

## Introduction to Building an Airplane

By David Gustafson



Today there are over 30,000 homebuilt aircraft on the FAA's registry. It's estimated there may be another 30,000 under construction. Some builders opt to just buy a set of plans and then go hunting for aircraft grade materials to cut up, piece together and roll it onto the flight line. That's called Scratchbuilding and it involves a lot of fabricating and assembly. Others send off a check for a complete kit with a lot of pre-fabricated parts, get a few very large boxes that they open up and then begin assembling their aircraft. Whatever the choice, that day when a builder takes off in an airplane that he built in his own workshop, will provide an experience that's akin to the birth of a child. The rush of adrenalin and sense of achievement on liftoff is almost unparalleled in most people's lives.



The Sonex may be the most inexpensive kit on the market... with an engine.

Some people accomplish the task in 6 to 8 months, others take years and some never finish at all. It's been said that building an airplane isn't a big job, just a whole bunch of little ones. Those little ones are usually an experience in precision. There's not much "eyeballing" in aircraft construction. There are no rules of thumb. It has to be exactly what the plans call for, no more, no less. It may require a number of skill sets, but most of those are relatively easy to acquire. It also requires perseverance, tenacity, a certain mechanical aptitude, and a lot of thought. Therein lie the challenges, however, and it is the challenges met, that provides satisfaction and a feeling of accomplishment.

It's called "homebuilding", because most people construct their aircraft in their own homes, garages or their personal workshop. So it comes out of a home as opposed to a production line in a factory, like the type run by Cessna, Piper or Beechcraft. The term homebuilding has been around since the early 1950's, when Paul Poberezny founded the Experimental Aircraft Association which initially focused entirely on "homebuilts". When the FAA issues a certificate of airworthiness for someone's homebuilt, it's certified and registered in the Experimental Amateur-Built category.

For those who've harbored a desire to build their own aircraft, and fly it, there are some issues that need to be confronted before making that first cut with wood, steel, aluminum, foam or fiberglass. Items like cost, skills and comfort levels with aircraft materials need to be considered. It's important to determine whether they want to start a scratchbuild design or a kit plane project, do they have construction space large enough to accommodate wings and a fuselage; how does the builder plan to use the finished aircraft, store it and maintain it; and finally, there's the personality of the builder: does he or she have the determination to finish all those little jobs and return to the workspace when they've reached the level where hours and hours of work produce little or nothing a builder can stand back and admire? Some people believe that 90 percent of the effort goes into the final 10 percent of the project. This much is certain: there are no mysteries or magic in aircraft construction. Virtually anyone of average intelligence can master the required skills and turn out airworthy parts. High school kids have built airplanes, prisoners have built airplanes while they were incarcerated (they didn't get to fly them), people lacking limbs have built airplanes and very old people have done it. Most of the tools needed for an airplane project can be purchased at a local hardware store and there are several companies that specialize in selling every type of material, hardware and tool that might turn up on a "needed" list.

**Consider the cost.**

Sixty years ago there were homebuilts gracing the flightlines that cost under \$1,000. In those days, it was possible to pick up a used aircraft engine for \$25 to \$50. In the 70's, it was still possible to bring in a project for under \$3,000. That number soon rose to \$10,000; then \$25K. Today, a new engine cost \$25,000! A prop



Vans RV-10 is one of the rare four-seat homebuilt kits and it's the most popular.

can run \$10,000. It's not uncommon to see modern homebuilts with IFR panels that now run over \$250,000. Of course, people make a lot more money today than they did in 1953 (the year EAA was founded), or in the 1970's.



Rans Aircraft has a number of two-seat designs, including this Coyote II.

Sonex Aircraft offers a complete kit for a two-seat aircraft, including an engine, for under \$28,000. They'll soon have a jet aircraft kit, including engine, for under \$120,000. Rans Aircraft has kits for the two-seat S-65 Coyote II for \$21K, add another \$14,000 for an engine. The two-place S-12XL Airaile is \$23K without; \$42K with.

A Sportsman 2 + 2 kit, airframe only, runs about \$54,000. An RV-10 quickbuild, airframe only kit, that will seat four people, runs just under \$57K.

It's important for a builder who has to seek out an engine, to keep in mind that an engine with 1,000 hours on it SMOH, could last a long time, since most pilots only manage to log between 50 and 100 hours a year. It's much cheaper to buy something used.

With a set of plans and the designer's blessings, projects like a Volksplane, Baby Ace or Pietenpol Air Camper airframe can be built for around \$10 – 15,000. An engine in decent shape could probably be picked up for \$8 – 10,000. These designs require that the builder locate all the materials and components for their project and while



Glasair Aviation has the Sportsman 2 + 2 which can be fitted with floats, tundra tires and skis.

the search for materials used to take 2 – 4 hours of effort for every hour that actually went into building the airplane, today it's possible to make a single phone call or spend an hour on the computer and order up complete

materials packages with everything needed to finish the airframe. Aircraft Spruce carries it all.

One extremely critical issue is the type of materials used in any aircraft construction project. While it's possible to save a lot of money buying bolts at the local hardware store, and it's legal, it can also be lethal. USE ONLY AIRCRAFT SPEC/GRADE MATERIALS. Hardware store bolts can come apart in flight. It's happened with horrible consequences.

There are hundreds of designs and kits out there to choose from. They go from ultralights with little weedeater engines to jets. Prices vary tremendously according to the number of seats, the materials used, avionics installed and the performance of the finished aircraft. There's no substitute for research. That study effort goes beyond choosing a design. It's a good idea to set aside a considerable amount of time to what the project is going to require in the way of skills, workspace, tools and construction methods. There are sample kits available for trying your hand at working with composites (it's a good idea to learn early if there's going to be an allergic reaction to resins), steel tubing, aluminum or wood. These kits provide the opportunity to experience hot wire cutting of foam and then covering the shape with fiberglass. A welding kit introduces a builder to a meaningful encounter with oxy-acetylene or Tig welding. There's an opportunity to join pieces of steel tubing and flat steel gussets together. A sample aluminum kit provides enough metal to pound out a couple ribs, bend some covering sheet around them, mark and drill holes and then insert clecos that get replaced with rivets. Wood kits usually consist of enough capstrip material and plywood to build up a wing rib.



Sonex Aircraft offers sample aluminum kits and holds workshops that focus on how to build a Sonex.

One nice thing about Scratchbuilding is that once the builder is familiar with ALL of the plans, he can start with some small part that's simple and inexpensive, like the rudder, elevator or stabilizer. Getting one of those smaller components completed builds confidence and spaces out the costs. Some kit makers will ship out a sample kit or a separate kit for the rudder or elevator which provides an

opportunity to try working with aluminum, steel tube, wood or composites before writing a huge check for the rest of the airframe.

Since so many people have already gone through the construction process, it's possible to get help in determining all the costs that a builder might encounter. If there isn't someone in the neighborhood who's built the exact same design a builder is thinking of choosing, there will be someone who's tackled something similar. This is where EAA comes in. They have nearly a thousand chapters worldwide. They cover quite a few communities. A builder would be well advised to find one, even if it's some distance away, join it and start talking to the people who have been through the aircraft construction process. Most people are quite eager to share their experiences, knowledge and skills about aircraft construction.

Typically, items like upholstery, engine, instruments and paint will come later in the process and may not be included in a kit. The price of these components needs to be factored in. Where an engine could easily run \$25,000, the installation of glass panel avionics could run two or three times that amount.

There will also be costs associated with creating a workspace. There needs to be a work table large enough to accommodate the wings and fuselage. While some kits require little more than hand tools for assembly, there are scratchbuild designs that would require access to some sophisticated tools, most of which can be picked up second hand. Bright lighting is a must and a source for heat (if outside the house) is also essential, especially in northern latitudes. Compared to the cost of the airplane, these items will be relatively inexpensive, but they still need to be added in.

Then, for good measure, it's wise to add ten percent to the figure for all costs. Mistakes will occur and materials or tools never thought about will become spontaneous expenses. Costs keep rising on all aircraft

spec materials and if the project takes several years, inflation is going to have an impact on the final phases. Another point to remember is that kit makers are wildly optimistic about how many hours it takes to put their kit together. Some companies flat out lie about it. Checking with other builders who have worked with the same kit or design



The Breezy is a scratchbuild design that is strictly a toy...but one that's a lot of fun to fly. (Complete material packages for the Breezy are available through Aircraft Spruce.)

provides a more realistic idea about how long it might take to get to the flightline.

**Evaluating a workspace.** Most aircraft components can be built and painted in a one-car garage, assuming the wing will be in two parts. If the plans call for a one-piece wing and it's not a biplane, most likely a larger space will be required.

The first order of business is a solid work table. Though the plans will dictate size, the minimum dimensions for the top will be around 4' by 16', though there's a good chance it will have to be larger. It should be one or two feet longer than the wings, it must be square and level and it has to be solid. It's essential that it be at a good height so that it's easy to reach across. If it's too low there may be a need for some Salonpas. Coffee table height just won't work here.

Invest in some good overhead lighting. A good table saw, drill press and band saw would be useful for just about any project. If the wings and fuselage are to be made of wood, a disc sander or vertical sander will be helpful. With all aluminum aircraft, right and left hand tin snips are essential and a bending brake would be valuable, though some kits come with all the sheet metal sheared, punched and formed, so that may alleviate some of the tooling demands. Those who work with 4130 steel will need a good tube cutter and a grinder, along with an oxy-acetylene unit or a TIG welding unit. It's important to understand the safe operation of each tool used in construction.

The wonders of composites make for exciting airframes, but the resins are toxic and can generate allergic reactions. It's essential to have good ventilation that doesn't take the vapors into the house, like a furnace intake.



The Kitfox has been a very popular design that is sold as a complete kit, with engine, and has folding wings.

**Developing skills and confidence.** EAA hosts a number of workshops around the country that are designed to introduce people to the skills required to be able to build just about any aircraft. Some of the kit makers, like Sonex, host regular workshops where people can get their hands dirty with tools and

metal. The participants leave with the basics that will be needed to build a Sonex. Some people choose to attend workshops to learn about the various materials that are used in advance of selecting a design. Though a lot of builders are afraid of welding, it's a skill that almost anyone can pick up and refine with practice.

Every Spring and Summer, Sun 'n Fun and EAA's AirVenture have workshops that run all day, every day during the conventions. None of the workshops create Journeymen, but they do give a pretty good idea of what a builder is getting into.

**The spouse connection.** Most builders are married, or at least, used to be. An airplane project is like a mistress: she'll take up a lot of time, use a lot of money, and drive a wedge into any relationship... unless steps are taken to either engage the spouse in the program (good luck!) or find some creative ways to make it up to her. Mink coats come in handy. Romantic evenings don't have to disappear in favor of shop time. Making sure that she or he (yes, women have built airplanes) has a full grasp of what's about to ensue will be essential to domestic tranquility. Please can be effective when it comes to sewing up upholstery or needing an extra set of hands while attaching wings.

**Selecting a design.** Every December, January and February, Kitplanes Magazine puts out a list all the aircraft that can be built. In December they list the kits available for homebuilders. They also feature Ultralights, powered parachutes, and rotorcraft. There are also some annual publications out there that list everything people can build and fly.

But there are some critical issues that need to be considered. For those who want to go fast, there will be an expensive engine and probably a bundle of costly avionics. Aerobatics are fun, but they often come at the expense of cross country capability. Amphibians and floatplanes are exciting, especially in regions populated with lakes and rivers, but the insurance is going to be a significant cost. Every aircraft is a series of compromises, but with nearly 400 designs out there to choose from, most people find something that fits their moods, their personality, or their wild dreams. An airplane like the Breezy is a wonderful toy on a hot summer day, but it's just a toy. Those who smile a lot should bring toothpicks. There are some sprightly single seaters out there, but most pilots eventually regret not being able to take a friend along with them from time to time. Open cockpit biplanes are fun and often aerobatic, but there's not much legroom and if someone's head gets outside the windscreen, the slipstream takes away the fun. They have limited baggage area and unless the aircraft has a full canopy, winter flying is just about out of the question.



The Marquart Charger was designed for open cockpit fun. It's a scratchbuild design that will take some time to fabricate, but it's such a joy to fly.

### Checklist.

1. What will it be used for?
2. How many people do you want to take along?
3. How many copies of a favored design have been built and flown...how long did they take to build and how much did they cost in today's dollars?
4. What are the horsepower options and what will they cost?
5. What is the range, cruise speed, landing speed, and handling like?
6. Is it designed to be built out of a material you are comfortable working with and how complicated is it? (Bigger ones take more time.)
7. Do you have the space to store the wings and fuselage?
8. Are hangars available at the local airport?
9. If it's a taildragger, do you know how to fly one?
10. Can you insure the aircraft? What will the cost be?
11. Do you really have the patience, determination, skills, time and funds to complete the project? The number of unfinished projects runs into the thousands.
12. Can you find someone with a copy of your dream machine or visit the kit maker and get a ride in it?



If you don't already belong to EAA, the Experimental Aircraft Association, join now. Visit [www.EAA.org](http://www.EAA.org). Find out where the nearest Chapter is and go to their next meeting. Subscribe to Kitplanes. Go to Fly-Ins. Locate and contact the nearest FAA office that will be responsible for issuing you Certificate of Airworthiness and talk to the local inspector or DAR. Learn about what they will be looking for and make sure you are prepared to give them what they want. Be certain you fully understand the requirement to build 51% of the aircraft.

In the end, there's no substitute for getting the plans, making a list of materials (if not included), creating a workspace, and fabricating that first part for *your* aircraft. It may take a long time to get around to making or attaching the final part, but in between most people go through a lot of different experiences and emotions. As the project grows, so does the builder's pride and sense of accomplishment. It's a wonderful feeling.

Go build one.