Reexamination of Stall and Spin Prevention Training

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Stall and spin accidents continue to cause nearly 25 percent of the fatalities in general aviation each year despite the FAA's emphasis on stall prevention. The effectiveness of past studies, the military's successful approach to stall and spin training, and pilot judgment training are examined; all of these factors may partly explain the relative constancy of the stall and spin accident rates. Recommendations of many past stall and spin studies were examined to determine whether they had been implemented and, if so, whether they had been effective. Second, military flight training programs approach stall and spin prevention very differently and with more successful results. The U.S. Air Force's stall and spin prevention training program is compared with civilian training programs and reveals significant differences in spin training requirements, standardization, pilot knowledge and instructor training and professionalism. Third, pilot judgment has been cited as a causal factor in 95 percent of all stall and spin accidents. Pilot judgment training during private pilot training is also evaluated, and it is found that judgment training has not been incorporated into civilian training syllabi as suggested by previous studies. The investigation determined that the stall and spin problem, rather than being treated as a single issue, really is more symptomatic of several larger issues that must be confronted in general aviation flight safety. Recommendations are made for flight training, flight instructor qualifications, professionalism and skills, pilot knowledge, and aircraft certification; if implemented, these suggestions could reduce the overall accident rate in general aviation.

The most useful purpose of accident investigation is to learn from past mistakes to prevent future accidents. However, the history of stall and spin accidents sounds like a broken record. Spin proficiency was required for private and commercial pilots by Civil Air Regulations (CAR) Part 20 until 1949. Despite the mandatory spin training and demonstration of spin proficiency for certification, spins are listed as the primary cause for 48 percent of the fatal accidents from 1945 to 1948.

In 1949 the Civil Aeronautics Administration reexamined pilot certification and concluded that because an airplane cannot spin unless it has stalled, the accident rate could be reduced by changing the emphasis of training from actual spin recovery to an enhanced stall awareness and recovery (*1*). Spin training was then deleted from the aeronautical skills requirements for private and commercial pilot certificates.

Since 1949 the stall and spin accident rate has been reduced to the point that in recent years, stall and spin accidents account for approximately 12 percent of the flight accidents each year, a statistic that the FAA uses to indicate the success of enhanced stall awareness training (*2*). Despite changes to flight instructor certification and suggested changes to flight training syllabi, efforts to reduce further the accident rate due to stalls and spins have been ineffective. Stall and spin accidents continue to be the cause of 12 percent of the total accidents each year, but in terms of fatalities, spins are consistently the cause of approximately 25 percent of the total fatalities in general aviation (*3*). Among all accident causes, a spin has the greatest potential for fatal injuries—even greater than a midair collision—because of the uncontrolled condition of the aircraft when it hits the ground (*3*).

Perhaps no other topic in general aviation has generated more heated debate than the issue of reinstating mandatory spin training for private pilots. The Experimental Aircraft Association believes that

> better pilots would be produced if there was a return to good solid basics, and that having spin entries and spins explained, demonstrated, and then practiced in the presolo hours adds confidence that reflects in the student's overall flying abilities. The student with spin training will have a better idea of what to do in the case of inadvertent spin entry.

The association adds that too much emphasis is placed on instrument flying, so pilots concentrate inside the cockpit rather than outside the aircraft (*3*). The Air Safety Foundation believes that the current approach, which stresses awareness of aircraft attitude, reliance on indicated airspeed, and use of stall warning devices, does not get the job done (*3*). It should be pointed out that an aircraft can stall at any airspeed, because stall is strictly related to angle of attack and not to airspeed. Therefore, a pilot should not rely on indicated airspeed to prevent a stall. In Crossfield's experience, the pilot who is least likely to be victimized by an inadvertent stall is the one who has developed a sensitive feel for what is happening to the aircraft (*3*). Others counter that 95 percent of all accidental spins occur at low altitudes that leave insufficient time for recovery, and therefore spin training will be of little value. The FAA expresses a concern about the possible increase in training accidents if mandatory spin training were reintroduced (*3*). The president of the National Association of Flight Instructors (*3*) and Tony LeVier, a noted Lockheed test pilot, agree that requiring spin training for a private pilot without corresponding actions to improve the quality of flight instruction would lead to an increase, not a reduction, in stall and spin accidents.

Silver determined that aircraft design changes have been the primary cause of the reduction in stall and spin accidents, not changes in pilot training (*4*). It is also significant to note that, in the instructional category, spin accidents with a certified flight instructor (CFI) on board are three times more

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frequent than in solo student operations where no instructor is present (*4*). Yet another sobering fact is that more than 25 percent of all twin-engine aircraft accidents occur with flight instructors on board, most of those accidents being associated with simulated engine failure demonstrations and practice (*5*).

Many past investigations have addressed general aviation accident statistics. According to the National Plan for Aviation Human Factors, human error has been identified in 88 percent of all general aviation fatal accidents (*6*). The National Transportation Safety Board (NTSB) determined that the pilot was a broad cause/factor in 97 percent of all first type stall and spin accidents (*7*). Hegwood determined that flaws in judgment and decision making were present in 66 percent of general aviation accidents, loss of attention of distraction in 30 percent, and deficiencies in skills and knowledge in 40 percent (*8*).

Campbell asserts that skill and knowledge are necessary for a good pilot but that proper judgment, which leads to correct decisions, is essential (*9*). Good judgment is more difficult to learn than flying skills. During U.S. Air Force (USAF) pilot training, instructors frequently recite, "a superior pilot uses his superior judgment to avoid situations that require superior skills." Many accidents are caused not by a failure of knowledge or skill but by a lack of judgment (*10*), Collins points out that the second leading cause of Piper Cherokee accidents is improper pilot conduct at low altitude, resulting in a stall, despite constant emphasis on stall avoidance training, thus showing a lack of judgment (*11*,p.59).

The FAA's stance on stall and spin training continues to be "avoid, avoid, avoid." The author will not argue with this, but the accident record indicates that this approach has been ineffective in significantly reducing the occurrence of spin accidents during the past 30 years. Accidents are not caused by a single factor; they are the coordinated occurrence of several flawed decisions, performance breakdown, or oversights (*12*). Nance states that "to have any hope of preventing such an error from causing an accident again and again, the REASON the error was made in the first place must be discovered, and the underlying cause of that human failure must be revealed and addressed in future operations" (*13*). Melton asserts that accident investigations of the past has not been effective in preventing human factors accidents (*14*).

In 1972 the NTSB emphasized the need for initiating new and innovative efforts to reduce these types of accidents (*7*). The FAA then undertook a study to determine the most effective training techniques to avoid imminent spins (*15*). However, the FAA's primary changes to spin training have been regulatory in nature. Past experience has shown that stricter regulations will not necessarily reduce accidents (*16*). Melton maintains that education is the most practical method of change available (*14*).

The military services take a different approach. Few pilots are placed at the extremes of aircraft performance as consistently as military pilots. An examination of the military's training objectives and procedures, combined with a relatively long record of accident statistics, renders a number of extremely important lessons. The USAF and Navy would prefer that their pilots avoid spins, but both services attack the spin problem through a standardized program of rigorous and realistic training that teaches spin recognition, recovery, and prevention (*3*).

RESEARCH PROBLEM STATEMENT AND STUDY DESIGN

Previous studies have investigated both the overall general aviation accident and stall and spin records and discovered areas that need improvements (*2–5,7*). This investigation does not seek to reiterate such findings, nor does it seek to determine every single issue that must be resolved to reduce general aviation stall and spin accidents. Instead, the study is designed to complement previous investigations so that a comprehensive approach to solving the stall and spin problem could be found. Accordingly, this investigation sought to determine answers for the following questions:

1. Have recommendations of past stall and spin studies been implemented, and, if so, what has been their effectiveness?
2. What differences between military and civilian flight training could explain their respective stall and spin accident records Which of these differences could be implemented in civilian flight training?
3. What judgment training, both formal and informal, is provided during private pilot training?

Evaluating statistics can be an effective technique in answering some questions, the main effort of this study concentrated on gathering information at the flight-line level to determine more precisely what is happening so that a more accurate assessment could be made to build the necessary curriculum and certification changes.

RESEARCH METHOD

The study consisted of three phases. The first phase addressed the question of whether past recommendations had been implemented and, if so, how effective the changes had been. A search of previous special studies on the stall and spin problem was conducted to compile a list of specific recommended actions (*2–5,7,15*). To determine the procedures currently used in flight training, separate surveys were conducted of pilots, flight schools, and flight instructor recertification clinics. The pilot population was randomly chosen through a distribution of the questionnaire to parked aircraft at two Southern California general aviation airports. Three hundred questionnaires were distributed, and 173 pilots responded. The questionnaire was designed to obtain information about the pilot's training, experience, certificate level, date of certification, and understanding of the stall and spin problem.

The 43 flight schools surveyed were located in selected counties of three widely separated geographical regions: Mississippi/Tennessee, Southern California, and Utah. Chief pilots were interviewed about the training procedures used at the schools, and training course outlines were examined for Federal Aviation Regulation (FAR) Part 141–certified flight schools.

Training course outlines were obtained from nationally advertised refresher clinics for flight instructors to determine the information presented for recertification of flight instructors. Additionally, three courses were monitored.

The information collected from the pilots, flight schools, and refresher clinics was then compared with the recommendations of the special studies. A comparison of the accident

statistics of 1967–1969 (*7*) and 1988 (*17*) was also conducted to determine if any significant changes had occurred.

The second phase consisted of a comprehensive study of the USAF's training curriculum, procedures, and instructor qualifications used in the Undergraduate Pilot Training program conducted by Air Training Command (ATC) and comparing them with those used in civilian flight training. Training requirements of the ATC syllabus were compared with both the requirements of FAR Part 61 and the syllabi obtained from flight schools. A survey similar to the aforementioned pilot questionnaire was prepared for CFIs. The survey also sought to determine the instructor's knowledge of aerodynamics relating to stall and spin phenomena, sources of guidance and information, professional activities, career goals, and activity in spin instruction. The surveys were distributed to 59 instructor pilots and 78 student pilots of the 37th Flying Training Squadron at Columbus Air Force Base in August 1985. The same questionnaire was distributed to flight instructors at the flight schools surveyed in the first phase of the study. Many flight instructors operate on a freelance basis, so the surveys were also distributed to flight instructors at seven FAA Accident Prevention Program seminars conducted for flight instructors in Los Angeles and Salt Lake City and at three flight instructor refresher courses. Surveys were also distributed to designated pilot examiners at a regional annual recertification course held in Salt Lake City and at an initial qualification course conducted in Oklahoma City, both in 1992. A total of 513 surveys were collected from the civilian flight instructors, and 28 from designated pilot examiners.

Five aviation professionals (hereinafter referred to as "reviewers") were chosen to grade the survey answers. Answers to each aerodynamic question were scored on a scale of 1 to 5 (1 = unsatisfactory, 2 = marginal, 3 = average, 4 = good, 5 = excellent). A mean score for each question was then computed. All five reviewers were flight instructors (three were military and four held CFI certificates) and had received formal college courses in aerodynamics. Two were accident investigators, two were aviation safety officers, and four had been involved in aeronautical education as either ground school or general aeronautical course instructors. Grading standards were determined mutually by the information in aeronautical research of the National Aeronautics and Space Administration (NASA), journal literature, and *Aerodynamics for Naval Aviators* (18).

The final phase consisted of a separate survey distributed to 126 student and private pilots asking specific questions about formal judgment training during ground and flight training. The survey also asked respondents to remark about informal judgment (both positive and negative) training and experiences during ground and flight training. This phase also examined the syllabi and training course outlines for 11 flight training programs, 9 of which were certified by FAR Part 141.

FINDINGS

Application of Past Recommendations

Past studies have made specific recommendations for changes to stall training, situational judgment and successful prevention techniques, enhancements in aircraft design, and re-evaluation of the spin training requirement (*2–5,7,15*). Phase 1 of this investigation centered on determining whether these recommendations had been incorporated and, if so, what their effectiveness had been.

Innovation in Ground and Flight Training Curricula

Private pilots are required to demonstrate competency in stall entry and recovery from various flight attitudes and power combinations. Stalls are taught at high altitude (greater than 1,500 ft above ground level). Unfortunately, during typical training situations the student is keenly aware that the stall is coming and is concentrating on recovery. Realistic stalls occur unexpectedly, near the ground—and while the pilot is concentrating on something else (*11*,p.59). Despite many recommendations suggesting that stall training become more realistic (*3,4,7*), the study found that stall training is still conducted in the same manner. Three specialized aerobatic flight training programs did present stalls in more realistic situations.

Study To Determine Situational Judgment

In response to the recommendations of research conducted by several aviation safety organizations, the FAA initiated the Accident Prevention Program in 1985, which cosponsors a large number of seminars and disseminates material to pilots. To date, about 45 pamphlets addressing different safety issues have been produced and distributed to general aviation pilots through this program. Most of the pamphlets contain detailed information to help pilots learn from past accidents in order to prevent future accidents. Pilots who regularly attend accident prevention seminars speak positively about the value of the seminars and handouts. The program appears to be very effective for the pilots that it reaches. However, the value of the program to pilots who do not participate is doubtful.

Enhancing Airplane Design

The NTSB, General Aviation Manufacturer's Association, and the Society of Experimental Test Pilots believe that FAR Part 23.221 should be reviewed with applying new standards that would allow the designer to concentrate more on preventing the spin rather than on recovering from it. The FAA is considering a redraft and will soon publish a change to this regulation.

Modern aircraft design has been shown to be the most effective approach in reducing the number of stall and spin accidents (*4*), but unfortunately the general aviation manufacturing industry is in a severe slump and fewer than 250 new single-engine aircraft are produced each year (*19*,p.43). Thus, most general aviation pilots will not be able to benefit from this research for many years.

Evaluation of Reinstating Minimum Spin Training

The FAA's chief of flight operations states that any decision to return to spin training must address all issues (*3*). The FAA

cites the following issues for its opposition to reinstatement of spin training:

- Possible increased training accidents,
- Many current training aircraft not certified for intentional spins,
- Impact on the increased duration and cost of flight training,
- Economic impact to upgrade the current fleet of trainers, and
- Airspace limitations with urban sprawl and restrictions (federal aviation regulations prohibit aerobatic maneuvers over any congested area of a city, town, or settlement; over an open-air assembly of persons; or within a control zone or federal airway).

The FAA did amend flight instructor applicant training requirements in April 1991 to specifically require spin training and allowed examiners the option of specifically requiring spin demonstration during the practical test.

Spin Training Requirements

The second phase of the study identified significant differences between the FAA's and Air Force's approaches to the stall and spin problem. The Air Force first extensively screens pilot applicants before they are accepted into the Undergraduate Pilot Training program, which is obviously not possible among general aviation pilots. The effect of this screening is not examined in this study; instead, differences in actual training methods are examined.

In the Air Force, spin training has always been a major element in Undergraduate Pilot Training. The primary phase explores the full stall region: recognizing a stall, preventing a spin, recognizing the initiation of incipient spin, and flying the aircraft out. It is a 74-hr program that normally includes 25 intentional spins and 25 spin-prevention maneuvers while exploring the full range of the aircraft envelope. Proficiency is required for student pilots before they solo and checked at mid- and final-phase checkrides.

In contrast, the FAA requires only flight instructor applicants to show a logbook endorsement certifying that the applicant is proficient to teach spins. All other pilot certificate levels are not required to have spin training.

Standardization

Standardization is provided by the ATC headquarters staff of spin examiners who yearly give all T-37 instructor pilots mandatory spin proficiency checkrides. Checkrides, required weekly training, and oral and written exams are all used as tools to ensure standardization of the training objectives, procedures, and course materials throughout the five Air Force training bases.

However, the FAA establishes specific tasks under pilot operations in the practical test standards that must be accomplished for certification. Each area of operation is referenced to a specific handbook for standardization. FAR Part 141–certified flight schools perform yearly checkrides for instructors, but there is very little industry standardization in the area of stalls and spins. Stall procedures varied greatly among the flight schools.

Ground Training and Knowledge

The Air Force has a mandatory course on aerodynamics, of which a 2-hr block is devoted to stall and spin aerodynamics. Additionally, each day student pilots are quizzed orally on various emergency procedures, including stalls and spins, and a mandatory emergency procedures quiz must be completed satisfactorily each week.

Results of the ground school survey determined that the average time spent during civilian ground training courses on stall and spin was less than 30 min. No further training on stall and spin was required in any of the training course outlines inspected in this study. The pilot surveys showed that additional ground training in stall and spin did not occur after the initial ground school course.

The depth of the reference material also differed greatly. The required reading material for the Air Force program was assembled from data at the Air Force Flight Test Center; it explored stall and spin aerodynamics, causes of spins, functions of the controls, effects of improper control movement, and recovery. The T-37 flight manual has a complete section on stall characteristics, spin characteristics for the varying spin modes, the spin envelope, effects of controls, and the proper spin recovery for that aircraft.

The required texts for ground school courses at civilian flight schools devoted an average of 1.6 pages to the discussion of stall and spin and primarily centered on the stall character of an older airfoil design. Pilot operating handbooks for training aircraft contain no information about the spin characteristics of the aircraft. Approximately 97 percent of surveyed pilots and 94 percent of surveyed flight instructors cited popular periodicals as their main sources of information. Both pilots and flight instructors relied heavily on their previous flight instructors for information (85 and 96 percent, respectively.)

As part of this study, more than 250 books, magazine articles, technical papers, research summaries, and conference proceedings pertaining to spins were reviewed. The popular literature reviewed included monthly magazines from the mass media, trade groups, and the FAA dating back more than 30 years. The study found that the popular literature (and several FAA publications) contained very little new material, and what it did contain was repetitive, cursory, incomplete, poorly documented, and of questionable accuracy. In general, the books by Kershner (*20*), Mason (*21*), and Lowery (*22*) were very accurate, readable, and complete.

The study also found that the several excellent FAA publications addressing stall and spin phenomena are not well disseminated. Very few flight instructors were even aware of the Accident Prevention Program handouts, and fewer had copies for their personal libraries and extras for students. Several informative advisory circulars share this fate.

USAF instructor pilots demonstrated good to excellent levels of working knowledge of spins, and USAF student pilots demonstrated overall good levels. Civilian designated pilot examiners, however, demonstrated an overall average level of knowledge (Figure 1). Civilian CFIs and designated pilot

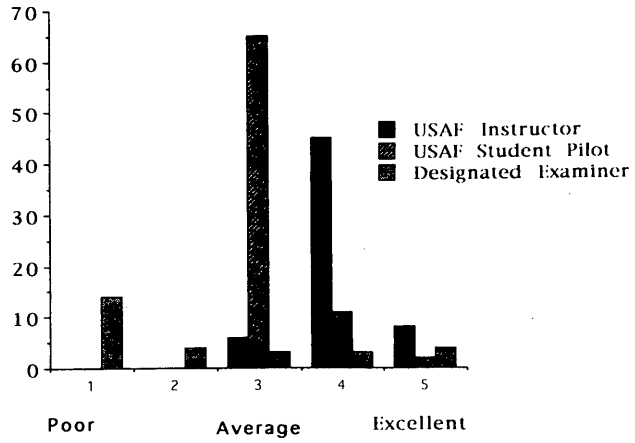

FIGURE 1 Stall and spin knowledge.

examiners demonstrated overall marginal performance levels in the following areas concerning stalls:

- Stall aerodynamics,
- Effects of control deflection on stall,
- Airfoil stall development,
- Planform effects on stall development,
- Spanwise flow effects,
- Stall warning signs on aircraft and the effects on aircraft motion,
- Secondary effects of flight controls, and
- Roll control at high angles of attack.

As for spins, civilian flight instructors and designated pilot examiners demonstrated overall unsatisfactory performance in the following areas:

- Pro- and antispin forces;
- Autorotational and stabilized spin motion;
- Effects of various variables on spins (e.g., location, mass distribution, pitch, direction, mass imbalances, power);
- Spin phases, phase differences on recovery, and spin modes;
- Effects of the controls on spin motion and recovery; and
- Common student recovery errors and the effects on aircraft motion.

The FAA modified stall and spin training regulations on April 15, 1991. Yet more than a year later, 97 percent of surveyed flight instructors—including all 35 survey participants who had been certified since the training amendment—were not aware of these changes to the regulations, nor were they aware of the FAA's excellent advisory circular giving guidance on ground and flight training. The performance of this recently certified group on the survey was as poor as the rest.

Another interesting point occurred during the analysis of survey results. Flight instructors who stated that their aviation goal was to attain an airline cockpit position performed at poor and marginal levels, whereas the few surveyed flight instructors who stated other long-term goals in aviation performed at an overall good level (Figure 2).

Instructor Training and Quality Assurance

ATC introduced instructor spin qualification and standardization in 1962 to ensure that all instructors were well versed in all aspects of spinning. Instructor spin training is conducted by certified spin examiners. Extensive academic training is based on manuals and work performed at the USAF Flight Test Center to ensure rigorous quality standards. Flight instructor training is conducted with an emphasis on conditions leading to inadvertent spins, spin performance, proper instructional techniques, student error analysis, spinning in various modes, and the effects of controls.

Ninety-eight percent of the responding civilian flight instructors stated that their spin training consisted of no ground training and just two spins (one in each direction) before they were endorsed as being proficient to teach spins. Ninety-five percent of the respondents did not receive training that emphasized conditions leading to inadvertent spins, spin aerodynamics, common student errors, and the effects of the controls in a spin.

Proficiency Demonstrations and Reviews

All T-37 pilots are scheduled for annual spin seminars conducted by spin examiners, and all USAF pilots undergo fre-

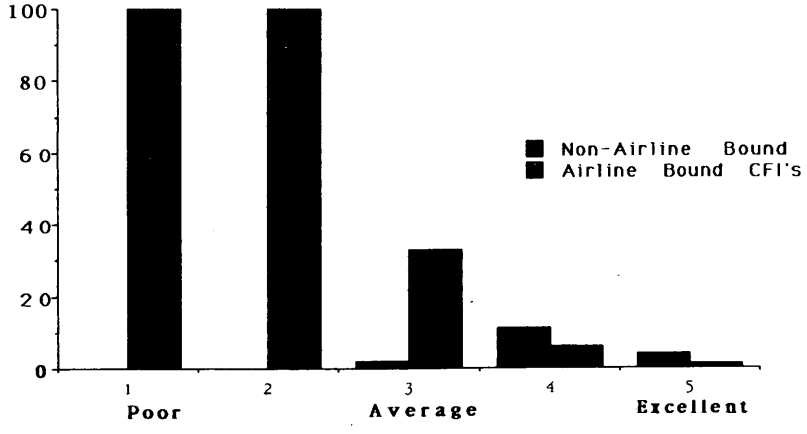

FIGURE 2 Stall and spin knowledge of flight instructors.

quent periodic evaluations (an average of five evaluations each year.)

FAR Part 61 requires all certified pilots to undergo a biennial flight review every 24 calendar months. Yet, despite this regulatory requirement, 20 percent of all accidents occurred within a month of biennial flight review (*5*). Pilots responded that very few proficiency maneuvers were required during their last biennial flight review.

Once a civilian flight instructor is certified, there is no mandatory requirement that the flight instructor be evaluated in flight ever again. The flight instructor can renew a certificate by attending a flight instructor refresher course.

Instructor Professionalism

Perhaps more disturbing were findings that a professional standard has not been well established and promulgated in civilian flight instruction. The following facts about the professional activities of flight instructors were determined from the survey:

- Three percent attended advanced training clinics and seminars;
- Two and a half percent were involved in formal training to upgrade knowledge;
- Less than 1 percent read advanced training materials;
- Ninety-seven percent relied on mass popular literature for information;
- Four percent were aware of advances in flight sciences, research efforts, and technology;
- Twelve percent were active in professional associations and pilot groups;
- Thirteen percent maintained a limited professional reference library; and
- Ninety-four percent were unaware of NTSB/NASA accident reviews for lessons learned from past accidents.

It should also be noted that flight instructing is frequently used as a strategy for obtaining a more permanent position. Among flight instructor respondents, 97 percent claimed that their goal is to upgrade to a commercial or corporate flight crew member position as soon as practical.

Additional Items

This study also found that not a single civilian flight instructor had a prespin checklist of critical items before spin practice. Previous flight test investigations have shown that items such as fuel loads, fuel balance, aircraft weight and balance limits, control alignment, and systems operating procedures are critical factors that must be checked before spinning an aircraft (*23*). Ninety-eight percent were largely unable to describe a set of procedures or steps they would undertake to determine whether an individual aircraft was safe to spin. Ninety-four percent did not understand the limitations of aircraft spin requirements in the certification process and did not know where to obtain information on recommended spin entry techniques and spin motions of the aircraft.

The survey also found that 96 percent of multiengine flight instructors showed poor understanding of multiengine aerodynamics, particularly with regard to simulated engine failure practice, and a lack of awareness of critical warnings published in aircraft flight manuals and safety newsletters by aircraft manufacturers.

Judgment Training

The training course outlines for the surveyed flight schools did not incorporate any formal judgment training into ground or flight training curriculums.

All 126 respondents replied that ground and flight training courses taken between autumn 1989 and spring 1992 contained no formal judgment training. Ninety-three respondents related incidents in which judgment was taught unintentionally during flight training. Twelve of these respondents recounted incidents that taught good judgment, of which five occurred during dual flight instruction. Eighty-two respondents related experiences during dual flight instruction that taught poor judgment.

CONCLUSIONS AND RECOMMENDATIONS

There is no single solution to this complex issue. It involves much more than flight instruction. The subject of stall and spin improvement by including spin training in the flight training syllabus cannot be treated alone. The pilot as a final product must be the goal. The FAA has regulatory control over flight safety but cannot do it alone.

This study determined that recent regulatory changes and all other past FAA efforts have not translated into effective changes in flight and ground training. Rather than a mere change in regulations, a combination of approaches must be considered and effectively implemented at the flight-line level to include changes to flight training, increased flight instructor qualifications, higher professionalism and skills, effective dissemination of information to line pilots and instructors, and more spin-resistant aircraft. The recommendations of this paper, if implemented, could reduce the overall accident rate in general aviation, not just the stall and spin numbers.

Flight Training

Some spin training could help to prevent accidents, but the training needs are far broader than the demonstration of spin entry and recovery techniques. Consideration must be given to enhancing the quality of ground and flight training on the following topics:

- Pilot proficiency and ability to handle distractions,
- Planning,
- Judgment,
- Coordination exercises,
- Learning to read the subtle signs of an aircraft,
- Visual illusions,
- Wind effects,

- Lessons from the past,
- Traffic pattern operations conducive to stall and spin accidents,
- Reeducation in dangers of low-level flight, and
- Aircraft motion at high angles of attack.

The biennial flight review should be used more effectively to update pilots and enhance pilot proficiency. The FAA has published guidelines and regulatory changes to upgrade the performance of a biennial flight review. The FAA and several trade groups have disseminated excellent materials to aid flight instructors in making biennial flight review more effective, but the material has not been used widely. A concerted effort must be made to enforce this important requirement.

The FAA has produced several manuals on judgment training. This study found that these resources had not been incorporated into ground or flight training syllabi, nor had judgment training been specified formally as an objective in any course. A method of incorporating judgment training into both ground and flight syllabi and flight instructor methodology must be investigated.

Flight Instructor Training, Certification, and Professionalism

Flight instructors form the backbone and the first line in quality assurance of the general aviation pilot's knowledge, judgment, and proficiency. Yet, this survey determined that the main motivation of flight instruction is to build experience for obtaining an airline pilot position, with the result that devotion to flight instruction professionalism is questionable. More time must be spent with CFIs to ensure that they correct the deficiencies mentioned in this paper. Flight instructors must be totally dedicated to making objective assessments of matters involving aircraft performance and pilot training.

Common sense would require instructor spin proficiency because not all students will adequately handle incipient spin recovery during their training cycles. Flight instructors should feel fully at home, be excellently qualified, and have every aspect of spins under their control to teach it. The Society of Experimental Test Pilots, although it generally avoids making public judgments, endorses at the very least instructor spin recovery proficiency as a requirement for a flight instructor certificate (*3*). At present, flight instructors are required to demonstrate spin proficiency, but this study has shown that pilot examiners are largely unqualified to make this determination and previous flight instructor training has been received from inadequately trained instructors. Unless the suggestions for upgraded instructor and examiner qualifications and testing are incorporated, the regulations amended in 1991 and the recommendations of this study will be relatively ineffective.

The government and industry, including the trade associations, need to set a professional standard for flight instruction. Standards, requirements, and conduct required of professionals should be addressed by a cooperative effort to upgrade the level of flight instruction. Before professional licensing, these requirements should be met.

This investigation determined the following deficiencies in professional standards:

1. Continuing education at advanced levels;
2. Participating in flight safety and aeronautics conferences and seminars;
3. Keeping current with the latest research findings and techniques;
4. Updating knowledge and skills through advanced professional training;
5. Participating in professional organizations; and
6. Maintaining and reading a professional library of classic texts, professional peer-reviewed periodical literature, research studies, and accident prevention materials.

It is unlikely that significant improvement in flight instructor professional standards will occur on a volunteer basis as long as flight instruction is the main track for civilians hoping to build experience for airline pilot positions. It is unfortunately left to the professional licensing body to enhance instructor professionalism.

Flight instructors must incorporate more judgment training and lessons learned from the past into ground and flight training. Most survey respondents replied that flight instructor actions actually left more impressions on the development of judgment than formal lectures, so flight instructors must become more aware of their role in judgment training. This point is worth investigation to explore its potential further.

Knowledge and Dissemination of Information

This study strongly suggests that a comprehensive text and videotape should be published to address the areas of deficient pilot knowledge of stall and spin aerodynamics and to serve as a standardized source of factual information intended for use by pilots. Included in the book and videotape would be the previously listed areas of deficient knowledge, common stall and spin accidents, prespin checklists, training maneuvers that would enhance "stick and rudder" skills, determination of an individual aircraft's suitability for spinning, lessons learned from the past, and a historical perspective.

The combined textbook and videotape could set a precedent of accuracy, standardization, cost-effectiveness, and completeness. The FAA could stipulate that flight instructors, safety inspectors, and designated pilot examiners satisfactorily complete a test on this topic before their next renewal, thus ensuring that the material will be disseminated within 2 yr.

The FAA has recognized special situations in which flight instructors are required to be additionally rated, such as instrument and multiengine flight instruction. Given the unique body of knowledge and expertise required for spins and aerobatics, the number of instructional stall and spin accidents with flight instructors, and the overall lack of stall and spin knowledge within the flight instructor corps, this study suggests that consideration be given to a special certification procedure to license designated examiners and instructors who are truly qualified to give spin instruction and checkrides. This corps of instructors and examiners could then provide better spin instruction and better quality assurance.

Like the Air Force has, we must learn from flight tests what airplanes will do in common pilot input error situations. The information should be communicated to the pilot in terms of perception (aircraft buffet, control lack of effectiveness), not

just in terms of the airplane performance. Each training aircraft should experience an empirical test determination of its spin characteristics, similar to the Cessna Aircraft Corporation's tests of its training series (*23*). Testing should be followed by suitable recommendations, or notation, in all operator's manuals, and pilots and flight instructors should be qualified to interpret them.

The FAA's Accident Prevention Program should be used to an even fuller extent as a medium for disseminating information. A cooperative effort between industry, trade groups, pilot associations, and local flight standards offices has been effective in providing continuing education to the general aviation pilot. This approach further serves an important role in maintaining a positive working relationship between pilots and the FAA.

This study determined that the vast majority of pilots obtain flight information from popular periodical literature. It is realized that journalists will not consent to review of their works, but they must realize their effect on pilot knowledge. It would be helpful for authors to follow the standards expected in writing, that of citing references, giving credit to original works, and conducting some in-depth research rather than merely quoting or copying older articles. This study also suggests that a system of peer review be established to boost accuracy.

Aircraft Design

In the future, the FAA and manufacturers must realize a pilot's limitations in being able to perceive, decide, and respond effectively if he has not been exposed to the incipient spin environment under controlled training conditions. Aircraft must be designed to minimize the surprise and rapidity with which an aircraft departs from controlled flight in typical operational environments.

Unfortunately, because of economic factors, the restricted number of single-engine aircraft produced today means that the lessons from NASA's stall and spin research will not be available to the general aviation pilot for a long time.

SUGGESTED FURTHER RESEARCH

Aviation authorities such as LeVier, Crossfield, and Mason have suggested that general aviation pilots obtain a limited amount of aerobatic training to improve fundamental pilot skills (*3*). The argument certainly has merit and deserves to be studied.

Many aviation authorities still insist that spin training be reinstated (*3*). The military's results show the worth of actual spin training. A controlled long-term study of civilian pilots using different training methods should be undertaken to determine the effectiveness in preventing spin accidents and, perhaps more important, producing better overall pilot skills.

With pilot activity declining because of the high cost of aircraft rental, the effect on a pilot's ability to maintain flying skills must be questioned. Not only is proficiency affected by currency of experience, but judgment skills are also developed and maintained through regular experience. The effectiveness of developing lower-cost alternatives and their effects on flight activity and pilot proficiency and judgment should be studied. This will aid the FAA and industry in guiding future aircraft production and regulatory policies in order to help pilots fly more and maintain and build better flying skills.

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