Among the keys to global success will be accentuating the positive and eliminating the negative.

Teaching UPRT

BY SUNJOO ADVANI

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Upset prevention and recovery training (UPRT) will take many airline pilots out of their comfort zone, exposing them to places unknown. For most of their instructors, too, these places until recently were unfamiliar territory. This article explains why that is the case, and will help newcomers to this subject quickly grasp the essentials of the paradigm shift under way.

Now that international standards and recommendations have been published (see "Starting Lineup," p. 47), one of the significant remaining challenges to UPRT implementation will be to assure a quality standard for all UPRT instructors that supports consistent and accurate training delivery.

New tools soon will be available for pilot-performance assessment by instructors in the simulator; however, instructor exposure to the threat environment, escalation and recovery also is essential. On-aircraft UPRT — recommended for different pilot groups in the new official documents — is increasingly recognized as a critical component to developing effective UPRT simulator instructors (*ASW*, 10/13, p. 40).

Sound Paradigm

For those unfamiliar with the evolution of airplane-upset terminology, *UPRT* today describes a systematic response to the steady growth in the number of accidents resulting from loss of control–in flight (LOC-I). During the past decade, LOC-I has been the no. 1 cause of worldwide commercial airline fatalities, according to the annual analyses of data published by Boeing Commercial Airplanes. The response

is a comprehensive integrated approach to train pilots in awareness, recognition and avoidance, and recovery skills to mitigate LOC-I events.

In 2009, the Royal Aeronautical Society's International Committee for Aviation Training in Extended Envelopes (ICATEE) proposed the term *upset prevention and recovery training,* in which the *prevention* element was emphasized. This slight but significant adjustment to the previous term *upset recovery training* generated a broader acceptance and cooperation among the many stakeholders that the industry needed to produce training requirements that would be adopted globally.

So, what exactly is UPRT? First, an *airplane upset* is defined as unintentionally exceeding the flight parameters normally experienced in line operations or training. In other words, the airplane is not doing what the pilot intended and is approaching unsafe parameters: that is, the airplane has a pitch attitude greater than 25 degrees nose up or greater than 10 degrees nose down, or a bank angle greater than 45 degrees, or the airplane is at an airspeed inappropriate for the condition. In fact, many uncorrected upsets result from a stall if the crew fails to effectively recover from the stalled condition. Preventing, recognizing and, if necessary, recovering from an upset are now considered essential if we want to curb LOC-I.

ICATEE identified three levels of mitigation — awareness; recognition and avoidance; and recovery — the first two of which create a prevention perimeter (Table 1).

If prevention fails to mitigate the upset risk, the recovery skill is the final defense against a possible LOC-I situation. It is also important to understand that, even though a stall is a form of (or precursor to) an upset, it can lead to a further exacerbation of the flight condition if recovery is not immediate. The crashes of Colgan Air Flight 3407 (*ASW,* 3/10, p. 20), Turkish Airlines Flight 1951 (*ASW,* 6/10, p. 32) and Air France Flight 447 (*ASW,* 8/12, p. 14) are all well-known, stall-related fatal accidents. Thirty-six percent of LOC-I events are stall-related. Experts have cited the following possible causal factors:

- Limited awareness of the aircraft energy state;
- Distraction caused by sudden roll-off or unexpected control behavior near the stall; and,
- Adherence to inappropriate recovery techniques, such as not reducing angle-of-attack as the primary means to eliminate a stall.

Furthermore, there was a limited emphasis during training on the additional challenges of high-altitude stalls. At high altitude, for example, a stall may require a considerably longer and sustained application of nose-down pitch (and possibly trim) to maintain a reduced angle-of-attack to prevent a secondary stall. The industry felt the urgency to carry out enhanced

ICATEE Levels of Aircraft Upset Mitigation

Upset Mitigation Level	Learning Objective	Example
Awareness	Threat and error management related to upsets by developing an appreciation of the potential operational threats.	Appreciation of kinetic and potential energy available at varying altitudes; for example, recognizing performance limitations at higher altitudes and the possible need to trade off altitude for airspeed.
Recognition and avoidance	Early recognition of ensuing threats and unintended deviations from the normal flight path and preventing exceedance of the flight envelope.	Ability to give proportional flight control counter-response to a developing wake vortex, before the aircraft has exceeded normal attitude parameters.
Recovery	Returning the aircraft to the normal flight envelope/conditions following an upset in a timely and effective manner, without endangering the airframe.	Ability to prioritize the appropriate flight control inputs needed to safely and effectively recover from a developed stall.

Source: International Committee for Aviation Training in Extended Envelopes (ICATEE)

Table 1

stall training, and one result was the *Airplane Upset Recovery Training Aid* published in August 1998, with revisions in August 2004 and November 2008. (Available at <flightsafety.org/archives-and-resources/airplane-upset-recovery-training-aid>.) Yet, further challenges have been recognized more recently. In order to explain them, additional background is useful.

The Startle Reflex

Training to prevent, recognize and recover from airplane upsets is all about developing knowledge and skill sets that make pilots aware of the threat and prompt them to initiate timely action. However, we also know that when an upset occurs in actual flight, pilots often do not respond as they were trained. In such instances, the common belief is that they were startled.

Startle is a volatile emotional response. This intense reaction can cause inappropriate or incorrect human behavior. In time-critical events, such as the escalation of an upset, an incorrect reaction may worsen the situation and make recovery (both mentally and aerodynamically) more challenging.

A pilot's startled condition is worsened when he or she is confronted with a flight condition requiring higher levels of concentration to recover from an unknown or unexpected upset event. It is worse when the person is tired, fatigued or emotionally stressed. If an event triggers the startle process, it becomes difficult to resolve the situation without tools readily available. These tools are the knowledge and the trained ability to analyze and to resolve the problem developed through recurrent practice or, better yet, real-life exposure.

Pilots need a "Been There, Done That" UPRT T-shirt. Yet, sadly, many airline pilots — including instructors — have not been in an actual stall since the single-engine flights in their early training. Compounding this, the industry has a history of erroneously emphasizing "minimum loss of altitude" over the immediate reduction of angle-of-attack (*ASW,* 4/11, p. 46).

Latest Stall Recovery

Many of today's simulators are limited in their ability to present actual type-specific characteristics of stalls. In order to mitigate and to reverse the unfortunate history of stall accidents, a number of preventive actions were introduced, including a stall-recovery template and advisory circulars recommending maneuver-based and scenario-based stall training (Figure 1).

One significant change, as noted, was the recommendation to eliminate the older stall recovery technique (i.e., apply full power and try to minimize altitude loss) and replace it with a new one, recommending immediate reduction of angle-of-attack, and trading off potential energy (altitude) to gain kinetic energy (airspeed). The pilot should, in fact, always apply the same stall recovery technique at the first indication of stall, which could be an aural warning, aerodynamic buffet or activation of the stick shaker. Test pilots have shown that, regardless of the maturity of the stall (i.e., either an approach-to-stall condition or a fully-developed stall with g-break), the recovery invariably requires use of the steps in the template.

A Surprising Study

Making this stall-recovery template a memory item was considered the "silver bullet" answer to stalls: Pilots would simply apply the procedure, and stalls would be a thing of the past. However, a study by the U.S. Federal Aviation Administration showed that there is actually no substitute for exposure to stalls in a realistic setting, and to realistic distractors caused by the nonlinear behavior of the airplane during the stall. In the 2013 study, of the 45 airline pilots involved, fewer than 25 percent applied the template satisfactorily. Despite prior familiarity with the template, a common reaction was to fight the stall and prioritize roll control instead of unloading (i.e., decreasing the load factor by reducing the angle-of-attack). The study, conducted in a Boeing 737NG full-flight simulator, raised awareness that unexpected stall scenarios should be added to today's

Stall Recovery Template

1.	Autopilot and auto-throttle	Disconnect
2.	a) Nose down pitch control	Apply until stall warning is eliminated
	b) Nose down pitch trim	As needed
3.	Bank	Wings level
4.	Thrust	As needed
5.	Speed brakes/spoilers	Retract
6.	Return to the desired flight path	

Source: International Committee for Aviation Training in Extended Envelopes

Figure 1

maneuver-based training to ingrain the proper recovery technique.

Instructor Limitations

UPRT requires that instructors have the ability to impart the correct skills to be used in times of distress. By applying aeronautical and systems knowledge, and having the tools to analyze and resolve the situation, instructors can train pilots more effectively than in the past. Yet, there are challenges to making this a reliable, repeatable and affordable process. Fortunately, there are solutions — once we understand and address the hurdles in achieving them.

The most common tool that will be used in UPRT is the full-flight simulator. However, this costly training device is only as good as the instructor operating it. The instructor needs an awareness of how to develop upset recovery skill sets and self-confidence within the pilot. Therefore, as noted, instructor exposure to the actual threat environment is considered an important ingredient to making a good UPRT simulator instructor. The argument is that without knowing one's own limitations, it is nearly impossible to teach others how to overcome them.

Clarke McNeace, a former airline captain and fighter pilot, and currently a vice president at Aviation Performance Solutions (APS) at the Breda International Airport, Netherlands, says that such experience has not been common. "A typical simulator instructor has had little to no formalized on-aircraft upset training. … Many simulator instructors have never been beyond 60 degrees of bank angle or in a deep stall in an actual aircraft themselves," he said. Furthermore, because there has been no formal guidance on simulator-based UPRT delivery for decades, most simulator instructors teach recovery techniques that they personally have decided are appropriate, without any quality assurance to prevent negative transfer of training.

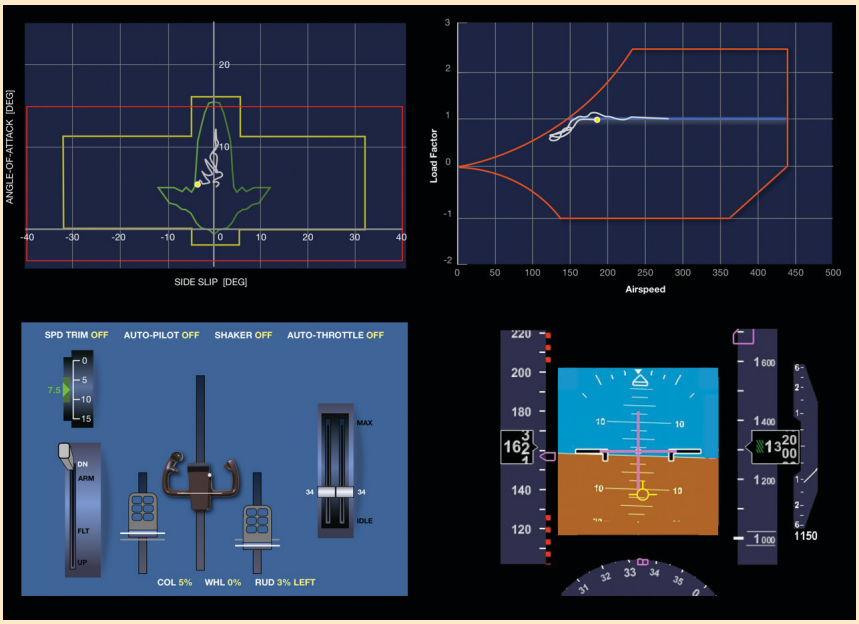
Simulator Limitations

Simulators are an excellent resource for training upsets, but transport aircraft behavior can deviate from simulator behavior during an upset. Therefore, empowering the instructor with appropriate information is an essential element, as is giving the instructor the ability to impart surprise scenarios during the training in order to not to rely exclusively on the rote repetition of maneuvers.

One of the unique tools that will become part of full-flight simulators adapted for UPRT is an instructor-feedback display with graphics focused on avoiding and recovering from the edges of the flight envelope. First and foremost, an instructor must be able to monitor the pilot's use of controls pertaining to the flight condition. For example, the immediate use of nose-down pressure and trim may be necessary and should be emphasized, but without the display, the inputs may not be visible to the instructor in the dark simulator cockpit. Similarly, improper use of rudder pedal inputs, such as rapid side-to-side pedal inputs that could lead to structural damage, must be detected and corrected.

The resulting aircraft responses should be within the acceptable safety margins visible on the display during the avoidance or recovery maneuver. Exceeding the structural limits must be avoided; unloading the wings by reducing the angle-of-attack — thereby allowing the aircraft to safely fly below the critical angle-of-attack — should be emphasized. Furthermore, the simulation is only valid to a certain angle-of-attack and sideslip. These are established

UPRT Instructor Toolkit Screen



UPRT = upset prevention and recovery training

Source: International Committee for Aviation Training in Extended Envelopes

Figure 2

during flight testing and, in some cases with enough confidence, through wind-tunnel testing or other engineering methods. Knowing if these limits of validity have been violated also is important because simulator accuracy of actual aircraft behavior degrades as it departs from the validated training envelope.

An example of a UPRT instructor toolkit screen is shown on a display (Figure 2). The toolkit software provides a comprehensive overview of the pilot's control inputs (lower left) and resulting aircraft responses. These are correlated with flight instrument display indications, and the aircraft loading (V-n diagram, upper right) and validated angle-of-attack versus sideslip envelope, (upper left).

When instructors are properly trained to use UPRT tools like these, their ability to teach in the simulator increases significantly. Even more importantly, emphasizing the pilot's positive performance while eliminating the negative traits during training and de-briefing can become one of the key assets to preventing LOC-I. Again, it all comes down to proper training of the pilots and the instructors.

In summary, check airmen and flight instructors who conduct training or checking in simulators must *themselves* receive training on the operation of the simulator and its limitations. Forthcoming regulatory requirements in many countries and regions will include enhanced simulator instructor training. The majority of today's instructors were trained only in simulators, with a greater emphasis on teaching procedures than on basic airmanship and flying skills.

If we want to curb LOC-I, we also will need to rethink the way we teach basic flying to pilots and instructors — from the ground up.

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Notes

1. Lambregts, A.A.; Nesemeier, G.; Wilborn, J.E.; Newman, R.L. "Airplane Upsets: Old Problems, New Issues." American Institute of Aeronautics and Astronautics Modeling and Simulation Technologies Conference and Exhibit, Aug. 18–21, 2008, Honolulu. AIAA 2008-6867.