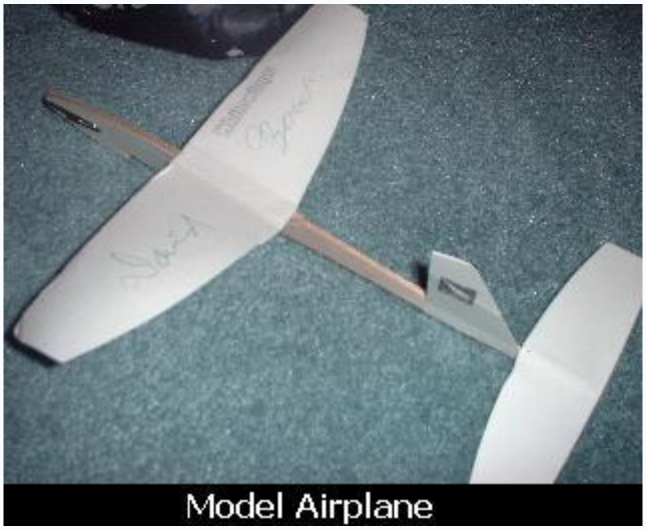
Model aircraft



Static model aircraft

Aircraft modeling or aeromodelling is a hobby that has been popular since the 1930s. It is constructing small airplanes using materials such as balsa wood, foam, fiberglass, etc. A vast array of designs are possible, from ultra-simple gliders such as that pictured, to highly accurate scale models, some of which can be very large - maybe 1/3rd scale or more.

Models may be built either as static non-flying models, or as flying models (also known as **aeromodelling**). Construction techniques for the two are usually very different.

A static model Fokker F28.

Static model aircraft, those not intended to fly, are commonly built using plastic detail parts, photo etched brass, and wire, though other materials such as wood, metal, and paper are also often used. Some static models are scaled for use in wind tunnels, where the data acquired is used to aid the design of full scale aircraft.

Models can be bought already built and painted, as well as models that require construction, painting and gluing, or snap fit models (most of which come with decals or paint already applied).

The collector can choose from plastic and diecast military and commercial helicopters and planes; and for the less skilled collector, snap together military and commercial planes. Snap models are becoming increasingly popular because of their ease of construction.

Plastic model plane manufacturers include Revell who are generally recognized as the most popular manufacturer of plane models in the US, Airfix, whose name is synonymous with the hobby in the UK, Hobbycraft, DML, Frog, Matchbox, Minicraft and Hasegawa, Tamiya and Testors. The peak of the plastic modelling hobby was most probably the 1970s, and while it is still very popular today, at that time the hobby could support a considerable number of competing, large companies. During the 1980s, many of them were forced to radically downsize, restructure, merge, or go out of business. Some attribute this to the rise of computer games over the more traditional type of hobbies. Another consideration is that kits have generally required considerable skill and patience to achieve good results, and that ready-made or more quickly constructed models have taken over the market for those simply looking for a toy to play with.

Plastic scale model aircraft kits usually come in standard scales such as 1/144, 1/72, 1/48 (also known as quarter-scale), and 1/32. This scale indicates the relationship between the size of the model and the size of the actual aircraft. For example, in 1/48 scale, 1 mm on the model represents 48 mm on the actual aircraft. One of the most expensive airplane models in the world, that of a Boeing 707 made in the 1/10 scale, is valued at US$18,000.

Due to the prohibitive costs of producing molded plastic models, there are relatively few manufacturers of injection-molded plastic models. Smaller manufacturers primarily produce models of lesser-known subjects, or accessories to enhance mainstream kits. In order to avoid large costs, small manufacturers cut production costs by producing kits using lower-quality moldings, vacuformed plastic, or resin casting.

Die-Cast model plane manufacturers include Dyna-Flytes (recognized as the first manufacturer of that type of model), Schabak, Gemini Jets and Herpa Wings.

Snap Fit plastic plane models include Wooster, Long Prosper (In South Africa, Long & Prosper), and Flight Miniatures of Cottonwood, Arizona.

Vacuum formed kits are generally for the more skilled collector and are manufactured by small companies such as Koster Aero Enterprises. Specialized kits cast in resin are also available.

Another category are scale plane models made from heavy paper or card stock. Several card model kit companies exist, smaller even than Vacuum formed manufacturers, among them being ModelArt, Halinski, Modelik, JSC and FlyModel. Many card models are also distributed through the internet, and several are offered this way free of charge. Card model kits are also not limited to just airplanes. Such kits are available for all types of vehicles, buildings, computers, firearms, even animals.

Most of the world's airlines allow their fleet aircraft to be modelled as a form of publicity, some of the most notable being Delta Air Lines, Air France, British Airways, Aerolíneas Argentinas, Avianca, Aeroméxico, Fed Ex, Polar Air Cargo, Air New Zealand, Qantas, China Airlines, South African Airways, Finnair, and Royal Jordanian.

[edit]

Flying model aircraft

Modified Parkzone F-27 Stryker. Built by Spencer Johnson.

Miniature 15 gram aircraft by Prof. Jean-Daniel Nicoud

Flying models are usually what is meant by the term **aeromodelling**. Most **flying model aircraft** can be placed in one of three main groups:

- Free flight (F/F) model aircraft are designed and built in a manner that allows the craft to fly without any attachment to the ground.
  This type of model pre-dates the efforts of the Wright Brothers. [1]
- Control line (C/L) model aircraft are designed and built to be flown using cables (usually two) leading from the wing to the pilot. A variation of this system is the Round-the-pole flying (RTP) model.

"Mini Funtana" glow-powered stunt plane from E-Flite Balsa Models

- Radio control. Radio controlled airplanes have a transmitter operated by the pilot on the ground, sending signals to a receiver in the craft.

Some flying models resemble scaled down versions of piloted aircraft almost as much as static models do, while others are built with no intention of looking like piloted aircraft. There are also models of birds and flying dinosaurs. One company, Flying ThingZ of Stroudsburg, Pennsylvania, makes a line of rather whimsical models in addition to a lineup of conventional aircraft. Their more unusual offerings, produced from laser-cut corrugated plastic include a witch on a broomstick, a flying Abrams tank, a flying race car and even a 2/3-scale flying lawnmower.

Construction

Flying models have to be designed according to the same principles as full-sized aircraft, and therefore their construction is very different from most static models. Flying models borrow construction techniques from vintage full-sized aircraft (although models rarely use metal structures.) These might consist of forming the frame of the model using thin strips of light wood such as balsa, then covering it with fabric and subsequently doping the fabric to form a light and sturdy frame which is also airtight. For very light models, very thin paper can be substituted for fabric. Or, heat-curing plastic films ("heat shrink covering" or "solarfilm") can be ironed on - a hand-held iron causes the film to shrink and adhere to the frame. A hair dryer can also be used.

Home-grown model-construction techniques consist of using formers and longerons for the fuselage, and spars and ribs for the wings and tail surfaces. More robust designs often use solid sheets of wood to form these instead, or might employ a composite wing consisting of an expanded polystyrene core covered in a protective veneer of wood, often obechi. Such designs tend to be heavier than an equivalent sized model built using the traditional method, and would be much more likely to be found in a power model than a glider.

The lightest models are suitable for indoor flight, in a windless environment. Some of these are made by bringing frames of balsa wood and carbon fiber up through water to pick up thin plastic films, similar to rainbow colored oil films. The advent of "foamies," or craft injection-molded from lightweight foam and sometimes reinforced with carbon fiber, have made indoor flight more readily accessible to hobbyists. Many come ready-to-fly, requiring little more than attachment of the wing and landing gear. See: ParkZone Slo-V.

Flying models can be built from scratch using published plans, or assembled from *kits*. Plans are intended for the more experienced modeller, since all parts must be sourced separately. The kit contains most of the raw material for an unassembled plane, a set of (sometimes elaborate) assembly instructions, and a few spare parts to allow for builder error. Assembling a model from plans or a kit can be very labour-intensive. In order to complete the construction of a model, the builder typically spends many hours assembling the frame, covering it, and polishing/refining the control surfaces for correct alignment. Furthermore, the kit does not include necessary tools, and these have to purchased separately. Finally, a single overlooked error during assembly could compromise the model's airworthiness, leading to disaster.


ParkZone P-51D Mustang

To address these concerns, and increase the hobby's accessibility to the inexperienced and less interested alike, vendors of model aircraft introduced Almost-Ready-To-Fly (ARF) designs. Compared to a traditional *kit* design, an *ARF* design reduces the amount of time, skill, and tooling required to assemble the model. The average ARF aircraft can be built with less than 4 hours of labor, versus 10-20+ for a traditional kit aircraft. More recently, Ready-To-Fly (RTF) radio control aircraft have all but eliminated assembly time (at the expense of the model's configuration options.) Among traditional hobbyist builders, RTF models are a point of controversy, as many consider model assembly as integral to the hobby. Brands associated with these types of aircraft include Great Planes, Hobbico, Carl Goldberg Products, Lanier RC, E-Flite, Hangar 9, GWS, HobbyZone and ParkZone.

Gliders

Gliders are aircraft with no internal powerplant. Model gliders are usually hand-launched or catapult-launched (using an elastic bungee.) The newer "discus" style of wingtip handlaunching has largely supplanted the earlier "javelin" type of launch. Other launch methods include ground based power winches, hand-towing, and towing aloft using a second powered aircraft. As gliders are unpowered, flight must be sustained through exploitation of the natural wind in the environment. A hill or slope will often produce updrafts of air which will sustain the flight of a glider. This is called slope soaring, and when piloted skillfully, R/C gliders can remain airborne for as long as the updraft prevails. Another means of attaining height in a glider is exploitation of thermals, which are bubbles or columns of warm rising air created by hot spots on the ground. As with a powered aircraft, lift is obtained by the action of the wings as the aircraft moves through the air, but in a glider, height can only be gained by flying through air that is rising faster than the aircraft is sinking relative to the airflow.

Sailplanes are flown using available thermal lift. As thermals can only be indirectly observed through the reaction of the aircraft to the invisible rising air currents, pilots find sailplane flying challenging yet rewarding.

Powered models

Powered models contain an onboard powerplant to propel the aircraft through the air.

Old and Cold

An old method of powering free flight models is Alphonse Pénaud's elastic motor, essentially a long rubber band that is wound up prior to flight. It is the most widely used powerplant for model aircraft, found on everything from children's toys to serious competition models. The elastic motor offers extreme simplicity and survivability, but suffers from limited running time, an exponential reduction of thrust over the motor's operational cycle, and it places substantial stress on the fuselage. Stored compressed gas (CO_2), similar to filling a balloon and then releasing it, also powers simple models. A more sophisticated use of compressed CO_2 is to power a piston expansion engine, which can turn a large, high pitch prop. These engines can incorporate speed controls and multiple cylinders, and are quite capable of powering ligthtweight scale radio control aircraft. Gasparin and Modella are two current makers of CO_2 engines. Rubber and CO_2 are known as "cold" power because they become cooler when running, rather than hotter as combustion engines and batteries. Thermodynamically, this means that both store negative entropy, rather than energy, and extract heat energy from the surrounding environment.

Steam, which is even older than rubber power, and like rubber, contributed much to Aviation history, is now rarely used.

Baronet Sir George Cayley built, and perhaps flew, internal and external combustion gunpowder fueled model airplane engines in 1807, 1819 and 1850. These had no crank, working ornithopter-like flappers instead of a propeller. He speculated that that fuel might be too dangerous for manned aircraft.

Internal Combustion

For larger and heavier models, the most popular powerplant is the **glow-engine**, a form of internal combustion engine. Glow-engines appear similar to small gasoline motorcycle-engines, but glow-engines are considerably simpler in operation. The simplest (and cheapest) glow-engines use a two-stroke cycle engine, glow plug to burn fuel, and an external ignition system (a dry cell or other low voltage source.) The fuel is a mixture of slow burning methanol, nitromethane, and oil lubricant (castor oil or synthetic oil.) The reciprocating action of the cylinders applies torque to a crankshaft, which is the power-output of the engine. Vendors of model engines rate size in terms of engine displacement. Common sizes range from as small as 0.01 cubic inch (in^3) to over 1.0 in^3 (0.16 cc - 16 cc). As Richard Feynman mentioned in his famous *There's Plenty of Room at the Bottom* lecture, the speed an engine can rotate without breaking tends to go as the inverse of the linear dimension (inverse 1/3 power of the displacement). However, the intake air flow improves less quickly than that with small scale, due to decreasing Reynolds number and, eventually, to viscous flow.

Not all simple internal combustion model airplane engines use glow plugs. There are also "diesels", that used to be popular in Europe. These also are carbureted, not fuel injected. They have an adjustable compression ratio and burn a more easily ignited mixture of ether and kerosene (with lubricating oil). These are preferred for endurance competition, because of the higher energy content of the fuel.

Internal combustion (**IC**) engines are also made in upscale (and up-price) configurations. Variations include four-strokes, multi-cylinder engines, and even spark ignition gasoline powered units. All IC engines generate substantial noise (and engine exhaust) and require routine maintenance. In the 'scale-R/C' community, glow-engines have long been the mainstay until recently.

Jet and Rocket


Miniature jet turbine

A recent development is the use of small jet turbine engines in hobbyist models, both surface and air. Model-scale turbines resemble simplified versions of turbojet engines found on commercial aircraft, but are in fact new designs (not based upon scaled-down pre-existing commercial jet engines.) The first hobbyist-developed turbine was developed and flown in the 1980s, but only recently has commercial production made turbines readily-available for purchase. Turbines require specialized design and precision-manufacturing techniques (some designs for model aircraft have been built from recycled turbocharger units from car engines), and consume a voracious mix of A1 jet fuel and synthetic motorcycle-engine oil. These qualities, and the turbine's high-thrust output, makes owning and operating a turbine-powered aircraft prohibitively expensive for most hobbyists. Jet-powered models attract large crowds at organized events; their authentic sound and high-speed make for excellent crowd pleasers.

Pulse jet engines, operating on the same principle as the WW II V-1 flying bomb have also been used. The extremely-noisy pulsejet offers more thrust in a smaller package than a traditional glow-engine, but is not widely used. A popular model was the "Dynajet".

Rocket engines are sometimes used to boost gliders and sailplanes. In the 1950s, a type of model rocket motor called the Jetex engine was quite popular. Today, flyers mount readily-available model rocket engines to provide a single, short (<10second) burst of power. However, government regulations and restrictions have rendered rocket-propulsion unpopular even for gliders.

Electric Power

Parkzone F-27 Stryker

In electric-powered models, the powerplant is a battery-powered electric motor. Throttle control is achieved through an electronic speed control (ESC), which regulates the motor's output. The first electric models were equipped with DC-brushed motors and rechargeable packs of nickel cadmium, giving modest flight times of 5-10 minutes. (A fully-fueled glow-engine system of similiar weight and power would likely provide double the flight-time.) Later electric systems used more-efficient brushless DC motors and higher-capacity nickel metal hydride batteries, yielding considerably improved flight times. The recent development of lithium polymer batteries (LiPoly) now permits electric flight-times to approach, and in many case surpass that of glow-engines. There is also solar-powered flight, which is becoming practical for R/C hobbyists. In June 2005 a new record of 48 hours and 16 minutes was established in California for this class.

Electric-flight was tested on model aircraft in the 1970s, but high-cost prevented widespread adoption within the industry until the early 1990s, where falling costs of motors, control systems and, crucially, more practical battery technologies came on the market. Electric-power has made substantial inroads into the *park-flyer* and *3D-flyer* markets. Both markets are characterized by small and lightweight models, where electric-power offers several key advantages over IC: greater efficiency, higher reliability, less maintenance, much less messy and quieter flight. The 3D-flyer especially benefits from the near-instantaneous response of an electric-motor. As the size of a model aircraft increases, the cost of electric-flight increases much more rapidly than traditional glow-engine flight. As of 2005, an electric-flight conversion for mid-large scale-models (above 0.60in^3 glow-engine) is prohibitively expensive (>$400 USD.) Most such models remain powered by the venerable glow-engine, as their pilots prefer the sound and smell of a genuine 2 or 4-stroke IC-engine.

Airscrews

Most powered model-aircraft, including electric, internal-combustion, and rubber-band powered models, generate thrust by spinning an airscrew. By far, the *propellor* is the most commonly used device. The blades of the rotating propellor push against the atmosphere, and by Newton's Third Law, the air's reactionary force pushes the aircraft.

As in full-size planes, the propellor's dimensions and placement (along the fuselage or wings) are factored into the design. In general, a large diameter and high-pitch offers greater thrust at low airspeed, while a small diameter and lower-pitch sacrifices thrust for a higher maximum-airspeed. In model aircraft, the builder can choose from a wide selection of propellors, to tailor the model's airborne characteristics. A mismatched propeller will compromise the aircraft's airworthiness, and if too heavy, inflict undue mechanical wear on the powerplant. Model aircraft propellors are usually specified as diameter × pitch, given in inches. For example, a 5x3 propellor has a diameter of 5 inches, and a pitch of 3 inches. The pitch is the distance that the propellor would advance if turned through one revolution in a solid medium. Additional parameters are the number of blades (2 and 3 are the most common).

There are two different methods to transfer rotational-energy from the powerplant to the propellor.

- With the *direct-drive* method, the propeller is attached directly on the engine's spinning crankshaft (or motor-rotor.) This arrangement is optimum when the propellor and powerplant share overlapping regions of best efficiency (measured in RPM.)
- With the *reduction* method, the crankshaft drives a simple transmission, which is usually a simple gearbox containing a pinion and spur gear. The transmission decreases the output

RPM by the gear ratio (thereby also increasing output torque by approximately the same ratio). Reduction-drive is common on larger aircraft and aircraft with disproportionately large propellors. On such powerplant arrangements, the transmission serves to match the powerplant's and propellor's optimum operating RPM. Geared propellers are rarely used on internal combustion engines, but very commonly on electric motors.

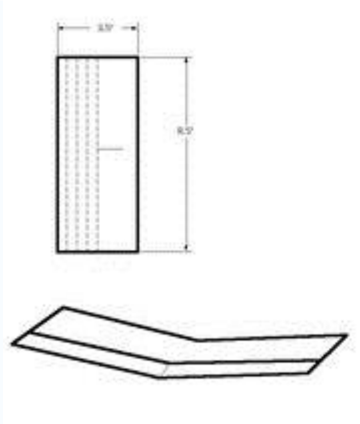
In some designs of aircraft, the propeller is replaced by a *ducted fan* unit. The fan-unit is an assembly of the spinning fan (a propellor with more blades), held inside a shaped-duct. Compared to an open-air propellor, a ducted-fan generates more thrust per crossectional-area. The shaped-duct often limits installation to recessed areas of the fuselage or wings. Ducted fans are popular with scale-models of jet-aircraft, where they mimic the appearance and feel of jet engines, as well as increasing the model's maximum airspeed. But they are also found on non-scale and sport models, and even lightweight 3D-flyers. Like propellors, fan-units are modular components, and most fan-powered aircraft can accommodate a limited selection of different fan-units.

In jet-powered model aircraft, the engine is a single-piece assembly with no user-changeable parts. The turbine-wheel spins at extremely high speed (>150,000 RPM), limiting most adjustments to the original factory.

Finally, ornithopters do not use airscrews at all. In ornithopters, the reciprocating-motion of the wing structure immitates the flapping-wings of living birds, producing both thrust and lift.

Model Aerodynamics

The flight behavior of a shape depends on the scale to which it is built. The Reynolds number depends on scale and speed. Drag is generally greater in proportion at low Reynolds number, so flying scale models usually require larger than scale propellers. Mach number depends on speed. Compressibility of the air is important only at speeds close to or over the speed of sound, so the effect of the difference in Mach number between a slow piloted airplane and a small model is negligible, but models of jets are generally not efficient flyers. In particular, swept wings and pointed noses are used at high Mach number to reduce compressibility drag and tend to increase drag at small Mach number. Angular momentum also depends on scale. Since torque is proportional to lever arm length while angular inertia is proportional to the square of the lever arm, the smaller the scale the more quickly an aircraft or other vehicle will turn in response to control or other forces. While it may be possible for a pilot to fly an unstable aircraft (such as a Wright Flyer), a radio control scale model of the same aircraft would only be flyable with the center of gravity moved forward. Static stability, resisting sudden changes in pitch and yaw, is generally required for all models and is usually considered a requirement for piloted aircraft. Dynamic stability is required of all but tactical piloted aircraft.



Free flight models need to have both static and dynamic stability. Static stability is the resistance to sudden changes in pitch and yaw and is typically provided by the horizontal and vertical tail surfaces, respectively, and by a forward center of gravity. The three dynamic stability modes are phugoid, spiral and Dutch roll. An airplane with too large horizontal tail may have a plugoid with increasing climbs and dives. Insufficient dihedral and sweep back will generally lead to increasing spiral turn. Too much dihedral generally causes Dutch roll. However, these all depend on the scale, as well as details of the shape and weight distribution. For example the paper glider shown here is a contest winner when made of a small sheet of paper but will go from side to side in Dutch roll when scaled up even slightly.

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See also

- Model airport
- Radio controlled model
- Radio controlled airplane
- Aviation history