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General Aviation Leveloff, Roundout, and Accident Rate Analysis

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Transitioning the aircraft from the approach attitude to the landing attitude is one of the first obstacles that confronts student pilots. This visually guided procedure is known as the *landing flare* but is poorly understood and underreported. To stimulate interest in and accentuate the importance of the landing flare, in this study, we analyzed 6,655 National Transportation Safety Board accident reports and surveyed 92 aviators in two Part 141 flight schools. The results show that flare accidents accounted for 17.88% of landing accidents, that the landing flare was equated with the roundout, and that the procedures used to round out the aircraft were obscure. Practical recommendations are provided for future studies and flight training instruction.

Transitioning the aircraft from the approach attitude to the touchdown attitude is known as *flaring* the aircraft (Federal Aviation Administration, 1999). The landing flare is crucial to smooth and safe landings because it effectively reduces the descent rate at touchdown. This is achieved by an increase in the aircraft pitch attitude and angle of attack (Federal Aviation Administration, 1999). General

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aviation pilots initiate the maneuver 3 to 6 m (10 to 20 ft) from the ground and continue to increase the pitch attitude until the aircraft gently settles on the main landing gear. Increasing the pitch attitude too early or too late may lead to an excessive descent rate, a hard landing, or structural damage (Christy, 1991; Jorgensen & Schley, 1990).

Learning to appropriately flare the aircraft has been traditionally acknowledged as one of the most difficult tasks that confronts student pilots (Bramson, 1982; Langewiesche, 1972; Love, 1995). Prior research has found that pilots of different experience levels believe the landing flare to be an especially difficult maneuver (Benbassat & Abramson, 2002b). This finding was replicated with nonpilots that were trained to land a Cessna 182 Skylane simulator (Benbassat & Abramson, 2002a).

As shown in Figure 1, the difficulty of the landing phase of operations is supported by statistics. However, the difficulty of the lading flare remains anecdotal because the National Transportation Safety Board (NTSB) does not distinguish between flare accidents and landing accidents. In an initial study, Benbassat and Abramson (2002b) reported that landing flare accidents accounted for 18.33% of the total landing accidents in 1995, 1996, and 1997.

Although the landing flare maneuver is traditionally described as a continuous process, it is possible to break the flare down into two distinct phases (Bjork, 2001). That distinction becomes apparent when one considers that the flare is also known as the *leveloff* or the *roundout* (Collins, 1981; Jeppesen, 1985; Langewiesche, 1972). The leveloff relates to the appropriate timing of the landing flare, during which the aircraft is close to the ground and altimeter readings may be faulty (Title 14 Code of

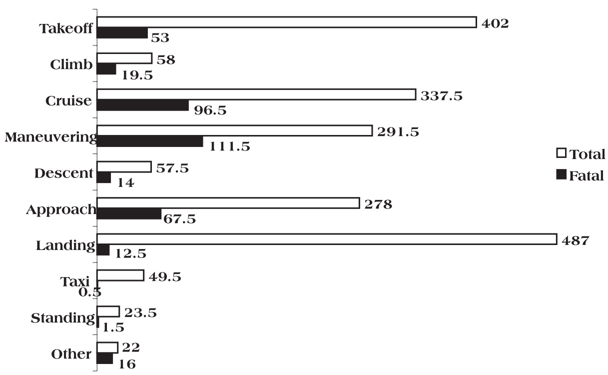

FIGURE 1 A breakdown of mean total and fatal-accident-involved aircraft by first phase of operation for 1995, 1996, 1997, and 1998 (adapted from National Transportation Safety Board, 1998b, 1999, 2000b). The total landing accident rates for 1998 were obtained through personal communication with L. Groff (June 30, 2003).

Federal Regulations). It marks the initiation of the flare maneuver and the initial decrease in rate of the descent in "what appears to be" (Federal Aviation Administration, 1999, pp. 7–6) 3 to 6 m (10 to 20 ft) from the ground.

Nevertheless, this visually guided process is poorly understood, and experienced pilots are often unable to verbalize it. Some certified flight instructors (CFIs) advise their students to flare at hangar height (Kershner, 2001), others advise students to flare at one half of the wingspan (Christy, 1991), and yet others resort to comments such as "flare now" or "you're too high!" (Bramson, 1982; Penglis, 1994). Findings from a recent study suggest that student pilots learn to time the flare in a trial-and-error fashion, flaring high at times and low at other (Benbassat & Abramson, 2002a). An obvious drawback of this method is an increase in the likelihood of improper flares and flare accidents.

The roundout is the continuous application of back elevator pressure after the leveloff. Pilots round out the aircraft to further decrease airspeed to touchdown velocity and gently settle the aircraft onto the landing surface (Federal Aviation Administration, 1999). According to the *Airplane Flying Handbook* (Federal Aviation Administration, 1999), "back elevator pressure should be gradually applied to slowly increase the pitch attitude and angle of attack. This will cause the airplane's nose to gradually rise toward the desired landing attitude" (pp. 99–100). Nevertheless, the handbook does not define what it considers to be a "desired landing attitude." The problem is especially acute when one considers that the roundout, like other flight maneuvers, is counterintuitive. Instead of lowering the nose of the aircraft prior to touchdown, pilots are required to continually raise the nose and maintain back elevator pressure.

When attempting to clarify what is meant by a desired landing attitude or how much back elevator pressure should be applied during the roundout, many instructors present conflicting instructions. For example, some maintain that the pitch attitude should be increased until the aircraft nose covers the far end of the runway (Fowler, 2000; Penglis, 1994). Others maintain that increasing the pitch attitude should be continued until the nose completely covers the runway and ground reference (Butcher, 1996; Kershner, 2001).

The purpose of this study was to conduct a trend analysis of flare accident rates first reported by Benbassat and Abramson (2002b) to estimate the contribution of the leveloff and roundout to the variability of flare difficulty and to conduct an exploratory investigation into the roundout phase.

METHOD

Study 1: NTSB Accident Reports

To be included in this study, reports had to be labeled as *final* and *fatal* or *nonfatal*. Narratives marked as *final* contained information from the final accident investigation report and included probable cause. Those marked as *fatal* or *nonfatal* excluded minor cases and met the NTSB criteria for an accident or incident. This study assessed 6,655 NTSB reports produced between January 1, 1998 and December 31, 2000 (1998: $N = 2{,}228$; 1999: $N = 2{,}209$; 2000: $N = 2{,}218$).

The following criteria were used to classify a report as a landing flare accident. First, reports were classified as landing flare accidents if the NTSB determined the probable cause to be "improper flare" or "misjudged flare." Second, reports were classified as landing flare accidents if the narrative contained explicit clues that implicated an improper flare. An example of such a clues was "the solo student pilot said that his initial flare on landing, was high" (NTSB, 1998a).

Study 2: Pilot Perception Questionnaire

Participants

Participants were 92 (male = 83, female = 9, *M* age = 22.83) pilots from Oklahoma State University (OSU) and Tulsa Community College (TCC) in the state of Oklahoma. OSU operated two Part 141 flight instruction campuses. The main campus was located in Stillwater and provided flight training at Stillwater Municipal Airport. The second was located in Tulsa and provided flight instruction to both OSU–Tulsa and TCC students at Tulsa Jones Riverside Airport. Both training locations operated Cessna 152 Aerobat and Cessna 172 Skyhawk aircraft as primary trainers for private, instrument, and commercial certificates and ratings.

Three levels of pilot experience were defined to determine the effect of pilot experience on perceptions. *Novice pilots* ($n = 38$; total flight time $M = 24.06$, $SD = 22.57$, $Mdn = 13.50$; M age = 21.26, $SD = 3.78$) were defined as pilots with a total flight time of at least 10 hr but not more than 60 hr at the time of the study. *Intermediate experience pilots* ($n = 29$; M total flight time = 178.58, $SD = 38.06$; M age = 22.27, $SD = 5.08$) were defined as pilots with a total flight time of at least 150 hr but not more than 250 hr at the time of the study. Finally, *expert pilots* ($n = 25$; M total flight time = 919.00, $SD = 733.54$, $Mdn = 645.000$; M age = 25.88, $SD = 6.78$) were defined as CFIs actively involved in flight training with a total flight time of 300 hr or more.

Materials

A five-item questionnaire was developed with the assistance of pilots of different experience levels. Each item appeared on a separate page and, for each item, participants were asked to assume optimal conditions (i.e., no crosswind and unlimited visibility) and normal landing procedures (i.e., no obstructions, adequate runway length, and hard surface). Item 2 was omitted from this article and will be included in a future article.

Perceived Difficulty of Leveloff and Roundout

The first purpose of the questionnaire was to estimate the contribution of the leveloff and roundout to the variability of flare difficulty.

Descent, leveloff, and roundout diagram. As shown in Figure 2, participants were shown a diagram depicting a general aviation aircraft on descent, leveloff, and roundout. Participants circled the maneuver they believed to be most difficult and were provided with blank space to write why the maneuver they circled was most difficult.

Leveloff and roundout definitions. On a separate page at the end of the questionnaire, *leveloff* and *roundout* were defined as "leveloff (determining the aircraft height and beginning the flare)" and "roundout (increasing the angle-of-attack by raising the nose of the aircraft after the leveloff)." Participants identified the maneuver they believed to be more difficult and were provided with blank space to write why the maneuver they identified was more difficult.

Perception of Roundout Procedures

The second purpose of the questionnaire was to conduct an exploratory investigation into the roundout phase.

Roundout attitude. Participants were presented with two Microsoft Flight Simulator 2000 Professional Edition screenshots. The two screenshots depicted a Cessna 182 Skylane instrument panel and anterior view on landing for Runway 12

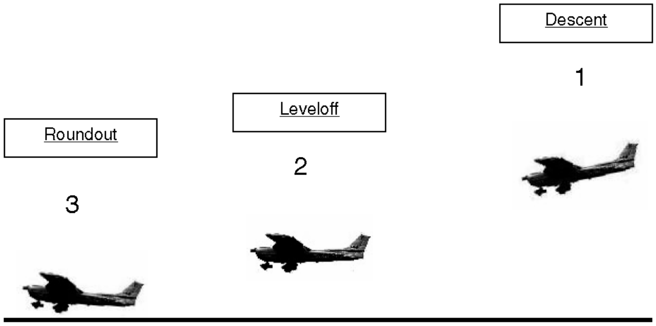

FIGURE 2 Descent, leveloff, and roundout diagram. The figure was reformatted to journal specifications.

at Mojave Airport. The aircraft were configured for a normal approach and weather conditions were optimal (clear sky, 10-m^2 visibility, and unlimited ceilings).

With all other variables held constant, Figure 3 shows that the two screenshots depicted the aircraft at different roundout attitudes. Screenshot 1 depicted the aircraft at a 12° nose-high attitude, and the airport, airport facilities, terrain features, and horizon were not visible. Thus, the anterior view in Screenshot 1 consisted of a patch of blue sky. Screenshot 2 depicted the aircraft at a 5° nose-high attitude, and the horizon, incursion runway (Runway 4–22), control tower, airport facilities, and terrain features were visible. Thus, in Screenshot 2, the nose of the aircraft was placed on the horizon, and the attitude allowed for anterior terrain visibility. The following instructions preceded the two screenshots:

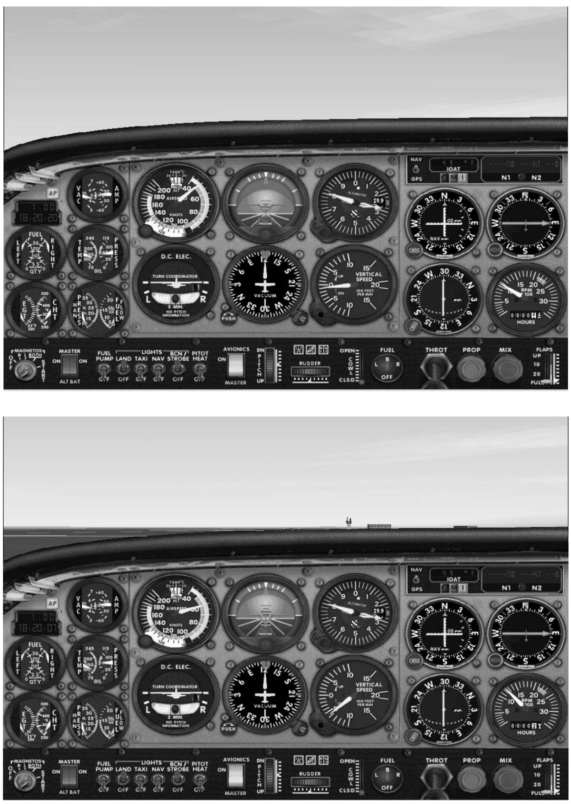

FIGURE 3 Microsoft Flight Simulator screenshot depicting 12 and 5° roundout attitudes. The top screenshot, depicting the 12° roundout attitude, was labeled *1*. The bottom screenshot, depicting the 5° roundout attitude, was labeled *2*. The figure was reformatted to journal specifications. From Microsoft® Flight Simulator 2000 Professional Edition. Copyright Microsoft Corporation. Reprinted with permission.

> After leveling off the aircraft you wish to increase the angle-of-attack by gently raising the nose of the aircraft and allowing it to settle on its main landing gear. … Please *circle* the diagram number that best depicts the ideal angle-of-attack before touchdown.

Roundout procedures. On a separate page, participants identified the roundout procedures they used to transition the aircraft to an optimal nose-high attitude [ranging from 1 (*most appropriate*) to 5 (*least appropriate*)]. The options consisted of "I don't know," "I use the attitude indicator and raise the nose _____ degrees," "I raise the nose until I can't see the horizon," "I keep the nose of the aircraft just under the horizon," and "I keep the nose of the aircraft on the horizon." Participants were also presented with blank space to write alternative procedure(s).

Procedure

The OSU Aviation Sciences program provided ground instruction to OSU–Stillwater students on the main Stillwater campus. TCC provided ground instruction for OSU–Tulsa students through the Aviation Education Alliance. Both programs followed Part 141 Federal Aviation Regulations regarding flight school instruction.

The assistance of appropriate program coordinators was solicited, and appropriate ground school instructors were contacted during the 2002 Fall semester. Ground schools included private pilot, instrument, commercial, and CFI. The questionnaires were completed in a group setting at respective ground school labs. Exceptions to the rule were CFIs that did not attend ground school. The CFIs were provided with questionnaires and completed them at their convenience.

RESULTS

Study 1: NTSB Accident Reports

Flare accident rates were derived from the analyses of 6,655 NTSB accident reports. According to the reports, the NTSB investigated an average of 7.16 (SD = 2.32) flare accidents per month in 1998, an average of 6.75 (SD = 3.01) flare accidents per month in 1999, and an average of 5.91 (SD = 3.84) flare accidents per month in 2000. Consistent with previous findings (Benbassat & Abramson, 2002b), most flare accidents occurred in warmer months and involved single-engine aircraft (single = 80.16%, helicopter = 10.54%, multi = 5.90%, jet = 1.68%, gyroplane = 0.84%, and glider = 0.84%).

The flare accident rates for 1998, 1999, and 2000 were contrasted with those from 1995, 1996, and 1997 (Benbassat & Abramson, 2002b). As illustrated in Figure 4, the trend analysis indicated no significant difference in mean flare accident rates across 1995 ($n = 78, M = 6.50, SD = 3.31$), 1996 ($n = 109, M = 9.00, SD = 4.39$), 1997

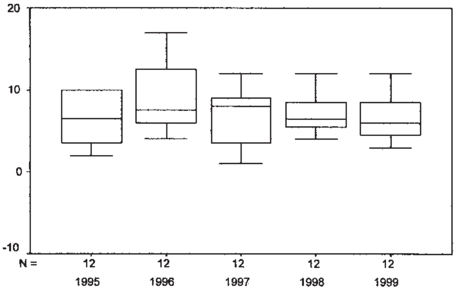

FIGURE 4 Boxplot of flare accident rates.

($n = 81$, $M = 6.75$, $SD = 3.62$), 1998 ($n = 86$, $M = 7.16$, $SD = 2.32$), 1999 ($n = 80$, $M = 6.75$, $SD = 3.01$), and 2000 ($n = 71$, $M = 5.91$, $SD = 3.84$), $F(5, 66) = 1.104$, $p > .05$ ($\eta^2 = .077$, power = .369). Overall, 17.88% of all landing accidents in 1995 (16.60%), 1996 (21.63%), 1997 (16.60%), and 1998 (16.63%) were flare-related accidents (annual reviews of aircraft accident data for 1999 and 2000 were not available).

Study 2: Pilot Perception Questionnaire

Perceived Difficulty of Leveloff and Roundout

Descent, leveloff, and roundout diagram. A goodness-of-fit chi-square was used to determine a preference for leveloff or roundout difficulty, and the results are depicted in Figure 5. There was a significant difference among observed and expected leveloff and roundout difficulty, $\chi^2(2, N = 87) = 23.24$, $p = .001$. Participants perceived the roundout ($f_o = 50$) to be more difficult than expected. However, participants perceived the descent ($f_o = 16$) and leveloff ($f_o = 21$) to be less difficult than expected. Further analysis was conducted to explore a significant relation between experience and perception. A test-of-independence chi-square revealed no significant relation between experience and perception of leveloff (novice = 11, intermediate = 5, expert = 5) and roundout (novice = 16, intermediate = 17, expert = 17) difficulties, $\chi^2(2, N = 71) = 2.60$, $p > .05$.

Leveloff and roundout definitions. A goodness-of-fit chi-square was used to determine preferences for leveloff or roundout difficulty. There was no significant difference among observed and expected leveloff ($f_o = 34$) and roundout ($f_o = 52$) difficulties, $\chi^2(1, N = 86) = 3.76$, $p > .05$. Further analysis was conducted to explore a significant relation between experience and perception. A test-of-independence chi-square revealed a significant relation between experience and perception of leveloff and roundout difficulties, $\chi^2(2, N = 86) = 6.52$, $p = .038$. Figure 6 depicts the proportion of perceived difficulty by experience and maneuver. As shown, expert pilots believed the leveloff (f_o = 4) to be less difficult than expected.

Notwithstanding the perceived difficulty of the roundout in the diagram, an interesting pattern emerged when pilots were asked to explain why they perceived the roundout as difficult. Overall, 40.38% of participants that chose the roundout indicated an inability to determine altitude AGL as probable cause. Figure 7 indicates the proportion of roundout difficulty that was accounted for by an inability to determine altitude AGL (novice = 12.50%, intermediate = 52.94%, expert = 58.82%). Furthermore, 17.24% of participants perceived the roundout as more difficult when it was presented as a diagram but perceived the leveloff as more difficult when it was presented as a definition (novice = 5.26%, intermediate = 33.33%, expert = 18.18%).

Perception of Roundout Procedures

Roundout attitude. A goodness-of-fit chi-square was used to determine preferences for roundout attitude. There was no significant difference among observed and expected 5° (f_o = 39) and 12° (f_o = 49) roundout attitudes, $\chi^2(1, N = 88) = 1.13$, $p > .05$. Further analysis was conducted to explore a significant relation be-

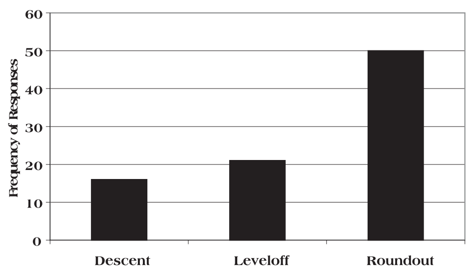

FIGURE 5 Perception of leveloff and roundout difficulties.

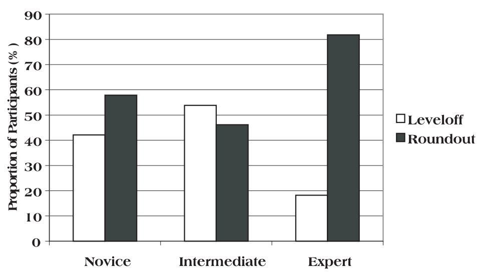

FIGURE 6 Perception of leveloff and roundout difficulties by experience.

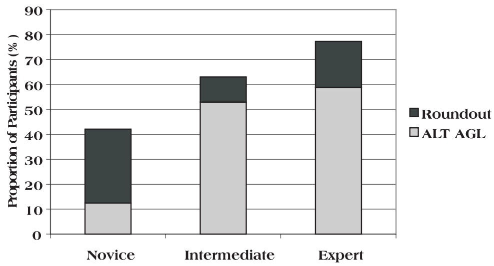

FIGURE 7 Proportion of roundout difficulty that was attributed to an inability to determine altitude AGL by experience.

tween experience and roundout attitude. A test-of-independence chi-square revealed no significant relation between experience and preference for a 5° (novice = 19, intermediate = 15, expert = 15) or 12° (novice = 19, intermediate = 13, expert = 6) roundout attitude, $\chi^2(2, N = 87) = 2.65, p > .05$.

Roundout procedures. A goodness-of-fit chi-square was used to determine preferences for roundout procedures. There was no significant difference among "I don't know" ($n = 12$), "I use the attitude indicator and raise the nose ____ degrees" ($n = 18, M = 7.77°$), "I raise the nose until I cant see the horizon" ($n = 25$), "I keep the nose of the aircraft just under the horizon" ($n = 12$), and "I keep the nose of the aircraft on the horizon" ($n = 15$), $\chi^2(4, N = 82) = 7.14, p > .05$.

Further analysis was conducted to explore a significant relation between experience and roundout procedures. A test-of-independence chi-square revealed no significant relation between experience and "I don't know" (novice = 8, intermediate = 3, expert = 1), "I use the attitude indicator and raise the nose ____ degrees" (novice = 6 [*Mdn* = 5°], intermediate = 7 [*Mdn* = 5°], expert = 3 [*Mdn* = 10°]), "I raise the nose until I cant see the horizon" (novice = 8, intermediate = 8, expert = 9), "I keep the nose of the aircraft just under the horizon" (novice = 5, intermediate = 3, expert 4), and "I keep the nose of the aircraft on the horizon" (novice = 10, intermediate = 4, expert = 1), $\chi^2(8, N = 80) = 10.54, p > .05$.

DISCUSSION

Summary

NTSB Accident Reports

The first purpose of this study was to provide a trend analysis of flare accident rates first reported by Benbassat and Abramson (2002b). Benbassat and Abramson reported that 18% of landing accidents in 1995, 1996, and 1997 were flare-related accidents. At the time this study was conducted, flare accident rates continued to be embedded within the NTSB landing phase of operation and necessitated further analysis.

This analysis consisted of 6,655 NTSB accident reports from 1998, 1999, and 2000 (NTSB, 1998a, 2000a) and exposed a trend. Benbassat and Abramson (2002b) reported that the NTSB investigated an average of 7.44 ($SD = 3.91$) flare accidents per month in 1995, 1996, and 1997. That mean did not change significantly in 1998, 1999, and 2000 ($M = 7.01$, $SD = 3.49$). It is important to note that the rates reported previously are conservative in nature. Many NTSB accident reports included the symptoms of improper flares but were not diagnosed as flare-related accidents. It is possible that flare accidents are difficult to diagnose and depend on multiple factors.

One of these factors may be pilot testimony. Many pilots may underestimate flare incidents, may not be able to attribute an incident to improper flare, or simply fail to report a flare incident. On October 14, 2000, a Cessna 310 landed hard and sustained structural damage. Nevertheless, the pilot continued to fly the aircraft for an additional 8 hr before a mechanic discovered the damage (NTSB, 2000a).

Another factor may be the extent to which the NTSB investigator is familiar with or sensitive to the symptoms of improper flares. Most flare accidents from 1995 to 2000 occurred in 1996. The same year also included the most detailed flare accident synopses with probable causes such as "improper level-off" (NTSB, 1996a) and "failed to round out" (NTSB, 1996b).

Perceived Difficulty of Leveloff and Roundout

The second purpose of this study was to investigate pilot perceptions of the leveloff and roundout phases. One avenue of research included an attempt to explore the proportion of flare difficulty that can be attributed to the leveloff or roundout. When pilots were introduced to a diagram depicting an aircraft on descent, leveloff, and roundout, the roundout was perceived as most difficult regardless of experience. Nevertheless, the roundout and leveloff were perceived as equally difficult when pilots were provided with textual definitions of the roundout and leveloff.

Postulating why pilots regarded the roundout as more difficult when presented with a diagram but not when presented with a definition may have direct implications to flight training. The *Airplane Flying Handbook* (Federal Aviation Administration, 1999) makes no mention of the leveloff and labels the transition from approach attitude to landing attitude as "roundout (flare)" (p. 99). Labeling the flare as *roundout* is not unique to the *Airplane Flying Handbook,* and it is possible that pilots consider the two to be synonyms. Moreover, it is possible that most pilots never learned to associate the leveloff with the flare maneuver. Because most pilots consider the flare maneuver especially difficult, it should come as no surprise that the pilots in this study regarded the roundout as most difficult.

The significant differences between the perception of roundout and leveloff difficulties were canceled with the definition of each. That more novice and intermediate pilots perceived the leveloff as more difficult when it was defined is significant. Articulating the leveloff may have primed an intuitive difficulty sensed by the novice and intermediate pilots. The same cannot be said for expert pilots, who continued to perceive the roundout as more difficult.

With experience, the flare maneuver becomes a "continuous process until the airplane touches down on the ground" (Federal Aviation Administration, 1999, p. XX), and the transition between the leveloff and roundout becomes automatic. It is possible that the ability to distinguish between the leveloff and roundout and, as a consequence, to recognize leveloff difficulty fades with experience. It is especially interesting to note that almost 60% of expert pilots attributed roundout difficulty to difficulty in perceiving altitude AGL. This difficulty is symptomatic of the leveloff, not the roundout during which pitch attitude is of primary concern. We must qualify this discussion by saying that the leveloff may become easier with experience because the ability to determine altitude AGL improves with experience.

Roundout Pitch Attitude and Procedure

Roundout procedures may seem counterintuitive to some student pilots. The natural tendency while landing an aircraft is to lower the nose, not raise it. Nevertheless, roundout instructions are not standardized or do not exist. For example, the *Airplane Flying Handbook* (Federal Aviation Administration, 1999) states that the "roundout should be executed at a rate that the proper landing attitude and the proper touchdown airspeed are attained simultaneously just as the wheels contact the landing surface" (p. 100). This idealized procedure may be of little help to students who cannot determine the aircraft pitch or roundout attitude.

Although traditionally ignored, there have been some attempts to provide roundout procedures. These procedures seem to fall into two broad categories. The first encourages a roundout attitude that permits anterior vision. For example, Fowler (2000) and Penglis (1994) maintained that the perfect landing attitude could be accomplished by the placement of the aircraft nose on the far end of the runway. If the runway end is visible before touchdown, the attitude is too low; if it is not, the roundout attitude is too high.

The second category encourages a roundout attitude that completely blocks anterior view (Butcher, 1996). Within this category are authors that have compared the roundout attitude to the takeoff attitude (Bramson, 1982; Jeppesen, 1985). Roundout attitude ambiguity is further complicated when one considers that some aircraft have low noses and others have high noses (Kershner, 2001) and that roundout procedures change with changing aircraft configuration, weight, and even seat height (Love, 1995).

The lack of standardization in roundout procedures was reflected in this study. There was no significant difference in the proportion of pilots that preferred one roundout attitude over another. Pilots were as likely to choose a screenshot that depicted a 5 or 12° roundout attitude, and there was no significant difference in the procedures used to round out the aircraft to either 5 or 12°. Thus, pilots were as likely to use the attitude indicator; place the aircraft nose above the horizon, under the horizon, or on the horizon; or not know the procedure used to round out the aircraft to the optimal attitude.

Conclusions and Recommendations

This results of this study support the need to further investigate the flare maneuver by the provision of landing flare accident rates. These rates have not changed significantly since 1995, 1996, and 1997 and accounted for 17.88% of all landing accident in 1995 to 1998. More specifically, the NTSB investigated an average of seven flare accidents per month in 1995 to 1998. These findings complement anecdotal reports of flare difficulty and are a testament to the importance of this aviation maneuver.

Leveling off and rounding out the aircraft require experience and repeated practice. Learning is evident by improved performance, but what is learned is explicitly unknown. Thus, teaching landing flare procedures is especially difficult for instructors and frustrating for students (Penglis, 1994). Furthermore, reliance on leveloff and roundout perceptions may yield inaccurate or misleading data (Benbassat, Abramson, & Williams, 2002). As a consequence, behavioral techniques should be encouraged and performance data emphasized. Such an approach was pioneered by Benbassat and Abramson (2002a) to teach nonaviators to land a Cessna 182 simulator. The method was effectively used to teach altitude AGL perception and, consequently, reduce landing impacts.

Regarding the flare as a continuous maneuver may have direct implications to flight training. If expert pilots cannot distinguish or cannot articulate the leveloff from the roundout, it stands to reason that they neglect to include the distinction in pilot training. Similarly, if expert pilots regard the leveloff as less difficult than novice and intermediate pilots, it is likely that CFIs underemphasize the leveloff.

The reduction of landing flare accident rates may depend on the distinction between the leveloff and roundout. The first landing flare task pilots should anticipate is leveling off the aircraft 3 to 6 m (10 to 20 ft) AGL. Mental resources at this phase are dedicated to determining altitude AGL and bleeding airspeed. As airspeed declines and the aircraft transitions to ground effect or begins to drop, the pilot may transition to the second task of determining roundout attitude. At this stage, mental resources are dedicated to transitioning the aircraft to a nose-high attitude to further reduce aircraft velocity and ensure that the aircraft settles on the main landing gear.

Compounding the leveloff and the roundout adds apprehension to an already stressful phase of operation. One intermediate-level participant noted that

> I seem to skip this [leveloff] portion of the landing. I usually make a steep descent and come to the roundout. … I have not learned a level-off technique. I don't remember that part of landing training much if at all.

It is possible that many pilots simply skip the leveloff phase and attempt to immediately round out the aircraft. This tendency may lead to ballooning, especially because most student pilots approach at high velocity. Perhaps that is why many flight instructors complain that students tend to rush the landing.

Whether breaking down the landing flare into the leveloff and roundout will improve landing flare performance is empirical in nature. Further studies are encouraged in the interest of general aviation safety and efficiency.

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