The AR-6 Racer

MICHAEL FRIEND EXAMINES A NEW FORMULA ONE CONTENDER FROM THE DRAWING BOARD OF MIKE ARNOLD

A sleek new shape has taken to the pylons of the Reno air race course, and it seems to be following in the footsteps of its record-setting predecessor. The AR-6 is the latest design from the drawing board of Mike Arnold, a designer who in 1992 set an FAI (Federation Aeronautique International) speed record of 186kts in an aeroplane (the AR-5) powered by a 65 horsepower Rotax! This was impressive enough to earn him the prestigious Louis Blériot medal from the FAI. If sleek looks count for anything, the AR-6 may well set its own records.

The AR-6 design was commissioned a few years ago by David Hoover, an enterprising pilot who wanted to see if the lessons learned from the record-setting AR-5 could translate into Reno-winning speed around the race pylons. Construction started in 1998, and first flight was achieved in April 2005.

To be up there with the winners, the AR-6 must achieve an average lap speed of around 250 miles per hour, with a straight and level maximum speed in excess of 217kts. These are numbers consistent with those put up by Nemesis, the dominant but now-retired Formula One racer of the last decade. So what tricks will the AR-6 need to have up its sleeve if it is to reach these speeds?

Particular attention has been paid to the engine cooling. David Hoover worked with aerodynamicist David Lednicer to manage the air as it enters the cowl and decelerates

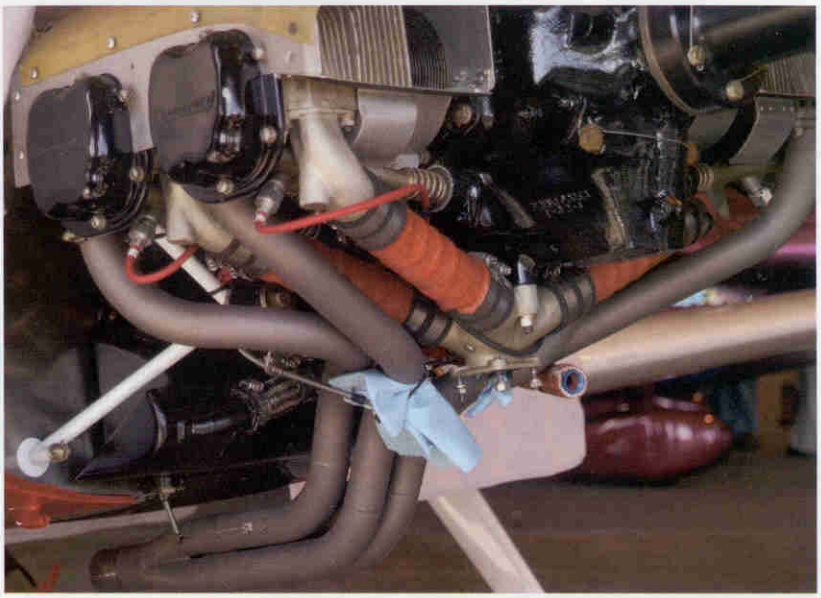
LOADS OF UP TO SEVEN GS HAVE BEEN RECORDED!

over the engine, and Mike Arnold designed the exit shape. There is a separate plenum box for each set of cylinders. Initial testing has shown that it works too well, with cylinder head temperatures all the way down to 127°C. Experiments to cut down on the already small intakes have now brought the temperatures up to the 200°C considered optimal.

Another subtle detail is the way that the fuselage is held at a constant width to just near the wing trailing edge. Aerodynamicist Bruce Carmichael explains this trick, used previously on the AR-5: "To give away as few drag points as possible on this important juncture, Arnold did not allow the fuselage to contract until very near the wing trailing-edge. There is a stagnation-relieving fillet at the leading edge, a corner radius fillet and an expanding fillet on the aft portion to soften the adverse pressure gradient. The bottom of the wing is flush with the bottom of the fuselage, thus virtually eliminating two intersections. This juncture should help reduce the interference problem common to low-wing aircraft, particularly at the higher lift co-efficients, and, no doubt, it helps also at high speed and low lift co-efficients." Attention to small details like this can make the difference between a good

ABOVE To be up there with the winners, the AR-6 must achieve straight and level maximum speed in excess of 217kts. (ALL SHERWIN ENG UNLESS STATED)

BELOW The AR-6 was designed by Mike Arnold, who in 1992 set an FAI (Federation Aeronautique International) speed record of 186kts with his AR-5. This was powered by a 65 hp Rotax! (MIKE ARNOLD)



Right Particular attention has been paid to the engine cooling, and there is a separate plenum box for each set of cylinders.

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THE DESIGNER – MIKE ARNOLD

Mike is a real 'Renaissance man', moving easily between the worlds of video production and aircraft design. He put himself through a self-facilitated course in composites, working in a glider repair shop and helping to build the Rutan-designed Amsoil Racer. His AR-5 was a masterpiece, each detail so well executed that aerodynamicist Bruce Carmichael paid him this compliment: "Engineering judgment and superb detail design are found everywhere in the AR-5". The words 'engineering judgment' are important, as there are few people in the world both experienced enough and canny enough to be able to blend a myriad of structural and aerodynamic details into a well-integrated aeroplane such as the AR-5.

aeroplane and a truly fast one.

During my discussions with Mike, he made a few observations about the design of the AR-6, and how it was built. "If you cover the cowl on pictures of the AR-6, especially the views from the front, you'll see that it's basically an AR-5 with curves. They are both low-wing, high aspect ratio aeroplanes with razorback canopies. Both use solid foam-cored, laminar flow wings, and the landing gear geometry is basically the same. I used the same relationship between wing location and maximum fuselage cross-section on both aeroplanes. The main differences between the two are the result of the larger engine, and the fact that the AR-6 places much more emphasis on reducing wetted area on the fuselage.

He commented on the part of the design that made him think the hardest. "I spent more time on the wing design than on any other part of the aeroplane. It was the first thing I designed. I had heard reports from Formula One pilots of other high aspect ratio racers being unusually rough riding in turbulence, which I took to be the result of aero-elastic divergence. I had worried about it on the AR-5, but its wing was so thick and stiff (18% at the root) that it didn't turn out to be a problem. The AR-6 wing is longer and thinner (14%), so I wanted to try to reduce or eliminate the tendency of the wing to increase its angle of attack when loaded, which is what I suspected was happening on the other long-winged racers. I addressed the problem by using a carbon fibre 'D tube' spar design, and covering the remainder of the wing with fibre-glass, thereby keeping the stiffest part of the structure as far

Below The AR-6 is fitted with an Owens Composite propeller, and spins the O-200 Continental engine up to a giddy 4,200rpm.

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LEFT The wide-set main gear gives the AR-6 good runway handling, uncommon for a high-strung racer.

forward as possible. David reports that it seems to work, and the initial testing shows that the aeroplane gives a smooth ride while having good roll response from the ailerons."

Mike's friend Harry Riblett came up with a very promising airfoil, using the basic NLF (the airfoil Nemesis used) thickness distribution, on a mean line of his own design. He also did some 'magic' on the wing leading edge.

Mike did the initial design of the AR-6 in 1993, after meeting race pilot Troy Channing at Oshkosh. When Troy was killed later that year, he put the project aside. A meeting with David Hoover in 1997 re-ignited the design process and Mike finished detail design in 1998.

HOW WAS IT BUILT?

Mike Arnold built the fuselage, cowl, and canopy master plug. The firm of Composites Unlimited of Scapoose, Oregon, created the moulds and made the carbon and honeycomb parts from them. Craig Cato, a well know West Coast composites fabricator, made the wing and horizontal stabilizer, and David Hoover and friends assembled and finished the aeroplane in Hayward, California. The engine comes from Ly-Con, a company with a great deal of experience in making racing engines hold together. The project started in 1998, and took five-and-a-half years of serious effort and many man-hours before it was ready for flight. Over the same period, David also started a new family - the arrival of two children slowed down progress a bit!

David spent a long time getting the side-stick controller position right, mocking up several prototypes before settling on one that felt just right. As he had never flown with one before, he was initially apprehensive, but has found that it feels very natural and allows him full roll control in the tight confines of the racing cockpit. He has installed an armrest that allows him precise control, even in the bumpy conditions around the race pylons.

As late as August 2005, final sanding and painting was getting underway. The aeroplane appeared at the Reno Air Races in September with a red fuselage, painted with race number 11 and the name *Endeavour*. Of course, the initial plan was to complete it with plenty of time to spare, but this was an effort that went on right until the

THE PILOT – DAVID HOOVER

David Hoover, who comes from the San Francisco Bay area, works in the world of finance. He began flying in 1981 and received his PPL in 1982, while still in high school. His association with Formula One began in 1991, when he started crewing for noted test pilot and racing pilot Dave Morss In 1992 he bought a tired old Cassutt, race number 66, and spent the next two years completely rebuilding the plane from the tubing upwards, with a new cowl, baffles, canopy, tail, wheel spats, fuel tank, and covering the fuselage with foam and fibre-glass. The new plane was given the name Frenzy, and over the next six years was continually modified and updated. The empty weight was reduced to 255kg from 270kg. When Dave Morss qualified the plane in 1991, his speed was 150kts. The last year that David qualified Frenzy, the speed was 212kts - an increase of 62kts! As well as being a race pilot, David has been President of the International F1 Association and has served as the training pilot for new entrants to the F1 racing circuit.

LEFT The sleek design has resulted in a tight cockpit.

Top Right The bottom of the wing is flush with the bottom of the fuselage, thus virtually eliminating two intersections. This juncture should help reduce the interference problem common to low-wing aircraft.

Above Right David spent a long time getting the side-stick controller position right. He has installed an armrest that allows him precise control, even in the bumpy conditions around the race pylons.

Top The initial testing shows that the aeroplane gives a smooth ride while having good roll response from the ailerons.

Right The AR-6 is the latest design from the drawing board of Mike Arnold. Construction started in 1998, and first flight was achieved in April 2005.

last minute. The initial post-painting test flights were carried out around the pylons at Reno!

HOW DOES IT FLY?

David Hoover made the first flight in April 2005 and has had a relatively trouble-free flight test period. Initial impressions of the handling were all positive. He reports that the stall occurs at a surprisingly low 55kts and is quite benign, with no tendency to drop a wing. He uses an Owens Composite propeller, and is spinning the O-200 Continental engine up to a giddy 4,200rpm. The top speed observed so far is "consistent with a lap speed of 217-225kts," he says.

The real validation of speed will come around the pylons at Reno, as he does not currently have a very well-calibrated pitot-static system. In a racer, the only part of the airspeed indication that needs attention paid to it is in the approach and landing phase. David was initially approaching at close to 90kts, but this resulted in excessive 'floating' down the runway. After becoming more comfortable with the stalling speed and characteristics, he reduced the speed to 80-85kts and now has no problem, even on relatively short runways. The wide-set main gear gives the AR-6 good runway handling uncommon for a high-strung racer.

One aspect of Formula One racing not apparent to spectators is the loads imposed on the plane and pilot. During a typical race, a load of four Gs is not uncommon. David generally likes to keep below three-and-a-half Gs, so as not to load up the wing too much and cause excessive drag. In turbulent air behind another aeroplane, loads of up to seven Gs have been recorded!

Normally, every racing aeroplane goes through a 'teething period', during which a myriad of detail is worked on. David Hoover reports that in the 42 hours of flight-testing conducted, there have been remarkably few problems to work out. It is clear that the AR-6 has the potential to be a race winner.

EPILOGUE

Reno 2005 was the AR-6's racing baptism. The week started well for *Endeavour,* which qualified second at 217kts. In the heat races, its speed picked up, clocking 221kts and coming a very close second place twice. The closeness of the finish in the two heat races led to suspicion that David Hoover was holding a bit in reserve for the finals, unwilling to show just what the AR-6 was capable of. In the final Gold race, David and *Endeavour* got off to a slow start, the propeller working well at high speed but not giving good acceleration for the standing start used in F1. In fifth place at the first pylon, David worked his way through the field as the aeroplane gained momentum.

Photographer Sherwin Eng noted that he used a markedly different cornering style from the other contenders, taking an early apex and diving through the turn. One after another, his rivals fell victim to the speed of the AR-6. At the finish, a mere four seconds separated him from a maiden victory. David noted that if he had had one more lap, he would have been able to catch winner Gary Hubler. Another year of fettling and honing on the AR-6 could give him that winning edge.