Tomahawk Revisited

Piper's Tomahawk has been criticized for its stall-spin behavior. How does it compare with other spins-approved airplanes?

BY RICH STOWELL

Perhaps no other certificated, spins-approved trainer has generated as much controversy in recent years as the Piper Tomahawk. With fewer than 2500 copies produced from 1978 through 1982, the airplane has sparked international debate regarding its stall and spin characteristics, earning it the nickname "Traumahawk." Along the way, the NTSB, FAA, New Piper Aircraft Company and AOPA have been at odds over whether the airplane meets the acceptable stall and spin behavior spelled out in certification standards. Aircraft designers, test pilots, safety advocates, instructors and pilots have also weighed in on both sides of the issue.

Aircraft Tested

To verify the Piper Tomahawk's spin chracteristics and compare them with other aircraft certificated for intentional spins, the following aircraft were spin-tested and their documentation reviewed:

Piper PA-28-112 Tomahawk, N9431T, s/n 38-78-A0101
Bellanca 8KCAB Decathlon, N5035N, s/n 470-79
Cessna 150, N704SL, s/n 15078837
Aviat Pitts S-2B, N17PW, s/n 5148
Bellanca 7ECA Citabria, N50380, s/n 1291-79
Beechcraft T-34A Mentor, N34EP, s/n G-74

Much has been published not only about the airplane's stall/spin characteristics, but also about the airplane's high number of strikingly similar flat spin encounters, several of which resulted in fatal accidents. According to a 1997 AOPA Air Safety Foundation publication, *Safety Review: Piper Tomahawk PA-38-112*, the Tomahawk "has significantly different stall and spin characteristics, by design, from other comparable trainers."

What's the real story? How "different" is its stall/spin behavior? What do Tomahawk pilots need to know about its characteristics?

After Piper Aircraft Corporation's bankruptcy, the Piper Aircraft Irrevocable Trust took responsibility for aircraft made before 1995, including the Tomahawk. *Aviation Safety* made several attempts to contact the Trust for comment on this article.

Just The Facts, Please

Piper designed the PA-38-112 back in the mid-1970s, when demand for GA airplanes was much higher. The company needed a "new-technology" trainer to replace the venerable Cherokee 140 and compete against Cessna's 150/152. The T-tail was all the rage back then, and Piper got a lot of things right: The Tomahawk has a roomy cabin, a well-placed fuel selector and a number of other features making it popular.

The FAA certified the Tomahawk for intentional spins in the Utility Category to the same standards as other spins-approved airplanes of the time. But, comparing accident rates on several levels for the period 1982 through 1990, the AOPA Air Safety Foundation found the Tomahawk's stall/spin accident rate to be 1.7 to 2.5 times that of the Cessna 150/152 and 2.0 times that of the Beechcraft Skipper. An NTSB analysis for the period 1984 through 1994, however, placed the Tomahawk's stall/spin accident rate as 3.4 to 5.6 times that of the Cessna 150/152. The numbers, regardless of the source, are statistically significant.

Reviewing The Literature

In a 1995 letter to the NTSB, the leader of the Tomahawk's Advanced Design team stated that the goal "was to produce a docile, no surprises basic trainer aircraft that met Piper's marketing specifications." This concept translated into experimental and conformity prototypes which were used for stall and spin tests. Piper Aircraft Corporation's Flight Test Report FT-118 states: "Spin entry and recovery *is conventional* although some occasional difficulty was noted in inducing a power-off spin to the right at extreme aft loadings. Irrespective of the loading or entry or number of turns, the aircraft will recover in one additional turn after input of anti-spin controls.... The most effective recovery technique was found to be full rudder against spin rotation followed immediately by full forward elevator control. At forward loadings, it is necessary to relax forward yoke pressure as the stall is broken to prevent uncomfortable negative acceleration forces." [emphasis added]

The spin recovery actions published by Piper for the Tomahawk mirror NASA Standard recommendations. The information contained in the Tomahawk POH is consistent not only with Piper's stated design goals and Flight Test Report, but also with certification standards, information found in the operating handbooks of comparable airplanes, and generally observed spin dynamics. Piper does not use the phrase "significantly different" when discussing Tomahawk stall or spin behavior. In fact, the literature clearly leads pilots to believe that the Tomahawk should display typical stall/spin characteristics.

Methodology

The Tomahawk's design either meets FAA certification standards or it doesn't. If it does, the question becomes whether its spin behavior is consistent with other spins-approved GA airplanes or are the standards broad enough to result in truly unique stall/spin characteristics among spins-approved designs? We attempted to answer this question two ways: first, by comparing manufacturers' documentation with other stall/spin literature, and second, through a series of simple spin tests using six airplanes approved for intentional spins, as listed on the preceding page.

Takeoff weights were roughly 90 percent of each airplane's spins-approved, maximum gross weight. As flown, the centers-of-gravity in the Citabria and T-34 were practically at their forward limits; however, CG in the remaining airplanes were about 40 to 43 percent of their spins-approved aft limits.

Thus, all spins were conducted within the forward half of each airplane's spins-approved CG envelope. Variations in weight and CG certainly can affect spin and recovery characteristics; nevertheless, evidence of a range of "normal" spin behavior should emerge in the data.

Results

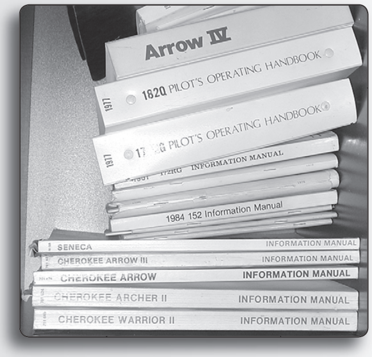
Spins were performed to the left and to the right while flying solo in six different spins-approved airplanes. The intent was to fly the airplanes "as is," in other words, as a pilot might find them on the flight line. Spins were entered from wings-level flight, in the clean configuration, with the power idle and the ailerons held approximately neutral, while decelerating at a constant altitude. Spin entry was initiated at the airplane's indicated wings-level stall speed plus 5. Entry and recovery inputs were applied sequentially. Thus for timed events, the entry sequence was rudder–elevator–timer; the recovery sequence was timer–rudder–elevator. Upon cessation of rotation, opposite rudder was neutralized followed by a +2.5 to +3.0 g pullout to level flight. Power remained at idle until returning to a level flight attitude. In some cases, g's were recorded by a g-meter installed in the airplane; in other cases, g's were estimated based on my experience. The following data were collected:

One-turn spins: Total altitude loss was recorded from spin entry, through one full rotation, spin recovery, and back to level flight; the number of turns required for recovery were recorded as well. Two spins were performed in each direction for each airplane. Altitude loss and the turns for recovery were averaged.

Three-turn spins: The rate of rotation was timed, the number of turns for recovery was recorded, the elevator position at the time of recovery was estimated, and the altitude loss per turn was calculated. Two spins were performed in each direction for each airplane. Times were averaged.

The first 1000 feet in a spin: The rate of descent was timed and the

Comparing Manuals



One Tomahawk Pilot's Operating Handbook (POH, Report 2126, Revised April 1981) notes, "An approaching stall is indicated by a stall warning horn, which is activated between 5 and 10 knots above stall speed. Mild airframe buffeting and gentle pitching may also precede the stall."

That same POH contains 18 paragraphs regarding spins. The information provided matches nearly verbatim the information issued for the Piper PA-28-140 Cherokee (first as Service Bulletin 753 and later as a Special Airworthiness Information Bulletin). A comparison of Tomahawk information with that offered in the POH for a 1978 Cessna 152 is equally insightful.

While Spinning

Tomahawk: "The ailerons must remain neutral throughout the spin and recovery because aileron application may alter spin characteristics..."

Cessna 152: "Careful attention should be taken to assure that the aileron control is neutral during all phases of the spin because any aileron deflection in the direction of the spin may alter the spin characteristics..."

During Recovery

Tomahawk: "Apply and maintain full rudder opposite the direction of rotation."

Cessna 152: "Apply and hold full rudder opposite to the direction of rotation."

Tomahawk: "As the rudder hits the stop, rapidly move the control wheel full forward and be ready to relax the forward pressure as the stall is broken.... In all spin recoveries, the control column should be moved forward briskly, continuing to the forward stop if necessary.... In most cases, spin recovery will occur before the control wheel reaches the fully forward position."

Cessna 152: "Just after the rudder reaches the stop, move the control wheel briskly forward far enough to break the stall. Full down elevator may be required."

Tomahawk: "Normal recoveries may take up to 1½ turns when proper technique is used."

Cessna 152: "Application of recovery controls will produce prompt recoveries of from ¼ to ½ of a turn. [But] If the spin is continued beyond the 2- to 3-turn range.... [recoveries] may take up to a full turn or more."

number of turns was calculated. One spin was performed in each direction for each airplane.

The altitude loss during a one-turn spin and recovery ranged from 475 feet in the Cessna 150 to 900 feet in the Pitts S-2B; the Tomahawk required 650 feet.

In spins-approved airplanes, the maximum allowable number of turns for spin recovery is 1½ turns. The number of turns required for recovery from a one-turn spin varied from 1/8 turn in the Cessna 150, Citabria and T-34, to ½ turn in the Tomahawk. The number of turns required for recovery from a three-turn spin varied from ¼ turn in the Citabria up to one full turn in the Decathlon; the Tomahawk required ¾ turn.

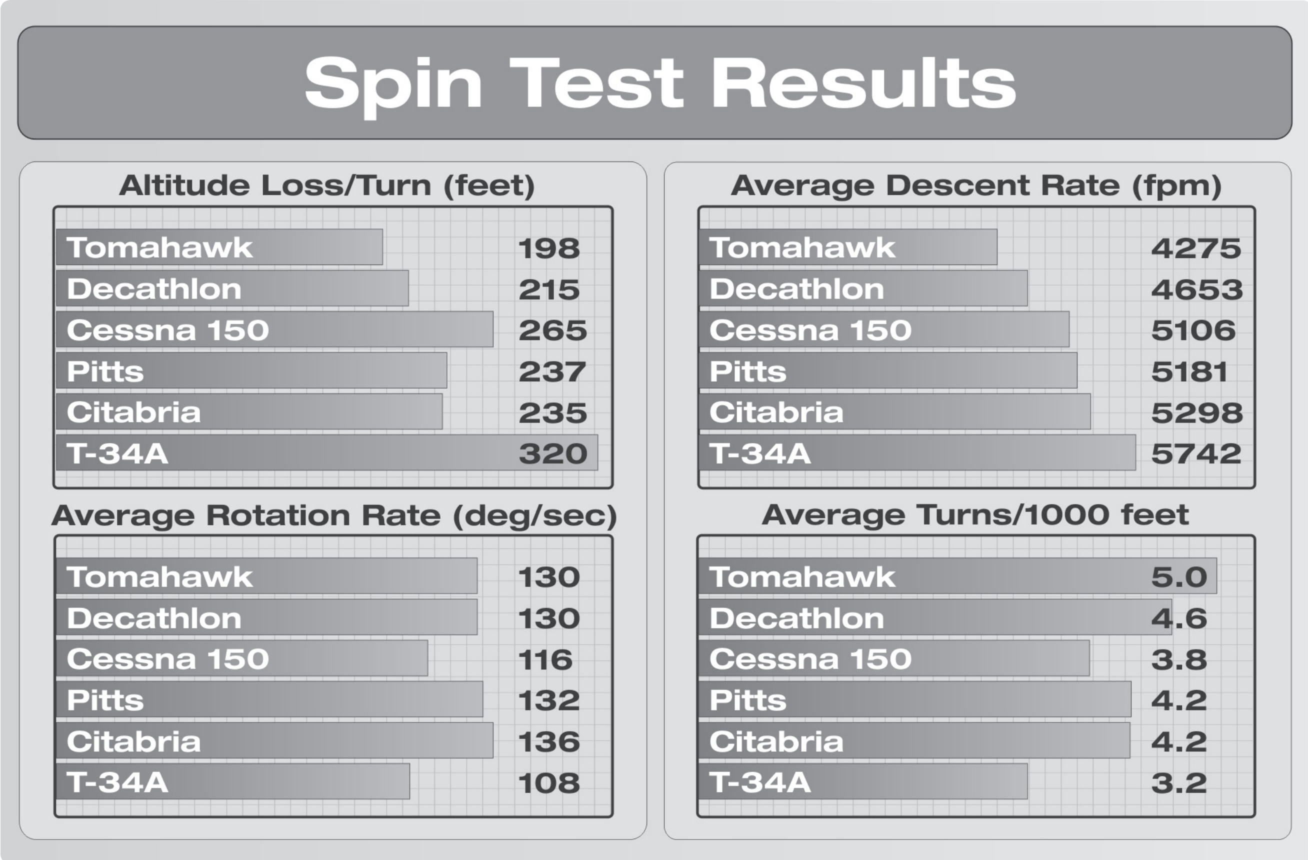
The average rate of rotation varied from 108 degrees per second in the T-34 to 136 degrees per second in the Citabria; the Tomahawk averaged 130 degrees per second. The calculated average altitude loss per turn during a three-turn spin ranged from 198 feet per turn in the Tomahawk up to 320 feet per turn in the T-34.

Data for left spins in a seventh airplane—Cessna 150, N704JH, s/n 15078644—is included here as well. Although not spun specifically as part of this exercise, the conditions under which rate of rotation and rate of descent were measured were similar to those used in this test.

Spin data for Cessna 704JH were collected for two cases: left spins with idle power maintained throughout, and left spins with full power applied throughout. This additional information allows not only a comparative look at two airplanes within the same family—Cessnas N704SL and N704JH—but also a look at how spin behavior changes in the same airplane when one variable is changed—in this case, power setting.

Note that in Cessna 704JH spinning with full power, the rate of rotation was nearly 14 percent faster while the altitude loss per turn was nearly 22 percent less compared to its idle-power spins.

The average rate of descent ranged from 4275 fpm in the Tomahawk to 5742 feet per minute in the T-34. The calculated average number of turns in 1000 feet ranged from 3.2



turns in the T-34 to 5.0 turns in the Tomahawk. Spinning with full power applied in Cessna 704JH slowed the rate of descent 10 percent compared to its idle power spins, thus allowing one additional turn to be accomplished in 1000 feet. With idle power, Cessna N704JH behaved more like its sibling, N704SL; on the other hand, Cessna N704JH with full power spun more like the Tomahawk and the Decathlon. Yet with or without power, the behavior of N704JH still falls within the range of values found for the other six airplanes.

Elevator position at the time of recovery from a three-turn spin was estimated to be near neutral in the Tomahawk, the Decathlon and the Pitts. The Cessna 150 and the Citabria required the least amount of forward elevator during recovery–about midway between the neutral and fully aft positions.

In addition to the data collected above, I have at times performed spin entries from left skidded turns in each of these airplanes. The typical set-up involved slow flight in the clean configuration. A coordinated left turn with 20-30 degrees of bank was established. To simulate a common base-to-final accident scenario, left rudder was then smoothly and continuously applied, followed by a smooth and continuous application of aft elevator in an attempt to hold the nose "up" on the horizon.

Each airplane consistently departed into an accelerated stall/spin to the left from a nose-low, banked attitude. All of the airplanes—including Tomahawk N9431T—behaved similarly during the spin departure and ensuing recovery.

More Data Needed?

I have performed in excess of 26,200 spins in more than 160 different spins-approved, single-engine airplanes, representing a dozen different low-wing types and nine different types each of high-wing and biplane airplanes. Every airplane reveals unique nuances while spinning. In the case of Tomahawk N9431T, right spins appeared to be smooth and steady throughout, while left spins appeared to oscillate mildly before settling into a slightly steeper attitude between two and three turns.

Yet in the broader context of allowable spin behavior, known spin dynamics, and consistent actions by the pilot, a range of "normal" spin characteristics becomes evident in these spins-approved airplanes. Under the conditions tested, Tomahawk N9431T exhibited normal spin characteristics—its spins were unremarkable compared with the other airplanes. Moreover, Tomahawk N9431T performed as Piper literature states it should perform.

Based on Piper's own literature and my spin experience in Tomahawk N9431T, it seems reasonable

Continued on page 29

Tomahawk Revisited

Continued from page 7

to expect other Tomahawks to fall within the range of normally-anticipated, normally-acceptable spin characteristics (provided of course the airplanes are operated within their spins-approved weight and balance envelopes). To be meaningful, claims of "significant differences" in Tomahawk stall/spin behavior need to be quantified with supporting data. And if substantiated, those claims need further investigation.

The otherwise standard spin information already provided by the manufacturer may need to be revised as a result, too. For example, the following have been reported about Tomahawks, yet no reference to such behavior is found in POH Report 2126:

During Stalls: Sharp roll-off to one side, extreme bank angles at the stall break, unpredictable behavior, noticeable oil canning (dimpling/creasing) of the wing skin, no perceptible nose-down pitch change and the propensity to spin from an otherwise routine stall.

During Spins: Flat spinning tendencies and deformations in the supercritical wing that might adversely affect spin behavior.

Some investigations have been conducted over the years, with mixed results. Aviation authorities in New Zealand, for instance, reported that the Tomahawk exhibited totally conventional stall and spin behavior; yet, flight testing of the Tomahawk in both Australia and Sweden reported that the airplanes did not comply with Part 23 certification standards.

A Tomahawk used during FAA stall tests in 1997 displayed stall behavior typical of light airplanes conforming to Part 23 certification standards, yet a 1998 study found that the tested Tomahawk exhibited inconsistent nose-down pitching at the stall (of 60 stalls performed, only 22 percent exhibited nose-down pitch behavior and abrupt roll-off was experienced). These results raise the issue of whether every Tomahawk was created equally.

Conclusions

Allegations of "significantly different" stall/spin behavior mean one of three things:

1. Either those making the allegations may lack a thorough understanding of stall/spin dynamics and/or stall/spin certification requirements;
2. Some Tomahawks may indeed behave outside the realm of normally-expected spin behavior, in which case it is highly likely that those characteristics would be deemed unacceptable vis-à-vis certification standards; or,
3. A combination of the above.

> To be meaningful, claims of "significant differences" in Tomahawk stall/spin behavior need to be quantified with supporting data.

The simplest way to resolve the Tomahawk issue would be to spot-check the spin behavior of a number of airplanes here in the U.S. Unfortunately, neither several similar spin accidents, nor seemingly credible reports of unusual stall/spin behavior, nor numerous articles warning of unpredictable spin behavior, nor NTSB recommendations to retest the airplane have been able to persuade the FAA or Piper to consider spinning a Tomahawk or two. Contrast this with the approaches taken to deal with allegations of questionable spin behavior in two other spins-approved airplanes:

In Australia in the 1950s, all it took was one spin accident for Australian authorities to launch a re-check of the spin behavior of every de Havilland Chipmunk in that country.

Subsequently, another report in Australia of difficulty in recovering from a spin in a Chipmunk resulted in nearly 100 test spins being performed in the suspect airplane. All it took in the U.S. in the early 1970s was a couple of reports made by a couple of flight instructors (who had little or no understanding of spin dynamics or of the importance of adhering to the manufacturer-recommended protocols) about the spin behavior of the Cessna 150 for the issue to be addressed head-on. In these cases, the additional spin tests exonerated the airplanes and resulted in the dissemination of more detailed information about each airplane's spin characteristics.

For those flying Tomahawks: Please proceed with extreme caution until additional data comes forth that either confirms that the Tomahawk fleet as a whole behaves normally in this regime—clearly as was intended—or reveals that some airplanes may not conform to the applicable certification standards.

Rich Stowell is a NAFI Master Instructor of Aerobatics who specializes in spin, emergency maneuver and aerobatic training. He has performed more than 25,000 spins with students in his 6100 hours of flight instruction.

Thanks to Jim Skogen of Minnesota for collecting the spin data for his T-34 Mentor, which the author has had the pleasure of spinning on many previous occasions. Thanks as well to the following for making their airplanes available to the author for this exercise: Lyle Shelton of "Rare Bear" fame (Pitts S-2B); Aviation Pacific, Inc. of Oxnard, Calif. (Tomahawk); and especially CP Aviation, Inc., of Santa Paula and Oxnard, Calif. (Cessna 150, Citabria, Decathlon).