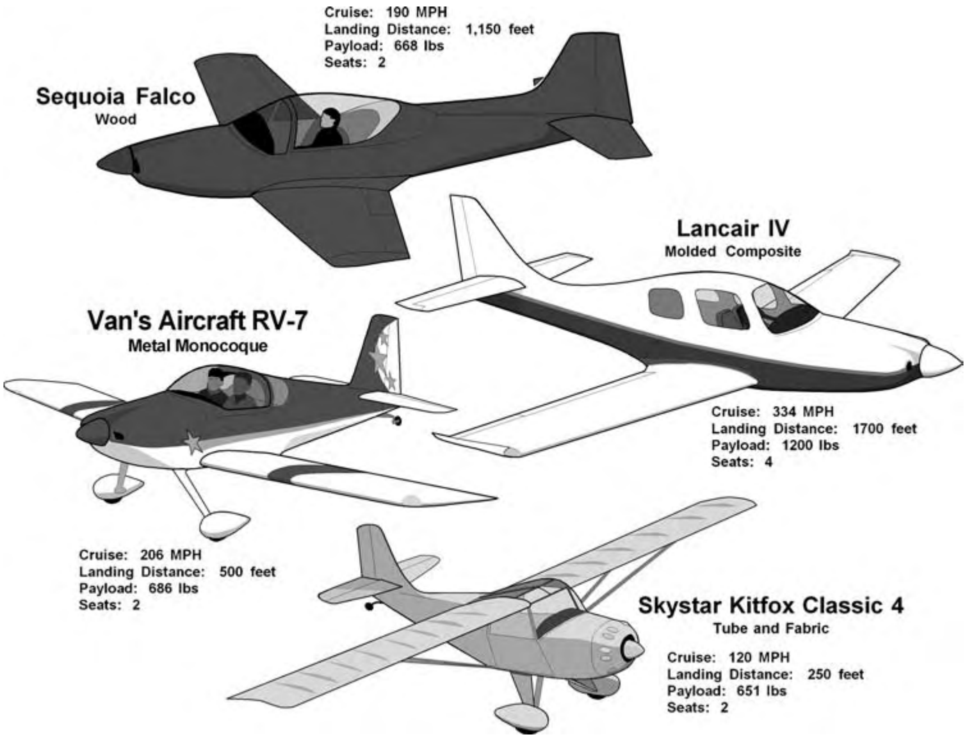

Fig. 2-6. *The four major types of homebuilt aircraft construction.*

Types of construction

To some people, the term "kitplane" is synonymous with "composite airplane." As Fig. 2-6 illustrates, there are several types of construction common to kit aircraft. Let's look at composite first.

A composite material is nonhomogeneous; it doesn't consist of solely one component. Wood is a composite—not only does it contain air bubbles, which allow it to float, but the differences in grain provide the same effect. As far as aircraft construction is concerned, a composite material is made artificially by bonding materials together. It doesn't have to be high-tech. One early example was an aluminum and balsa sandwich. Plywood is a composite material because it consists of several thin layers of wood held together by glue.

Composite construction works by combining two (or more) materials whose advantages complement each other and whose deficiencies cancel out. In the simplest form, strong but flexible fiberglass cloth is soaked in stiff but brittle epoxy (itself a mixture of resin and hardener) to form strong-and-stiff components such as cowlings and wheel pants.

If such a composite isn't strong enough, layers of cloth and epoxy can be separated by a sheet of foam. Composite sandwiches like these form the basic structure of a number of kitplanes.

How does it work? Imagine an ordinary piece of paper. It's easy to tear and fold, but it resists stretching. Imagine, now, a sheet of Styrofoam. The foam resists bending and crushing but crumbles when stretched.

Glue a sheet of paper on either side of the foam. Apply a bending load, and the tension strength of the paper resists. Inserting the foam has changed the bending moment (to which the paper has little resistance) to a stretching moment.

The advantage of composite construction is the easy workability of the component materials. The fiberglass cloth can be cut by a scissors, the foam can be cut or shaped by ordinary hand tools or a hot-wire "cheese slicer," and the epoxies are easily mixed and applied.

The two basic types of aircraft composite construction are *molded* and *moldless.* The first uses a mold to define the shape of the structure; fiberglass layups are made directly on the mold, allowed to harden, and then removed; the mold is then ready to make another piece. These are your fundamental composite kitplanes, where fuselage halves and wing panels are supplied with the kit. Because the molds are expensive and time-consuming to make, molded construction is best suited for mass-produced kitplanes. Examples include the Lancair IV, the Glasair, and several other aircraft.

Moldless composite aircraft can be built in a number of ways. Most common is to build the basic structure out of wood, glue foam to the structure, then carve out the desired shape, and apply the fiberglass and epoxy. Or one can eliminate the wood and carve the shape from foam alone. The moldless method is used for the Velocity, the Co-Z, and the Vision.

There is actually a third type of composite, called *Taylor paper/glass* (TPG) after its inventor, the legendary Molt Taylor. TPG, used on Taylor designs such as the Mini-Imp (Fig. 2-7), uses a type of cardboard for its core material.

Metal-monocoque construction is used by aircraft manufacturers from Piper to Boeing. A thin sheet of flat metal is pretty flimsy. But roll the metal into a wide tube, and it becomes stiff. Attach some bulkheads inside to prevent the tube from collapsing under heavy loads, and you've got a light, strong structure ideal for aircraft.

The metal of choice is aluminum that is alloyed with other metals to optimize its characteristics. Typical aluminum homebuilts include the Van's Aircraft RV series, the Murphy Rebel, and the Zenith line.

Tube-and-fabric construction is another of the traditional ways to make light aircraft. The main structural shape of the fuselage is defined by a metal truss. The wing can be built in one of several methods. The spars, for example, can be solid wood, built-up wooden boxes, or metal extrusions. The ribs can be stamped metal, cut plywood, built-up shapes, or even foam. Fabric is applied to the structure, hence the term "ragwings," and then sealed with dope to produce an enclosed, streamlined shape. Commercial tube-and-fabric light planes include the Piper Cub series and the Aviat Husky.

Tube-and-fabric kitplanes use prewelded steel tubing, such as the Kitfox, or aluminum tube with gussets or extrusions pop-riveted in place, such as the Murphy Renegade.

Wooden aircraft are built just like scale balsa models. The fuselage structure consists of longerons and bulkheads glued into the proper shape. As with tube-and-fabric

Fig. 2-7. *The Mini-Imp uses a third method of composite construction, Taylor paper/glass.* *Mini-Imp Aircraft Company.*

aircraft, the wings can be built in several ways and are either sheathed in plywood or covered with fabric. Wooden kitplanes include the Fisher R-80 Tiger Moth replica and the Sequoia Falco.

The preceding is only a general guide—all kitplanes incorporate welded-steel components, require builders to fabricate fittings from aluminum, and usually need some fiberglass work (Fig. 2-8). Sometimes major components even use different construction modes. The fuselage of the GlaStar consists of a steel-tube framework covered by a composite shell; its wings and tail are of conventional metal-monocoque construction. Even composite airplanes such as the Velocity embed wood hardpoints in the fiberglass for bolt attachments.

Generally, designers keep to one major mode of construction throughout. Not only does it make the parts list simpler, but also it reduces the construction time because the builder won't have to learn two unrelated skills.

Advantages/disadvantages

Each type of construction method has its own advantages and disadvantages both during construction and afterwards.

Composite construction is the most controversial. There's no question that the most streamlined shapes are produced by composites and that it's far easier to bond two fuselage halves than to jig up bulkheads and drive 10,000 rivets. Composites

Fig 2-8. *Just because you pick one type of construction, don't expect to escape working with other materials. This wing assembly features aluminum-tube spars, wooden ribs, and a fiberglass wingtip.*

don't rot like wood; they don't corrode like metal. And no one doubts the strength of composite aircraft.

Curiously, its very strength works against it. Controversy rages regarding the crashworthiness of composite airframes. Composites have no "give." A metal aircraft slightly deforms on impact and absorbs some of the crash forces before they can affect the occupants. Composite structures maintain their shape against high forces and then shatter, allowing those forces to be transmitted to the passengers. Yet this doesn't always seem to be true. In one well-publicized case, a composite aircraft prototype crashed into a housing development after an engine failure. Two houses, a van, and the plane were wrecked, but the aircraft occupants walked away.

However, another important point is *repairability.* Major damage to a structural component usually will require replacement of the entire component. One then must hope that the kitplane manufacturer is still in business and still retains the molds for one's particular aircraft model. This doesn't mean that minor damage isn't repairable, though. With new production composite aircraft such as the Cirrus and the Diamond, the repair techniques are fairly well established.

Yet another drawback is temperature sensitivity. Some composite formulations lose strength when warmed excessively, such as might happen if the plane sits outdoors in the sun for long periods. The FAA requires that certificated composite aircraft, mostly sailplanes, be painted white to reduce this problem.

Speaking of sensitivity, some composite kitplane builders develop allergies to the materials used. The introduction of safer epoxies has reduced this occurrence, but always follow handling and safety instructions.

One thing that can't be escaped is the odor. The epoxies have a strong chemical smell and require excellent ventilation of the workspace. In addition, these chemicals must be used within particular temperature ranges, and the workshop therefore might have to be heated during the winter months.

Metal-monocoque and tube-and-fabric construction methods have several advantages over composite. Crashworthiness is good, aluminum or steel allergies are almost unheard of, and aluminum or fabric-covered aircraft can be painted any desired color. However, metal is not as easily formed into the swoopy curves necessary for high-speed aircraft. Aluminum can be bent into complex shapes, but the necessary skills take time to learn.

On the plus side, aluminum doesn't care what the temperature is, so one doesn't have to heat the workshop as long as the builder doesn't mind bundling up. However, if the exterior skin (aluminum or fabric) is installed in the cold, wrinkles can appear during the summer. Unlike composites, there are no special restrictions on exposure to the elements. But outside storage in coastal areas can accelerate the corrosion process.

Approved procedures exist for repair of damaged monocoque or tube aircraft. However, if a metal tube kit comes with a prewelded fuselage, you won't acquire the skills necessary to repair the fuselage should it get damaged. For persons both accident-prone and pain-sensitive, aluminum construction uses many sharp tools and creates sharp edges on metal.

Wood has a combination of the advantages and disadvantages of the other construction modes. Like composites, wood construction requires a climate-controlled workshop, and the finished aircraft must be protected from the elements. Like metal construction, wooden aircraft have good crashworthiness, and approved damage repair methods assist reconstruction. Because of the nature of the material, wooden kitplanes include fewer precut parts and generally require more work on the part of the builder. Additional skills might be required because the builder must learn to make scarf joints in plywood and to gusset and nail other joints and the myriad other tasks of the woodworker. However, this problem is reduced in modern kit aircraft such as the Loehle line of World War II fighter replicas (Fig. 2-9).

Some advantages of wood are subjective in nature. Sawdust is a far more pleasant aroma than that of composite epoxies and is easier to vacuum than metal chips. Wooden airplanes seem more solid and quieter than other types. While wood rot is still somewhat of a problem, modern preservatives drastically reduce the danger.

The 51 percent rule and you

Recall the various subgroups under the experimental category; experimental/amateur-built aircraft are under the strict limitation of the 51 percent rule.

The rule exists to prevent the sale of nearly-ready-to-fly aircraft that do not meet the requirements of standard category. We've already explained the process involved in certificating a factory aircraft and how this process ensures stable and predictably

Fig 2-9. *Many modern wooden kits, such as this Loehle P-40, feature prefabricated components and reduced construction time.*

handling aircraft. Without the 51 percent rule, a manufacturer could bypass the regulations merely by requiring the installation of a few small parts. Such kits are allowed in the light sport aircraft category, but more stringent controls are applied to LSA kits (see Chap. 3).

As mentioned earlier, the 51 percent rule came about in response to some poorly engineered modifications of existing planes. However, this *doesn't* mean that you can't use components of existing aircraft. Few FAA inspectors will complain if the entire firewall-forward section of a factory airplane appears on your homebuilt. Several older homebuilt designs, such as the Breezy, even use complete wings from factory planes. However, these homebuilts are complex enough to make up for the existing parts.

One good fallout from the popularity of homebuilt aircraft has been a certain amount of standardization and centralization on the part of the FAA. The FAA now has a standard process for determining whether a given kit qualifies under the 51 percent rule, and the agency publishes this list online as the "Revised Listing of Amateur-Built Aircraft Kits." Using a search engine such as Google or Yahoo, search for "amateur-built aircraft kits." The FAA list typically comes up very early in the search window; look for a link to the file name "ama-kits.pdf."

Note that if a kit *isn't* on the list, that doesn't mean that it can't be certified as an experimental/amateur-built airplane. The list is just designed to make things easier for the individual FAA regions.

While it's up to the kit manufacturer to ensure that its product meets the rule, you're the one who'll suffer if the FAA refuses to license your airplane as amateur-built. All you could ever expect to recover is the cost of the kit, and kitplane manufacturers go out of business with sad regularity.

But there's another way the 51 percent rule can cause you problems, although not with the FAA. Let's take a look at the rule from another perspective. Let's say that a kit manufacturer proudly states, "Our kit meets the 51 percent rule." So you order the kit, and when you open the box you find

- Sketches of an aircraft design
- The deeds for a bauxite mine in Oregon and an iron mine in Minnesota
- Six spruce logs and a chainsaw
- A dead cow and instructions for how to make glue from the carcass

This meets the 51 percent rule—and how!

Truism Number One. "The 51 percent rule means that the builder must perform *between* 51 and 100 percent of the total work."

This makes it hard to compare kits—they all meet the 51 percent rule, but which kits require more work? Careful selection analysis is required. Hints on determining actual construction methods can be found in Chap. 4.

The kit manufacturer's dilemma

The cheapest (legal) way to acquire an airplane is to purchase a set of plans and then convert raw materials into aircraft components. The most expensive way is to buy a manufactured model such as a Piper or a Cessna.

By regulation, the kit company can do between 0 and 49 percent of the work. Obviously, the less work left for the builder, the better most buyers will like the kit. But the kit manufacturer has to charge more, which will reduce interest in the product. Figuring out the breakeven point is a major source of ulcers in the kit industry.

Truism Number Two. "If it costs a kitplane manufacturer x dollars to include a step that reduces building time, the additional cost to the builder is at least twice that amount."

In other words, if a manufacturer decides to predrill critical holes, and that costs him \$100 per airplane, the price of the kit increases by at least \$200.

When subcontractors are involved, the cost to the kit buyer increases geometrically. Super Subcontractor Incorporated supplies wing spars to the FlySoon Kit Company. FlySoon decides to reduce the building time by having the holes predrilled through the spars and inserting bushings into the landing-gear mounts. It costs Super Subcontractor \$250 to perform the operation, and it bills FlySoon for \$500. The price of FlySoon's kit then rises by \$1,000 to cover the additional expense.

Sometimes it's worth it. Minor changes at the manufacturer's level can cause drastic reductions in building time. Stoddard-Hamilton Aircraft greatly reduced the building time between the Glasair I and Glasair II kits. The kit price also doubled, but much of that was due to inflation. However, some of the rise must be laid at the door of the more complete kit.