HOMEBUILT AIRCRAFT SAFETY 1998–2006

Experimental/Amateur-Built rates are comparable to the certified fleet's, *but we could do better.*

BY RON WANTTAJA

My previous two articles for this magazine on homebuilt accident causes focused on specific three-year periods: 1998 to 2000 for my article in 2004, and 2002 to 2004 for a similar article published in 2006. Each of these studies addressed a separate set of about 650 accidents—not a bad amount, but larger sample sizes are always better.

By adding the NTSB data from the year 2001 (between the two studies) and two later years, my database now covers from January 1998 to December 2006. That gives us a nine-year period with almost 2000 homebuilt accidents. Let's see how the numbers come out.

Fleet Accident Rates

First up, let's look at the homebuilt accident rate. As Figure 1 shows, the overall accident rate for U.S.-registered aircraft is about 0.61% per year, while the homebuilt rate is 0.87%. In other words, the homebuilt accident rate is about 44% higher.

This included both new homebuilts and those that had completed their Phase I flight test. If we eliminate the homebuilts that had fewer than 40 hours flying time (i.e., for many of them, still in their test period or phase) and reduce the yearly total of aircraft by the number of new aircraft added that year, we can form a rough estimate of the accident rate after the airplanes complete their test periods: 0.71%. Quite a bit lower, but still 15% higher than the overall U.S. fleet.

Note how the accident rate for Cessna 172s built since the company restarted production in the mid-'90s is twice that of the 172s in general. This doesn't mean the new 172s are less safe than the old ones. A lot of the older aircraft remain on the FAA rolls even though they may be abandoned or even scrapped, and these skew the results a bit.

What this means is that the actual fleet accident rates—the accident rate for active aircraft—are undoubtedly higher than the results shown in Figure 1. However, this probably affects homebuilts and conventional aircraft types about equally, so we can assume that the relative accident rate between homebuilts and the overall U.S. civil aircraft fleet remains about the same.

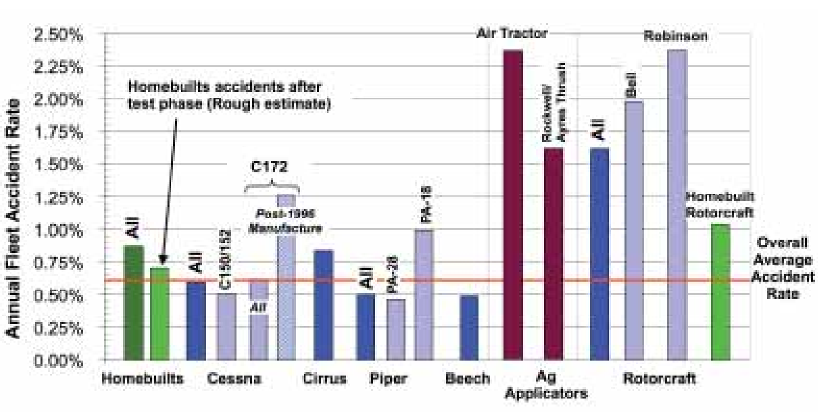


Figure 1: Fleet Accidents Rates, 1998-2006

Accident Causes

The big question: Why is the homebuilt rate higher? For each homebuilt in the NTSB database, I studied the accident narrative to determine the "initiator" for each accident. Initiator is my term for

Illustrations: Ron Wanttaja, Photo: Kevin Wing the event that triggered the emergency situation. While the NTSB's Probable Cause formed a major portion of my initiator determination, I sometimes came to a different conclusion.

Take, for instance, a typical engine-failure accident. If the pilot overshot during his or her forced landing, the NTSB often assigned probable cause to "...the failure of the pilot to maintain proper glide path." The engine failure itself was often listed as secondary.

In contrast, I assigned the engine failure as the initiator of the accident. This has the effect of reducing the number of Pilot Error accidents, but highlights cases where mechanical problems were the first event in the accident chain.

To allow a comparison with a typical non-homebuilt general aviation aircraft, I performed the same type of analysis to a control group consisting of combined Cessna 172 and Cessna 210 accidents. This gives a mix of simple versus complex aircraft like the homebuilt fleet, albeit without taildraggers.

Figure 2 presents the results. Homebuilts are better in just three categories: Pilot Error: Failure to Control, Fuel Mismanagement and VFR into IFR Conditions.

The Pilot Error: Failure to Control category traces pilot mistakes in ordinary handling of a fully functional aircraft (inadvertent stall, improperly judging the approach, losing control in gusty conditions). Homebuilts score much better here—but are they easier to fly than Cessna 172s and 210s?

Probably not. Pilots in homebuilt accidents tend to be more experienced to begin with. Pilots of the control group had a median total time of 506 hours, while the homebuilt pilots had almost twice the time (median of 950 hours). In addition, pilot inexperience was cited by the NTSB investigators more often in homebuilt accidents: 3.7% of the time, versus 2.9% for the control group.

When it comes to the categories where homebuilts score worst, the biggest standout is probably Builder Error. More than 5% of homebuilt accidents are directly caused by mistakes made during the aircraft's construction. More than a third involved the aircraft's fuel system, with an additional 30% due to mistakes

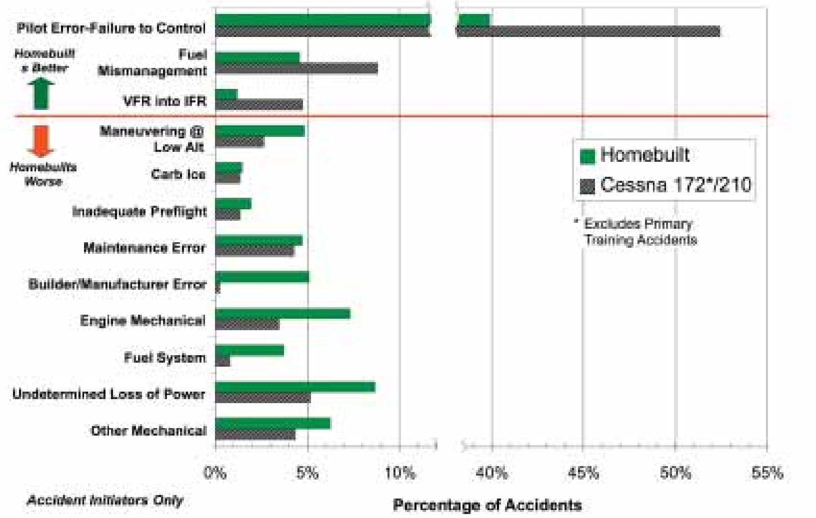


Figure 2: Accident Causes

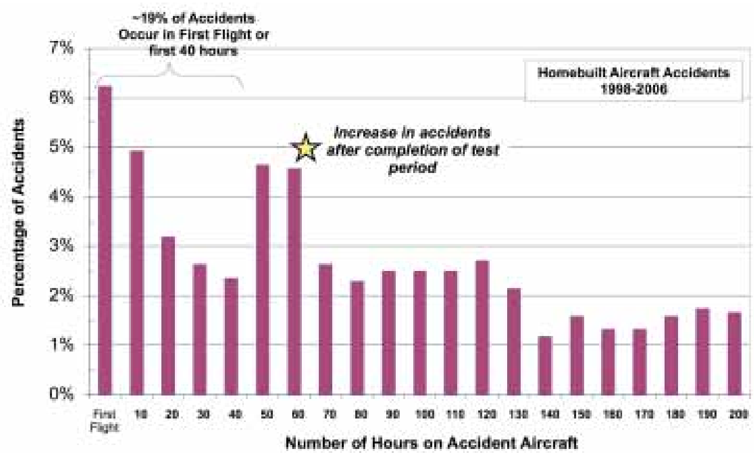


Figure 3: Total Time at Accident Occurrence

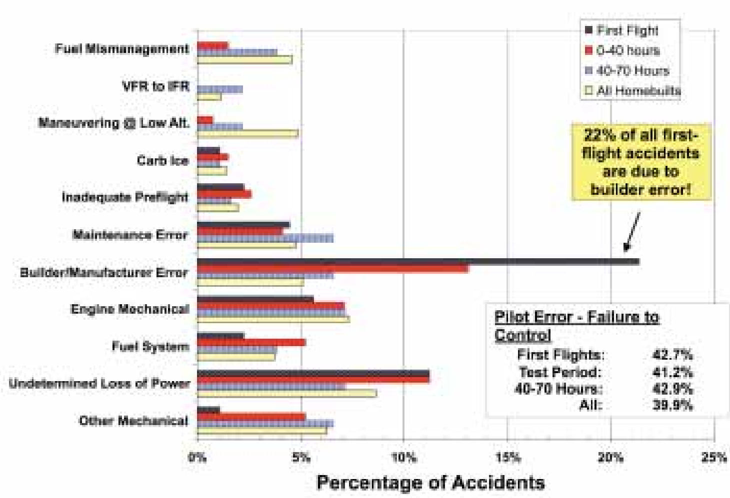


Figure 4: Causes of Accidents by Flight Period

made with the engine or drivetrain.

Another standout is in the Engine Mechanical category—accidents that involve incidents such as thrown rods, magneto or electronic ignition failure, PSRU failures, oil system breakdowns, etc. The homebuilt percentage is about twice that of the control group.

More than two-thirds of the Engine Mechanical homebuilt accidents involved an engine other than the traditional Lycoming and Continental (or clone). More on that later.

How Often Do Accidents Occur on First Flight?

The first flight of a homebuilt is obviously a danger point, with an untested machine being flown for the first time by someone who may not be up to the challenge. To estimate how often a first flight ends in a reportable crash, two things are necessary: an estimate of how many airplanes made their first flights and identification of which accident aircraft were on their first flight.

Let's start with estimating how many planes made their first flights during 1998 through 2006. Subtracting the number of homebuilts in January 1998 from the count in January 2007 won't work. It provides only the net change—new homebuilts, minus the hundreds of homebuilts removed from the registration database each year.

To get the answer, I studied the changes in the homebuilt rolls between 2002 and 2006. Each year typically saw about 1400 new N-numbers identified as homebuilts. Of those, about a hundred were previously registered planes with changed N-numbers. I projected this over the full nine-year period, which gives us an estimate of about 11,700 new homebuilts in our time period.

This leads us to identifying the "maiden flight" aircraft in the NTSB accident database. The narratives sometimes identify the aircraft as being on its first flight, but many more cases record the aircraft as having less than a half-hour of flight time without any statement that it was the aircraft's first flight.

As it is recommended that new homebuilts undergo at least an hour of ground runup time prior to first flight, a recording tach might list several hours at the time the plane dashes down the runway for the first time. There's one "maiden flight" accident that lists 13 hours total aircraft time.

For the purposes of this analysis, I assumed that airplanes that had fewer than 2 hours of flight time, or were so identified by the NTSB investigator, were on their maiden flights. During my nine-year span of analysis, 90 homebuilts met these criteria. Ninety identified first-flight accidents for 11,700 total new homebuilts translates to an accident rate of about 0.77%.

This is an "at least" value, because almost a quarter of the homebuilt accidents didn't list the aircraft total time, and some of those probably met our first-flight criteria. Assuming the same proportion of aircraft with 2 hours or less, the total number of first-flight accidents would be around 110, giving us 0.92%, instead.

In either case, it says that less than one in every hundred homebuilts crashes on its first flight. Seems pretty good, at first. But consider: The overall rate of accidents in the homebuilt fleet is 0.87% over an entire year. In other words, the first flight of a homebuilt aircraft has one year's worth of risk…all wrapped up in a single hour.

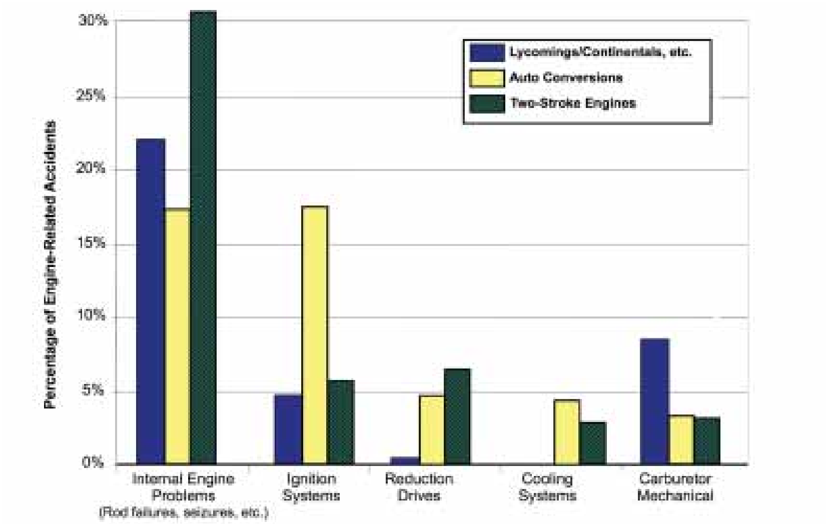
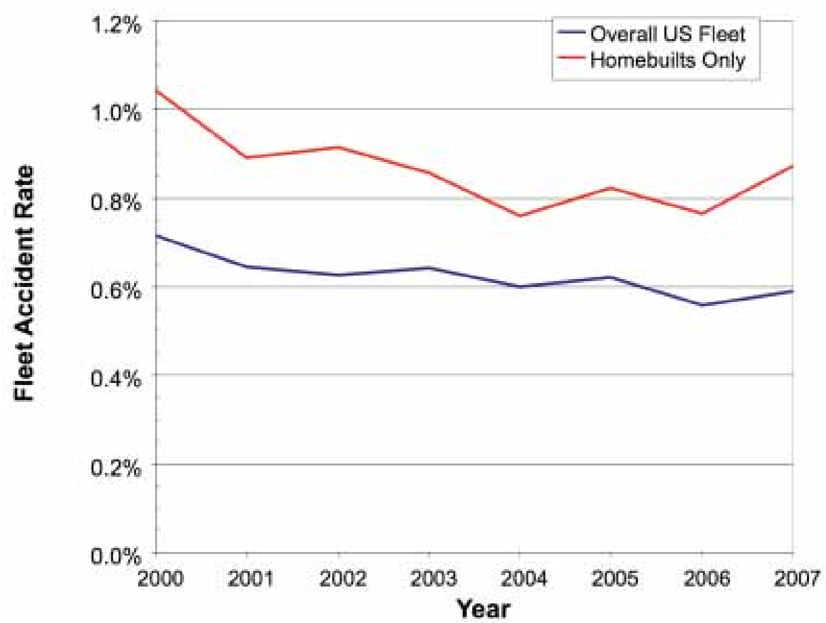


Figure 5: Traditional Engines vs. Auto Conversions & Two-Strokes



Accidents Versus Aircraft Total Time

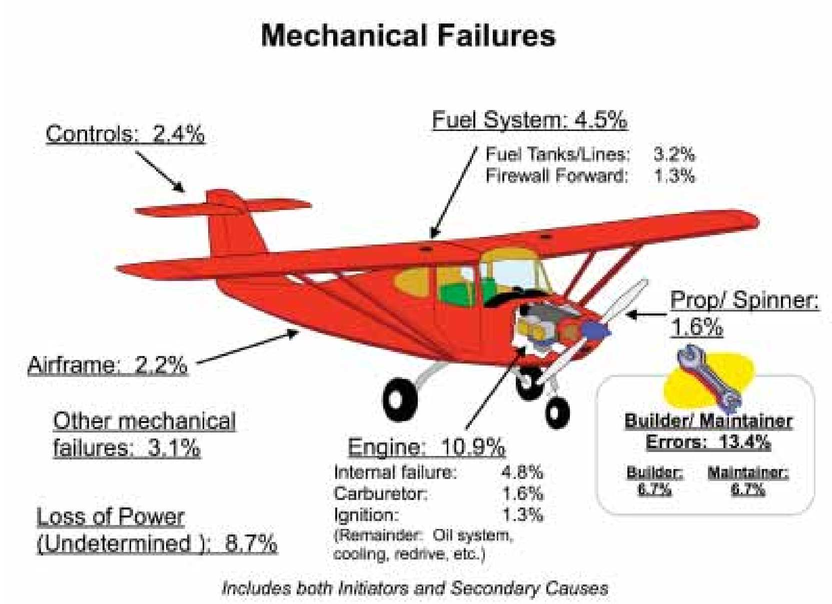
Plotting the percentage of accidents versus the aircraft total time (Figure 3) produces some interesting results. About 6.2% of all homebuilt accidents occur on the first flight. About 19% of the total accidents occur before completion of the nominal 40-hour test period (which can be less for some aircraft).

But look at the spike after 40 hours. Why is the accident rate jumping again? Two factors are at play. First, by the 40-hour point, most planes are past their Phase I flight test restrictions. They start being flown to places rather than chasing around the test area—which also means they start running out of gas on the way, or they hit ugly weather en route.

However, the other factor is an increase in mechanical problems, especially failures related to faulty maintenance. The average homebuilt flies around 60 hours a year, which means that these maintenance-failure cases are occurring right about the time of the first annual condition inspection. Just because a component lasted 40 hours doesn't mean it isn't wearing abnormally. Building a brand new airplane doesn't give the owner any experience in interpreting wear patterns on used parts. Incipient problems on relatively new amateur-built aircraft are apparently not being recognized by their amateur mechanics.

Figure 4 (on Page 26) compares the causes of accidents of three phases of homebuilt operation against the overall results. The three phases are first flight only, first flight to 40 hours total time, and the 40-70 hour period identified by the "spike" above. Note the rise in Maintenance Error in the 40-70 hour period…even higher than it is for the overall homebuilt fleet.

But the most arresting result: Almost one quarter of first-flight accidents are due to builder error! Finally, see how close the four categories are in the Pilot Error–Failure to Control category. Yes,



it's a bit higher early on, but it stays surprisingly close to the percentage of the overall fleet.

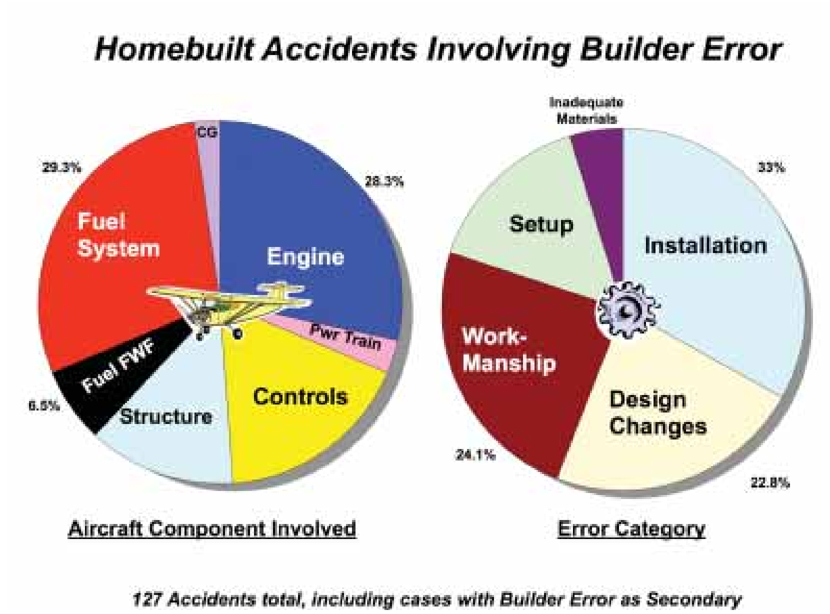
Accident Causes by Type

With the NTSB records including the aircraft type, it's a relatively simple process to compare the accident causes among different models of homebuilts. Table 1 lists the number of total accidents in the 1998 to 2006 time period for a collection of common types, with a breakdown of the number of occurrences of several causes.

Few definitive answers are found in this data, but a lot of interesting questions are raised. For instance, why are there three times more Engine Mechanical accidents for Avid Flyers than Kitfoxes, when there were more than twice as many Kitfox accidents? It's interesting to note that more Kitfoxes than Avid Flyers mounted two-stroke engines (35 versus 30), but the two-stroke engines on the Avids were more likely to be the cause of the accident (40% of the time versus 25% of the time for the Kitfoxes).

The Avid's instances of Builder Error is also high—note that there's only one fewer occurrence than the RV-6, and there were almost three times as many RV-6 accidents. Two out of the five examples were mistakes made in the control system.

The Kolbs, Velocities and two-seat Lancairs lead the Maintenance Error category, but there are no common threads in the mistakes made. To me, one of the strangest results was the Glasair leading the Maneuvering at Low Altitude category. Four out of the eight cases involved low-level aerobatics, always a high-risk game.



Auto Engines Versus Traditional Certified Engines

One of the oldest controversies in the homebuilt world is the use of converted auto engines. Unfortunately, we cannot come up with an overall accident rate based on engine type. Sure, the FAA registration database lists hundreds of homebuilts as powered by Volkswagens, Subarus, Fords, etc., but thousands more are listed as mounting AMA/EXPR engines. We don't know how many of these have Lycomings or Continentals at their core, or those that sprang from GM or Subaru, so we can't reliably calculate an overall rate.

However, most NTSB accident reports list the type of engine. We can easily determine how often a loss of power was the cause of the accident, and compare the rates for traditionally powered aircraft with those mounting auto-engine conversions. Obviously, a higher percentage means a higher relative number of engine failures.

While we're at it, let's show the two-stroke engine results as well.

Traditional Aircraft Engines: 12.2%
Two-Stroke Engines: 28.9%
Auto Engine Conversions: 30.5%

The differences are even more striking when *only fixed-wing* homebuilts are included:

Traditional Aircraft Engines: 12.3%
Two-Stroke Engines: 32.8%
Auto Engine Conversions: 37.5%

So, if a fixed-wing homebuilt has an accident, the probability is three times

TABLE 1: ACCIDENT CAUSE (Number of Occurrences)

Homebuilt Type	Total Accidents	Pilot Error: Failure to Control	Fuel Misman-agement	VFR to IFR	Maneuver-ing at Low Altitude	Carb Ice	Inad-equate Preflight	Undeter-mined Loss of Power	Engine Mech.	Other Mech.	Fuel Sys.	Builder Error	Maint. Error	Other
RV-6/6A	109	47	5	2	5	2	3	10	7	4	4	6		14
Kitfox & SkyStar	88	45	2		5	2		6	3	2	7	4	2	10
Glasair	52	24	2	1	8		2	3	3		2	2	3	2
Lancair 235/360/ Legacy	50	23	2	2	1		1	4	2	1	2		4	8
Avid Flyer*	39	11				1	1	3	10	3	3	5		2
Velocity	31	9	3	1					3	3	3	3	4	2
Lancair IV/IVP	29	15		1				4	2	2		1	1	3
RV-8/8A	26	7	1	2	1			3	4	1	1	2		4
RANS S-12	25	9			4			1	3	2	3			3
Skybolt	25	10	4		3			1		1	1	1	1	3
Kolb	23	7			2		2	1				3	3	5
GlaStar **	22	10		1		1		2			2	1		5
Christen Eagle	21	6			3				2	3			1	6
Long-EZ	21	6			1		2	4	2	1			1	4
SeaRey	23	12						1		2	2	2		4
Zenair CH-601	19	4					1	5	4	1				4
Zenair CH-701	16	7						2	1	3	1	1	1	

Includes only U.S. accidents of N-numbered aircraft for which the NTSB has issued a probable cause. Airshow accidents not included.
* Avid Flyer includes variations of the basic Avid Flyer airframe (Commuter, Bandit, etc.) but not the Magnum or the Amphibian. ** GlaStar includes Sportsman model.

higher that the engine was the cause of the accident if an auto-engine conversion was installed!

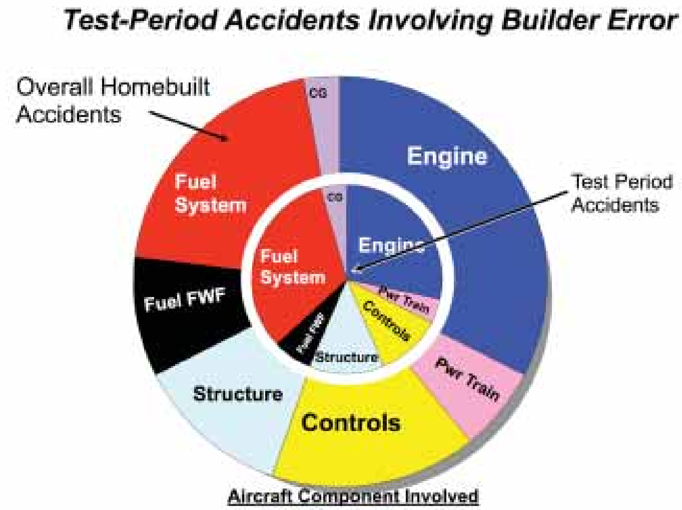
(Please note, this does *not* mean it has an accident rate that is three times higher. Fewer than 20% of homebuilt accidents involve problems with the engine, and not all of those are directly the engine's fault.)

For years, auto-engine naysayers claimed that the internals of the engines were more prone to failure than traditional engines. A comparison of engine-failure causes in Figure 5 (on Page 28) indicates otherwise. Auto engines seem to suffer from internal problems at a lower rate than traditional aircraft powerplants.

However, auto engines are worse in three major areas: ignition systems, cooling systems and reduction drives. The need for a reduction drive on most auto-engine conversions provides a failure source that the traditional engines don't generally face (the 0.7% shown in Figure 5 is a single accident involving the drivetrain on a helicopter). Neither do traditional engines have external cooling systems—though some of those internal failures may well be due to poorly baffled engines. The water pumps, belts, hoses and radiators on many auto conversions provide another failure source the traditional certified engines avoid by design.

The biggest difference is in ignition system failures: Auto engines suffer them four times as often as conventional aircraft. Sure aircraft magnetos are primitive, and individually they are probably less reliable than a modern electronic ignition. But the vast majority of homebuilts with Lycomings and Continentals carry two magnetos that are completely independent of any other aircraft system.

Several of the ignition failures in auto conversions were due to electrical power problems with electronic ignitions. Electrical systems do fail, so a completely independent backup power source is vital.



Wrap Up

Take a look at the flight line at your next fly-in—about one out of every 115 homebuilts parked there will crash in the next year. But statistics apply to the aggregate, not the individual. A 0.87% fleet accident rate doesn't mean you have a 1 in 115 chance of having an accident next year.

There are ways to improve your odds:

- Take advantage of the EAA Technical Counselor program and other experienced builders to have your work checked during construction.
- Ensure that you get the appropriate training to prepare you for your first flight. The EAA Flight Advisor program can help here.
- Grab some assistance for your first annual inspection so that you have experienced eyes to help spot potential problems.
- Make the right decisions as pilot-in-command. Don't push the weather, don't buzz, and don't try to save a couple of cents per gallon on fuel costs by stretching your range.

Homebuilt aircraft are, by definition, built by amateurs. Most of the time, they're maintained by amateurs. Often, they're even designed by amateurs, and an increasing number of them are powered by amateur-built conversions of engines that started life in cars. So it's no surprise that our accident rate is higher than that of the professionally manufactured, professionally maintained, certified-engine aircraft fleet. What is impressive is how close our accident statistics are to those of production aircraft. But there's still room for improvement, folks. ✢