Loss of Control in Flight

Training Foundations and Solutions

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Executive Summary

Although the overall accident rate has decreased, the category of loss of control-in flight (LOC-I) continues to outpace other factors as the leading cause of fatal accidents worldwide in the last 20 years. This paper will trace how the mind set and approach towards all-attitude/all-envelope flight instruction has contributed to this trend. Also reviewed are methods, techniques, and systems currently employed in the ongoing effort to lower the rate of LOC-I accidents. Finally, details of recent work by the International Committee on Aviation Training in Extended Envelopes (ICATEE) will be presented showing the technical and training solutions being addressed.

Loss of Control in Flight: Training Foundations and Solutions

Although the overall Loss of Control in flight (LOC-I) accident rate has decreased, the category of LOC-I accidents continues to outpace other factors as the leading cause of fatal accidents in the last 20 years. While we have reduced threats due to once common hazards such as weather, engine failure, and even controlled flight into terrain, we must go back to the days when training in all attitude aircraft control was a common element of training for both military and civilian aviators in order to trace how we have arrived at this situation.

Foundations: Historical changes in attitudes regarding all attitude aircraft control
In the 1920's and 30's, there was little difference between the training of military and civilian pilots and the types of aircraft employed in their training. The majority of available training aircraft of the day were capable of acrobatics/aerobatics (the terms are used interchangeably). These trainers, mostly biplanes, possessed high strength and drag which made them capable of demonstrating and practicing not only spin recovery (a licensing requirement of the day) but an assortment of "stunts" involving maneuvering in 360 degrees of pitch and roll. Born out of pilots' need to maneuver to advantage in the First World War, and their use in the public displays of aviation that followed after the war, flying and aerobatics were at the time nearly synonymous. Aerobatic proficiency was a mainstream component of pilot training in the years between the World Wars. A pilot's education was generally not considered complete without the ability to fully master control of an aircraft in all three dimensions.

The term "stunt", commonly applied to aerobatic maneuvers, was telling in regard to how the utility of these maneuvers came to be viewed in the years following the Second World War. By this time, specialization within aviation had led to greater divergence between military and civil aviation roles and aircraft capabilities. While the military retained aerobatics as a tool in the development of air combat maneuvering and other skills, in the civilian world such activities were often seen as a throwback to an age that many were desperately trying to put behind them. Airline travel demanded confidence from the travelling public that the white scarf days of the past were gone, replaced by the professionalism and discipline that was rapidly increasing the safety of this fast new mode of transportation. This rebranding of aviation required jettisoning the vestiges of aviation's youth, and discontinuing the practice of acrobatics for civilian pilots seemed a good place to start on the path to creating the perception of safe and dependable air travel. From the period of the late 1940s until the mid 1980's, requirements to demonstrate proficiency in maneuvering beyond 60° of bank, spin recovery, or other extreme attitudes were removed from civil pilot certification requirements worldwide. Attitudes beyond 45°-60° of bank or 20° of pitch are now often referred to as "unusual".

It is interesting to note that while continued specialization within the military often led to separate training tracks for pilots destined to transport versus fighter aircraft, early exposure and training in aerobatic maneuvering was retained for many military aviators, despite later aircraft assignment. In fact, such training is often even provided to helicopter aircrew before specialized rotary wing training. Despite the difference in budgetary structure for such government funded flight training, all fiscal sources are finite. Even the military must justify their training expenditures (perhaps now more than ever) yet the practice of three dimensional maneuvering persists. The militaries of the world clearly see benefits for providing training in the performance of aerobatics for pilots destined for aircraft incapable of such maneuvering.

As the size and sophistication of airline aircraft continued to evolve, the perceived need for pilots to receive training beyond the normal operational maneuvering envelope further diminished. The development of autopilot and various stall protection systems, culminating in today's fly-by-wire envelope protected aircraft, seemed to deliver us to a point where providing civil transport pilots with training outside of their aircraft's normal operating envelope was as pointless as teaching the captain of a modern-day maritime freighter or tanker how to sail.

The advances made in aviation safety through the identification and relentless reduction or elimination of one threat after another has resulted in what is, in general, the safest form of transportation known to man. After all of these improvements in safety, then why is LOC-I still a problem?

What Changed: Uncovering the Problem

Part of the predicament has nothing to do with LOC-I at all; in fact it is the reduction of *other* accident causes that left LOC-I as one of the last remaining causal factors to be "tamed". To be clear, the overall number of accidents and fatalities due to LOC-I have not been increasing. It is the improvement in other accident categories that has resulted in the emergence of LOC-I as the leading cause of fatal accidents in air transportation worldwide. It's as if when the "swamp" of the aviation accident pool was drained of other causal factors, the "snakes" of LOC-I were exposed. It is only in the past five years that LOC-I has overtaken Controlled Flight Into Terrain (CFIT) as the leading fatal accident category among airline aircraft worldwide. While other accident areas have improved, LOC-I has stagnated at an unacceptable rate.

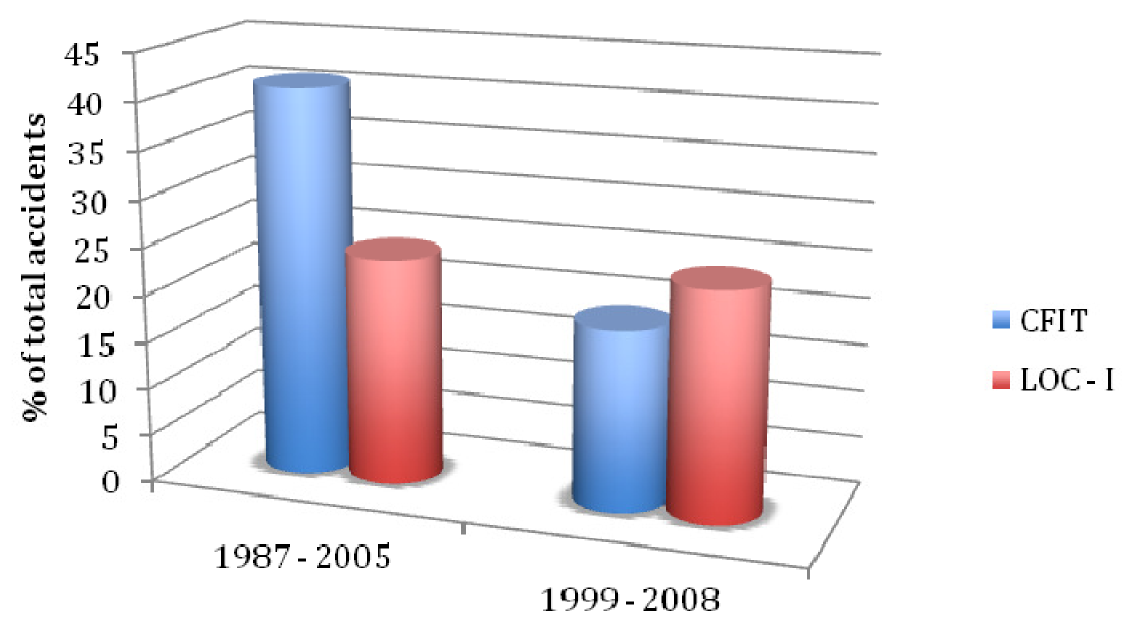

Figure 1

Prepared by Captain Robert A C Scott FRAeS [1]
"Aeroplane Upset Recovery Training, History, Core Concepts & Mitigation", Royal Aeronautical Society Flight Operations Group

The lack of improvement in LOC-I is evidenced by it's relative contribution to the overall fatality rate. From the period of 2001 to 2008, LOC-I experienced a 29% increase in the contribution of this category towards the overall fatal accident rate. For the ten year period ending in 2008 the next closest accident category was CFIT, at 20% (roughly one half of LOC-I fatalities) [2].

Loss of Control in Flight as a percentage of Overall Fatalities

Reporting Year	% of Fatalities
2001	30.4%
2006	30.6%
2008	**39.5%**

Increase by category: **29%**

Source: Boeing Commercial Airplanes Statistical Summary of Commercial Jet Airplane Accidents-Worldwide Operations, 2002-2009

While a reduction of other factors may be how LOC-I rose to become the top contributor to fatalities, there are two reasons that the LOC-I accident rate may differ significantly in its solution from many accident areas that have been targeted and reduced in the past, and both involve the pilot training basis of the problem.

Technology as the answer for LOC-I?

Most, if not all, of the previous accident areas that have been significantly reduced have been the result of newly introduced or improved technology. Windshear and CFIT incidents were mitigated through use of Ground Proximity Warning Systems (GPWS), mid-air collisions through Traffic Collision Avoidance Systems (TCAS), and CFIT further prevented through enhanced Terrain Awareness and Warning Systems (TAWS). It appears that with regard to LOC-I there is not a new acronym on the horizon to save us. Although there are many factors that can result in the chain of events leading to an LOC-I accident, it appears that the most complex system onboard represents the best line of defense: the pilot.

While it is true that fly-by-wire (FBW) flight envelope protections and enhancements to autopilot capabilities provide technological solutions to protection from LOC-I, they have proven fallible and unable to subdue LOC-I as effectively as the reductions demonstrated for many other threat areas. With common degraded flight modes involving alternate or direct control law modes, many envelope protection features are lost. It is here that the common risk reduction principle of redundancy speaks to providing pilots with the ability to provide an additional defense against loss of aircraft control. We should also remember that despite an increasing number of FBW aircraft in design and entering service, the majority of the world's aircraft, transport or otherwise, will have conventional (non-FBW) flight control systems for some time into the future.

With regard to envelope protected FBW aircraft, when all systems are working correctly, the appropriate response from pilots to an initial disturbance is often no pilot response at all. In most cases the aircraft can handle the situation as well or better than the pilots could. Unfortunately there are several recent instances of apparent wake turbulence encounters in which, rather than waiting for the aircraft's digital flight controls to correct a situation, pilots have intervened in ways that made the situation worse than if they had let the aircraft sort things out. It can be argued that pilots who are appropriately equipped with the knowledge and skills necessary to correct a worsening uncommanded aircraft attitude diversion or other undesired aircraft state are more likely to employ the desired "sit on your hands" approach than pilots who react impulsively because they are less familiar with non-standard attitudes and necessary recovery procedures.

Reductions in the Military Pipeline: The diminished presence of all-attitude/all-envelope skills

In the following discussion regarding the reduction of the number of former military pilots as a percentage of the overall airline pilot population, the only factor being considered is the higher incidence of aerobatic (all-attitude maneuvering) skills introduced during initial pilot training among military aviators. This is a generalization; not all military aircrew receive such training, but the demographic shift is such that the underlying point is still valid. There is a lower percentage of airline pilots with exposure to all-attitude maneuvering now than we have seen in the past.

Although it was stated earlier that civil pilot proficiency in all-attitude/all-envelope maneuvering and control had been reduced or eliminated more than three decades ago, it is not any change to civil training standards that has resulted in the greatest reduction in all-attitude maneuvering skills in the cockpits of many of the world's airlines. The preferred training template for most of Europe and North America's airlines has not been the training standards set by civil authorities, but the training provided by their assorted branches of military aviation. Until the 1990's the de facto standard for airline pilot training was held by military air arms for that was where the majority of the airlines' pilots received their flight training.[3]

The combination of a reduced supply of military produced aviators along with the growing demand from increased worldwide travel has resulted in the majority of airline hiring now coming from civilian trained sources, with no existing requirement for all-attitude experience or recovery proficiency. Although ex-military pilots may not have been hired out of any regard for the all-attitude/all-envelope training backgrounds, this experience came along with them. While this military to civilian transition trend is valid for the more mature travel markets of the world, the emerging airline markets experiencing the most aggressive growth today have an even smaller percentage of pilots with military training and all-attitude maneuvering exposure.

The question remains: even if the numbers of pilots receiving aerobatic orientation are declining, is it a problem? After all, it is acknowledged that flying is a safe, perhaps the safest, form of travel available. Despite the fact that LOC-I accidents are increasing in relative terms, the actual occurrences are so low that it is reasonable to expect that most pilots will never experience an unexpected aircraft upset in their entire flying career. To answer this question of acceptable risk, let's examine the statistical chance of a fatality from an LOC-I accident in comparison to several other accident types.

The Relative Threat: Higher risk, less effective training

To get a perspective on whether or not we should be concerned about a reduction in all-attitude experience in the cockpits of the world's airliners, we will examine the relative statistical threat of a fatal accident from several categories of accidents.

The worldwide chances of an LOC-I death by comparison to other accident categories

Accident Category		Chances of an LOC-I fatality are this many times greater
Runway Excursion: (Combined Take Off & Landing)	x	**2.3**
Non-engine systems failure:	x	**5.6**
Runway Incursion: (By a Vehicle, Aircraft, or Person)	x	**9.1**
Engine Failure:	x	**879.5**

Source: Boeing Commercial Airplanes Statistical Summary of Commercial Jet Airplane Accidents, 2000-2009[4]

With the statistics above, it would be reasonable to expect that pilots trained in accordance with an evidence based training system employing modern Safety Management System principles would be trained as well in the recovering from an aircraft upset as they would be to address a systems related abnormal or emergency situation. Unfortunately this is seldom the case. While most common system related failures have appropriate checklists presenting procedural solutions, unexpected aircraft upsets that lead to LOC-I accidents rarely present themselves to procedural solutions since the variables to be considered are too numerous to fit conveniently into stock solutions. Additionally, while pilots have been trained to utilize the crew concept in response to most emergency situations, commonly administered unusual attitude/emergency maneuver/upset recovery training is conducted individually. Using the "I've got it" (disturbance input presented), "You've got it" (demonstrate recovery) method which seldom simulates realistic occurrence scenarios or any element of surprise, most unusual attitude training currently fails to replicate significant factors in real world accidents.

To summarize, although LOC-I accidents are our greatest threat, we train for upset recovery less effectively than we do for most other potential accidents.

LOC-I: The Training Solution

In June of 2009 the Royal Aeronautical Society (RAeS) held a conference titled "Flight Simulation - Towards the Edge of the Envelope" addressing the growing LOC-I threat and how it might be dealt with by the flight simulation community. An outgrowth of that conference was the establishment the International Committee for Aviation Training in Extended Envelopes (ICATEE) operating under the auspices of the RAeS and devoted to focusing on how various training solutions (technical and operational) could reduce the incidence of LOC-I accidents. The ICATEE is comprised of experienced aviation professionals from a wide spectrum of disciplines including academia and research communities, engineering, simulator and aircraft manufacturers, line pilots, training providers, and regulators. The ICATEE mission statement is "To deliver a complete and comprehensive long-term strategy to eliminate or reduce the rate of Loss of Control In-Flight accidents and incidents through enhanced Upset Prevention and Recovery Training (UPRT)". The scope of ICATEE efforts covers all segments of aviation. While much of ICATEE's work is being devoted to determining current limits of simulation and identifying future improvements, the discussion here will focus principally on training versus technical considerations.

ICATEE Training Matrix

A central feature of this effort was to identify the basic training elements that pilots should be provided to minimize the occurrence of in-flight upsets and to maximize their ability to achieve a safe recovery if an upset is encountered. To this end, a subgroup was established to create a Training Matrix delineating necessary elements of training, identifying where in the training spectrum they should be introduced, and determining what training resources or platforms should be utilized. In this effort, the group analyzed the available accident records and ensured that actual situational hazards were represented within the identified training. This was not meant to be a theoretical exercise; the purpose of the Training Matrix is to identify training that will save lives and then work toward implementation. Although the work of ICATEE and the full development of the Training Matrix are still efforts in progress, what follows is a description of some of the ICATEE Training Matrix subgroup work and findings to date. After evaluating the accident database, a broad-based approach was taken which identified and focuses on three fundamental areas of training:

<u>Awareness</u>

The Awareness area of training covers the knowledge, skills, and attitudes necessary for pilots in identifying upset hazards, assessing risk, and employing recovery strategies. Awareness of these areas of learning will make pilots less susceptible to encountering an upset and will increase the likelihood of a safe recovery, if required. Consciousness of these areas of information is gained not from academic exposure alone, and in many cases will be thoroughly and completely understood only through experiential training and practiced skills. Special emphasis is given to knowledge or skills that are not currently addressed through flight training required in the existing regulatory or operational framework.

Recognition and Avoidance
The Recognition & Avoidance area of training covers the information specific to recognizing and avoiding the hazards associated with unexpected aircraft upsets and in-flight loss of control events.

Recovery
The Recovery area of training is devoted to the knowledge, skills, techniques, and procedures required to accomplish a safe recovery when a lack of awareness or an inability to avoid or mitigate hazards has resulted in the onset of an aircraft upset. These competencies involve the timely, measured, and proportionate use of primary or alternate control strategies that cannot be mastered by academic understanding alone. Some of these recovery skills are perishable in nature and may require recurrent training.

Training Matrix Development
In the assessment and analysis undertaken in the development of the ICATEE Training Matrix, the group reached strong consensus on three fundamental concepts. The principles which emerged in some cases challenge the existing status quo regarding how upset recovery training is often being conducted today.

The first concept involves the application of an integrated approach to the delivery of UPRT. **Strong consistency and correlation between the delivery of academic information and practical skill development has a multiplier effect in both the comprehension and retention of material.** Examples of how this integrated approach can be applied involve common descriptions and terminology being used in the classroom environment and delivery of training in the cockpit. In essence, the aircraft or simulator should be utilized as a laboratory environment to bring to life the concepts introduced in the classroom. While this overlapping approach has benefits in most areas of flight training, this combined approach has particular benefits when addressing the complexities and nuances of UPRT.

In the paper "*Defining Commercial Transport Loss-of-Control: A Quantitative Approach*"[5], authors Wilborn and Foster examined six LOC-I accidents and incidents. They defined the interval between the time of the first envelope excursion and the time when control was lost as the *critical window*. In the six situations analyzed the average time available to the flight crew to provide a corrective response was under 7.6 seconds. While the critical window for other LOC-I events may vary, it is clear that available recovery time is a major recovery consideration. The combination of psychological surprise, possible accelerative forces, and presence of multiple simultaneous warnings makes executing a safe upset recovery challenging even *with* the appropriate training. This leads to the second concept uncovered as part of the Training Matrix development effort: given the time critical nature of most aircraft upset events it is highly unrealistic to expect flight crews to be able to recover from attitudes for which they have never previously had any firsthand experience or exposure. For that reason it is strongly believed that **all pilots, at least once at some point in their training, must be exposed to the full flight envelope from which a recovery could be safely executed.** This goes well beyond the maneuvering limits to which most flight students are currently trained.

The last principle relates to the contribution of various delivery platforms (aircraft, continuous G simulators, fixed base simulators, and full flight simulators) considered for different elements of training. For economic and practical considerations the lowest level of device capable of satisfying recommended learning objectives was identified. While the final details of simulator features and fidelity are still being addressed, it was clear that in some areas of UPRT, the boundaries of synthetic training are reached by both technical and human factors limitations.

On the technical side, existing flight test data, certification criteria, motion systems, and other factors are being looked at by the Technical wing of ICATEE. Examples of these technical limitations might involve demonstration of the roll/yaw coupling present in a cross controlled stall situation, or the presence of roll instability at high angles of attack which is beyond the ability of most existing hexapod full flight simulators to accurately replicate for reasons of incomplete data.

The more fundamental limitation involves the boundaries between overall virtual or synthetic training (simulation) and the real world; the psychological component. Although there is no technical challenge in creating a visual scene of a 110° bank attitude with the nose 30° below the horizon, the learning experienced while viewing that scene from the security of a simulator bay has no relation to the knowledge and attitudinal changes received from viewing that very same attitude strapped into an aircraft. **The development and acquisition of skills related to correctly and appropriately responding to the psycho/physiological reactions inherent in confronting undesirable aircraft states is fundamental to executing a safe recovery from an unexpected aircraft upset. The required learning cannot be achieved absent from the consequences faced in actual flight.**

What this means is that some training in an aircraft is required to fully prepare a pilot for an aircraft upset encounter. The specific elements in which an aerobatic capable aircraft must be utilized to provide the necessary training and experience have been identified. In line with the integrated training concept discussed earlier, while an aerobatic aircraft platform is necessary for the introduction of some elements of training, the use of a type specific full flight simulator is required for the practical skill development regarding specific aircraft systems and performance. Together with the underlying academic understanding, this comprehensive approach seeks to provide pilots with the tools necessary to recognize and avoid potential aircraft situations that could result in the loss of aircraft control and recover from unforeseen aircraft upset events.

ICATEE advocacy for elements of training in aerobatic capable aircraft and previous discussion of the use of aerobatics in military pilot training may suggest that ICATEE is a proponent of aerobatic flight training. While there are certainly some benefits to the all-attitude/all-envelope exposure received through that type of training, UPRT through the presentation and understanding of aerodynamic principles and appropriate use of the best resources for specific segments of training provides training more focused to defeating the LOC-I threat. The following matrix helps to illustrate the distinctions between the use of aerobatic maneuvering and UPRT in the development of all-attitude/all-envelope aircraft maneuvering and control skills.

All Attitude/All Envelope Flight Training Methods

Aspect of Training	Acrobatics / Aerobatics	Upset Prevention and Recovery Training
Primary Objective	Precision maneuvering capability	Safe, effective recovery from aircraft upsets
Secondary Outcome	Improved manual aircraft handling skills	Improved manual aircraft handling skills
Aerobatic Maneuvering	Primary mode of training	Supporting mode of training
Academics	Supporting role, if included at all	Fundamental component
Training Resources Utilized	Aircraft (few exceptions)	Aircraft, fixed base simulator, full flight simulator, or continuous G devices (depending upon element of training)

All-attitude/All-envelope Aircraft Training Considerations
A recommendation for the inclusion of elements of aircraft training in all attitude maneuvering and UPRT concepts cannot be made without addressing some of the major considerations that such training entails. Some of the potential concerns involved with aircraft based UPRT are:

Flight Safety
One of the greatest concerns involves the relative safety of all-attitude/all-envelope flight training in aircraft versus the simulator environment. Flying aircraft in severe attitudes certainly involves a greater risk than simulator based training. In fact, to some extent, the *perception* of risk is a necessary component of UPRT.

By employing elements of Safety Management to identify and minimize risk, and through the application of strict and disciplined operational protocols, the required elements of UPRT training can be taught as safely as any other element of primary training. However, it is one thing to make that simple statement; applying it under the demands of daily operation is an entirely different thing, and cannot be underestimated without consequence.

Specifically, the training and qualification of instructors is the largest single hurdle to the safe implementation of UPRT. It should be remembered that existing instructors are unfamiliar with the principles to be taught since there is no existing basis for much of the training being recommended.

When assessing overall system safety, however, it should be remembered that during the decade of 2000-2009, 1848 people died worldwide in 20 LOC-I commercial airline accidents.[6] In a paper titled *"The Paradoxes of Almost Totally Safe Transportation Systems"*[7], the non-intuitive conclusion is drawn that the safety optimization of system *components* may not increase the safety of the system as a whole. In other words, acceptance of the elevated risk in the delivery of UPRT training through aircraft based training will improve the overall safety of the air transportation system as a whole. It would seem that a more proper distribution of risk would place the weight of hazard upon pilots in training more appropriately than upon the travelling public.

Transfer of Skills
There is regular questioning of the correlation between the proficiency gained in all-attitude/all-envelope training in a light aircraft to the more demanding requirements of an upset recovery in a transport aircraft. While there is no argument in the performance differences between platforms, the principles of physics and aerodynamics to be demonstrated apply universally. Addressing the difference in handling and other performance based factors is the role of an appropriately trained UPRT instructor. Once initial skills are introduced they should later be applied with type specific considerations in a full flight simulator.

It should be understood that the majority of the principles of UPRT are not specific to an aircraft type; they apply equally to a single engine aircraft, a multi-engine turboprop, or a swept wing jet transport. The situation is analogous to initial instrument training. We routinely teach pilot candidates initial instrument proficiency in lower performance aircraft and simulators with the understanding that those instrument skills will largely transfer to other aircraft on which their specific handling and performance characteristics will be learned. The same concept applies to the transfer of skills in UPRT.

Economic Considerations and Impact
While it was not that difficult to identify and specify training that could lower the LOC-I accident rate, that training does not come without a cost. A cost analysis of ICATEE recommended training is planned for the future. What is known is that rather than adding Training Matrix elements to existing training programs, it is preferred that such training be "woven into" training programs. In many cases rather than *additional* training, there is simply a change in *how training may be presented*. An example is illustrated

through the table below, which shows how the escalation of threat involved in high angle of attack flight might be presented in stall training.

Escalating Stall Threat

Threat	1. Slow Flight: Imminent Stall	2. Aerodynamic Stall	3. Incipient Spin	4. Developed Spin	5. Ground Impact
Prevention Phase	Proportional Counter Response	Pre-Stall Recovery	Stall Recovery	Incipient Spin Recovery	Spin Recovery
Defining Aero Element	Imminent Stall	Stall Break	Yaw-Roll Couple Developing	Auto-Rotation Established	**Hull Loss**
Recovery Phase	Pre-Stall Recovery	Stall Recovery	Incipient Spin Recovery	Spin Recovery	**NONE**

Similar changes in emphasis can be made in some areas of simulator training, resulting in qualitative versus quantitative changes. Yet for real improvement, some additional training may be required. With regard to the aircraft training components identified, all elements of training assigned under the “Aircraft” resource can be completed within five hours of flight time, some of which can be offset through reductions in existing training.

Training Placement

One of the tasks of the Training Matrix development was assigning the appropriate place in training in the overall span of a pilot’s career span. This was completed for the legacy or “classic” licensing path as well as the MPL licensing track. In the standard PPL/CPL/ATPL licensing track all elements of training were assigned prior to ATPL, with the philosophy that licensing should assure that pilots have the required professional level when they reach the level of being employed as a pilot. In MPL this is an underlying principle and the various elements of training were placed at the most appropriate Phase of training within the MPL system. ICATEE is currently seeking feedback from existing MPL providers on the recommendations made.

Secondary Considerations

Although ICATEE generally, and the Training Matrix subgroup specifically, has focused on reducing the LOC-I threat, it is easy to see several potential areas where secondary benefits could be realized through the training being advocated.

The UPRT principles of Awareness, Recognition, and Avoidance are based on avoiding aircraft upset occurrences. It is believed that these elements of training will help in reducing situations where recovery skills need to be used; this is the basis of “Prevention” in Upset Prevention and Recovery Training.

Another secondary benefit is improved manual handling skills. Although it is essential for a comprehensive UPRT program to address all levels of automation, airmanship in the form of aircraft handling skill may still be the last line of defense. Development of skills for recovery from the edges of the envelope has certain applications in normal operations as well, and with ever greater application of automation, any areas that can assist in averting the erosion of manual handling skills is an asset.

Conclusion

The knowledge and awareness brought to flight crews through UPRT will provide a greater appreciation of the LOC-I threat which will benefit the threat and error management skills employed. Pilots will experience greater confidence in the knowledge that, no matter how rare the incidence of an aircraft upset, they have been provided with training to meet the threat through well thought out strategies of avoidance and recovery. The implementation of comprehensive UPRT along with the technical improvements being addressed through ICATEE provide the greatest hope for the reduction of the worldwide LOC-I accident rate.

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