Keeping Cool Through Upset

Unusual **attitude training** requires an airplane

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P-51 Upset Training (nose low, inverted)

JETUAT

It has been a routine trip capped off by a routine instrument approach to your favorite big city airport, say San Francisco International (SFO), in the winter. The gear and flaps are down and the 1,000-ft. chime announces you are about to get to the most critical part of the flight. Two miles ahead and to one side on a parallel runway an Airbus 380 wanders off course. Seconds later, and quite alarmingly, you're unexpectedly inverted with the airspeed headed up and the altimeter headed down. Can you survive?

Upset recoveries have been a hot topic for several years now and most pilots with a fair amount of simulator time will tell you they know what to do. (They probably believe that, too.) The sad truth is that unless you've been trained for upset recoveries in an airplane, you are probably unprepared to deal with the three related factors that can kill you. First, you must be able to execute the correct recovery procedures without making a mistake, even when the upset comes when you least expect it. Second, you must combat your natural instincts to pull back on the yoke or stick and know how to unload the airplane to just over 0 g. And the third factor is one most pilots are unwilling to discuss or even admit: You must be able to deal with fear.

At this point, experienced pilots who've mastered nose-high and nose-low unusual attitude recoveries in the simulator are likely to tune out. But they should not. Many of those pilots would likely fail all three fatal factors, including the only one they could have learned in a sim.

Getting It Right the First Time

The key to correct recovery the first time is to understand where things can go horribly wrong and how to best get the airplane back to right-side up. Properly executed, each step of the process makes the next step easier. While acronyms sometimes serve more to confuse than clarify, you might consider this one: RUTAP.

Recognize. The first step is to either recognize that you have a problem or verify that a problem really exists. You may not always have a cockpit filled with instruments speaking with a single, loud, coherent voice.

Most transport category aircraft are required to have three attitude indicators, giving pilots a tiebreaker in the event of a single failure. There may be times, either by poor design or multiple failures, when two out of three are in error. A nose-high or nose-low attitude drastic enough to require immediate action should be accompanied by several easily verified clues. If you are significantly nose low, for example, the airspeed should be building, the altimeter should be decreasing, and the cockpit should be getting so noisy it becomes difficult to communicate. When significantly nose-high, the instruments are opposite and the cockpit gets eerily quiet.

Pitot-static systems should be good sources of additional information but often can be fooled. Even an airplane with three independent pitot-static systems will produce erroneous altitude and airspeed information if all three static ports are blocked. In 1996, a perfectly flyable AeroPeru Boeing 757 crashed into the Pacific Ocean at night after the flight crew failed to notice aircraft cleaners left each static port covered with metallic tape.

In just about every aircraft upset there are two primary threats: running out of sky or running out of airspeed. In the first situation ground contact is imminent. In the second, stall is imminent and with that the possibility of a spin, which is probably an unrecoverable event in most transport category aircraft. In either case, the next step is counterintuitive.

Unload. Once you've recognized the upset, the first thing you should do is disengage the autopilot, which could very well be the cause of the situation in the first place. Next, the best thing you can do in all but one situation is unload the airplane. In plain English, you need to push forward on the yoke or stick to put the wing as close to 0 g as possible. The only exception is when the upset leaves the airplane mostly right-side up and pulling gains you immediate altitude when close to the ground.

The first and immediate benefit to unloading is removing the threat of an aerodynamic stall, which will send the airplane downward and risks a spin. Not all aircraft pitch down when stalled, some T-tailed, swept-wing aircraft actually pitch up. Pitch up or down, a stall makes upset recovery more difficult and must be avoided.

The second benefit of unloading the wing is that the aircraft's roll rate improves dramatically. You will lose less altitude when recovering an inverted, nose-low airplane by pushing to near 0 g, rolling crisply to right-side up, and then pulling to level flight. This holds true even when you are significantly nose low. Where a typical business jet can take 5 sec. or more to roll upright with 1 g or more on the wing, the roll can be completed in 1 or 2 sec. when closer to 0 g.

Thrust. Novice pilots are quick to grab a handful of throttles in an attempt to fix things as quickly as possible but can make things worse if their initial reaction is wrong. Consider two alternate strategies when it comes to power lever management.

If you have good autothrottles that adjust thrust to maintain an airspeed, consider leaving them alone. In many late-model systems, the autothrottles are smarter than you are. If the nose is high and the speed is decreasing, the autothrottles know what to do. They should be equally adept when the nose is low and the speed is increasing. Give them a chance. You can always override them after a second or two.

L-39 upset training (nose high, inverted)

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If you don't have autothrottles you can trust, consider taking a breath before reacting. If the situation is dire, it should be obvious you need to take action. If the nose is moderately high, say around 45 deg. nose-up, cruise power isn't going to hurt you more than pulling to idle by mistake. If the nose is straight up and the only sound is your beating heart, adding power becomes a no brainer. Remember that under-wing-mounted engines can induce pitch changes when thrust is changed.

Of course aircraft with speed brakes have another arrow in the quiver that can help in a nose-low situation. But grabbing the speed brake handle at the wrong moment can turn a moderate nose-high situation into a severe nose-low upset. Consider leaving the boards alone unless the nose is very low and the airspeed indicator and the "barber pole" are merging into a single pointer.

Ailerons. Waiting until step four to roll the aircraft has two benefits that some pilots may not have considered. It gives you a second to decide which direction you need to roll and unloading the wing makes the roll faster. Note that the roll is handled with ailerons only. Fighter pilots have long known the danger of "rolling g's," but the risk of damage is even higher in an airplane not designed for combat maneuvering. VA, maneuvering speed, does not consider any rudder input at all and loading the wing with any kind of yaw risks losing airplane parts.

In a nose-high recovery, simply pushing forward with wings level takes time and risks running into negative g limits and sending unsecured objects in the cabin flying. You need to increase bank to help the nose fall to the horizon. In a nose-low recovery, there are various methods for recognizing which direction to roll, such as "roll to blue" or "roll to the sky pointer." These indicators are aircraft-dependent and pilots must know how their attitude systems will react to an unusual attitude. Once you've determined where the sky is, roll in the shortest direction to level the wings.

Pitch. The last step in the nose-low recovery process only happens once the airplane is upright. If imminent ground contact is not a threat, keeping within the aircraft's g-limits will not only make the recovery possible but also will keep the airplane flyable once recovered.

In a nose-high recovery you are in a race with time to get the aircraft's attitude under control before you run out of airspeed. How far do you roll to help the nose fall back to the horizon? Most upset courses use small, nimble fighter-like aircraft that can "knife-edge" beautifully. Rolling to 90 deg. of bank and holding close to 0 g allows the nose to fall back to the horizon quickly and removes the threat of a stall. A quick snap of the wrist returns the airplane to level flight. That may not be true with your aircraft. A typical Gulfstream, for example, is quite a bit heavier and rolls much more slowly than a P-51 Mustang. If you allow the Gulfstream to knife-edge to the horizon, the momentum of the falling nose may put you into a nose-low upset by the time you roll wings level. For these aircraft, rolling to 60 deg. of bank may get the nose down expeditiously while allowing the pilot enough time to judge the roll out.

Anytime the nose is above the horizon the chance of an aerodynamic stall is increased. But just because you are below the stall speed listed in your flight manual, it doesn't mean you will be in a stall.

Aircraft Envelope — The Magic of Near 0 g

Pilots are taught early the dangers of aerodynamic stall and the need to keep air flowing over the wing. Most understand there is a magic airspeed above which "airplane happy" and below which "airplane unhappy." While that knowledge may be good enough for an introductory flight lesson, it misses an important point. An airfoil does not stall at a magic airspeed, it stalls at a particular angle of attack (AOA). Yes, the speed changes with altitude and aircraft weight. But it also changes with g-loading. The best way to figure when an airplane really

stalls is by looking at its operating envelope.

An aircraft's operating envelope is plotted on a V-G diagram, so called because it plots airspeed (V) against load factor (G). There is a unique V-G diagram for every combination of gross weight, configuration and altitude. The construction of a V-G diagram is detailed in FAR Part 25.333, but manufacturers are not required to provide pilots with this information. That is too bad, because V-G diagrams speak volumes on how to keep an airplane flying. You can construct your own using Part 25.333, your aircraft manual's limitations and stall performance numbers. (I walk you through the process at **http://www.Code7700.com/operating_flight_strength.html**)

Fortunately, you need only see an example of a similar aircraft's V-G diagram to learn the necessary lessons. A Gulfstream 450 behaves conventionally, tolerating between -1 and 2.5 g's when in the clean configuration, and makes for a good example of a passenger-carrying aircraft.

Looking at the example V-G diagram for a sample aircraft, we see the red area depicts where exceeding airspeed and g-limits risks damage to the airplane. The orange area illustrates where we risk aerodynamic stall. What remains — the cyan, blue and green — is the aircraft's operating envelope. The airplane is flyable anywhere in this region. But we normally limit ourselves to the green zone, where we are flying faster than the aerodynamic stall, slower than maximum operating speed, and between 1 g and the airplane's maximum load factor.

We choose not to operate in the negative-g zone, the cyan, because we don't want our passengers or any unsecured objects in the cabin flying about. That leaves us with the blue area, where we are at less than 1 g but more than 0 g. We as pilots try very hard to stay out of that zone too, because it can be uncomfortable and risks scaring our passengers. But we should become familiar with it, especially just above 0 g, because it can save you following an aircraft upset.

Notice that our aircraft has a 1-g stall speed of 130 kt. under the sample conditions. Let's say an upset leaves the nose very high and your airspeed is 200 kt. and heading south fast. After you've rolled the aircraft and the nose is falling nicely, you find the speed approaching 130 kt. Reducing the load factor to 0.5 g reduces your stall speed to 92 kt. That half a g bought you nearly 40 kt. of airspeed.

So we can agree that unloading the aircraft to less than 1 g gains you a faster roll rate and greater stall margin. We also realize that going to less than 0 g risks passenger injuries from flying objects and people in the cabin. But how do we know we are unloading enough, but not too much? As good as current simulator technology is, it still cannot simulate sustained g forces. There is no substitute for actual flight experience, where you actually hang from the straps to know what negative g's feel like, or get light in the seat to judge a fraction of a g.

Feeling sustained negative g forces not only gives pilots an experience-based seat of the pants barometer for unloading a wing, it also prepares them to overcome what can paralyze pilots without that training.

Fear — The Only Solution Is to Desensitize

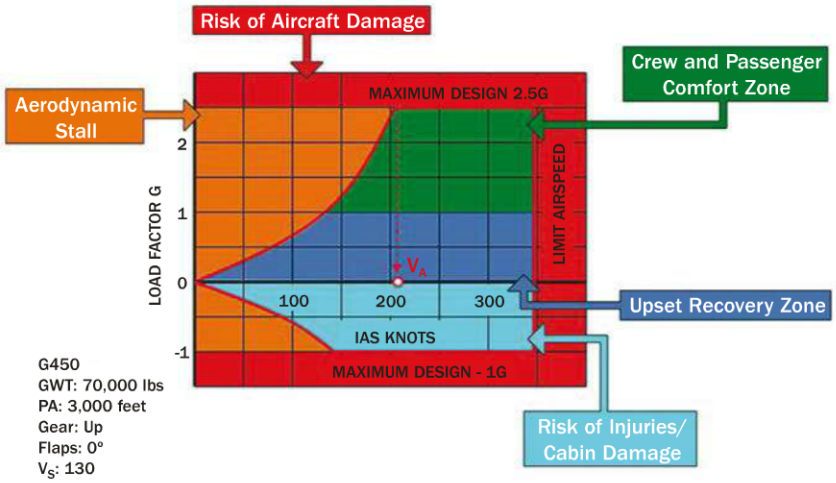
Highly experienced pilots who have never been inverted or felt 0 g in a jet for more than a second or two can be prone to air sickness and an inability to complete memorized recovery tasks. Pilots with military training tend to react properly, even decades after their "yanking and banking" days. The difference is the military pilots were subjected to desensitization that made upside-down just another phase of flight.

Long ago, pilots were advised to fly in the middle of the air and to avoid the edges. (The "edges" comprise the ground, water, buildings and extraterrestrial space.) Because you never truly risk death in a simulator, you are not properly trained for dealing with an aircraft upset until you've been trained in a high-performance airplane. There is risk in flying any airplane and when that airplane is pointed to the edge, every pilot's inner warning and caution system turns from amber to red. But every time you deal with that inner alarm, you get better at it. So, my advice is to practice in an airplane in a controlled environment before the alarm sounds when you least expect it.

You may very well have a long and prosperous career without ever venturing into aerobatic flight. ATC and TCAS may protect you from this day forward and your bank indicator will never exceed 30. In short, you can rely on luck. But a true professional pilot plans for the worst and trains accordingly. You can only properly prepare yourself for an aircraft upset by (1) practicing the correct procedures often in a simulator, then (2) honing those skills in an airplane while developing an instinctual sense of what near 0 g feels like, and (3) desensitizing yourself to the fear that comes naturally to any pilot seeing a windscreen filled with earth instead of sky for the first time. **B&CA**

Author's note: There are several high-quality unusual attitude recovery courses out there. The accompanying photos are from my experiences with Unusual Attitude Training, based in Kissimmee, Florida (**http://www.JetUAT.com**). The instructors there are highly experienced, the airplanes are well maintained and you end up with a USB stick with great videos of you in the seat of a P-51 Mustang or an L-39 jet trainer. This is just my opinion, but if you get the chance to fly a P-51, you have to take it.

Example V-G Diagram



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