EXPERIMENTAL Flight Test Program

This Article from the EAA has been modified to be used as information to fine tune your successful test program. Modify as needed.

STAGE ONE: MAKING PREPARATIONS FOR FLIGHT TESTING

STAGE TWO: MAKING THE INITIAL FLIGHT TEST

STAGE THREE: EXPANDING THE FLIGHT ENVELOPE

Note: In order to establish a common starting point, the assumption is that the FAA certification requirements have been met and the aircraft has just been issued an Airworthiness Certificate in the Experimental Category (Amateur Built). Let's begin our flight test program at that point.

Incidentally, this is not intended as a Primer on "How To Fly" - the test pilot selected should already know how, and should be familiar with basic flight maneuvers.

Stage One: Making Preparations For Flight Testing

1. SELECT A GOOD AIRPORT - If your airplane is not yet at an airport, select the best airport in your area having at least a 3,000 foot runway, preferably paved, and with good approaches. A fast homebuilt with a retractable gear and a high wing loading will have an even greater need for a long runway . . . say one in excess of 4,000 feet. If flying an aircraft like a Pietenpol or Baby Ace it may be preferable to have an airport with a smooth grass strip alongside the paved runway. Many aircraft prefer three point landing in grass until you are familiar with their tendancies.

The greater the number of other facilities and resources at the airport, such as the availability of fuel, hangars, maintenance, etc., the fewer problems you will have to cope with alone.

Obtain permission from the airport owner or manager beforehand to conduct the test flights.

If at all possible, obtain the use of a hangar during the testing activities at the airport. Hangar space is scarce at most airports but often arrangements can be made to share a hangar temporarily.

2. SELECT THE TEST PILOT - It doesn't have to be the builder. If you do not have the experience and current qualifications to make the first flight, find someone who is willing and capable of performing it for you.

Don't let your emotions and foolish pride override your better judgment. You spent years and a lot of money building the airplane and too much is at stake to risk EVERYTHING now.

Talk with or correspond with others who have flown this kind of aircraft. You can learn much from them regarding the flight and handling characteristics of the airplane. Remember though, you may have modified your airplane "slightly", or your aircraft may be much heavier (or lighter) and may not perform or handle exactly as "advertised".

If possible, try to get checked out by a sympathetic owner of the same kind of aircraft. Even a ride would be helpful. Unfortunately, you don't have this option when the test airplane is an original design, or a single seater.

At the very least, read as much as you can about the design's flight characteristics. For example, some kitplane manufacturers have excellent flight manuals containing extremely valuable guidance for that particular design . . . don't ignore it. (Sequoia now has a Flight Testing Manual and even an Advanced Flight Testing guide for their Falco builders.)

Aviation magazines are another source for flight reports covering numerous homebuilt types. These are fairly good general sources of information. Still, if possible, get your information from more than one such source.

Be sure the pilot you choose is current and has flown aircraft similar to yours. Obviously, if the test airplane is a taildragger, the selected test pilot must be proficient and experienced in the type.

3. COMPLETE A LAST MINUTE READINESS INSPECTION - Not another inspection?? Yes! You can't be too careful at this point. Not when 38% of the accidents or incidents have been attributed to mechanical failure - primarily due to engine failure, propeller tip failures and to poor fuel system installations.

Even though your aircraft has been issued its FAA Airworthiness Certificate and Operating Limitations, certain last minute preparations and functional tests must be accomplished, or even re-accomplished before any attempt is made to fly the homebuilt for the first time.

Although your aircraft may have passed its certification inspection, it may not, in fact, be ready . . . or safe to fly.

There is always that risk that something may have been completely over-looked. Too often it is a missing nut, bolt or cotter pin.

This last minute shakedown inspection should be made with the help of an extra pair of eyes. Ask an experienced aircraft mechanic, EAA Technical Counselor or fellow builder for help with the inspection. You, having been so close to the project, might have missed some important detail even though you have inspected everything several times over.

This time you and your helpers should account for the presence of every single nut and bolt. Don't just look . . . touch, twist, pull and tug on everything checked - that's the only way to inspect.

As for the recommended functional and systems checks, these can be accomplished in a few hours. You may notice though that the list is generalized on and not all-inclusive. Your particular aircraft might require attention to additional details peculiar to that design.

Most or all of the following checks should have been completed prior to the FAA inspection. If not, do them now. Sure, it might take you longer to get ready for the test flight but be patient and don't rush . . . remember, eternity is forever.

4. FUEL FLOW TEST (Described in my book, Firewall Forward, page 175) - This test is extremely important and should have been completed prior to the certification inspection. If not, do it now.

Pressurize the fuel system if an electric fuel pump is installed and check for leaks.

You must be convinced that the engine will be getting all the fuel it needs at full throttle (actually 125% more than it needs) and at extreme climb angles.

5. WEIGHT AND BALANCE CALCULATIONS - Go over your figures one more time. How will the airplane be loaded for the test flight? Will it be under gross?

Don't fly the airplane with an aft CG condition. If necessary, add ballast and fasten it securely. Be sure the ballast will not interfere with the controls, or chafe on installed wiring and fuel lines.

Carry plenty of fuel for the first flight but limit it to no more than half your fuel supply.

If you distrust your calculations, use actual weights and remeasure the moment arms.

6. RECHECK THE WHEEL ALIGNMENT - Toe-in or a cocked wheel could lead to dangerous runway control problems. Strive for a zero toe-in/toe-out, or a neutral alignment. If you have to deviate slightly - opt for a bit of toe-out rather than toe-in.

7. THE BRAKE SYSTEM - Check it for positive pedal pressures, leaks and the fluid level. In the case of mechanical brakes, the security and correct routing of the cables, especially at the wheels, should be verified. Locked brakes can spell real trouble.

New brake pucks have to be burned-in properly, otherwise continuous heavy brake applications can carbonize and ruin the brake pads.

8. FLAP OPERATION - If installed, activate them. They must function smoothly, and the control handle or flap switch must be easy to reach and should operate in the logical direction.

The maximum deployment angle should be limited. Could a safe go-around be initiated with full flaps?

9. ENGINE OPERATION - With the cowling removed, look the engine compartment over. Look for possible chafing of wiring, hoses, as well as fuel and oil cooler lines. Secure all wiring and lines that need to be kept away from the exhaust pipes.

Operate the engine briefly through full power (not more than 30 seconds - or as permitted by the engine manufacturer) to assure yourself that the acceleration and power is there.

Make magneto check for both mags. Momentarily switch the ignition switch off (at idle rpm) to be sure the magneto ground connections are good and that the engine will stop.

If necessary, adjust the idle rpm to that recommended for your engine. You don't want it to quit on throttling back for landing. On the other hand, if idle is too high, you may not be able to reduce the rpm enough to land.

When shutting the engine down with the mixture control, you should get a slight rise in rpm as the mixture control is moved to the idle cut-off position. Otherwise, the mixture should be readjusted.

If the engine exhibits fluctuating fuel pressure, excessively high oil temperatures or cylinder head temperatures during ground operations, do not attempt to fly without correcting the problem. They will only become worse with the high power settings, and the relatively low speeds encountered during take-off and climb.

Finally, with the cowling and propeller spinner reinstalled, make a full power check to be sure the engine will accelerate and run smoothly at full throttle. Keep the airplane pointed into the wind to take advantage of the cooling air. And, of course, the aircraft should be chocked. It wouldn't hurt to tie it down either during engine operations.

NOTE - A serious engine break-in problem faces some amateur builders for which there has been little guidance. For example, a newly overhauled engine with chromed cylinders, or even a new engine, must be broken in properly. That is, the engine needs to be operated at high rpm and the temperatures kept low or the rings will never seat. Unfortunately, this means that the engine temperatures during initial ground operation will be critical, and often the engine operations must be severely limited. This usually precludes prolonged taxi testing and high speed runway tests. Such a limitation, unfortunately, coupled with an untested airplane, creates a dilemma that begs for a solution.

It's ironical but this is a situation that gives all the initial advantages to the builder who has had to install a used engine in his airplane without overhauling it. He may not have a fresh overhaul, but neither does he have an engine break-in problem to worry about. In addition, he can, ordinarily, perform all the taxi tests he feels he needs, concentrating on testing the airplane and not the engine.

An untested engine in an untested airplane doubles the potential for the unexpected happening.

You must . . . whatever the status of your engine . . . operate it in strict conformance with the manufacturer's recommendations. To do otherwise will result in serious engine damage or an engine that, at the very least, will always burn a lot of oil because the rings failed to seat.

10. RETRACTABLE LANDING GEAR - If installed, perform another retraction test to verify that the gear goes down and locks, that the gear doors are adjusted properly and that the limit switches are set correctly.

Extend the gear with the emergency crank (or system). No need to manually crank it up, really, unless the entire retraction system is strictly manual.

Do your warning and gear position light indicators work?

11. TAXI TESTS - Unless you have already done so, try a number of slow taxi tests (no faster than a fast walk) to familiarize yourself with the steering and braking effectiveness, and to become proficient in handling the aircraft on the ground. Learn how much runway or taxiway width is needed to turn the airplane around.

12. HIGH SPEED TAXI TESTS – The real purpose for high speed taxi testing is to learn how the airplane feels and behaves just before reaching lift off speed.

For safety's sake, select an abort reference point (marker) about halfway down the runway. You should be able to cut your power when you reach that point and still have sufficient runway left for a safe stop without burning up the brakes and tires.

High speed runs down the runway must be limited to approximately 10 mph below anticipated lift-off speed.

Control effectiveness can be readily determined within that speed limitation. All flight controls, even the ailerons, normally become effective at relatively low speeds. You should, therefore, be able to work the controls to determine whether or not they are operating properly . . . and do so without trying one of those kamikaze lift-offs.

"Controlled lift-offs", particularly down a runway that is less than 5000 feet long, are dangerous and should not be attempted by inexperienced test pilots.

High speed taxi runs can also be helpful in verifying your weight and balance estimates. For example, if the tail is difficult to raise (taildragger) at moderate runway speeds, you probably have a tail heavy (aft CG) weight and balance situation. Return to the ramp and recheck the weight distribution and your figures again. Correct the problem.

Similarly, with a tricycle gear airplane, try raising the nosewheel after the elevator becomes effective. If you can't pick up the nosewheel at a fairly high taxi speed, you may likewise have a weight and balance problem . . . a forward CG condition. The proper technique is to get up to speed (10 mph below estimated take-off speed) - cut the throttle and check for rotation. This will save you the embarrassment of an accidental kangaroo take-off.

Make a couple of runs with and without a partial deployment of flaps. Is there a noticeable difference?

Pay attention to the amount of rudder input that is necessary to counteract engine torque and to keep the airplane straight on the runway. Watch out for fast applications of throttle at low speeds.

VW engines generally rotate opposite to the Lycomings and Continentals so be prepared to use left rudder on takeoff for torque correction.

Glance at your airspeed indicator during the high speed runs to see that it is working.

Monitor fuel and oil pressures, oil temperature and, also, the cylinder head temperature. If any of the indications are suspect, return to the ramp immediately.

Keep the tailwheel on the ground, with stick back pressure, at low runway speeds (taildraggers) until rudder effectiveness is obtained (about 30 mph) . . . especially in crosswind conditions. Likewise be very careful when the throttle is reduced after a high speed tail high taxi run and the tail starts to settle. Inadvertent back pressure on the control stick (too soon and too quick) might cause a surprise lift-off and difficult runway control problems.

NOTE - Complete each of the following component and system checks even if you know you have previously accomplished them prior to certification.

13. THE CONTROL SYSTEM - Your control system is vital to safe flight and requires very close scrutiny.

Operate the rudder, elevator and aileron controls through their maximum travel.

Assure yourself that ALL the controls are connected, secured and safetied -and that they ALL OPERATE SMOOTHLY AND IN THE CORRECT DIRECTION.

No play should be permitted in the control hinges . . . sloppiness may induce flutter. Likewise the trim tabs, if installed, must be free of play.

Do your control stops allow sufficient control travel?

The control balance weights must be secure and must not interfere with the control travel.

14. THE FUEL SELECTOR VALVE HANDLE - Some types can be installed in any of four positions. Is yours correctly positioned? Labeled? It must function easily with a definite click in each tank position.

Verify that the engine will continue to run in each tank position selected (except OFF, naturally).

15. TAILWHEEL – If one is installed, examine it to see that its pivot axis is vertical or, preferably, slopes back slightly (trails). Difficult runway handling often results when the tailwheel pivot axis is raked forward and the tire contacts the ground ahead of the imaginary projected pivot axis.

Be sure the linkage and springs on a steerable tailwheel are tight (slightly tensioned).

16.PROPELLER - Retorque and resafety the propeller bolts - especially if a wood prop is installed.

Track the propeller and check the spinner for run-out.

17. FUEL CONNECTIONS - Smell fuel in the cockpit? Check the connections for each fuel line. A fuel leak cannot be tolerated.

Are your vent lines open (are you sure?) and properly exited outside the aircraft? Protect vent openings with aluminum screen wire to keep bugs out.

18. ENGINE CONTROLS -Verify direction of movement and security of attachment at the engine. This means somebody needs to check the movement at the carburetor . . . takes two people to do it.

Beware of possible spring-back or inadvertent locking in the linkage when any engine control (throttle, mixture, prop, carburetor heat, etc.) is moved to its extreme position.

19. COCKPIT PLACARDS AND CHECKLISTS - No excuses, you need them. Review them for accuracy, completeness and ready access.

20. IGNITION SWITCH - Will it kill the engine when turned off (good ground connections)? Is it mounted securely and is the wiring behind adequately protected and separated behind the panel?

21. RADIOS OPERATIONAL?

22. SAFETY BELTS AND SHOULDER HARNESSES - Check them good. Are the attachment ends secured and safetied?

23. CANOPY LATCH - Be sure it works and is easily reached. What provision do you have for a rapid escape in an emergency? In a nose over? For an inflight bail out?

24. COWLING - It has to be secure. All fasteners in place?

25. CARBURETOR HEAT - Is it connected and functioning properly? With the engine running and warm, application of carburetor heat should cause a definite drop in rpm.

26. ELECTRICAL SYSTEM - Check the functioning of all installed electrical gages and units. If it is there (installed), it must work. Be sure the battery is secure and correctly vented.

27. CORRECT ALL DISCREPANCIES FOUND.

28. OTHER IMPORTANT PREPARATIONS - Try to plan and prepare for all possible contingencies. Assure yourself that your standby crew knows where the nearest phone is located -and that they have the EMS and Fire Station phone numbers.

A car should be available and your standby crew (one or two dependable gents) should have a few tools, a fire extinguisher and first aid kit onboard - and, possibly, a hand held radio to permit two-way communications.

A chase plane would be comforting to have, especially if a retractable gear or pusher type aircraft is being tested. Be sure both pilots know the radio frequency to be used (122.750).

A pusher pilot would have no early warning of an engine compartment fire unless reported by a chase plane.

Similarly, a pilot of a retractable may need to know if his gear is down in the event of some system failure.

A Final Note

All preparations are now completed and you know the airplane is in tip-top mechanical condition.

Service the airplane with sufficient fuel and oil for the scheduled test flight. Put the airplane away for today and go home and relax knowing your airplane is ready to fly.

Don't allow yourself to be rushed now after years of hard work.

Wait until tomorrow, or the next day when you are physically and mentally rested.

Stage Two: Making The Initial Flight Test

Today is the day!

The aircraft has been thoroughly checked, operated and taxied, and you know it is, mechanically, as near perfect as it will ever be. So, if all goes as planned, your homebuilt will, at last, fly for the very first time.

THE TEST FLIGHT SCENARIO

There are several different scenarios that could categorize a particular initial flight test.

The worst possible case scenario would be one featuring A LOW TIME BUILDER-PILOT with little or NO TAILDRAGGER EXPERIENCE who insists on testing his newly completed ORIGINAL DESIGN homebuilt which is fitted with a CONVERTED AUTO ENGINE and A HOMEMADE PROPELLER . . . and trying to do it from a SHORT DIRT STRIP on a WINDY DAY.

Here he is confronted with many unknowns - hoping that everything will work right and prove to be airworthy . . . all in a single test flight! This could prove to be very dangerous.

Obviously, he should minimize the risks by limiting the number of unknowns for the initial flight test. For one thing, at the very least (as explained last month), an experienced pilot should be allowed to perform the initial flight test.

How many other risk factors does he have control over?

Unfortunately, in the case of a new homebuilt equipped with a newly overhauled engine, or an unproven auto engine conversion, that increased risk factor has to be accepted.

At any rate, regardless of the number of unknowns to which any test flight will be subjected, the safest initial flight test will be one that is carefully thought out and planned before hand. The test flight must then be flown according to that plan . . . doing no more and no less than called for in the plan.

Develop your initial flight test plans along these lines:

WEATHER

I'm sure you tried to pick an ideal day for the flight. We all know that the best time to fly is during the early morning hours or late afternoon. That's when everybody makes their best landings.

The wind should be calm or light and down the runway. Although conditions are seldom ideal, don't be so eager to fly that you accept gusty or crosswind conditions for that most important first flight.

If the winds are gusty, high or quartering across the runway - postpone the flight until another time. Remind yourself that it took years of patient work to get to this point, so don't get impatient now.

EMERGENCY PLANS AND PROCEDURES

On the way to the airport, and after you get there, review your emergency plans, procedures and ground support needs.

1. Know what your ground support will do and can do. Hopefully you did not invite a crowd. An initial flight test needs no such distraction or tension inducing atmosphere. This is not an air show. However, the first flight of a homebuilt, for most of us, is a once in a lifetime event and should be appropriately recorded on film. Try to get someone with a telephoto lens and/or a camcorder to do the honors.
2. Emergencies do happen when least expected, so know what you are going to do IF:

- . . . . the engine quits soon after take-off.
- .. . . there's a fire on board and the cockpit fills with smoke.
- . . . the airplane is terribly wing heavy, tail heavy or nose heavy, and very hard to control.
- . . . . you lose communications with your crew, unicom, tower or chase plane (if you have one).
- . . . . the propeller throws a blade, or the spinner breaks.

- . . . . the throttle jams and cannot be moved.
- . . . . one of the controls jams, or a cable breaks.
- . . . . the engine temperatures rise rapidly and peg past the redline.
- . . . . oil splatters your windshield and the oil pressure begins to drop.
- . . . . your canopy latch fails and the canopy pops open.
- . . . . some part of the aircraft structure fails.

Obviously these are not the only things that can happen without warning on that first flight test, however, they are probably the most life threatening.

Prepare yourself mentally, before the flight, and review the options and logical corrective action you could take should one or more of the conditions occur.

Keep this essential thought in mind. You must, when airborne, regardless of the emergency that arises, CONTINUE TO FLY AND CONTROL THAT AIRPLANE! DON'T LET IT STALL. FLY IT ALL THE WAY TO THE GROUND IF YOU HAVE TO, BUT DON'T LET IT STALL.

Of course, it is unlikely that any of the conditions will befall you, but be prepared, and know what you would do (could do) if something unexpected did happen.

PERFORM A PREFLIGHT CHECK

You already know your airplane has been checked and rechecked (we covered all that last month), and is in perfect condition. But, remember, according to regulations you are still required to perform a preflight check before you fly it today. Make it a good preflight. Use a prepared preflight checklist - at least for this occasion. Here are some important items you should not overlook:

1. The first, of course, is to see that the ignition switch is OFF, that the throttle is retarded and that the wheels are chocked.
2. Pull the prop through five blades. This will assure you that:

- . . . . the engine has compression in all cylinders.
- . . . . the clicking noise you hear means that the magneto impulse coupler is working - and that portends a normal start.
- . . . . the inspection of the propeller blades and spinner will not be overlooked.

1. Check your fuel and oil to see:

- . . . . that you have plenty of fuel for the flight, Don't rely completely on the fuel gages. Use a dipstick to check the fuel level visually against the fuel gage reading. Don't fill your tanks completely. About half the normal fuel capacity should suffice.
- . . . that there is no water present in your fuel sumps.

4. Clean your windshield, complete the other recommended walk-around preflight inspection items for your particular aircraft, and you will be ready to go.

NOTE: A crash helmet and parachute should be worn . . . all professional test pilots wear them. Some amateur test pilots wear a crash helmet but few bother with parachutes. Their rationale for that? The most critical phase of the test flight takes place at low altitude and a chute, they feel, most likely would be ineffective below a thousand feet of altitude anyway. Besides that, no structural testing is planned for that first flight. Now, the decision is yours to make.

Give last minute instructions to your standby crew. Start the engine.

1. Use your Pre-Start Checklist.

2. Immediately monitor your oil pressure. Check and set the other instruments.

3. Switch fuel tanks and run the engine on each tank. Set the fuel selector to the take-off tank.

Taxi to the take-off runway and hold position. Complete your pre-take-off cockpit check.

NOTE: A small 4 cylinder Continental or Lycoming aircraft engine, at full throttle, should yield at least 2,000 rpm, static, with a fixed pitch propeller. This minimum rpm requirement will at least assure you of sufficient power for the take-off . . . even if it doesn't prove to be the ideal cruise or climb propeller for that aircraft engine.

1. Make your engine run-up as recommended by the engine manufacturer. Using your checklist:

- . . . . cycle the prop (if a controllable propeller is installed.)
- . . . make your magneto check. Be sure you return the ignition switch to the BOTH position. If you have been doing a lot of taxiing, or have been idling the engine for quite awhile, the spark plugs may have become a bit oil fouled and, consequently, your magneto drop could be a bit high. Run the engine briefly at a higher rpm and re-check the mags.
- . . . check the carburetor heat and other items on your checklist.
- . . . do not attempt a take-off if the cylinder head temperature (CHT) is near or at the limit. The engine could fail. If this occurs return to the ramp and correct the problem.

1. If appropriate, turn on your electric fuel pump and deploy whatever amount of flaps is recommended for take-oft.

THE TAKE-OFF

1. Without further delay, clear the area (don't forget to look down the runway, too).
2. Announce your intentions to the local traffic, or if appropriate, call the tower for clearance. Align the airplane with the runway centerline and start your take-off roll.

3. Advance the throttle smoothly to FULL throttle. Glance at the tachometer to see that you are getting take-off rpm. If yours is a taildragger, keep the tailwheel firmly on the ground (with stick back pressure) until the rudder becomes effective (about 30 mph).
4. If you are not airborne by mid-field, abort the flight.
5. Allow the airplane to fly itself off.
6. Don't pull it off. Guard against an excessive nose high attitude. Some airplanes will get off quickly only to settle back to the ground after climbing out of ground effect.
7. Should you notice a vibration just before and immediately after take-off, apply brake pressure to stop the wheel rotation . . . your tires may be out of balance.
8. Immediately feel out the controls . . . but gently. Do not overcontrol. Most homebuilts are quite sensitive to even small control inputs.
   NOTE: If excessive pressure is required in any control, or if anything is amiss, abort the take-off immediately. However, if you must do so, don't chop the throttle suddenly. Retard it smoothly, otherwise you may encounter severe controllability problems. Land on the remaining runway, or straight ahead. This same rule applies to an engine failure immediately after take-off. Land straight ahead. Don't allow the airplane to stall. Maintain flying speed all the way down.
9. A quick glance at the airspeed indicator at lift-off will provide you with the knowledge that the airspeed indicator is working, and this will, also, give you a rough idea of what your landing speed may be later. If you have a retractable gear, leave it down and locked for the first flight. A retracted gear would only add to your problems should an emergency develop.
10. Climb out in a shallow climb angle at full throttle. If you used flaps for takeoff, you can milk them up now. Start a gentle turn after passing through 500 feet AGL so you won't get too far from the airport. Continue climbing as you turn downwind.
11. Do not even think of retarding the throttle or changing any engine control settings unless the engine redline rpm is being exceeded. Many engine related take-off failures seem to coincide with the initial power reduction.
12. If you used a fuel booster pump for take-off, you can turn it off now.
13. Glance at the oil pressure, oil temperature and cylinder head temperature gage (if installed). If any indications are excessive, discontinue your climb and expedite a landing. Otherwise, continue to 3,000 feet and level off. Continue making gentle turns to stay over the airport.
14. Adjust engine power and trim to cruise flight. Be on the alert for any unusual vibrations, strange noises or binding in any of the controls. Keep monitoring the engine gages. All O. K.? If not, immediately return and land.
15. If everything is O. K., look around and relax . . . great, isn't it? If you have a chase plane, allow the pilot to pull up and look you over. You could also use the opportunity to compare indicated airspeeds.

PRE-LANDING AIRWORK

If everything is quite manageable, clear your area and make a few power-on and power-off approaches to stalls. Complete (deep) stalls are not necessary. Merely slow the airplane to the point where the controls get mushy and a slight tail buffet becomes apparent. Careful. Some airplanes can stall/spin without much warning. Note your approach-to-stall airspeed indications and make a mental comparison of these with your take-off speed . . . assuming you remembered to look at it.

Everything may be going so good that you are tempted to try something else. DON'T! You'll have plenty of time for all that in follow-on flights. Stick to your original flight test plan.

Keep your flight short . . . say, 30 to 45 minutes.

LANDING

1. Run through your Pre-Landing Checklist, or at the very least go through that ol' reliable GUMP check:
   G = Gas
   U = Undercarriage
   M = Mixture
   P = Prop
2. Announce your intentions to land, and enter traffic. You may want to make a practice approach to landing. If so, use a power approach and don't get too low and too slow.
3. If you have flaps, use them but watch that airspeed. Make your final approach at a speed at least 1.5 times higher than your earlier noted approach to stall speed. This is probably a bit high and may cause the airplane to float a bit, but you can, later, as you become more proficient in the airplane, reduce your approach speeds to suit.
4. Be prepared to make a go-around if you are not satisfied with the approach, or are too "hot", and find you are overcontrolling and leveling off too high.
5. Homebuilts with their smaller wing areas characteristically have steeper descent angles than do commercially produced aircraft. It is, therefore, wise to use some power all the way to touch down.
6. On touch down, concentrate on keeping the airplane straight and let it roll out. Stay off the brakes if you can. Be gentle with them if you do have to use them.
7. Clear the runway and taxi back to the flight line and to the congratulations that you have earned and deserve. It's 0. K. to grin and wave at your friends now.

Stage Three: Expanding the Flight Envelope

1. Sometime after that memorable initial test flight, and before you fly your airplane again, check conditions inside the engine compartment. You can't be too careful at this early operational stage. Remove the cowling and look for fuel and oil leaks, loose clamps,

wiring problems, and the security of all installed components. It might, also, be advisable to remove all inspection covers and take a look inside.

2. Incidentally, you should plan to make a similar inspection of the airplane after it has been flown about 10 hours - just to reassure yourself that everything is O. K.
3. **What Lies Ahead**
4. Your flying for the next 25 to 40 hours will have to be within the limits of your assigned flight test area. This could be very monotonous if you were to merely bore holes in the sky with no particular objective other than flying off the mandatory hours in ever decreasing concentric circles like the mythical "Kiki Bird". But, this need not be.
5. That initial test flight proved your airplane will fly and that it is reasonably controllable. Now you will have to prove to yourself that it can perform safely under a variety of service conditions.
6. This means you should now begin to gradually, and carefully, expand its flight envelope. After all, there's still much you don't know about the airplane and a lot of questions need answers.
7. For example, your initial flight was probably made with only half the fuel capacity and with a minimum payload. But how will the airplane behave with full fuel, and at gross weight . . . and what effect will that have on the CG? Will it remain safely within design limits?
8. Although you may have been pleased with the controllability and flight characteristics exhibited on that first flight, be realistic and accept that you may yet have to face up to some quirks that are not so good.
9. At this early stage, it's normal to experience a degree of anxiety and doubt regarding the homebuilt's controllability in the high speed ranges, and most of all regarding its freedom from flutter. These particular evaluations are considered critical and are potentially the most dangerous characteristics to explore.
10. The only way to get all the answers you want is by working the airplane through a variety of flight conditions while gradually working up to the maximum performance limits you hope to establish for the airplane. This is what is meant by "expanding the flight envelope".
11. Start your evaluation tests by systematically performing all the ordinary maneuvers normally encountered in flight. We all know what these are. There's nothing complicated about them. They should include at least the following:
12. - Climb performance tests
13. - Establish service ceiling and absolute ceiling
14. - Slow flight maneuvers - Gliding tests - Stall tests - Stability tests - Landing/take-off trials
15. The following evaluations and ongoing tests can be worked in as you like throughout the entire test period:
16. - Airspeed calibration tests (as soon as possible)

17. - Engine cooling evaluation - Fuel consumption calculations - Propeller evaluation - CG loadings - Performance checks

    NOTE: The more potentially dangerous test evaluations, such as the following, should be deferred to sometime much later in your test program:
18. - Structural flight testing - Flight flutter tests - Spin tests - Inverted flight - Aerobatics
19. Each new maneuver and test you perform will reveal more and more about the airplane. In addition, performing these test maneuvers will help sharpen your skills for handling the new airplane as well.
20. Repeat tests, if necessary, until you are satisfied with the airplane's responsiveness, and your ability to perform them precisely . . . after all, you're not going anywhere for the next 25 (40) hours, anyway.
21. Don't slight any of the simple easy-to-do tests because you feel you should concentrate on others you believe to be more important.
22. Your assessment may be true, but all of them - even the simple ones - are important as they will provide you with the operational data you should know for your airplane.
23. Here is a sobering thought. Simple or not, you must assume that each test will involve an element of risk . . . or may even be downright dangerous to perform. Always approach a new test with caution, and be prepared for the unexpected.
24. Like most builders, you will probably opt for a limited number of very conservative tests with no spins or aerobatics intended.
25. On the other hand, you may be planning to undertake an extensive series of tests pushing the design limits - with each test thoroughly documented in a scientific manner (calibrated instrumentation, development of graphs, tables, etc.). If that idea intrigues you, go for it! After all, that is the kind of fascination this remarkable amateur built program holds for many of us.
26. **More Pertinent Thoughts**
27. Plan to devote the first portion of each flight to the performance of the one or two test elements selected. Don't waste your time. Know, exactly, what you intend to accomplish during that flight before you take-off. Think out how you will do it - and approach each test carefully and cautiously. Complete only the test items scheduled - no more . . .then spend the rest of the time sightseeing or just basking in the pleasure of flight.
28. To save time, you may find it convenient to perform two or more test evaluations in the same flight.
29. For example, you know that you will lose considerable altitude in the process of performing the gliding maneuvers. It would, therefore, be logical to begin the first part of that particular flight with a series of climb tests. The altitude gained can then be used to 'pay' for the gliding portion of the planned test flight.
30. Record all your observed results - instrument readings and other data, on a knee clipboard, or preferably, on a small pocket recorder. Don't trust to memory alone.

31. Except as previously pointed out, the sequence in which you schedule the various tests need not be accorded any particular priority. So, by all means, schedule them to suit the weather conditions, and your own personal preference.
32. Tests flown in windy conditions, and when the air is rough, are very inaccurate and, consequently, the conclusions reached will generally be unreliable or useless.
33. Do not try to undertake too many tests in one flight, but, by all means, allow as much time for each test as you want.
34. After each flight, debrief yourself. That is, review the things you did wrong (and right). Study the data gathered and try to absorb what you have learned.
35. Remind yourself, frequently, that you must correct whatever problems may arise during a flight . . . and do it before undertaking the next one.
36. Such problems as engine malfunction (however slight), a strange noise or unexplained vibration, signs of longitudinal instability, control difficulty, or major trim problems can be serious and MUST be corrected as soon as you detect them.
37. Let's review a few typical tests in greater detail.
38. **Climb Tests - Determine Your Best Rate of Climb**
39. Use full throttle and check the rate of climb for several different airspeeds. Start at a fairly low altitude soon after leaving the traffic pattern. At full throttle, stabilize your airspeed and begin your timing as you climb through the next thousand foot level. Note how many feet you climb in one minute, in two, three, four and five minutes. Notice how the rate of climb gradually falls off with altitude.
40. Beginning again at some lower base altitude, try some climbing turns to the left and to the right. Notice the difference in rudder pressures required. Look for any unusual control difficulties.
41. Try climbing with flaps deployed 10 degrees, and with half flaps. Could you make a go-around with full flaps?
42. **Determine the Best Angle of Climb**
43. Once again, set up a full throttle climb and note your position over the ground as you pass through a selected base altitude. Continue the climb for 200 feet (500 feet for a high performance homebuilt) and again note your position over the ground. Go back and repeat the process at a different airspeed. After checking your measured climb at several different airspeeds you will know what airspeed will get you up to that 200 foot level in the shortest distance covered over the ground. The results (best angle of climb) are only approximate even when obtained in dead calm air. Nevertheless, the information is useful to know should you have to one day decide whether you can clear some hills beyond the end of a short runway.
44. At some later date, repeat all of the climb tests at full gross weight and compare the results.
45. **Slow Flight Maneuvers**
46. The idea is to become familiar with the trim and attitude changes that take place while you are trying to maintain your altitude at minimum flight speed, with different power

settings. Try a few level turns at what you believe to be the minimum controllable speed. Careful, you could stall unexpectedly. Do these maneuvers at a safe altitude. Try a few level turns with and without flaps, and with the landing gear deployed (if your aircraft is a retractable).

47. **Gliding Tests**
48. In the event of an engine failure, it would be very nice to know what airspeed will give you the minimum gliding angle. These tests, logically, are most effectively performed following your climb tests because you could then use the altitude gained.
49. Always clear the area around and below you before performing any maneuvers in which altitude will be lost or gained.
50. Start with plenty of altitude and complete your last practice turn at least 1,000 feet above the ground (AGL). Clear your engine briefly after each 90 degree turn.
51. If you don't have a rate of climb indicator (VSI), time your descent through different thousand foot levels.
52. To learn how your airplane behaves in gliding turns, practice a few and note how the rates of descent changes with airspeed and increases in the turns. It is important to keep your gliding turns coordinated. Try doing them at different airspeeds and record your observations.
53. These gliding turns are essential to practice because you will be duplicating them each time you turn final for landing. Be careful - an excess of uncoordinated rudder input (slip or skid) and excessive back pressure on the stick can cause the airplane to snap over the top, or snap under to an inverted attitude. At traffic altitude, if turning final this can be fatal.
54. CAUTION: Should this happen, try to continue the roll with aileron input until you are right side up again. Do not pull back on the stick and split-S out . . . you might exceed structural limitations for the aircraft and pull the wings off . . . if you have sufficient altitude remaining.
55. Determine and record how much altitude is ordinarily lost in making a 90 degree gliding turn, a 180 degree turn and a 360 degree turn. Make similar checks with partial flaps and with full flaps deployed.
56. **Stall Tests**
57. You have done these countless times, too. Run through the whole series of stalls. I think most of us realize that the airspeed indicator doesn't read accurately at stalling speed. That fictitious indicated stalling speed of 38 mph or so would more likely be 58 mph or more. However, the readings are relative and you can believe that your gage will indicate the same stalling speed consistently - if the stall is approached at the same rate each time.
58. Plan to complete your last stall no lower than 1,500 feet AGL.
59. Except for accelerated stalls and secondary stalls, approach each slowly, while keeping the nose from turning with the rudder. Allow the speed to bleed off until you feel a slight buffet. Note the airspeed and recover with a smooth forward movement of

the stick as power is added. Maybe simply removing back pressure from the stick when the stall occurs would be sufficient for your airplane - maybe not.

60. However, to begin with, do your stalls by the book. Later you can modify your technique to suit yourself.
61. Look for any unusual behavior in stalls. If one wing has a sharp tendency to drop, try catching it by applying top rudder, and not by instinctively reacting with aileron input.
62. **Engine Cooling Checks**
63. You will, of course, monitor engine temperatures on every flight. However, you should also study and record the effects produced by aggressive mixture control manipulation, changes in power settings and airspeeds.
64. Prolonged climbs and glides will probably induce drastic changes in your engine temperatures and you should know to what degree. Remember, hot summer free air temperatures can intensify high engine temperature indications . . . often to a critical degree.
65. **Stability Investigation**
66. This sounds impressive and complicated. It is not. Stability tests are about as simple a series of checks as any you will make. They are, nevertheless, important. An inherent lack of stability in one or more axes could portend a dangerous condition.
67. Check for stability in all three axes, longitudinal (pitch), lateral (roll), and directional (yaw).
68. NOTE: You should delay your stability checks until after you have had the opportunity to get the airplane trimmed so that it will fly hands off. This may necessitate the addition of external fixed trim tabs.
69. Longitudinal (pitch) stability check -Trim the aircraft for level flight. Pull back on the stick until the nose rises and the speed drops off about 20%. Release the stick. The airplane will nose down and gain some speed before it starts to rise again. These oscillations should die out within 3 or 4 cycles - if the airplane is stable in its pitch axis. If not, the aircraft is unstable and you may have a weight and balance problem you didn't know about that needs correcting. If the oscillations continue or increase, it could be an indication of a serious design deficiency.
70. Lateral (roll) stability check - Trim level and hold a selected heading with the rudder. Move the stick to the maximum left (or right) position and release it. The wing should return to level attitude. Check the opposite side in a like manner. If the amount of roll stays the same or increases, the aircraft is laterally unstable and exhibits what should be considered a dangerous tendency.
71. Directional (yaw) stability check -Trim for level cruise and remove your feet from rudder pedals. The aircraft should hold the heading. Push on the left rudder and then release the pressure. The nose of the aircraft should weathervane back to the original heading if it is directionally stable. If not, or if it continues to 'hunt', it is directionally unstable. This is generally due to improper rigging, a misaligned vertical stabilizer, or one that has insufficient fin surface area.

72. **Propeller Evaluation**
73. Determine that you are getting the desired static rpm at full throttle on the ground as recommended by the engine manufacturer.
74. Also, your propeller should load the engine sufficiently in level flight so that the engine, at full throttle, will not exceed its redline limit. Similarly, the engine, with your installed propeller, should not exceed its maximum allowable rpm during take-off at full throttle. Unfortunately, some builders find that the two requirements are hard to meet in the same prop.
75. If you believe you do have a performance problem due to an inadequate propeller, you should seek help from a propeller professional in selecting the correct one for your airplane. On the other hand, your propeller performance may be as good as you can expect. When it comes to propeller efficiency and performance, some people lie a lot.
76. **Structural Flight Testing**
77. Do not test your airplane to higher structural load limits than those you expect to encounter in the type of flying you will be doing.
78. Perform your high speed evaluations with a forward CG only.
79. For these tests, try to borrow an accelerometer (G meter) if you don't already have one installed.
80. Since it is a self-contained unit with no connections required, obtaining the temporary use of one for your structural flight testing makes good sense. You won't need it after the testing is over.
81. Testing to a modest 3 G limit should be sufficient for most non-aerobatic lightplanes. (Commercial categories are 3.8 Gs and 4.4 Gs for the Utility category, while a 6 G capability is expected for aerobatic aircraft.)
82. In essence, the tests usually consist of a series of dives and pull-ups to impose the desired G loads. These pull-ups are performed at gradually increased speed increments. Carefully inspect the structure after each major increment of loading for signs of skin wrinkling, deformity or loose wires and fittings.
83. I believe the safest way to impose flight loads (Gs) gradually, and with the greatest control, is with steep turns -not by making Hollywood style speed dives and pull-ups.
84. **Flight Flutter Testing (Use caution)**
85. Flight flutter testing, like structural flight testing, requires the airplane to be flown at high speeds. This series of tests is the most dangerous. Unfortunately, these tests are essential to the establishment of the aircraft's freedom from flutter up to its red line (Vne or never exceed) speed. This speed is generally established to be about 10% higher than the maximum cruise speed you would expect to fly.
86. All aircraft will experience flutter at some speed . . . so, keep your goal conservative.
87. Conduct your flutter tests at high altitude, wear a parachute and be prepared to use it. If flutter develops, its intensity increases so rapidly that structural disintegration can occur before the pilot can react.

88. Make your first flutter investigation at a low speed (cruise) trimmed for level flight. Excite only one control at a time beginning with the elevator.
89. Slap the control stick in an aft direction. If there is no indication of stick oscillations, repeat the test at a slightly higher indicated airspeed (about 5 mph). This means that you will have to dive the airplane to pick up the higher speed. (ONLY use a light slap on Elevator control as pitch is more sensitive)
90. However, do not slap the control until you have caused the nose of the aircraft to begin to rise, and the speed begins to bleed off. If flutter should develop then, the airplane will already be slowing down and the control flutter may be dampened in time.
91. Test the ailerons and the rudder in the same manner - by striking the stick on the side (or kicking the rudder). Be sure you never slap (excite) any control until the nose is coming up and the airspeed is bleeding off.
92. Continue the testing cycles for the elevator, ailerons and rudder at increased 5 mph speed increments until you have tested the airplane to the maximum speed you want. Usually this is up to the figure established by the aircraft's designer, or when a speed 10% over the redline (Vne speed you want to placard) has been reached. All surfaces must be free from flutter up to that speed. But be very cautious in attempting to reach that speed. Flutter can destroy the structure in the blink of an eye.
93. **Spin Tests (not allowed)**
94. For all practical purposes, spin testing is considered to be unnecessary for the average low performance aircraft.
95. Do not attempt spin entry and recovery tests without a parachute, and a reasonable provision for exiting the aircraft if you do have to use it. Do not attempt to perform spins with a known aft CG condition.
96. It is generally believed that any airplane with a reasonable CG will easily recover from a one-turn spin. However, as the number of turns is increased before recovery is attempted, the greater the risk that the spin might become flat and difficult to impossible from which to recover.
97. The original military spin recovery technique, and the most reliable one, I think, is essentially as follows:
98. a) To recover - slam in full opposite rudder (against the spin). The stick is still back.
99. b) Wait a half turn.
100. c) Briskly shove the stick forward (down elevator). Be alert. As soon as the spin stops, ease off on the elevator forward pressure before you go beyond that normally steep dive to one that is near vertical, or inverted.
101. d) Pull up from the dive gradually (without pulling off the wings). Add power as the nose comes up through the horizon.
102. One or two other spin recovery methods have their advocates and may be equally effective for some aircraft designs.
103. You may prefer to placard your aircraft, "SPINS PROHIBITED".
104. **Inverted Flight and Aerobatics**

105. Inverted flight without an inverted system (fuel and oil) is impossible for any length of time, so why try it?

106. Aerobatics should not be performed unless your aircraft is designed with this in mind. If your aircraft is capable of doing some aerobatic maneuvers, record those that you have successfully accomplished and you should be able to get your Operating Limitations issued to reflect approval for those maneuvers.

107. Summary

108. The scope of foregoing tests is quite broad and should prove sufficient for any aircraft regardless of its intended use.

109. The limits to which any of the tests is carried is strictly up to each individual test pilot. He should, however, always be aware that he must complete each test at a safe altitude.

110. Test the airplane only to the degree needed, and then placard it so that the limits you safely met and established will not be inadvertently exceeded by yourself and others. This applies, in particular, to the aircraft's "redline" or never exceed speed.

Tips from Bill:

Having performed 20+ first flights and test flight programs there have been several things I have learned about performing these tests that I wish to make available to you as thoughts, ideas, or suggestions for you to incorporate into your plan.

- Be sure that you are current as a pilot and proficient. Go up with a CFI and get a current Flight Review. Ask that CFI to push you limits and spend time practicing or thinking through emergencies.
- If possible, fly as many different kind of aircraft as you can, safely, to give yourself a broader depth of flying experience. Many pilots would be happy to share flying with you. These experiences help you adjust the specific flying characteristics of each aircraft. When you fly a brand new airplane you are then more able to adjust quickly to its particular tendencies and adjust to its needs.
- Fly your test area. Go up prior to your test flight to review the area around your airport to locate any dangers, good emergency landing areas and any obstacles or areas to avoid. Google Earth can also help but nothing beats seeing it with your own eyes.
- Don’t have a large group there to watch the first flight. I keep it to emergency crew only and maybe one friend. I will call the fire department and ask them to come and watch and be ready if there are any issues. It is good practice for them and they appreciate it.
- I keep first flight to one or patterns around the field, land, and put the airplane away. This gets you over the initial jitters you may have and allow the next flights to be more objective.
- I don’t worry about looking at the gauges on initial take off and beginning of pattern. Fly the plane. Once stabilized then you can look. Stay calm.

- Sidestep. If you are clear of the trees and can no longer land on the runway (especially on single runways) I begin sidestepping or turning about 30-40 degrees away from the runway. One of the more dangerous things pilots try to do is the "impossible turn" if they experience power loss of some sort. If you start a 40 degree turn from the runway you are only at a high degree of risk for a few seconds…a loss of power once you are sidestepped or angled away from the runway allows for an easier return to the field than if you departed straight out. A straight out departure can increasingly become more dangerous until you have sufficient altitude (typically 500' or better AGL -) for a turn back in a safe manner. High drag or heavy aircraft may make this impossible due to poor glide performance. It is a good idea to review an airport diagram and your expected performance data to understand this phenomenon.
- Always be willing to say NO. It's not a problem to say you're not ready or something is not in your favor for a successful flight test and that you need more time or get some advice, or make an adjustment.
- Be willing to ask for help. I have done many first flights for people that have brought their aircraft to our field or I have flown out to do it for them. Once the plane has flown the first flight and any issues dealt with we put the builder in the left seat and transition him into the plane. This may have saved many pilots that were nervous and may have made mistakes on their own. Experience does matter.
- Balance your emotions between being excited, nervous, calm, stressful, scared and everything you are feeling in order to make good judgment calls. Emotions are very powerful can be helpful or detrimental. Enjoy the journey.
- Know the airplane you plan to fly. Be familiar with the appropriate numbers you need. I like to post them on a paper on the panel…they should also be marked on the airspeed indicator. Keep everything very basic for the first flight.

Aircraft Particulars:

Pietenpol / Zenith 750 Design:

The Pietenpol/750 Stol type aircraft are very high drag and you have a lower margin of airspeed to deal with. 10mph can make a very big difference on how the plane flies. Your glide ratio allows a controllable cone about 30-45 degrees around the airplane. Its high drag also allows for extending your takeoff leg much farther down the runway as it will slow down very quickly and land again on the remaining runway. Patterns would need to be closer to the runway for safety reasons compared to a low drag aircraft. Pietenpol aircraft would also perform better if you used a grass strip for landing initially as they are more"twitchy" than other taildraggers. The grass helps to smooth out the landings and provide a cushion effect. Zeniths have a tendancy to be pitchy on takeoff and landing and require a little power to maintain good elevator control. The nose will suddenly pitch down on flare if you don't have a bit of prop air going over the elevator (inverted airfoil design). Listen to and study the airplane you will fly as well as those who fly them to get the advice you need. If possible, get an introductory flight from another pilot in their aircraft.

Saberwing Type Design Addendum:

The Saberwing aircraft was designed to be an efficient cross county airplane. Therefore, the control systems are designed to be more responsive than other GA aircraft. Sudden movements of the controls will cause the airplane to move rapidly in response to those inputs. Fly the airplane with smooth and stable movements. The airplane has not been approved for spins or aerobatic maneuvers although the structure is designed to operate within fairly high limitations. For example: the spar may be designed to be able to endure an 8 G positive maneuver, but the human body cannot and once the pilot loses consciousness there is no one in control of the aircraft. Aerobatics and spins should only be performed by experienced pilots (any aircraft) and within the aircraft's limitations. Failure to do so can lead to catastrophic airframe failure and death.

In testing and building the airplane we builders tend to spend a lot of time considering the aircraft performance but fail to consider the pilot's performance. Many accidents are caused by the pilot making poor judgment decisions and or not respecting our natural tendency at times to push the limits. The Sabering is a lot of fun and performs very will in a wide flight envelope. This can tend to encourage the pilot to begin pushing his/her limitations beyond their abilities. Be smart and stay within your capabilities and allow margin for error. Study and learn about other accidents and what lead up to them, so you can develop your flight program and flying rules. My rule is one my dad taught me…" Pointy side forward, Dirty side down". I personally do not do any aerobatics or spins in the prototype, not because the aircraft may not be capable, but I might not be able to recover from a poorly made maneuver where I exceed my physical limitations.

Please take these lessons you may learn to heart as I have…mostly because I have lost friends who chose to push limits or break their own rules. If you have any questions about developing your safety plan and safe flying habits, please feel free to contact us.

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