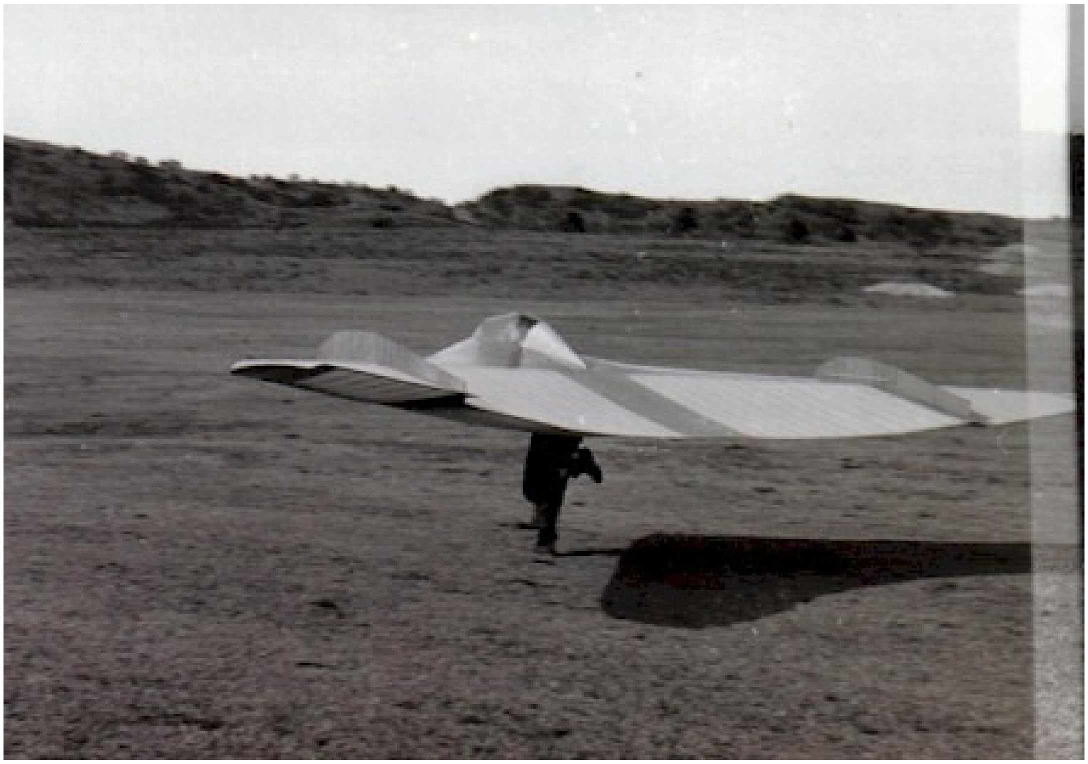
No. 372 JULY 2017

T.W.I.T.T. NEWSLETTER



(ed. - Came across this picture in my computer archives buy don't recall the original source. The file name is Ho 20Xa in May probably 1951 to 1953. If anyone knows the specifics, please let me know.)

T.W.I.T.T.
The Wing Is The Thing
P.O. Box 20430
El Cajon, CA 92021

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THE WING IS THE THING (T.W.I.T.T.)

T.W.I.T.T. is a non-profit organization whose membership seeks to promote the research and development of flying wings and other tailless aircraft by providing a forum for the exchange of ideas and experiences on an international basis. T.W.I.T.T. is affiliated with The Hunsaker Foundation, which is dedicated to furthering education and research in a variety of disciplines.

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Meetings are held on the third Saturday of every other month (beginning with January), at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive (#1720), east side of Gillespie or Skid Row for those flying in).

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PRESIDENT'S CORNER

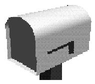
Sorry about this being late again this month. I will blame it on my continuing sore back that makes it uncomfortable to sit for long periods of time working on the computer.

I have included the obituary for William Foshag who passed away in April. He must have been and interesting man to talk with since it appears he was a great storyteller. I only talked with him once on the phone, but I found it most enjoyable. He was the key contact for getting copies of our newsletter on file in the Library of Congress, which we continue to this day for there is a permanent record available to everyone.

We would like to help the executor find homes for the various aviation oriented items like books and models so if you might be interested let me know. They are located in the Carlisle, PA area so if you are close I can put you in touch with him.

I hope everyone is having a good flying season so far. My back issue has slowed me down but the local Austin, TX, weather is cooperating for good flights by the club members. Many 400-500 km out and backs or triangles seem to be common place, but when I get back in the air it will be more local area flights until I get accustomed to the terrain and field orientation.

Andy

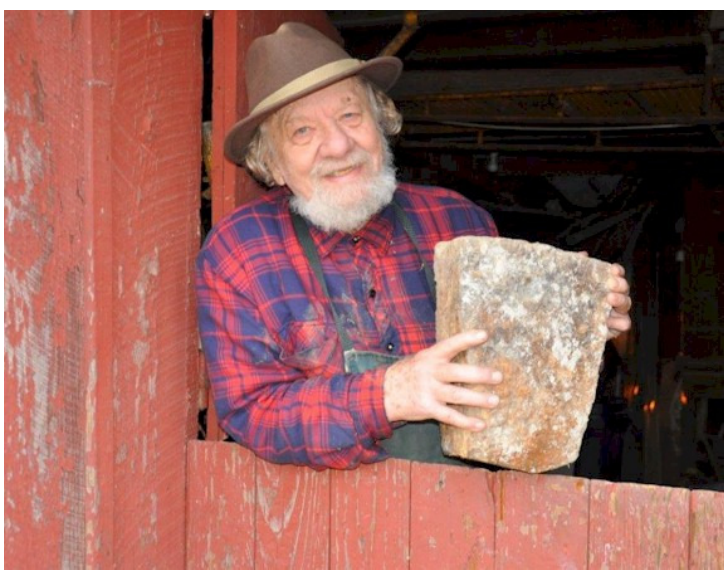


LETTERS TO THE EDITOR

(ed. – Below is a modified version of this obituary to include mostly what was related to aviation, although he had many of interests including music and historical preservation. William was a long time TWITT supporter and at one point made a significant financial contribution to the group that helped us get through a tough time as membership began to decrease to its current levels. See the June issue President's column for more information on what he left behind that would be of interest to aviation enthusiasts as part of his estate that is in the process of distribution.)

William Frederick Foshag (1928 – 2017)

Carlisle lost a brilliant, eccentric, gregarious citizen, William Frederick Foshag, affectionately known as "Willy," on April 27, 2017, at the age of 88. Anyone who encountered Willy would have observed a spritely temperament and a razor-sharp mind that never quit.



Willy's adventures involved growing-up near Washington, DC, and Mexico; studying at the University of Chicago, University of Maryland, and The Maryland Art Institute; designing flight technology in the Baltimore-D.C. corridor, participating in the bluegrass music scene, and retiring in Carlisle at Heishman's Mill.

Willy fulfilled a lifelong dream of owning a gristmill when he purchased Heishman's Mill in 1969. During nearly a half-century, he conscientiously and creatively worked to preserve the 200 year-old building. Heishman's Mill is characteristic of other mills within the Mid-Atlantic region, and it remains one of the best-preserved historical buildings in south-central Pennsylvania. His work in reconciling tensions between environmental conservation and historic preservation concerns culminated in the construction of the first designed and engineered fish passageway in North America. This addition to the site not only preserved the historical features of the site, but the passage also fulfilled environmental regulations that threatened the removal of the millpond's dam.

In early years, Willy never let school get in the way of his education, preferring to conduct his own guided research on topics ranging from anything Mexican to string-band musicians to biological species and flying machines. With his parents in Mexico, Willy spent most of his early training conducting research and pursuing his own interests. Returning to the D.C. suburbs., Willy lived in the Library of Congress., thus avoiding the classroom.

Professionally, Willy worked as an aeronautical engineer. Generally, he specialized in aircraft that can hover, take off and land vertically, or take off and land on short runways. Specifically, he made substantial contributions to technological advances in the development of sailplanes, ornithopters, and a variety of non-fixed wing aircraft.

Most of Willy's work was located in the Baltimore-D.C. corridor, except for his first job at Sikorsky Aircraft in Bridgeport, CT. At Sikorsky, Willy learned the discipline of technical innovation, flight design, and the details of the different aeronautical sciences. Next, Willy worked at Glenview Metal Products Company of NJ as it developed and produced its first two-place helicopter and at the U.S. Army's aviation schools and laboratories at Fort Eustis, VA, where his work ranged from developing the syllabus for helicopter maintenance to developments in the design of low-flying Army fixed-wing aircraft. Willy's background in vertical flight characteristics of helicopters led to his position at Fairchild Hiller in Hagerstown, MD, and the development of a type of wing flap, a jet flap, which would permit fixed-wing airplanes to take off much like a helicopter. His work in STOL, for short takeoff and landing, and VTOL, for vertical takeoff and landing, led to the development and deployment of military aircraft including the tiltrotor Osprey, a version of the F-35 joint strike fighter, and the C-17 Globemaster large transport.

Finally, Willy worked on visionary flying machines. At the U.S. Navy's David Taylor Model Basin in Potomac, MD, and Spacetronics in Bethesda, MD, his focus turned from finding ways for aircraft to leave the earth and fly to applying aero-physics to suspend land and watercraft just above the surface. Known today as hovercraft and wing-in-ground effect, these "aircraft" remain an innovative means of transport with untapped potential. Next, Willy was the chief engineer of the Aerophysics Company in Washington, D.C., where Willy applied his wealth of aeronautical knowledge to tackling a wide variety of visionary aircraft still under development today or awaiting the materials, computing, and control capabilities that would enable his innovations to take flight.

Willy remained colorful until the end. His friends will miss his enchanting conversations, his adventurous stories, his love of flying machines, his gregarious visits, his utter showmanship, and his love of life. He will always be missed.

Willy's memorial will be held on Saturday, July 29, from 2 – 6 p.m., at the Stern Center at Dickinson College. In lieu of flowers, contributions may be made to the Cumberland County Historical Society, Dept of Building Preservation, in Carlisle, PA.

LETTERS TO THE EDITOR

Hi Andy,

I have been exchanging ideas with this guy for a couple of years. I thought this recent email from him might be of interest to the TWITT newsletter readers.

Bob Hoey

Tony, Looking good!

I would suggest you install a temporary vertical tail surface somewhere for your first few flights (aft fuselage or attached to the wing trailing edge). You can then observe carefully whether you are getting adverse yaw from the ailerons, and make adjustments until that disappears. Then gradually reduce the amount of fin area.

Good luck and keep me posted.

Bob Hoey

Bob,

I have been working on getting the Bald Eagle flying and today I had a 45-minute flight on a Westerly slope at Ebey's Landing West Gunnery Site. (I could have stayed up for HOURS as the wind was perfect! It was blowing up the slope at 18-20 Kts.) This is the first successful flight of this plane after working on it for 5 years with many trial and error corrections along the way.

A big problem was I wanted to have a very positive sense of control of the "bird" without it Dutch Rolling around at slower landing speed. I hate that and it can cause a real challenge landing in the rotor wash of a slope site such as Ebey. I used 4 control surfaces on the trailing edge of the wing, each on separate channels for programmable mixing. The outers are aileron only and the inners mixed with outers are mixed elevator. I wanted no weight on the tail if possible such as conventional elevator control. The horizontal stab is 2mm white coroplast and is extremely durable and lightweight. I tried 2 separate, toed out "tiplets" on each wing made from polycarbonate to counter the adverse yaw of the ailerons and it did work, but the effect was mediocre at mid range speed and nil at low speed. On a previous test flight I launched the Eagle and it was initially nose heavy so it was going faster than a normal cruise speed and I was able to turn it but it was very slow. Once I got the pitch trimmed for cruise flight, it slowed and I had full right aileron input and it just flew straight ahead! YIPE! I got it to turn left back to the slope and it landed in a big bush and was relatively unharmed.

Fast forward, I decided to use a centerline fin/rudder. I dumped the "tiplets" and decided to go after the adverse yaw by making the fin a full flying rudder. I built an RC bald eagle in high school years ago and it flew right off the building board. I used a crude Clark Y airfoil and simply extended a Balsa trailing edge flat behind it and that acted as a reflexed airfoil. Just a kid with dumb luck because it worked flawlessly. I had made a very simple fin/rudder from music wire and saran wrap and tape. Yes, it was crude BUT it was light and it worked! I decided to use this same method for my current project and used flying wires made from Spectra composite and a Carbon fiber "kingpost" to keep it all light. Looks like it belonged on a kite more than an RC glider!

I got that made and just finished it this morning and the wind came up perfect at the slope. I had to go try again to get this thing in the air. I launched it at 5PM and landed at 5:45PM. It got so high it was a speck. Bad idea! Bald Eagles are Black and they shadow real bad. I tumbled out of the sky until it got low enough to see what it was doing. I learned to keep it lower.

Problem number two came within the first 7 minutes. Not a problem with the Eagle as it was flying awesome. We have a surplus of eagles here and since it was such a nice day to fly they came by and wanted (no, NEEDED) to check this bird out. I was attacked on sight! I built this thing to look real. However, it has no paint on the fuselage yet and no glass eyes. It didn't matter! Eagles HATE this thing! Well about 1 in 3 launched a full on attack. I definitely could not out speed an attack but there was one sure fire defense that worked...pull a loop and they just cannot deal with that! They dive at it at high speed, wings tucked and built tremendous momentum for the "kill". Pull a loop and the model flips over BEHIND them and that absolutely freaks them out and they usually just go away. This happened at least 12 times in 45 minutes.

The eagle is a fast flying glider. It uses an Hs-130 plank airfoil designed for DS soaring and is VERY fast for that purpose. The wing starts at 12% thick at the root and ends with about 7% at the tip area. The feather array was designed from your research. I built in a cascaded angle for each feather and this obviously produces low drag as this is one fast flying plane. I was flying with real eagles that had their wings partially tucked just to keep up with it. That was priceless to see as these are very fast birds. No ballast was added to the eagle either. I was impressed. My feathers are built from fiberglass and carbon fiber and are extremely flexible and lightweight. They are bolted to the wingtip with nylon bolts for easy replacement if damaged. Each feather has an airfoil shape and a carbon spine for strength.

The wings are foam cored, and made in halves. They are vacuum bagged with MGS structural resin and biased fiberglass skins in curved anhedral molds to give them the shape of a real eagle's wing.

I have no doubt this design could fly with wingtip ailerons. Real eagles twist their wings down in the direction of their desired turn and it works great.

I have sent some pictures of the successful design for you to see. You deserve that as YOU designed the tip feathers!

Too much to include here so bye for now,

Tony Johnson
Synergy Composites
La Conner, Washington USA

(ed. – The next two pages are the continuation of Phil Barnes' article on Principles of High-Efficiency Electric Flight that started last month. Depending on available material I hope to finish it in the August issue. If you want it before then, drop me an e-mail and I will send you the PDF file.)

Motor or Generator operation:

$$i_m R_e / \varepsilon_b = 1 - \nu \quad (1a)$$

$$\frac{\tau R_e}{k\varepsilon_b} = 1 - \nu - \psi \quad (1b)$$

Motoring $\{\nu < 1\text{-}\psi\}$:

$$\eta_s \equiv \frac{\tau\omega}{\varepsilon_b i_m} = \frac{\tau R_e}{k\varepsilon_b}\frac{k\omega}{\varepsilon_b}\frac{\varepsilon_b}{i_m R_e} = \frac{\nu(1-\nu-\psi)}{1-\nu} \quad (1c)$$

Generating $\{\nu > 1\}$:

$$\eta_s \equiv \frac{\varepsilon_b i_m}{\tau\omega} = \frac{1-\nu}{\nu(1-\nu-\psi)} = \frac{\nu-1}{\nu(\nu-1+\psi)} \quad (1d)$$

Motoring peak efficiency:

$$\eta_{opt} = 1 + \psi - 2\psi^{0.5} \quad (2a)$$

$$\nu_{opt} = 1 - \psi^{0.5} \quad (2b)$$

Generating peak efficiency:

$$\eta_{opt} = \frac{1}{1+\psi+2\psi^{0.5}} \quad (2c)$$

$$\nu_{opt} = 1 + \psi^{0.5} \quad (2d)$$

The system of Eqs. (1, 2), with any number (m) of machines connected to a battery or Voltage supply, is represented graphically in Figure 6 for the case of motoring. Although an exaggerated, fixed torque loss is depicted, such may vary with speed and other effects if they are known. Note that a 1% loss of stall torque typically yields a 10% loss of optimal-operating torque, then giving 90% peak efficiency.

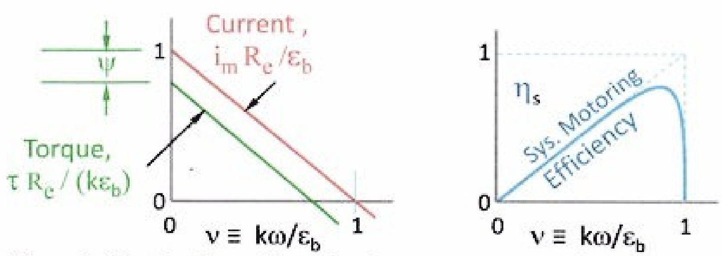


Figure 6. Sketch of non-dimensional parameters, motoring.

IV. Optimization of the Battery-Motor System at Full Power

Non-dimensionalization of the system parameters, together with focus on optimal efficiency, leads naturally toward a process for optimization, beginning with simultaneous solution of Eq. (1a) and the left-hand portion of Eq. (1c). First equating with these equations the battery EMF gives the *operating* motor current of Eq. (3a). Second, equating the motor current gives the *operating* battery EMF of Eq. (3b). Factoring the two equations obtains the necessary power balance. Finally, Eq. (3c) provides the corresponding EMF constant. Now for *optimal* conditions, we see in Figure 6 that both speed ratio and system efficiency will be about 0.9, set by Eqs. (2), and inserted into Eqs. (3).

Thus, for optimal efficiency, a given combination of torque, rotational speed, and "either-path" resistance sets the optimal battery EMF, motor current, and motor EMF constant.

$$i_m = \sqrt{\frac{\tau\omega(1-\nu)}{R_e\eta_s}} \quad ; \quad \varepsilon_b = \sqrt{\frac{R_e\tau\omega}{\eta_s(1-\nu)}} \quad ; \quad k = \nu\varepsilon_b/\omega \quad (3a\,;\,3b\,;\,3c)$$

Due to the inter-dependence of the many entities represented in Eqs. (3), the solution for optimal conditions will be iterative. First, motor resistance (R_m) [see Figure 7 trend][4] and battery resistance (R_b), the constituents of (R_e), depend largely on component scale, but also of course on component design. Second, system peak efficiency is tied to the specific torque loss (ψ) per Eq. (2a). The EXCEL/Visual Basic pseudo-code of Figure 8 outlines the predict-correct algorithm solving for the optimal conditions at full power (here, no effort has yet been made to expedite convergence, and the user must confirm convergence before using the results). The method has been applied, with details in the spreadsheet of Figure 9, to optimize the full-power architecture of a 0.1 kW_e UAV, where red boxes highlight key inputs and where ellipses highlight key outputs.

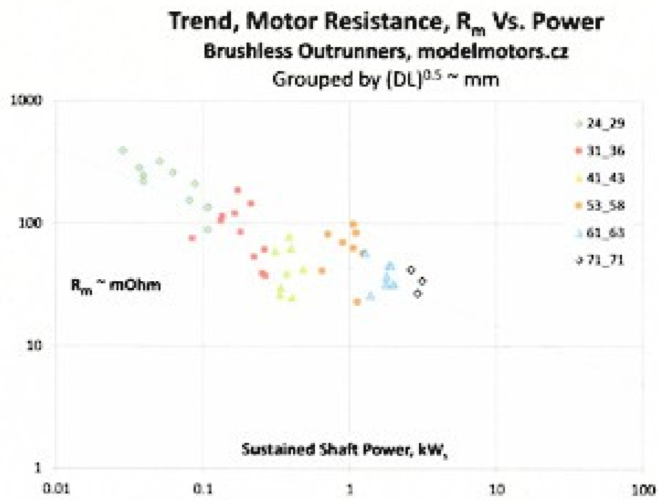


Figure 7. Brushless-outrunner motor resistance trend.

```
' Declare constants, i.e. pirad, mOhm/Ohm, Watts/kW, etc...
' Input motor torque (tau_Nm), loss (Lam_Nm),  RPM, resistance (Rm_mO)
' Input battery cell properties, EMFc_V, Rc_mO, # parallel strings (Np)
' Input number (motors) per battery, "margin" to left of nu at max eta
'
  psi = 0.01: Rb_mO = Rm_mO                       ' first estimates
  Re_mO = motors * Rb_mO + Rm_mO                  ' either-path resistance
  For i = 1 To 10                                 ' iteration counter
  nu = (1 - margin) * (1 - Sqr(psi))              ' speed ratio
  etas  = nu * (1 - psi / (1 - nu))               ' system max efficiency
  EMFb_V = _                                      ' updated battery EMF
  Sqr((Re_mO / mOhmOhm) _
  * tau_Nm * om_rads / (etas * (1 - nu)))
  Ns = EMFb_V / EMFc_V                            ' number of series cells
  Rb_mO = Rc_mO * Ns / Np                         ' battery resistance, mOhm
  Re_mO = motors * Rb_mO + Rm_mO                  ' either-path resist., mOhm
  psi = Lam_Nm * (Re_mO / mOhmOhm) _              ' specific torque loss
  / (k_NmA * EMFb_V)
  im_A = Sqr(tau_Nm * om_rads _                   ' motor current, Amps
  * (1 - nu) / ((Re_mO / mOhmOhm) * etas))
  k_NmA = nu * EMFb_V / om_rads                   ' motor EMF const., N-m/Amp
  Next i
' Auxiliary results:
  Kv_RPMV = 30 / (pirad * k_NmA)                  ' motor volt const., RPM/V
```

Figure 8. Predict-correct algorithm, full-power optimization.

In the pseudo code of Figure 8, we have highlighted key parameters updated in the iteration. One such parameter is battery cell resistance, which may vary with current.[5] Note also that we have appended units to all dimensional variables to reduce the risk of a "Mars Lander" scenario, where velocity "V" had units (ft/s) in one group and (m/s) in another. In the spreadsheet input/output[7] of Figure 9, we include the results of a separate optimization of an "isolated" motor working with fixed terminal voltage in lieu of a battery. This information is subscripted "isom." As might be expected, *the optimum battery EMF and motor voltage constant of an isolated machine vary considerably from those of the machine integrated with a battery*. For example, the isolated motor has 11V optimal "battery" EMF, but the integrated motor is optimal at 17V. Also for example, the optimal voltage constant (K_v) is 1377 RPM/Volt for the isolated motor, but 890 RPM/Volt for the integrated motor. Note that the method applied at model-aircraft scale often yields a larger optimal battery than what can be carried, in which case we can apply "margin," say 0.30 versus 0.03, operating at sub-optimal speed ratio, higher torque, lower efficiency, and reduced sortie duration with a smaller battery. But below 0.50 speed ratio, there may be some risk to system stability.

AVAILABLE PLANS & REFERENCE MATERIAL

Coming Soon: Tailless Aircraft Bibliography Edition 1-g

Edition 1-f, which is sold out, contained over 5600 annotated tailless aircraft and related listings: reports, papers, books, articles, patents, etc. of 1867 - present, listed chronologically and supported by introductory material, 3 Appendices, and other helpful information. Historical overview. Information on sources, location and acquisition of material. Alphabetical listing of 370 creators of tailless and related aircraft, including dates and configurations. More. Only a limited number printed. Not cross referenced: 342 pages. It was spiral bound in plain black vinyl. By far the largest ever of its kind - a unique source of hardcore information.

But don't despair, Edition 1-g is in the works and will be bigger and better than ever. It will also include a very extensive listing of the relevant U.S. patents, which may be the most comprehensive one ever put together. A publication date has not been set yet, so check back here once in a while.

Prices: To Be Announced

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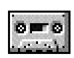
VIDEOS AND AUDIO TAPES



(ed. – These videos are also now available on DVD, at the buyer's choice.)

VHS tape of Al Bowers' September 19, 1998 presentation on "The Horten H X Series: Ultra Light Flying Wing Sailplanes." The package includes Al's 20 pages of slides so you won't have to squint at the TV screen trying to read what he is explaining. This was an excellent presentation covering Horten history and an analysis of bell and elliptical lift distributions.

Cost: $10.00 postage paid
Add: $ 2.00 for foreign postage

VHS tape of July 15, 2000 presentation by Stefanie Brochocki on the design history of the BKB-1 (Brochocki,Kasper,Bodek) as related by her father Stefan. The second part of this program was conducted by Henry Jex on the design and flights of the radio controlled Quetzalcoatlus northropi (pterodactyl) used in the Smithsonian IMAX film. This was an Aerovironment project led by Dr. Paul MacCready.

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An Overview of Composite Design Properties, by Alex Kozloff, as presented at the TWITT Meeting 3/19/94. Includes pamphlet of charts and graphs on composite characteristics, and audio cassette tape of Alex's presentation explaining the material.

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VHS of Robert Hoey's presentation on November 20, 1999, covering his group's experimentation with radio controlled bird models being used to explore the control and performance parameters of birds. Tape comes with a complete set of the overhead slides used in the presentation.

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