What factors affect accident fatality rates for pilots of homebuilt aircraft?

BY RON WANTTAJA

Last year, I participated in an FAA Flight Safety Review Board on homebuilt safety. It was a positive experience; those FAA guys ain’t “out to get us” as much as we think. At one of the meetings, I passed a copy of my accident database to one of the FAA analysts. At a later meeting, we compared statistics—and his were different from mine. Talk about a huge sinking feeling. Was there a fundamental problem with the way I was getting my numbers? Were my results bogus? The actual reason was pretty simple: I computed my statistics based on all of the accidents, and the FAA analyst looked only at the ones that resulted in fatalities.

It’s not that the FAA is indifferent to the “fender benders” of aviation. But when people die, it catches everyone’s attention—from FAA managers to congressional staffers to your local news media. About 18% of all U.S. aircraft accidents result in fatalities, versus about 25% of homebuilt, and this has led to recent FAA emphasis on the homebuilt rate of fatal accidents. Let’s take a look at the numbers.

Analysis Notes
For this analysis, we’ll call it a “fatal accident” if at least one person was killed. We’re analyzing based on the number of

The fatality rate for homebuilt aircraft is almost 50% higher than the overall rate.
accidents, so the statistics are based on counting the aircraft rather than counting the number of occupants who were killed. For comparison, we’ll occasionally look at the same statistics for Cessna 172s over the same time period (1998 through 2007).

Pilot Error
Are crummy stick-and-rudder skills the culprit? “Pilot Miscontrol” remains the main cause of accidents, but check out Figure 1. For both homebuilts and C-172s, the percentage of accidents due to Pilot Miscontrol drops significantly in comparison to non-fatal accidents. A moment’s thought gives a plausible reason. Most accidents occur during takeoff and landing, when planes are moving relatively slowly. Stall-spins aside, takeoff/landing accidents are more survivable.

This is probably more obvious in the Cessna statistics. Cessna 172s are often used as trainers, and, of course, training accidents are the classic fender-bending ego-busters. Cessna 172 pilots in fatalities had a median total flight time of 318 hours versus 240 for the non-fatal cases. Homebuilt pilots had roughly 900 hours, with a bit less variation between fatal and non-fatal.

A Matter of Judgment
What really stands out in Figure 1 is the way Pilot Judgment, which encompasses decision-making rather than stick-and-rudder skills, increases as a factor in fatal accidents. It includes trying to continue visual flight rules (VFR) flight into instrument meteorological conditions (IMC), fuel exhaustion or starvation, midairs, buzzing, etc.

The biggest hit? It’s obvious in Figure 2: Maneuvering at Low Altitude. This catch-all category includes traditional buzzing, doing aerobatics at low altitude, flying a low pass over the runway and pulling up into a high-speed stall, flying into box canyons or encountering rising terrain, or just flying too low and hitting something.

Maneuvering at low altitude is involved in less than 2% of the total homebuilt accidents, but more than 14% of the fatal ones. As Figure 3 illustrates, more than 60% of the low-altitude fatalities occur because a pilot performed aerobatics with insufficient recovery altitude, or accidentally stalled during a buzz job or a low pass over a runway.

Antenna Strike
Accident: FTW98FA377
Aircraft Type: Jodel F11

The builder had purchased the Jodel a month earlier.

The airplane took off to the west, circled the airstrip, and then executed a low pass (100 feet or less) over the hangar housing a local skydiving company. Following communication with the pilot of an airplane carrying skydivers, the Jodel pilot departed the area to the north.

Approximately 30 minutes later, the Jodel returned. It descended lower than the hangar’s roofline, pulling up steeply as it neared the hangar. Its left wing hit a television antenna installed on the roof. The Jodel entered a steep descent to the left and crashed. The antenna had been 34 feet above ground level.

NTSB Probable Cause: “The failure of the pilot-in-command to maintain obstacle clearance during an intentional low-altitude maneuver.”

Photos: Ron Wanttaja, BigStock Photo
About a third of the total came from just the hazards of the low-altitude environment—descending into the ground itself or hitting an obstruction such as a tree or building.

**Builder Error**

**Accident:** LAX02FA188  
**Aircraft Type:** Fisher Celebrity with a Continental A-65 engine.

The airplane had been completed about 14 years prior to the accident, and the pilot had purchased the plane the year before. Witnesses heard a “pop” and sputtering of an engine. When they looked up into the air, they saw the accident airplane with the left wings folded back. The airplane spiraled to the ground.

Investigators determined that the kit drawing indicated the spar cap stiffeners were to be rectangular in shape and run the full length of the spar. The accident airplane’s spar cap stiffeners were triangular in shape and terminated at the outer end of the filler blocks. According to the drawing, the filler blocks were to fill all of the space between the spar cap stiffeners. The filler blocks on the accident aircraft were thinner and occupied approximately 50% of the space between the spar caps. The filler blocks were also shorter than specified and did not taper at the upper and lower spar-cap stiffeners as specified. A plywood cap specified in the kit drawings was not installed. The failure location was primarily at the outboard end of the filler blocks.

Prior to the accident, the pilot had expressed concern over potential delamination of the wing fabric, but had taken no action.

**NTSB Probable Cause:** “Failure of the wingspars and the in-flight separation of the aircraft wing due to the builder’s inadequate manufacture of this Experimental aircraft. Also causal was the current owner/pilot’s continued flight with known mechanical discrepancies.”

What’s even more interesting is how fatal some of these mistakes are. If you make a mistake during low-level aerobatics, there’s only an 11% chance you’ll survive the accident. Low-altitude stalls have just a 23% survival rate.

Maneuvering at Low Altitude also contributes to the Cessna 172 fatality rate, but the rate is about 30% less. The majority of the reduction is due to a great decrease in the low-altitude aerobatics arena. Few people slow-roll their Skyhawks on takeoff.

Referring back to Figure 2, you’ll see that attempting to fly into IMC on a VFR basis also has a significant effect.
on accident mortality. Not as much as the Cessna 172 crowd, though—over 20% of all fatal accidents in Cessna 172s were due to continued VFR flight into instrument conditions.

**Where Training Works**

Figure 4 provides some comfort. It compares the accident rate for other common homebuilt accident causes, with the pilot error accidents eliminated. Note how “Engine Mechanical” and “Fuel System” accidents have a lower fatality rate. In most of these cases, it means the engine has quit, and these statistics imply that many of us are trained well enough to give us a fighting chance of surviving the event.

**Fatal Accidents and Aircraft Design**

What makes an accident survivable? Given the same basic conditions, two factors come into play: the amount of occupant protection and the aircraft’s speed at impact. The energy released when an object comes to a sudden stop is its mass times its velocity squared. If a plane loses its engine and lands short into the trees, the occupants are better off if they’re in a low-speed Cub clone than a fast cross-country airplane.

If you’ve been reading this series, Figure 5 should be familiar. It compares the fatality rates for a number of common homebuilt types. Over the last few months, I’ve received emails from readers who recognized an interesting trend. Take a look at the airplane types and the fatality rates, and see if you notice it. Yes, the fatality rate is rising with the plane’s cruising speed—but notice that the GlaStar, not slow but has one of the lowest rates.

Try this: Starting with the plane with the lowest fatality rate, say aloud the wing position of the design (low, mid, high). Notice that they’re all high-wingers on the lower part of the graph and almost all low-wingers on the upper part, with some transition in the middle.

It’s true that low-wing airplanes dominate in the high-speed portion on accident mortality. Not as much as the Cessna 172 crowd, though—over 20% of all fatal accidents in Cessna 172s were due to continued VFR flight into instrument conditions.

**Figure 3: Judgment Errors at Low Altitude in Homebuilt Accidents.**

The fire was of ground origin (no one hurt), but the melted center section of this Mooney reveals a welded-tube structure in the fuselage that might aid survivability.

**Foggy Sky, Foggy Mind**

**Accident: NYC07LA011**

**Aircraft Type: Bakeng Deuce**

The pilot had purchased the airplane about three years earlier. His destination was uncertain. He had received an abbreviated weather briefing, and was advised that VFR flight was not recommended.

Weather included a 100-foot ceiling with fog. Near dusk, about 15 minutes after takeoff, the airplane attempted to land at an ultralight field. A witness reported that the airplane “appeared to be blown off course, climbed out, banked hard to the right, and crashed into a wooded area.”

A post-mortem blood test revealed codeine (a narcotic), diphenhydramine (an antihistamine with a strong sedative effect), bupropion and paroxetine (two antidepressants).

**NTSB Probable Cause:** “The pilot’s failure to maintain airspeed during a go-around, which resulted in an inadvertent stall. Contributing was the deteriorating weather and diminishing light conditions, the pilot’s decision to take off despite the weather advisory, and the pilot’s use of a painkiller and an antihistamine.”

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of the spectrum. But one has to wonder if the structure added around the cabin to support a high wing also adds to survivability in case of an accident.

A low-wing, bubble-canopy aircraft is obviously more dangerous if the plane flips inverted on impact. Most designers add some sort of rollover structure, but there’s a lot to be said for having heavy-duty overhead protection. A couple of wingspars and the structure to support them do nicely.

**Speed Kills…Still**

The structural impact is debatable, but there’s no question the speed of the plane is a major factor. Figure 6 plots the published cruise speed (published cruise speed, folks—not necessarily the real cruise speed) for a number of homebuilts and production aircraft. The icons show the wing position for each aircraft type.

And, yes, for production aircraft as well as homebuilts, the fatality rate goes up with the cruise speed.

Homebuilts are really pretty much “in family” with production aircraft: Homebuilt fatality rates tend to cluster around those of production aircraft of different types. There are outliers, yes. But for the most part, when you see a production-type aircraft, there’s usually a homebuilt with the same general configuration and speed range quite near.

Note, though, that the production-type planes have less variation; they tend to form a tighter pack. Why? One possibility involves the CAA/FAA regulations that governed the certification of each aircraft. These regulations tend to make the airplanes similar in terms of handling qualities, structural margins and provisions for occupant safety.

Homebuilt designers are free from these limitations. The marketplace tends to reward companies offering higher performance, not better survivability. The better designers include occupant protection features such as roll bars and cockpit stiffening, but there are no specific standards to meet, and nothing preventing the builder from skimping on protection.
The rate of fatal accidents due to builder error is only slightly higher than that of non-fatal accidents.

Power Loss, No Tickets  
Accident: LAX05LA149  
Aircraft Type: RANS S-6ES

The two pilots had purchased the airplane a year previously. It had more than 800 flying hours. Witnesses reported that the airplane was flying around the local area when the engine started to “sputter” and then quit. The airplane turned toward the airport, then “went straight down.” Both occupants were killed.

The aircraft held only a half-gallon of gasoline in one fuel tank. Investigators were unable to locate any other evidence of fuel in the aircraft, or fuel contamination at the accident site.

While the two pilots had owned the plane for almost a year, they had not re-registered it in their names. Neither held a pilot or medical certificate.

NTSB Probable Cause: “The loss of engine power for undetermined reasons and the flying pilot’s failure to maintain an adequate airspeed that resulted in a stall and uncontrolled descent into terrain.”
Wrap-Up
One in every seven fatal homebuilt accidents involved flying in the proximity of the ground when it wasn’t necessary for operations. The homebuilt fatality rate in this category is almost four times higher than that of Cessna 172s.

Building airplanes with occupant protection in mind would help. Planning for survivability doesn’t begin and end with the installation of a seat belt. Going to mount the seat a bit higher to see over the nose better? Make sure your noggin will still be below the turnover structure. Don’t leave sharp edges in the cockpit, put a cover over the baggage compartment to help hold things in place, and make sure the shoulder harness is attached to solid structure, not just a bit of random sheet metal.

Again, there’s one big category involved in homebuilt fatalities: Pilot Miscontrol. The rate is lower, but 30% of our fatalities can still be attributed to stick-and-rudder errors. Get the right training, and fly carefully. All told, nearly 60% of our fatal accidents are due to the combination of Pilot Miscontrol and Pilot Misjudgment: Pilot Error, to use the vernacular. Reduction of our fatality rate should be a key goal for all of us.

To quote an old martial arts saying: “To stop the fist, stop the arm.” If the circumstances leading to fatal accidents can be reduced, the overall accident rate will drop, too.

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Ron is a systems engineer, engaged in satellite orbit/constellation design and analysis, launch vehicle and onboard propulsion system trades, and operations concepts for space systems. He worked on the early design studies for the International Space Station.

It almost goes without saying that if your airplane disassembles for transport, make sure it’s back together when it comes time to fly!