PART 3

Biplane Secrets

by CARL RISTEEN

Triplanes, monoplane comparison, knife-edge tips and more

PART ONE OF this article (see the June '94 issue) briefly covered the evolution of airplanes and how it led to biplanes, with their problem of mutual wing interference and methods to combat it. Also covered were the effects of stagger, decalage, wing flaps and incidence. Part 2 (July '94) covered further performance-enhancing refinements and offered a schematic for a "cheater" interplane strut that improves performance and reduces tip losses. In this issue, I'll look at triplanes, compare and contrast monoplanes and biplanes, comment on bipe fun-fly designs and fly through some of the most important points worth remembering.

IF TWO WINGS ARE GOOD, WHY STOP THERE?

The Sopwith triplane fighter burst upon the scene in 1916, immediately racking up a tremendous record in aerial combat. It was probably close to the optimum in triplane design for its time, and it precipitated a blizzard of imitators. The best known of these was the innovative, tricky-handling Fokker DR-1—one of the first multiplanes to seize the bracing-wire-eliminating advantage of thick wings. It was immortalized by the formidable von Richthofen.

Convinced that Stanley Sopwith had discovered something profound, less talented designers jumped on the multiwing bandwagon. Three wings had clobbered the two-wing opposition, so why not add another wing or two? They didn't realize that most of the Sopwith tripe's success was rooted, not in three wings, but in brilliant design.

Peter McDermott's 78-inch-span, ¼-scale Sopwith triplane took first at the '92 FAI Scale Internats in Muncie, IN. It's powered by a Laser 180 twin that spins an 18x6 Dynathrust prop.*

Brief forays into quadruplanes (four wings) and even pentaplanes (five wings) were rewarded with little success. The ultimate folly in this pile-on-more-wings aeronautical dead end was probably the enormous, 100-passenger, eight-engine, Caproni Ca 60 Transaero seaplane of 1921. It literally bristled with wings, nine in all, arranged in tandem along the fuselage in three triplane groups. With so many wings competing for much the same air, it was a complete flop. By dint of Titanic effort, it struggled a few feet above beautiful Lake Maggiore before stalling and frightening many fish. It burned before it could be repaired, reducing the anxiety of both pilots and fish.

By the early 1920s, triplanes were largely extinct because this more complex layout had little, if any, aerodynamic advantage over the biplane. Structural benefit was minor, in contrast with that of the biplane over the monoplane. A triplane of reasonable overall height can carry only a few percent more wing area within a given wingspan before induced drag exceeds that of the bipe. The middle wing, under aerodynamic assault on two fronts by the upper and lower wings struggles to develop a maximum of about 30 percent of an equal-wing tripe's total lift.

The Sopwith tripe's clever designers used a relatively high wing-aspect ratio of over 9, with a gap about equal to the chord. As a consequence, it suffered little, if any, induced drag beyond that of most contemporary biplane fighters that had wings with much lower aspect ratios. Revolutionary streamlined bracing wires chopped parasite drag. Its six ailerons needed relatively light stick forces to produce an excellent roll rate and superb handling.

A later Sopwith triplane fighter, the Snark, took a big step backward to much lower aspect ratio wings and was much inferior in handling. With the same wingspan as the earlier tripe, it was only slightly faster, even with more than double the horsepower.

I must confess to being a closet triplane fancier, with a stand-off-scale Sopwith tripe designed but not yet built. At the flying field, a tripe will instantly upstage just about everything, even the haughty bipes. Anyone for an aerobatic, tapered-wing sport tripe?

BIPE vs. MONOPLANE. WHICH IS BETTER?

Unless we are hung up on biplanes, why not simply slash the upper wing off a bipe and fit a new, larger, lower wing with roughly the same total area? Since there appears to be minimal structural weight advantage associated with wire bracing of a model bipe with thick, symmetrical-section wings, is there any good reason to use two wings at all? True biplane aficionados will, of course, condemn such drivel as blatant heresy, but here goes:

In theory, two wings, each of the same design and shape but half the area of a larger single wing, can be built to a total structural weight of only 71 percent of that of the larger wing. The necessary cabane and interplane struts will reduce the weight advantage somewhat, but the monoplane will need a longer, and thus heavier, fuselage to get the same stability and controllability. The monoplane's weight will be increased still further by the additional structure needed in the wing to provide the torsional stiffness that the biplane's wings get from the interplane struts.

The monoplane can use a lower-aspect-ratio wing than the biplane, as it does not suffer from mutual wing interference—a point in the monoplane's favor. The longer-wing monoplane will demand more aileron area to achieve the biplane's roll rate, and it will need roughly double the aileron servo effort—a minus point. The monoplane will have more mass farther from its center of gravity. This will increase its mass moment of inertia and thus slow its initial response to control-force input—another minus, at least for barnstorming-type flying.

After mulling over the monoplane-versus-biplane question, I decided that the only way to settle the issue would be to build an upstart monoplane with aspirations to bipe-like performance.

I lifted the fuselage design from one of my bipes and built a single wing with 95 percent of the total area of the previous bipe, using the bipe wing's structural design, with aspect ratio lowered by about 25 percent. The lower aspect ratio provided the additional torsional stiffness needed in the absence of interplane struts. The wing received detachable vertical fins—an experiment directed at recovering the lateral area that was lost along with the cabane and interplane struts.

The very large ailerons needed to match the bipe's roll rate would require two large, heavy servos. Figuring that the beast would win few beauty contests anyway, I equipped its ailerons with very effective, but ungainly, paddle-type aerodynamic balancers. With their assistance, one standard servo did the job. The result was a monoplane whose appearance, like Quasimodo's, might most charitably be described as distinctive. Despite its greater weight, it turns as tightly as the bipe, but that's about all. The slightly higher Reynolds number and lack of biplane mutual wing interference help lift a bit. It has little of the bipe's strong knife-edge capability, even with the ugly auxiliary wing fins in place. Sadly, I realized that I had not succeeded in fooling nature. A piped Webra* 120 propels the 8-pound gene-spliced hybrid like a tiger with its tail on fire, but it is no bipe.

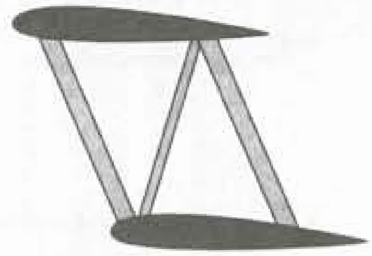
Bipe and monoplane; they're birds of different breeds and instinctive temperaments, and never the twain shall meet. Aerodynamic efficiency favors the monoplane, at some cost to barnstorming-type maneuverability. For precise, competition, pattern-type flying with large-radius, high-speed maneuvers, the monoplane layout is probably superior. For those with a bent toward exuberant, let-it-all-hang-out aerobatic hot-dogging, a well-designed, lightweight, high-powered bipe is hard to beat.

BIPE PATTERN MODELS?

Scrupulous attention to drag-reducing detailing can produce a bipe that is nearly as fast and (making some allowance for its shorter wingspan and fuselage) as precise as a monoplane pattern model, while retaining the bipe's entertaining hot-dogging character. Lengthen the bipe's fuselage to that of a monoplane pattern model of the same wing area and power, stretch and narrow its wings to an aspect ratio in the 8 to 10 region, and the bipe pattern model should be very close to the monoplane in smoothness and precision (although losing much of its delightful barnstorming character). Use of higher-aspect-ratio wings will also permit the lowering of the upper wing. Pulling the centers of gravity and drag down closer to the thrust line tends to boost aerobatic precision.

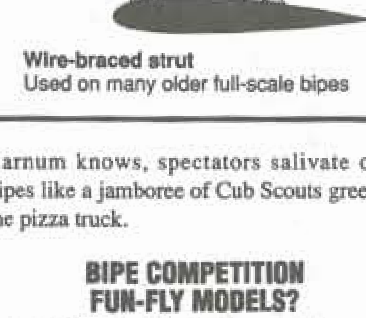
Frankly, current pattern rules offer little incentive to use biplanes. If the rules dictated a tighter routine, flown closer than half a county away, with more emphasis on knife-edge maneuvers, bipes could emerge as very scrappy contenders. As any air-show Barnum knows, spectators salivate over bipes like a jamboree of Cub Scouts greeting the pizza truck.

Interplane strut types



Basic N-strut
Members should be well-streamlined. Used on many full-scale bipes.

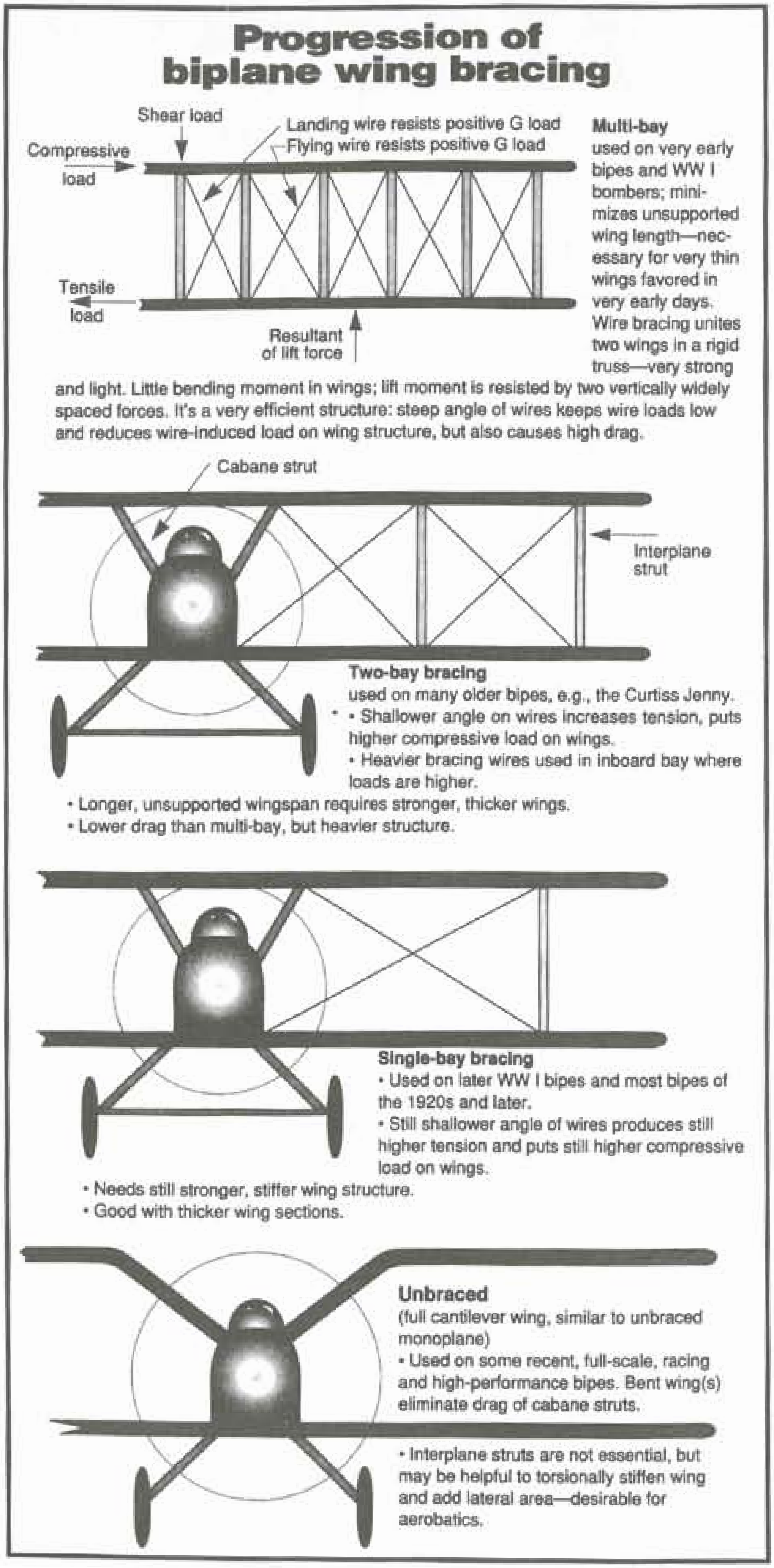
Unitized streamlined strut
Used on numerous, present-day, full-scale, aerobatic bipes. May be made of ¼-inch sheet balsa for models with .60 to 1.20 engines. Low drag and additional lateral area improve knife-edge and handling.



Wire-braced strut
Used on many older full-scale bipes

BIPE COMPETITION FUN-FLY MODELS?

One currently white-hot competitive arena that bipes just might shine in is competition fun flying. Looping as quickly as possible dictates a very low wing loading. Rolling at a rate that threatens to fling the wingtips into orbit is also very important, but this tends to impose a rather strict limit on wingspan. Increasing the wingspan will reduce induced drag and tend to produce quicker loops, but roll rate will suffer. Increasing the wing chord while retaining the existing span will



produce tighter loops, but the additional drag may slow the model so much that loops are only slightly quicker, and quickness is what counts.

Adopting a biplane layout would permit the use of considerably more wing area within a given wingspan without increasing induced drag. Result: quicker loops—without hurting roll rate—and a greatly reduced demand for servo torque—so saving all-important weight. The aerodynamic potential looks intriguing, but structural complexity will tend to dampen bipe fun-flier enthusiasm. My own bipe designs have successfully duked it out with many monoplanes in sport fun-fly competition. Generous lateral area and low wing loading lets you get away with murder without scattering divots on the flying field.

KNIFE-EDGE HINTS AND KINKS

The high-powered sport bipe with a big rudder is king of the knife-edge hill. The two wings tend to trap air against the fuselage sides and interplane struts and produce a lot of knife-edge lift. The shorter fuselage places the rudder in stronger propwash for powerful yaw control. Well-streamlined interplane struts with significant lateral area (similar to those used on some full-scale aerobatic designs) can provide a lot of knife-edge lift assistance. A devious schemer at heart, I often augment this by using airfoil-sectioned N-brace interplane struts that are actually little, clear-plastic-film-covered wings (see Part 2, in the July '94 issue). Majestic, horizon-to-horizon, slow rolls can be performed with very little rudder input and almost imperceptible yaw. With enough power, knife-edge square loops and even vertical square eights become easy. These "cheater" struts also seem to act as flow fences to reduce induced drag while enhancing lateral stability and controllability. Bipes with low effective wing-aspect ratios can use all the help they can get to reduce tip loss.

With a well-designed, lightly wing-loaded bipe, you can achieve remarkable knife-edge performance. Holding a full 45 degrees deflection of a large rudder while in knife-edge, power off, results in a nose-level descent, thanks to the cheater struts. Put some power on, and the descent stops, with the model crawling along at well under 10mph in knife-edge. The sub-fin and sub-rudder area help by placing the maximum possible rudder area in the propwash.

In giving further vent to my scheming nature, I have played around with other trick devices to boost knife-edge flight.

Clear-plastic-film-covered cabanes with their own rudders almost halve knife-edge loop diameter (they move in opposition to the rear rudder, analogous to coupled flaps and elevators), although the model starts to look a little weird. Interestingly, everything I have tried to augment knife-edge has also improved overall handling and resistance to stall/snap roll by increasing yaw resistance. NASA proved, by R/C model experiments, that strategically positioned additional lateral area improved the stall/spin resistance of several common full-scale aircraft.

Keep it light, and your bipe will reward you with many happy hours of error-forgiving aerobatics that may sometimes leave you wondering if the laws of physics were temporarily suspended for your flying layer cake.

BIPE TAIL FEATHERS

The airflow over a bipe's tail surfaces tends to be considerably more disturbed than that of a monoplane, particularly if the fuselage is somewhat dirty aerodynamically. To compensate, bipes need more tail area, particularly in the fin and rudder. Considerably enlarging the vertical tail can greatly help many a sloppy-handling bipe. I like to use vertical and horizontal tails having about 10 and 20 percent, respectively, of the wing area. Many of the common, scale-like designs currently available fall considerably short here, in my opinion. The Ultimate is a good example of a bipe with the kind of vertical tail area needed for superb lateral controllability. I would love to try an Ultimate retrofitted with longer, tapered wings to cut induced drag and make it less power-hungry.

This is the author's attempt to build a monoplane that performs like a bipe: 86-inch span; 1,230-square-inch wing; 8 pounds; all-moving vertical tail; spoilers; balloon-tire retracts; and paddle balancers on ailerons. The plane is currently powered by a piped Webra 120.

SUMMING UP

I find bipes friendlier when their wing loading is kept considerably lower, say 65 to 75 percent of that of an equivalent monoplane (no chore, with a well-designed bipe). Aspect ratio also enters this equation; higher-aspect-ratio bipe wings can happily shoulder a higher loading. Low wing loading helps a lot to more than make up for the higher parasite and induced drag of most bipes. Some of the smaller kit designs are short of the mark here and tend to fly on the engine. In my book, at a low power setting, a good bipe flies buoyantly with excellent control, and at high power, it flies spectacularly. A bipe will feel overweight at a wing and power loading that would be quite acceptable in a monoplane.

One very helpful guide is the concept of span loading. For a given amount of lift, induced drag is inversely proportional to the square of the wingspan. Increasing the wingspan by 10 percent will reduce induced drag by 19 percent, regardless of the chord, as long as the wing isn't stalled. A little extra wingspan is worth a lot in induced-drag reduction.

A biplane typically needs 85 to 90 percent of the wingspan of a monoplane to have the same induced drag as a monoplane of the same weight. Short-wing bipes must be built light. Desirable weight at a 48-inch span is well under 4 pounds, say 5 pounds maximum. Cut wingspan to 44 inches, and weight should be cut to about 3 pounds, say 4 pounds maximum, or performance will be substandard.

A little extra weight takes a lot of additional power to overcome, i.e., to recover lost flyability. A good rule of thumb, I think, is 25 percent more power for 10 percent more weight. Keep it light, and your bipe will reward you with many happy hours of error-forgiving aerobatics that may sometimes leave you wondering if the laws of physics were temporarily suspended for your flying layer cake. ■