot increased his airspeed slightly, placed the aircraft in a 90 degree bank, and started a rudder reversal again. He loaded the aircraft to moderate buffet, introduced full left rudder, and, as the aircraft approached the wings level position, it again snap rolled to the left. This time a fully developed spin resulted, which was very difficult to recover from using the procedures we had then.

- During an ACT engagement, the pilot executed a hard left turn in pursuit of the other aircraft. The turn was entered at 30,000 feet at approximately 350 knots. The pilot increased the load to approximately 5 Gs and applied left rudder. A sudden left snap roll resulted, followed by a fully developed spin. The pilot stated that just prior to the snap roll, he felt a slight uncommanded increase in roll rate.

- During ACT, another pilot initiated a hard left rudder roll at engagement. When he had reached approximately 70 degrees angle of bank, he attempted to reduce the roll rate and found that the aircraft wanted to keep rolling. To stop the roll, he held rudder and slight aileron against it. The aircraft immediately yawed sharply, pitched up, and entered a spin.

- The pilot was on a high-altitude snap-up mission with a late lock on and high angle off. As he attempted to maneuver the aircraft to center the dot, he used aileron at the beginning. He

then changed to rudder as airspeed bled off and the buffet increased. The nose yawed abruptly, followed immediately by a snap roll. A spin resulted.

In all types of maneuvering at a high angle of attack, when aircraft actions occur which are uncommanded by the pilot, the only recourse is to unload the aircraft. Zero G is the place to be when you have doubts as to your ability to fly out of a mess. It must be remembered, though, the aircraft will stall negatively. While the negative post stall is not nearly so dramatic as the positive one, the aircraft will not fly while stalled negatively either. If you have zero G, which approximates zero angle of attack, you will not stall. A normal reaction when the sudden terrible realization that you are about to lose control occurs is to fire wall the stick with both feet on it if necessary - negative overstress and negative stall are a distinct possibility if you do so. Tenderly is the way you do it, and zero should be your goal.

In summary, no one has ever suggested that flying a Century series fighter at or near the limits is easy. To do it requires knowledge, technique, and skill over and above that required for any other type of airplane herding. The very nature of the maneuvers required by our mission will, inevitably, if pursued *mechanically,* result in a control loss *every* time.

The full capabilities of the F-106 have been explored only in the last few years. The procedures established for our ACT are good ones.

There are "by the numbers" control inputs which cause the aircraft to attain maximum performance. There are "by the numbers" control inputs to recover the aircraft if-you slip beyond the limits. There are no "by the numbers" procedures to tell when you are about to slip beyond the limits. Combinations of maneuvers cause combinations of prestall symptoms. The individual characteristics covered above may be so well masked that none are purely evident. For instance, a buffet level which was found to be perfectly acceptable when not rolling, may result in a control loss every time when the aircraft is rolling. Buffet is not a good indication under all conditions. If the aircraft is maneuvered in roll or if there is a slip angle present, *do not* rely totally on buffet to keep you out of trouble.

When rolling, the aircraft may tend to increase its roll rate into the bank without control inputs, but - if you stop the roll, it may immediately try to roll or yaw against the bank. Therefore, to gain control, in addition to stopping the roll, you must also reduce the angle of attack.

An aileron input at high angles of attack will always cause adverse yaw (yaw against the application). Yet, if you try to stop a rudder roll with ailerons, you roll faster. If ailerons are used in an attempt to stop a roll-out from a steady
banked, high angle of attack, level turn, you may yaw into the roll. This may actually increase the overall angle of attack due to aerodynamic coupling.

Gs are normally an indicator of high angle of attack. But three-quarters of a G may be too much, depending on your airspeed. Bleeding off airspeed also bleeds your G capabilities: Five Gs might have been just fine at the beginning of the maneuver, but only seconds later, with you looking over your shoulder maintaining the load by feel, they may put you right out of control. Gs can only be used as a gauge when there is no change in airspeed.

There is one critical angle of attack where control loss will always occur. This angle of attack can be reached with 6 Gs or one. It can be lowered by the maneuver you are in, but it can never be increased. Critical angle of attack can
be reached by aerodynamic coupling with little or no warning. And - the angle of attack is the only thing which affects the aircraft. If the stall angle of attack is reached, a control loss will always occur.

When you fight using a machine, two basics are necessary. You must know your capabilities and limits; and you must know the machine's capabilities and limits - prior to the battle. There is only one way to gain this knowledge, and that is through training.

And, finally, as one of our Generals has said, it makes little difference if you get shot down or spin in. We have lost the combat capability of the weapon, and, probably, we have lost you, too.