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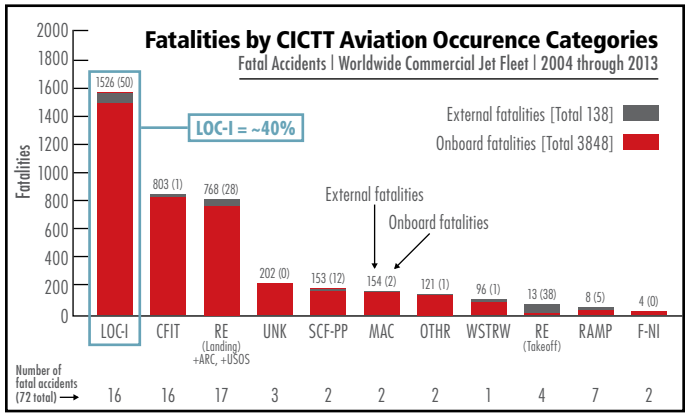
Threat and Error Management is a concept that seeks to minimize safety risks, thereby maximizing safety margins. Pilots consider not only the external influences that impact safety, but also their own reactions and mistakes as well. **Cessna Photo**

THREAT & ERROR MANAGEMENT

Applied to Loss of Control In-flight

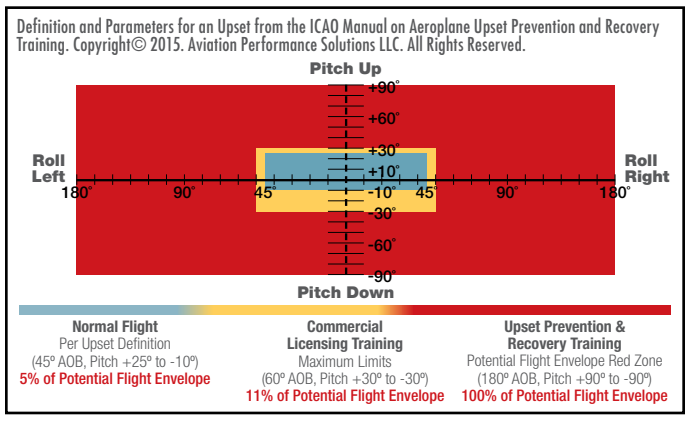
BY DAVID A. CARROLL

The pilot of a single-crew certified jet is climbing to FL410 on the autopilot with the throttles at max continuous thrust. During the climb, he notices that his airspeed is somewhat lower than expected. He reduces the vertical speed, thinking that doing so will allow the aircraft to accelerate. This action, however, is not enough and the aircraft continues to slow. Unbeknownst to the pilot, there is a malfunction in the angle of attack indication system that will prevent the stall warning system from functioning. The aircraft continues to slow with the autopilot holding altitude by applying increasing amounts of back-stick pressure until, during a moment when the pilot is distracted, the aircraft stalls without warning. An abrupt roll to the right that exceeds the autopilot bank limits causes the autopilot to disengage, resulting in an aggressive pitch down as the aircraft rapidly rolls back to the left. As the startled and disoriented pilot attempts to regain control of the aircraft, his instinctive control inputs actually aggravate the situation, and the aircraft executes five full rolls to the right and a vertical dive before control is eventually regained. The aircraft experiences a 25 per cent over-G resulting in permanent deformation of the structure.



THE RISK OF LOSS OF CONTROL IN-FLIGHT (LOC-I)

Commercial Aviation Safety Team statistics show LOC-I as the leading cause of commercial aviation fatalities (nearly 40 per cent). The National Transportation Safety Board (NTSB) identified reducing LOC-I mishaps as one of their top 10 priorities for 2015. Airline manufacturers, the International Commercial Aviation Organization (ICAO), and the Federal Aviation Administration (FAA) have all released guidance pertaining to LOC-I prevention. This article explains how the techniques of Threat and Error Management (TEM) can be leveraged to help mitigate the threat of LOC-I.



WHAT IS UPRT?

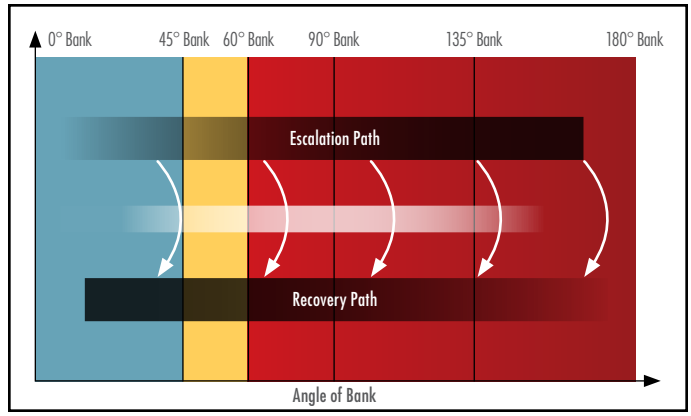
Upset Prevention and Recovery Training (UPRT) is specialized pilot training focused on mitigating the risks of LOC-I. The industry defines an aircraft upset as:

An airplane in flight unintentionally exceeding the parameters normally experienced in line operations or training:

a) pitch attitude greater than 25 degrees, nose up; or
b) pitch attitude greater than 10 degrees, nose down; or
c) bank angle greater than 45 degrees; or
d) within the above parameters, but flying at airspeeds inappropriate for the conditions.

The pitch and bank envelope comprising "normal fight parameters" entails only about five per cent (blue zone) of the entire all-attitude envelope. The envelope achieved during pilot certification training, +/- 30 degrees of pitch and 60 degree of L/R bank, expands this envelope to about 11 per cent (yellow zone). Unfortunately, aircraft in upset events are not restricted to these envelopes, but are free to explore the entire all-attitude envelope regardless of pilot expectation or experience.

FAA AC 120-111 says the goal of UPRT is for a pilot to "demonstrate knowledge and skill in preventing, recognizing, and, if necessary, recovering from an upset" through a "train-to-proficiency" methodology. The ICAO *Manual on Aeroplane Upset Prevention & Recovery Training* describes a training path that moves from academics, to on-aircraft training, to non-type specific Flight Simulation Training Device (FSTD) training, and finally to type-specific FSTD training. On-aircraft training is critical, as simulators are unable to accurately present the sensations necessary to present the psychological and physiological effects that pilots will experience in a real-world LOC-I event.



The intent of UPRT is to provide pilots with the ability to recover regardless of how severe the upset becomes. The pilot should be able to effectively apply a mitigation strategy to any flight condition, applying an appropriate remedy to return the aircraft to the desired attitude.

There are three categories of UPRT. Awareness Training presents the core concepts, exposing the pilot to the sights and sensations of aircraft upsets in a building-block approach while minimizing the likelihood of overwhelming him or her. The goal is to enhance recognition of precursors that lead to divergence, which enables avoidance of aircraft upsets. The next category is Recognition and Avoidance, which can be further divided into time-favourable and time-critical. Time-favourable situations allow the pilots to use Aeronautical Decision Making (ADM) to manage the outcome, while time-critical situations require immediate (on the order of mere seconds or less) response to a divergence. Recognition and Recovery becomes necessary when the aircraft exceeds the parameters defining an aircraft upset. Immediate application of appropriate recovery techniques is critical to safe recovery of the aircraft.

WHAT IS TEM?

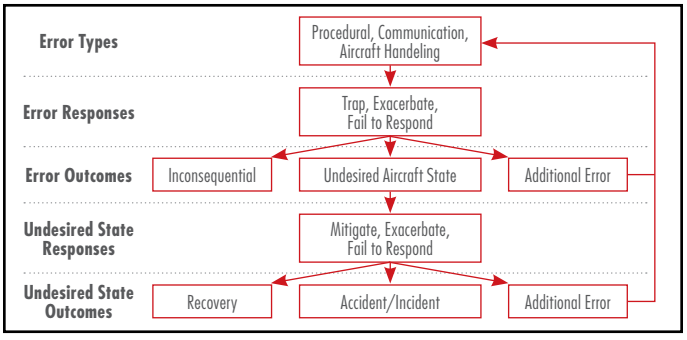
Threat and Error Management is a concept that seeks to minimize safety risks, thereby maximizing safety margins. In the TEM concept, pilots consider not only the external influences that impact safety, but also their own reactions and mistakes as well. The consideration of all these factors is a distinct advantage of the TEM concept.

A. Threats

Threats are events that are beyond the control of the pilots, increase flight complexity, and require flight crew management. Threats can be "expected" or "unexpected." Forecast weather, planned routing, and high-density airport operations are expected threats for which pilots can plan and devise defenses to accommodate. An example of an unexpected threat would be errors committed by others.

B. Errors

An error is any act by the pilots that results in a deviation from what they intended, reduces the margin of safety, and increases the likelihood of an adverse operational event. Procedural errors involve pilot divergence from policy, regulations, aircraft flight manual standards or procedures. Communication errors can be between the pilots or with those outside the cockpit. Aircraft handling errors involve skill or knowledge in handling the aircraft, resulting in deviations of aircraft direction, attitude, velocity, and configuration.



Pilot response to an error directly impacts the outcome of the event. First, the error must be detected. If the pilot detects the error, and the error is managed appropriately, the error results in a "trap." "Exacerbate" is the result when the pilot's response results in the situation worsening. If the pilot does not react at all, it is classified as "fail to respond."

There are three possible outcomes from the error, regardless of the response of the pilot. If there is no impact on the safe conclusion of the flight, the outcome of that error is "inconsequential." The pilot may commit an "additional error," which must be detected and managed. Third, and most critical, the pilot's response may result in an "undesired aircraft state (UAS)." This is a "position, condition or attitude of an aircraft that clearly reduces safety margins and is a result of actions by the flight crew. The error results in the aircraft being unnecessarily placed in a condition that increases risk."

If deviations in pitch, bank or airspeed become severe enough, the UAS becomes an "upset," with a resulting accident or incident categorized as a LOC-I.

Similar to the response to an error, the pilot may apply appropriate techniques and strategies to "mitigate" the situation, may "exacerbate" the situation, or may "fail to respond." The outcome of an undesirable aircraft state can be "recovery" of the aircraft back to a desired aircraft state, "additional error" which must be further dealt with by the pilot, or an "accident/incident." Through UPRT, pilots can be trained to manage UASs.

INTEGRATING TEM AND UPRT

Pilots can increase flight safety by integrating UPRT considerations into their TEM process. Including LOC-I threats during planning facilitates avoidance of those threats. Awareness of these threats during the flight makes pilots more likely to recognize an impending LOC-I, enabling early action to prevent the upset. The best mitigation is to avoid the threat completely.

In-flight awareness of situations conducive to LOC-I enables early recognition. This is especially important while on autopilot. During autoflight, pilots often assume a lower level of vigilance. In the presence of an LOC-I threat, such a relaxed attitude can lead to a sudden upset. The autopilot will progressively use more of its control authority in an attempt to keep the aircraft within the desired state. When those limits of authority are exceeded, in most aircraft, the autopilot will disengage, suddenly allowing the controls to return to neutral, and the aircraft may rapidly enter an upset. A vigilant pilot would notice the increasing control displacement and take over from the autopilot to prevent experiencing a disconnect with no pilot on the controls.

Another benefit of active LOC-I threat awareness is that the pilot is less likely to be startled should an upset occur. An unaware pilot may have twice the reaction time as an aware pilot. Research shows the window of opportunity available to resolve an airplane upset is often less than 10 seconds. With this limited recovery window, pilots should constantly remain aware to actively mitigate LOC-I threats.

CONCLUSION

Loss of Control In-flight continues to be the greatest threat of fatality in commercial aviation. The emergence of TEM has provided pilots with a valuable tool in identifying and mitigating threats. It is incumbent upon pilots to utilize all the available tools to achieve a safe flight. Application of the TEM methodology to the LOC-I threat can potentially decrease the mishap rate through better threat awareness, enhanced vigilance in its presence, and more rapid response should it strike.

If the pilot in the opening scenario had completed an effective UPRT course, it is likely that his recovery from the upset would have been more timely, efficient, and within the G-envelope of the aircraft. And, had he practiced active TEM, he might have noticed the unusual amount of back-stick pressure the autopilot was using to maintain level flight and taken action to prevent the incident from occurring in the first place.

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