NANOSAUR

We've been corresponding with Marc Vėpraskas for a couple of years now. During this time he's been attempting to design, build, and fly a thermal duration swept 'wing design utilizing the Eppler 222 - 230 series of airfoils and foam and balsa construction. He recently sent us the following report on his progress, together with a videotape of the first test flights.

The Nanosaur Flying Wing

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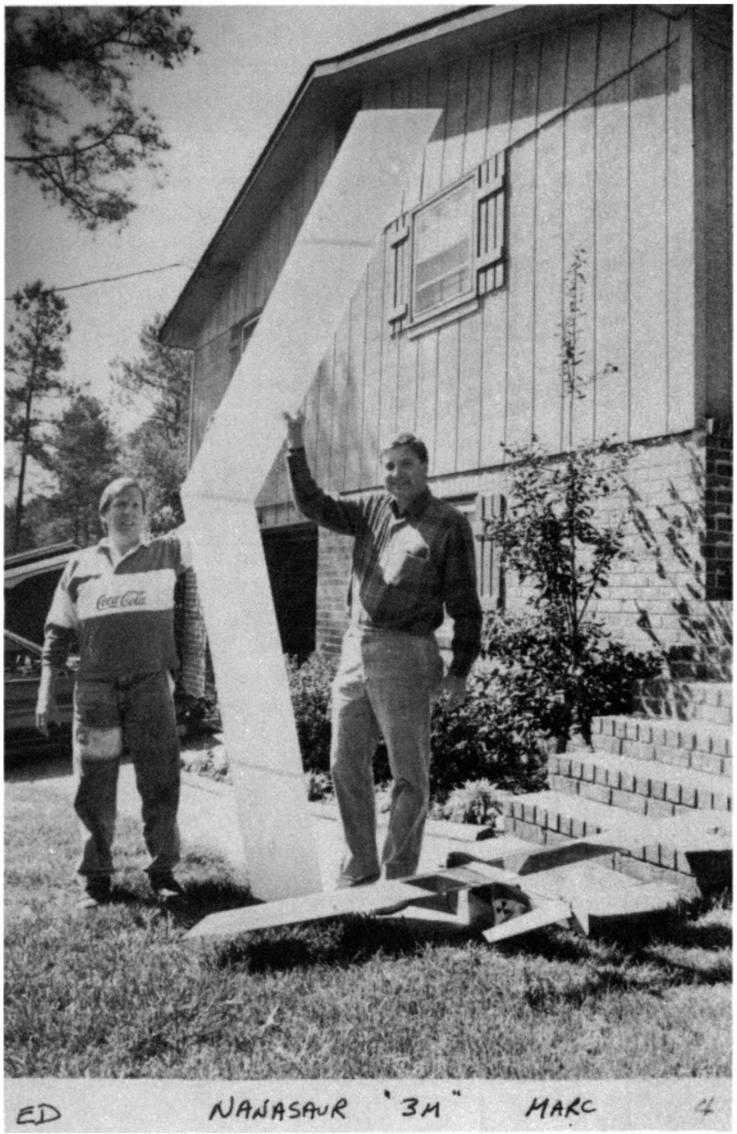
The ancestry of the Nanosaur project can be traced to Bill and Bunny Kuhlman's articles, "On the 'Wing," in RC Soaring Digest. I have always been fascinated by 'wings. In 1975 I built the RCM (RC Modeler) Standard Plank and in 1979 the RCM Windfreak, both plank designs. In 1989 I built the Klingberg two meter 'wing. Normally I fly a straight wing Sagitta 2M. I wanted to build my own 'wing design with the features B^2 (Bill and Bunny) discussed. The design of the Nanosaur Project utilizes all that I have learned up to June 1990. I had to freeze the design at some point and start building!

The inspiration to design was started by reading "Winged Wonders," a book on the Northrop N9M project. The N9M was a 60 foot span 1/3 scale flying model of the XB-35 bomber project of the 1940's. The author, Mr. Wooldridge, covered the complete story of the flying wings. Another book which helped me was "Faszination Nurflugel," a German book on the development of flying wing models up to 1988. Together, and after reading and looking at all the pictures, I was hooked and Nanosaur was born.

Design started in February 1990 with a letter to B^2 asking for advice. I needed a source to plot the new Eppler 222 -230 series of airfoils, specifically designed for flying wings. These airfoils exhibit a very small center of pressure movement as angle of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attack is changed. The use of the Eppler airfoils is important to limit the pitch sensitivity on a flying wing. I found the airfoils in Chuck Anderson's airfoil program and ordered the IBM version of the software. B^2 advised I use the E 222 at the root and the E 230 at the tip with 3 degrees of negative twist (T.E. raised) for thermal flying. I decided to use the E 222 for the root, transitioning to the E 226 at mid semi-span and then to the E 230 at the tip.

In researching articles on 'wings I came across a British White Sheet magazine of the Spring of 1986 (#36). One of the articles was by Reinhard Werner who stated "Flying wing designers should think big! The greater our wing chord and area, the greater are our chances to escape Reynolds number trouble and effect a wing loading adequate to conditions of minimum sinking speed." I chose 13.5" for my chord and 122" as my span as I would otherwise have trouble transporting the wing in my van!

Nanosaur was designed to be an open class thermal flying sailplane. The wing span is 122.5" with a constant chord wing of 13.5". The constant chord was used to help stability and reduce the twist required. The negative side of the constant chord is the roll rate is degraded slightly as more weight is on the tips. The wings are swept back 20 degrees and winglets are used at the tips. The winglets block the aft 75% of the wing tip. The winglets are designed to help reduce tip stalls and aid in visibility.

In order to design the rest of the wing I needed to determine the approximate CG position to help lay out the components. To caculate the CG the neutral point of the wing first must be found. After the NP is found the CG is 5% of the root chord ahead of the NP. The NP is the aerodynamic center of the wing. The NP is calculated as the mathematical addition of the leading edge sweep back distance at 1/2 of the semi-span and 25% of the wing chord. Where the two points add up is the NP. On Nanosaur this calculates as

$$\tan 20^{\circ} \times 30'' + (0.25 \times 13.5'')$$

$$= 0.3639 \times 30'' + (13.5'' / 4) = 14.3''$$

The neutral point (NP) is thus 14.3" back from the L.E. at the root. The CG is located 5% ahead of the NP or 13.5" back. My flying experience so far has the CG 12" back! My 3 degrees of twist possibly makes the wing overly stable, dictating a more forward CG.

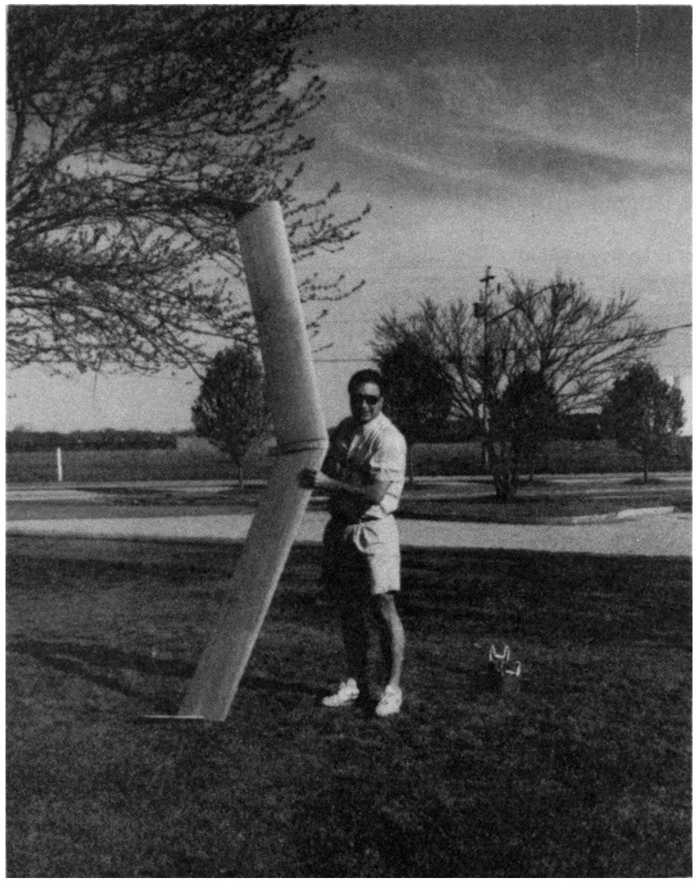
The wing's specifications are as follows:

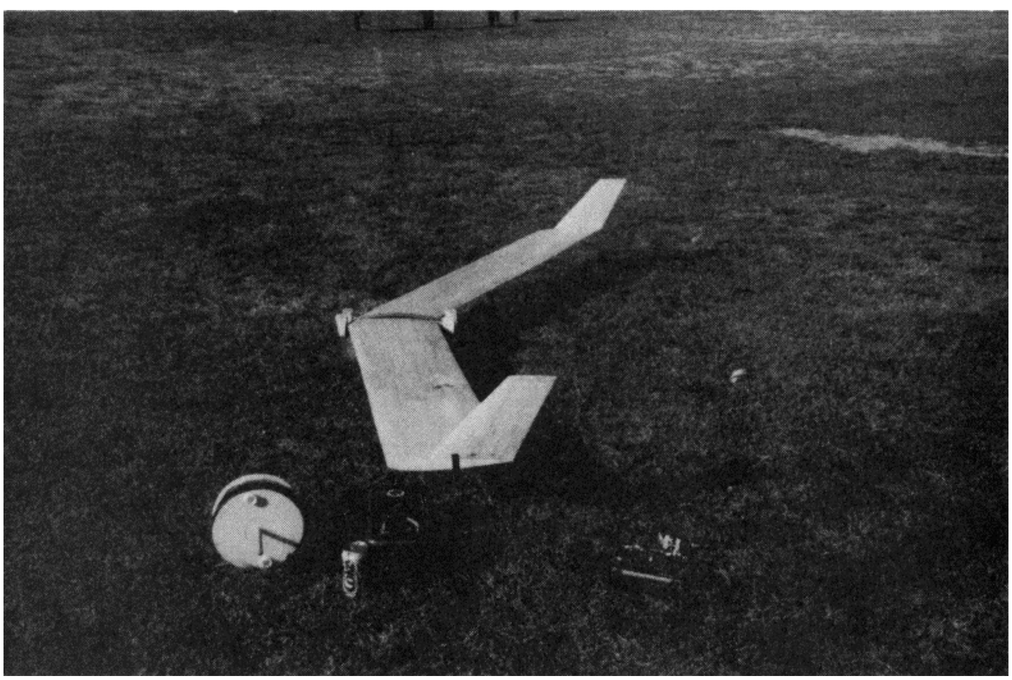
1 - Wing span of 122.5"
2 - Wing area of 1620 sq in (11.74 sq ft)
3 - Weight is 84 oz with CG at 12" back from the L.E.
4 - Wing loading is 7.6 oz/sq ft

The wing is shaped with foam cores and covered with 1/16" balsa. The balsa works well but is costly and requires hours of sanding. The cores were divided into two 30" panels 2" thick by 16" wide. A total of four panels were cut with the 20 degree sweep angle. Templates were made of the airfoils E 222, E 226, E 230 and cores cut out with a hot wire. The cores were cut to match the centerline of the three airfoils to allow the gluing of two panels into one wing half. I used the top and bottom of the foam blanks to "vacuum bag" the wing to "bed" shape. I bonded the 1/16" balsa skin to the cores with epoxy glue. The important point to remember is that with the 20 degrees of sweep the cores have to be cut with the airfoils placed in the direction of flight, not perpendicular to the leading edge!

The only control surfaces are elevons controlled by their own servo in the wing, located 7 inches ahead of the elevon. The elevons are 20% of the wing chord or 2.75" wide and 26" long. I used heavy 1/4 scale type pin hinges, five per elevon. The elevon ends 3" from the tip to allow the wing structure to hold the winglet. The servo is a standard Airtronics type with a 36" long lead running out the wing at the root 1.5" back from the leading edge.

The antenna tube is a 1/8" plastic tube running at mid-chord out the right wing 32". No radio problems or range problems have been seen. My radio is the excellent Airtronics Module SP7 on FM channel 38.





The wing joiner system is one of the keys to the wing's simplicity. Since the wing is over 1.5" thick I wanted to use two large diameter joiners. I used a joiner set perpendicular to the centerline at 37% and 75% of wing chord. The forward joiner is 12" long and the rear joiner is 24" long. Both joiners are 3/8" thickwall, stainless aluminum tubing. The wing rods are the next size of aluminum and 12" and 24" long. To help seat the two aluminum tubes in the white foam, which is weak in compression, I replaced 2" of white foam with blue foam at the two locations, 12" and 24" long. Blue foam is better for compression loading but weighs more.

The end result is the wing is rock steady on launch with no flutter problems. Each finished wing half weighs 28 oz ready to fly. Total building time was 96 hours!

The winglets are made removable with two hardwood dowels 1/4" and 1/8" inserted into brass tubing in the wing and winglet. The winglets are toed in 2 degrees as an experiment to see if they improve performance.

On the first flights I used two tow hooks located one inch below the wing on the side of the fuselage 1.5" forward of the CG. After several flights I realized one hook on the bottom was all I needed and the Y-yoke bridle was not needed. This allowed "normal sailplane flyers" to fly on my winch or hi-start.

The first launches were on Sunday March 18th 1991 with a hi-start into a 25 knot wind! The 5 pound plus wing flew straight up! Both 12 volt winch and hi-start launches have been used. The wing goes up like my Sagitta 2M! At this time only 12 flights have been flown as CG and control throws are still being sorted out.

I am now trying different tips and winglets and tow hook positions. The main goal has been reached as (with apologies to Jack Northrop) "The Wing Will Fly!" I will keep you posted on the flight performance of the Nanosaur.