

Kit Airplane Construction

Third Edition

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Beginnings

BREATHES THERE A PILOT WHO NEVER MADE A MODEL AIRPLANE?

I doubt it.

Who could resist the models shelves at the local toy or hobby store? The multi-colored boxes featured pictures of bombers soaring, fighters scrapping, and evil Huns going down in flames. Sure, there were more model cars than airplanes, and the boats took up a lot of room, too. But the section with the airplane models always had that special look (Fig. 1-1).

Deciding was agony. Get an ME-109? A P-51 to protect your B-17? Or an all-black Stealth Fighter? Finally, the allowance savings were doled out and the precious package tied to the bike for the trip home.



Fig. 1-1. *The model shelves of the local hobby store launched many a homebuilder.*

The magic moment came when the last decal was slipped into place. You'd hold the plane steady and stare into the cockpit. It was like you could feel the stick in your hand and see the wings stretching to either side. The roar of the engine. The whoooooosh of the slipstream. You could almost taste the pure, delirious joy of flight.

Then it was time for a strafing run across the desktop or a low-level mission against the family dog.

When you were a kid, all you had to worry about was getting glue on your fingertips. Mistakes could be painted over. If all else failed, a botched kit always could fall victim to that great allowance-waster, Fourth of July fireworks.

It's one thing for a 10-year-old to blow his allowance on the newest product by Revell or Tamiya. But now as an adult, you're considering dropping a year's salary on a kit for a homebuilt airplane. Page through the homebuilders' magazines. Every advertisement extols the virtues of a kitplane, from a fabric-covered fun plane to a fiberglass speedster. The phrases "Easy-to-build," "Requires only average skills," and "Average construction time 400 hours" leap out at you.

The 10-year-old in you says, "Go for it!" But decades of life's lessons have made you more cautious. How much do you really *know* about aircraft construction? Can you rivet? What does "prepreg" mean? Where are you going to get an engine? How much is everything going to cost? Do you know enough to even ask the right questions?

It's tough to get straight answers in the kitplane field. Kit advertisements can stretch the truth just like any other ad. Most articles in homebuilders' magazines are aimed at projects already well along: problem solving rather than information for beginners. They don't answer the basic question of the first-time builder: "Can I successfully build a homebuilt airplane?"

I can't answer that. Neither can anyone else.

But what I *can* do is provide enough information to allow you to make that decision. I'll help you to select the kitplane that is appropriate to your needs and skills. I'll provide an honest and realistic appraisal of the amount of time, money, and tools required. I'll show you the requirements of aircraft-quality workmanship. And finally, I'll demonstrate basic building operations of the various types of construction.

This last point requires some explanation. Don't look in the Contents and expect to find a chapter entitled, "How to Build a Lancair" or "How to Build an RV-9." To exceed the detail given in the manufacturer's plans, this entire book would have to be dedicated to a single kitplane.

Instead, detail is given on the typical operations required by various construction types. By reading the composite construction chapter (Chap. 8), for example, you'll see how to prepare the surfaces for bonding, how to make the layups, and how to prevent or correct typical errors. Similar chapters explain metal, tube, and wood construction.

Maybe you've already decided on composite construction or a simple tube-and-fabric airplane. Why bother with chapters on metal or wood construction?

Few kits use only one construction material. Metal airplanes, for example, usually have composite cowlings and fairings. Composite airplanes make extensive use of steel and aluminum fittings, panels, and brackets. Wooden kitplanes and many tube-and-fabric types use all materials: wood, metal, and composites.

By the end of this book, you'll know how to tell a good kit from a bad one. You'll have a fairly accurate estimate on the total cost of the whole project. Engine selection will be easier. You'll handle tools with new confidence. During construction, fewer surprises will sap your budget and enthusiasm.

Best of all, your chance of successfully completing the airplane will be far higher.

DEFINITIONS

Did you know that, legally, there's no such thing as a "homebuilt" aircraft?

Before going any further, then, let's define what we're talking about.

All aircraft licensed in the United States must hold an *airworthiness certificate*. There are two kinds: *standard* and *special* (Fig. 1-2).

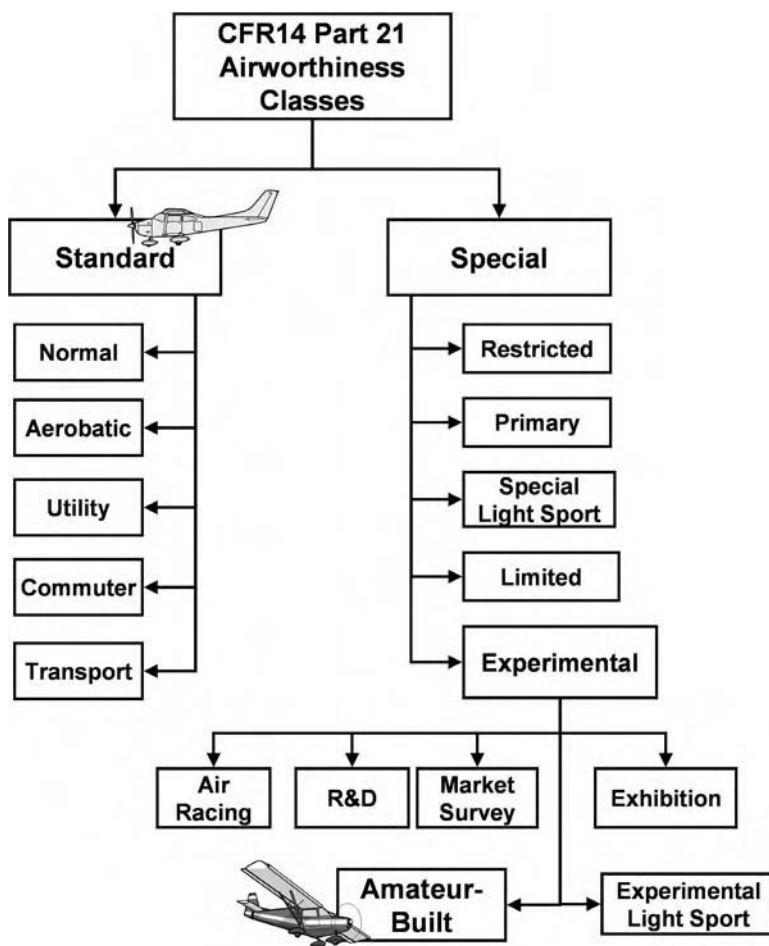


Fig. 1-2. All aircraft in the United States fall under either the standard or the special airworthiness category. Amateur-built aircraft fall under special.

Standard airworthiness

Aircraft with *standard* airworthiness certificates are your garden-variety factory-built aircraft. These must be designed to particular standards, and complying with those standards is neither easy nor cheap.

The manufacturer must prove that the aircraft design is adequately strong, both by analysis and by ground testing. An extensive flight-test program is necessary to demonstrate that the aircraft meets certain stability standards, is controllable through all normal phases of flight, and can withstand the designed airspeed range, G-loading, and the like.

When the Federal Aviation Administration (FAA) is satisfied, it awards the aircraft a type certificate in the appropriate category, such as normal, utility, aerobatic, and so on. This type certificate is the buyer's assurance that the plane meets FAA standards.

However, the type certificate also places requirements on the owner. First and foremost, most maintenance must be performed by a licensed airframe and powerplant mechanic (A&P). Annual inspections require an A&P with inspection authorization (IA). Any parts installed must be approved under a technical service order (TSO).

Not all problems will be discovered during the test phase. The existence of a type certificate grants the government certain powers. When safety-related problems arise, the FAA can issue an airworthiness directive (AD). Compliance with the provisions of the AD is mandatory.

Prior to award of the type certificate, an aircraft is tested in a variety of configurations. After certification, any changes that affect the flight characteristics or operation must be fully documented and proven safe, and aircraft operation with the changes is restricted until the FAA awards a *supplemental type certificate* (STC).

Common STCs include upgrading to a larger engine, installing speed modifications such as gap seals and special fairings, and tailwheel conversions of tricycle aircraft. Changes with only minor effect (such as a radio installation) can be approved as a minor or field alteration, but any change to the engine, airframe, or control system requires an STC.

To the uninitiated observer, this process can be drawn to ridiculous lengths. A number of years ago, an inventor developed an improved aircraft oil filter. The filter element was an ordinary roll of toilet tissue! The element didn't last very long, but one would expect it would be dirt cheap to replace.

Alas, 'twas not to be. Any component installed in a type-certificated aircraft's engine must be TSO'd, and the average supermarket doesn't sell TSO'd toilet paper.

Special airworthiness

Aircraft design is a study in compromise. The designer must take the performance objectives, customer preferences, and marketing inputs and generate a successful aircraft design. He cannot hope to please everyone; rather, the designer's goal is to create an aircraft that each can accept with minimal grumbling.

But sometimes the requirements for a standard airworthiness certificate conflict with the job the owner needs the airplane to perform. A plane designed to break speed records doesn't need the drag produced by the large tail surfaces necessary

to meet the stability standards for standard airworthiness. An aerial applicator can tolerate the higher stall speeds that will result if more than a given amount of chemicals are loaded into her crop-spraying airplane.

Or . . . well, sometimes, it's just logic. When a brand-new airliner rolls out the Boeing factory door, the FAA can't just grant it a standard airworthiness certificate. After all, since it hasn't flown yet, it hasn't yet demonstrated that it meets the requirements!

To cover these and other situations, the FAA will grant a *special* airworthiness certificate. Just as with the standard certificate, a number of aircraft categories fall under "special." These include *restricted*, *limited*, *primary*, *special light sport*, and *experimental*.

The experimental category

In most of the special categories, the aircraft receive type certificates similar to those in the standard categories. They usually require that some analysis and testing be performed prior to the first flight, and they are subject to mandatory maintenance items and limitations on owner modifications.

But the *experimental* category offers an escape from the restrictions of type certification: There are no STCs and no ADs, and airworthiness is proven aloft, not on the ground.

In every other category, the FAA's main aim is to maximize the safety of the pilot and passengers of the aircraft. In the experimental category, the FAA concerns itself mostly with ensuring that the aircraft in question doesn't endanger anyone else.

In the experimental category, designers can escape from the limitations imposed on "normal" airplanes. Design compromises can be taken on the side of performance. Individual aircraft can be modified to the owner's requirements. The qualifications for maintaining the planes sometimes are relaxed.

There are a number of subcategories under experimental, including:

- *Racing*. Aircraft intended for speed competition.
- *Research and development*. Aircraft undergoing flight test for either pure research or for certification purposes.
- *Exhibition*. Aircraft used for special purposes, such as movies or air shows. An example might be a highly modified Stearman used in an aerobatic routine.
- *Amateur-built*. Aircraft built for recreational and educational purposes.

All groups come with restrictions on their operation. Aircraft certified as *experimental/exhibition*, for example, usually can only be flown at shows, to and from shows, or for necessary pilot proficiency flights. You can't legally take anyone for a joyride. Similarly, under the *research and development* classification, you must present the FAA with your proposed test schedule. Flights outside that schedule are prohibited.

The category with the least restrictions? *Experimental/amateur-built*—the traditional "homebuilt" category.

While homebuilt aircraft have been around since the days of the Wright brothers, gaining the freedoms we hold today has been a long, difficult process.

HISTORY

In the years prior to World War I, all aircraft were essentially “homebuilt.” They might have been made by a factory, but the techniques used were the same as those of the shade-tree aircraft builder.

And nearly all of them were delivered as kits. When it took 84 days for Cal Rogers to fly the “Vin Fizz” from New York to California, it’s easily understood why the aircraft factories didn’t bother to deliver newly purchased planes to their owners by air. Especially when it is realized that, by the time it reached California, the only original components left of Rogers’ airplane were the rudder and one strut!

So when a sportsman ordered an aircraft, it arrived by train or wagon. If the sportsman were especially wealthy, factory mechanics would assemble his plane for him. In any case, though, pilot training at the factory would have included how to assemble and set up the aircraft. The new owner would consult his notes and grab his tools.

But not everyone could afford factory airplanes. They cost around \$5,000 to \$10,000, the equivalent of \$100,000 to \$200,000 today.

So hundreds of aviation enthusiasts began building their planes from scratch. Plans for “production” aircraft were readily available, and Demoiselles and Bleriot’s popped up in places the factories had never heard of. The only things needed were mechanical aptitude and piano wire from the neighborhood hardware store. Little separated the production aircraft from the homebuilt.

This situation didn’t change during the Great War; the greatest advance was the mass production of aircraft engines, which benefited the homebuilder as well. Design innovations arose, but airplane manufacturing took just shade-tree mechanics and a well-stocked general store.

Proof can be found at just about any fly-in. None of the World War I biplanes you see (Fig. 1-3) are original. Most are subscale or updated replicas, but some are built from original plans by typical homebuilders.

Emerging from the shade

Aviation left these low-tech roots as a byproduct of the striving for faster and bigger machines. By substituting cast or machined fittings for those made out of sheet stock or angle iron, the designers could greatly reduce weight and increase strength. Construction began to require presses, milling machines, and custom forgings and castings. Financially, the processes only made sense for large production runs. Shade-tree amateur builders couldn’t afford it.

But homebuilders benefited. For example, manufacturers needed something stronger and more reliable than piano wire, and thus came the development of strong, flexible aircraft cable for bracing and control wires. Some detractors might say that aircraft homebuilders have been riding the coattails of the “legitimate” aircraft industry. But homebuilders still lead the way, as witnessed by the composite revolution of the 1970s and 1980s. Aircraft such as the VariEze and Glasair have led the way for acceptance of composite parts in aircraft such as the B-2 stealth bomber and the Boeing 787.



Fig. 1-3. All flying World War I fighters are modern replicas, such as this Sopwith Camel. The skills and techniques used to build these aircraft originally are the same used today by homebuilders.



Fig. 1-4. The Heath Parasol was the first mass-marketed kitplane. This is a Super Parasol, slightly larger and more powerful than the original.

The biggest mass-marketed kitplane of the early years was the brainchild of a man named Ed Heath. In the late 1920s and early 1930s, he sold a number of his Heath Parasol kits (Fig. 1-4), which initially used a converted motorcycle engine as a powerplant. The Parasol had a ready-made market because most other production aircraft were aimed at the wealthy sportsman rather than the everyday fun flyer. You could buy the completed aircraft for \$975 or a kit for \$199 (Fig. 1-5). After several ownership and name changes, Heath Aircraft eventually became the nucleus of

General Price of Material Needed in the Construction of the "Parasol"

Fuselage	\$32.87	Instrument and cowl support.....	\$ 5.12
Controls	9.15	Tail unit	9.50
Pilot seat90	Landing gear	41.32
Tail skid	1.27	Center wing supports.....	3.11
Cowling	17.55	Outer wing supports.....	10.52
Engine mounting	3.44	Wings, gas tank, ailerons.....	76.00
TOTAL COST IF PURCHASED SEPARATELY (varies slightly with market)			\$247.00

SPECIAL PRICE ON COMPLETE BILL OF MATERIAL, \$199.00; BOXING, \$5.00

FOR GROUP PRICES SEE BLUE PRICE LIST

All Prices Subject to Change Without Notice

General Specifications of the "Parasol"

Span.....	25 ft.	Stabilizer area.....	5.5 sq. ft.	Useful load.....	300 lbs.
Chord.....	4 ft. 6 in.	Rudder area.....	3.8 sq. ft.	Gas capacity.....	5 gals.
Angle of incidence.....	4 degrees	Length over all.....	17 ft.	Oil capacity.....	6 qts.
Wing area.....	110 sq. ft.	Height over all.....	6 ft.	High speed.....	85 m.p.h.
Aileron area.....	10 sq. ft.	Weight, empty.....	285 lbs.	Landing speed.....	28 m.p.h.
Elevator area.....	5.2 sq. ft.	Rate of climb (first minute).....	600 ft.	Cruising radius.....	200 miles

Skis

The use of skis on your airplane doubles the usefulness of the craft. These handy appliances which you can attach in ten minutes can be bought ready built for \$25.00 or you can buy the material and blueprints for \$10.75 and make them yourself. You are never "snowed in" with skis.

Complete "Parasol" Prices

COMPLETELY ASSEMBLED, READY TO FLY AWAY AT CHICAGO.

Equipped with Heath B-4 motor and Walnut prop.....	\$975.00
Equipped with wheel brakes.....	add 35.00
Equipped with motor starter.....	add 25.00
Equipped with metal propeller.....	add 35.00
Heath Parasol without motor.....	640.00
Crating complete plane.....	18.00
Boxing, motor only.....	3.00

Notice

ALL ORDERS MUST BE ACCOMPANIED BY AT LEAST ONE-THIRD IN CASH; BALANCE C. O. D. OR SIGHT DRAFT.

Export orders must be accompanied by Cash in Full, and a reasonable amount for crating and shipping charges must be included. Personal checks must be certified.

The duty on aircraft material to most foreign countries, such as Canada, is in the neighborhood of 30 per cent.

Anyone that places an order for \$100.00 worth of merchandise from our price list will be supplied with a set of blueprints free or will get credit for the blueprints already purchased.

Any parts that are found defective may be returned to us upon receiving shipping instructions from us.

In case of damage in transit, notify your express or freight agent at once and have him verify damage, as our responsibility ceases with delivery of merchandise in good order to the common carrier.

Price, Complete Bill of Material, \$199.00

HEATH AIRCRAFT CORPORATION

LINCOLN 6196-6197

1721-29 Sedgwick Street

Chicago, Illinois

Fig. 1-5. *The Parasol was the first modern kitplane, at least from the packaging point of view. EAA.*

the Heathkit home electronics company. The company didn't keep selling airplanes. Pity.

For its day, the Parasol wasn't bad. It had a cruise speed of 70 mph and a stall speed of about 25 mph, and it got about 45 miles per gallon. The Parasol kit resembled several of today's kits: It could be built from plans, from material packages, or from a complete kit including prewelded fuselage and tail feathers.

With Lindberg's flight in 1927, interest in aviation exploded across America. Many enthusiasts couldn't afford the factory airplanes then being produced, and interest in homebuilt aircraft rose even higher.