

Free Flight Perils at Lost Hills — Aram Schlossberg photo

52nd ANNUAL REPORT OF THE NATIONAL FREE FLIGHT SOCIETY, SYMPOSIUM 2019

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The Symposium is presented annually by the National Free Flight Society. The primary purpose of the Symposium is to promote and encourage the investigation, discussion, and documentation of the technical and theoretical side of free flight. Papers addressing historical, administrative, documentary, and philosophical aspects of the sport are also welcome. Outstanding models and modelers are honored.

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EDITOR'S INTRODUCTION TO THE 2019 NFFS SYMPOSIUM

Rick Pangell – Editor
John McGrath – Co-Editor

Welcome to the 52nd Annual NFFS Symposium Report, 2019.

Something Old (Historical), Something Current (State of the Art) and Something New (Invention or Proposal)

The National Free flight Symposium presents technological advances, suggestions and their potential effect on the hobby, or is it a sport?

There always appear articles on "the future of" events, sometimes predicting and sometimes resolving. If one had to make a determination of what the future is one has to ask "the future of what?' Are we talking about free flight as an established entity that is technologically improving or are we talking about its future existence?

One "future" if you will is the incorporation of technologies that advance the sport and perhaps advance design technology. Hence, in this issue we, the editors, have attempted to present articles about the history of what became, and the "what is and what is coming" to the world of Free Flight. Does what go around come around?

Excerpted from my previous Forward in 2008,

"Will we be wearing silver suits and using "thought control" timers? Will we bring out our own "thermal generators" to the field instead of the streamer poles? Will chase bikes be anti-gravity vehicles so we won't hit ruts and crash? Will we have models that find themselves and radio back to us where they are, coupled with the voice device on the anti-gravity vehicle giving us verbal direction? Will Muncie turn into a true five-minute field?"

One out of five in ten years isn't all that bad!

For an activity that could be boiled down to "send model airplanes into the air and watch them fly for as long as they're able," the breadth of discussion this seemingly simple idea spawns never ceases to amaze. Very little in this fantastic hobby turns out to be simple at all, once you delve even a little beneath the surface. On the other hand, there's nothing complicated about the result. Models climbing enthusiastically, turning circles in the air, behaving well and gliding with dazzling efficiency can hardly fail to capture the imagination, and it takes a cold heart indeed not to glance up at the latest launch!

In this edition of the Symposium there are perhaps three themes:

- Operating, or Flying your models better
- Designing them to achieve greater performance
- Constructing them using fabrication technologies now reaching practical maturity

Plus two more that might be described as

- "Propagation of the faith." This last theme is honoring not only the efforts of those working to invite and retain new fliers, but also a look at some of the history that's kept this sport/hobby thriving and improving. Many people were interviewed for this effort.
- A bit of History and Commentary

You'll also notice a "Class of Emphasis" with several articles having to do F1E, its history, its development and its latest technology. Climb the hill with the F1E fliers and you'll find a part of Free Flight just waiting to be explored. Spoiler Alert: They don't just glide down the hill!

The growth of F1E in the world, mostly overseas, is an overlooked event here in the U.S. with maybe a dozen or so active flyers and the World Champion is among our ranks. The event flourishes in Europe. Read the history from George Arghir. F1E is another example where technology input has been influential, plus it is very adaptable to those hanger queen A-2's we have. Adding a bit of insight to all the year's results and the untold back stories is Daniel Petcu with his usual "out of the box" view.

Magnet steered models perform well, and from my own experience it is a very relaxing event and not at all a nerve wracking event to fly. And, the introduction of electronically steering for models has had

a profound effect on the flying of the event. Electronic F1E steering technology from Tom Ioerger and how to fly the event from USA Team flyer and a former World Champion, Bob Sfleet; An event to look into.

Taking our themes in turn, in the Operating models category you'll find a super article by Harry Grogan, who poses a very simple question: is a spiral climb or a straight one going to produce the best climb? His analysis breaks down the physics and dynamics involved. Paul Rossiter reprises his article from the 2016 Symposium with some updates on the nature and detection of thermals. Care to put more thought into trimming the power phase of gas models? Alex Andruikov shares his methods for using an on-board altimeter to guide you. For anyone who's ever stomped around the prairie (or the woods) trying to find a plane, England's Chris Edge shares the latest and greatest on the use of GPS for finding models. The news is good, and rapidly changing.

In the design of models, there are three offerings: Brian Eggleston, progenitor of Low Drag Airfoils for F1A, takes a swing at F1C propellers with some interesting conclusions. Sergey Vorvihvost draws from F1B front ends to produce a new take on F1Q powerplants. (F1Q—performing better all the time). Then there's David Aronstein's tour de force, "Indoor Model Optimization," which is an exquisitely deep look at the relationship between airframe and powerplant in certain indoor classes. Just a tease: ever wonder why some fliers do just fine under lower ceilings while others need those big rooms? Take notes.

Two articles in this Sympo address fabrication techniques, and they share the theme of Computer Aided Design. John Lorbiecki shares his setup and experience in the use of tabletop laser cutters (and the important influence it can have on design), and Paul Bradley explains the ins and outs of 3D printing. If you haven't thought about George Boole in a while (or ever), understanding 3D CAD design is the ticket to using this increasingly powerful method for producing small parts.

The third broad category is a perennial one. We usually think of it as Getting and Keeping Beginners, but that's too limiting. If you consider what keeps free flighters coming back for more, surely the steady development of ideas, the continual "newness" of it plays a role. But we need not forget what not only excites and keeps the youth coming back, but what excited flyers in the past. And, finding that one first model that guarantees success is usually that first rubber model like the "new beginners event P-18.

Bob Stalick, mentoring Adelaide Ulm, has a look at the retention question directly with his Youth Perspective article. But what does this say? How does one measure success? One word… retention. What turns youth on to Free flight, in their own words. The remarks made by the "youth" are pretty insightful. Adults spend a lot amount of time pondering the "youth" problem with programs, but what about those programs? What good are they if they have no follow up? The youth survey might give us some thought.

Notice what stands out from that article… a "mentor" whether it be mom, dad, grandpa, a friend… there was a mentor who was continuously there.

There is an opportunity missed if we do not follow up. I urge all of us that when those opportunities present themselves, be that mentor. Follow up and invite them to another event on your schedule. Don't expect that newly interested person to follow and search you out. Develop a list of "prospects" in your club and be proactive with them. In any membership growth program there has to be presentation, the person showing a genuine interest, and follow up

So, to accommodate that, here is what we, the editors, determine as the "Future of Free Flight."

For all of the active free flighters, looking back at where things started and the "roots" of many events and technologies, it's a good idea to reprise them. Current flyers utilize a lot of design innovations but

FROM THE EDITOR...



are not aware of how and when those innovations emerged.

Summing up, we included an article from Bill Gieskieng ghost edited on what got him motivated and his ideas about Free Flight and FAI Power. His name is in the archives, but it is amazing how he came to influence the hobby with his enthusiasm. It's kind of a lesson to others. Bill's ideas were adapted to all F1 events. Truly forward thinking modelers giving us what we now take for granted. Plus Aram Schlossberg trying to solve that ever perplexing problem of F1 Flyoffs.

Also excerpted from my previous Forward in 2008:

"One thing we can agree upon for the future. We would ALL like the ranks of free-flighters to increase. This is the biggest challenge we face. Years ago I remember a cartoon where a few old-timer free flighters were at table opening a dusty box with the very last piece of 4 # balsa left in the world. Our inventiveness has replaced that 4 # piece with carbon fiber; See? We are on the cutting edge. Our next challenge is to come to grips with our being a build/fly group or a fly/compete group, or somewhere in the middle. We have this other big challenge. Examples of what have transpired in the past, and what exists, is in this Symposium. I have no doubt that free flight will grow."



This is the contingent from the 2019 New Mexico Science Olympiad Champions from Albuquerque Home School led by Chuck Andraka. A new Senior F1M record of 10:15 was set by Josia Rose at the Round Valley Dome in April, 2019.

The NFFS is making an encouraging effort to keep your memberships current and or community growing. Membership is what is responsible for this Symposium, the "Free Flight Digest," NATs organization and many behind the scenes efforts.
Be a part of it.

This is your Sympo and we are only the facilitators.

Take your time and ponder over what it has for you.

Your Editors,



Rick Pangell



John McGrath

Again, our take on
"THE FUTURE OF FREE FLIGHT"

ACKNOWLEDGEMENTS:

– The National Free Flight Society

– Mike McKeever for Chairing the Hall of Fame

– Ross Jahnke for Chairing the Models of the Year

– Will Nakashima for his comic insight

– The Authors

– Steve Galbreath, *The Printer recording the experience*

SPIRAL VS. VERTICAL CLIMBS – WHICH IS BETTER?

AUTHOR
HARRY GROGAN

Introduction

Since the evolution of more powerful motors and improved model design there has been a running debate about the merits of vertical vs. spiral climbs. There is no question that a spiral climb travels a farther distance, but is it that much more than a vertical path? When flying non-VIT (locked down) models, are the trimming problems of a vertical climb worth the altitude gain over the more stable flight of a spiral climb? This article will investigate the differences in climb heights and resulting glide times of these two approaches. The performance numbers and main emphasis will be on the E-36/F1S electric power events.

The Spiral Climb

When a properly trimmed power model climbs, it follows a helical path around an imaginary cylinder (Figure 1). If climbing in the wind, the central axis of the cylinder is inclined downwind. The model climbs at a constant angle (θ) relative to the ground as shown in Figure 2. It also maintains a constant bank angle on the way up. When seen from the ground the model appears to be rolling as well as turning, but this is an illusion. From the ground it may appear to make one roll per complete turn, but from the perspective of the model it remains in a constant bank. The velocity of the model (V) has two components. One is the horizontal speed (V_X) relative to the ground, and the other is the vertical rate of climb (V_Y) as shown in Figure 2. The rate of climb times the time spent climbing is the final altitude before transitioning to glide. The altitude (H) can be calculated by the following procedure.

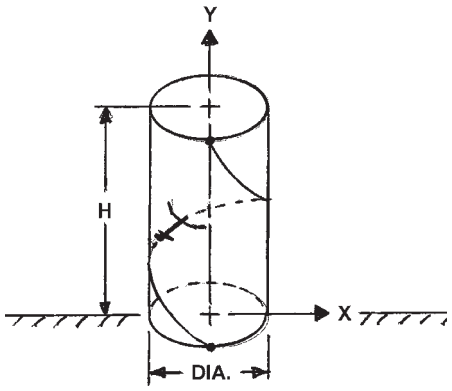


Figure 1. Geometry of a spiral climb

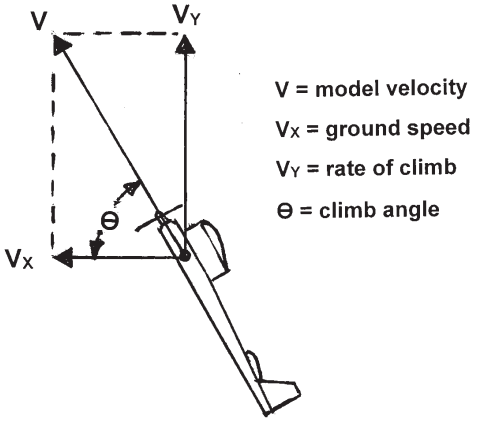


Figure 2. Horizontal and vertical components of model velocity

The circumference of a cylinder (C) with a diameter (D) is $C = \pi \times D$. Distance is velocity times time: $d = V \times t$, or $V = d / t$. If t_m is the motor run time and N is the number of turns on the way up, the time to make one turn is $t_c = t_m / N$. The horizontal component of the model's velocity is:

$V_X = d / t_C = \pi \times D / t_C$ (Eqn. 1)

Referring to Figure 2, the rate of climb (V_Y) is:

$V^2 = V_X^2 + V_Y^2$, so $V_Y = [V^2 - V_X^2]^{1/2}$ (Eqn. 2)

The climb height (H) is: $H = V_Y \times t_m$ (Eqn. 3)

The angle of climb is: $\theta = \cos^{-1} (V_X / V)$ (Eqn. 4)

For example, if a model's speed is 50 ft/sec. and climbs in a 40 ft. diameter circle, makes one turn every 5 seconds and has a 10 second motor run:

Eqn. 1: Ground speed: $V_X = \pi \times (40 \text{ ft.}) / (5 \text{ sec.}) = 25.1$ ft/sec.

Eqn. 2: Rate of climb: $V_Y = [\,(50)^2 - (25.1)^2\,]^{1/2} = 43.2$ ft/sec.

Eqn. 3: Climb height: $H = (43.2 \text{ ft/sec}) \times (10 \text{ sec.}) = 423$ ft.

Eqn. 4: Angle of climb: $\theta = \cos^{-1} (25.1 / 50) = 60$ degrees

The Vertical Climb

Current power models have levels of propeller thrust greater than their weight, so they are capable of vertical flight. A review of motor/propeller test data in Reference 1 shows that E-36 size motors with 6 to 7 inch diameter props have static thrusts that vary from 380 to 440 grams. Since typical E-36 model weights range from 140 to 180 grams, this produces static thrust to weight ratios of about 2:1 to 3:1. After launch, increasing speed reduces the propeller thrust until it equals the weight plus drag of the model. This is when the model reaches terminal (constant) velocity, and it happens in less than 2 seconds according to the altimeter data referenced in the next section.

Vertical climbs with locked down models can be achieved by two methods. One is to use large amounts of down thrust, typically 20 degrees, as specified in References 2 and 3. The other method is to use a high thrust line configuration (HTL) with a small amount of down thrust, or a very high thrust line (VHTL) with no down thrust, as described in Reference 4.

A perfect vertical launch and climb takes some practice. Often what appears to be a vertical launch to the flyer can be less than that to observers. Even a 70 degree climb can look like an almost vertical climb. For this analysis, climb angles of 60 to 90 degrees will be considered to determine how much they affect final altitude.

Consistently good transitions from vertical climb to glide with locked down models is not easy but it can be done. Since this is not a flying & trimming article, the details of how to do that will not be addressed. However, there are some basic principles that will help with efficient transitions.

- Light extremities reduce inertia. Build light wings, especially in the tip panels, build light tails, and locate the electrical components as far forward as possible to reduce the nose length.
- Use a generous amount of polyhedral (called dihedral coefficient) and relatively small vertical fins (called vertical volume coefficient). This allows the model to sideslip more and roll more quickly into the glide.
- Do not place the center of gravity too far aft. The needed decalage reduction will decrease longitudinal stability.
- Use cross-controlled flight trim. For example, left thrust and right rudder will initiate a right turn immediately after motor cutoff. On the other hand, too much down thrust can cause the nose to pitch up right after motor cutoff. This is undesirable when the model is vertical with very little airspeed.

When a model is not climbing straight up, some of its weight is not opposing the propeller thrust. Figure 3b shows the relationship

between model weight, drag and climb angle. If there is less weight opposing the direction of flight, the available thrust will increase the speed. This extra speed correction can be calculated as follows.

For a vertical climb at a constant velocity, thrust (T) equals weight (W) plus drag (D), as shown in Figure 3a.

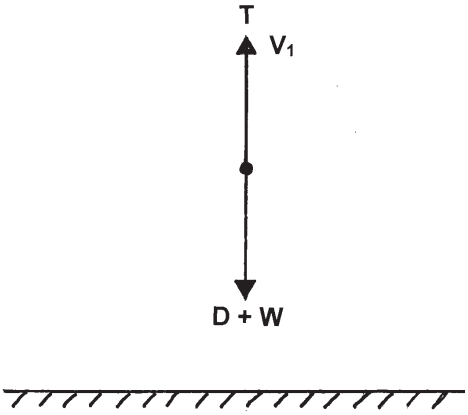


Figure 3A. Forces in a vertical climb

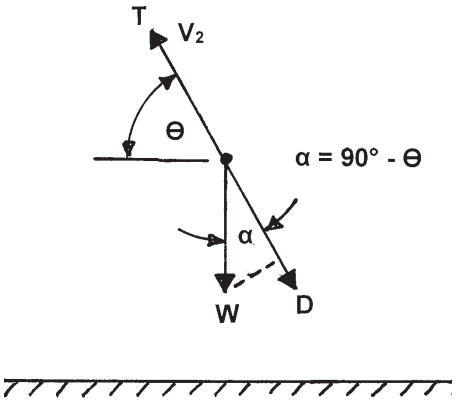


Figure 3B. Forces in an angled climb

$T = W + D = W + (\frac{1}{2} \rho V_1^2 S C_D)$ where ρ = air density, V_1 = model velocity in vert. flight

S = total wing and stab area, C_D = combined drag coeff. of the wing, stabilizer, and fuselage.

Since ρ, S, and C_D are constant for this analysis, they will be replaced by the constant $\underline{k}$.

$T = W + V_1^2 k$

$V_1^2 = (T - W) / k$

$V_1 = [\ (T - W) / k\ ]^{1/2}$ Eqn. 5

If the climb is less than vertical as shown in Fig. 3b,

$T = W \cos \alpha + (\frac{1}{2} \rho V_2^2 S C_D) = W \cos \alpha + V_2^2 k$
where α = 90 deg. -θ

$V_2^2 = (T - W \cos \alpha) / k$

$V_2 = [\ (T - W \cos \alpha) / k\ ]^{1/2}$ Eqn. 6

The increase in speed will be defined by the ratio V_2 / V_1.

$V_2 / V_1 = [\ (T - W \cos \alpha) / k]^{1/2} / [\ (T - W) / k\ ]^{1/2}$
$= (T - W \cos \alpha)^{1/2} / (T - W)^{1/2}$

$= [\ (T - W \cos \alpha) / (T - W)\ ]^{1/2} = [\ (T/W - \cos \alpha) / (T/W - 1)\ ]^{1/2}$ Eqn. 7

Static thrust to weight ratios (T/W) can be as much as 3.5:1 (per Reference 1) at launch but will decrease to about 2:1 at maximum velocity. This assumes that the total model drag is approximately equal to its weight. Substituting this into equation 7 results in:

$V_2 / V_1 = [\ (2 - \cos \alpha) / (2 - 1)\ ]^{1/2} = (2 - \cos \alpha)^{1/2}$ Eqn. 8

Equation 8 was used to compute the Corrected Flight Velocity for the near vertical flight results in the Appendix. This correction was not used in the spiral climb calculations because the three flight speeds chosen were representative but arbitrary. This helped to make easier comparisons between spiral and vertical climbs. The results will also show that the higher airspeeds of the less than vertical climbs did not make up for the farther distances traveled.

Figures 3a and 3b are simplifications of the many forces that occur in flight. They include wing and stabilizer lift, wing negative pitching moment, motor thrust angles, moments due to offset thrust lines relative to the center of gravity and center of drag, and others. This article is only concerned with forces in the direction of flight, so these other forces and moments are not applicable.

Typical E-36/F1S Climb & Glide Rates

In order to calculate rates of climb based on climb angle, spiral path diameter and number

of turns, realistic model speeds must be determined. Fortunately, the use of recording altimeters helped to provide a range of climb and glide data that is typical of current high performance models. Four references were used to provide this data. Two of them used vertical climbing models and two used spiral climbs. Altimeters measure vertical climb and glide rates but not flight velocities. The spiral climbing models had to be flying faster than their rates of climb. This is why the analysis used a range of flight velocities that were slightly faster than the recorded climb rates.

- Ref. 4 (Grunnet)

  10 sec. vertical climb: 130-150 m. (427-492 ft.) with Elmann 3 model

  2.5 sec. vertical climb: 60 m. (extrapolated to 120 m. at 5 sec., Eldromeda model

  Glide: .55 m/sec (1.8 ft/sec) with Elmann 3 model

- Ref. 5 (Linkosalo)

  5 sec. spiral climb: 80 m. (262 ft.) with DYS 2205/2550 Kv motor

  10 sec. spiral climb: 170 m. (558 ft.) with DYS 2205/2550 Kv motor

  10 sec. spiral climb: 150 m. (492 ft.) with Turnigy V-Spec 2205/2350 Kv motor

  Glide for first 30 seconds: .37-.76 m/sec (1.2-2.5 ft/sec)

- Ref. 6 (Linkosalo)

  5 sec. spiral climb: 75 m. (246 ft.)

  10 sec. spiral climb: 140-170 m. (460-558 ft.)

  Glide: .37-.74 m/sec (1.20-2.40 ft/sec)

- Ref. 6 (Buddenbohm)

  5 sec. vertical climb: 100-108 m. (328-354 ft.)

  10 sec. vertical climb: 152 m. (499 ft.)

  Glide: .50-.52 m/sec (1.65-1.70 ft/sec)

- Ref. 7 (McBride)

  5 sec. spiral climb: 90 m. (295 ft.)

  Glide: .46-.49 m/sec (1.5-1.6 ft/sec)

- Summary of data:

  5 sec. climbs: 75-108 m. = 15-21.6 m/sec (49-70 ft/sec)

  10 sec. climbs: 130-170 m. = 13-17 m/sec (43-56 ft/sec)

  Glides: .37-.76 m/sec (1.2-2.5 ft/sec)

  Average glide = .56 m/sec (1.85 ft/sec)

The 5 second climb rates were on average greater than the 10 second climb rates. This is probably due to the continual decline of battery voltage during the climb. There was no obvious advantage to vertical over spiral climbs in this data. The 5 second vertical climbs had a higher average altitude than the spiral climbs, but for 10 second climbs the average heights were reversed. Overall, the rates of climb ranged from 43 to 70 ft/sec. An assumption was made that the slowest spiral climb angle was at least 60 degrees, so the flight velocity would have been:

$V = V_Y / \sin 60° = (43 \text{ ft/sec}) / .866 = 50 \text{ ft/sec}.$

For the analysis of spiral and vertical climbs, it was decided to use a flight speed range of 50 to 70 ft/sec (15 to 21 m/sec).

The diameter of a spiral climb is harder to estimate. A slow climbing locked down model will naturally turn in large circles, whereas a high performance model will climb steeply on its own and turn in tighter circles. A steep spiral climb can also be trimmed to turn in very tight circles, that is, a corkscrew pattern. After watching the climbs of many high performance E36/F1S models, the author has estimated the spiral diameters to be about 30 to 40 feet (9-12 meters). For this analysis a range of 30 to 50 feet was chosen.

The glide data varied quite a bit, from 1.2 to 2.5 ft/sec sink rates. Some of this spread could have been from the flyers concentrating on

maximum climb instead of glide. However, this shows that flight times depend on the model's sink rate as much as the climb height, perhaps more. For example, high performance E-36 models can climb to at least 500 feet (152 meters) in 10 seconds. The altimeter data suggest the glide can range from 1.2 to 2.5 ft/sec, or 1.8 +/-.6 ft/sec. From 500 ft. the glide times could be between 208 and 416 seconds, or about 312 +/- 104 sec. The climb heights ranged from 130 to 170 meters (426-558 ft.). Assuming an average sink rate of 1.8 ft/sec., the glide times could vary from 237 to 309 seconds, or 273 +/- 36 seconds. The variation in calculated glide times from a fixed height (+/- 104 sec.) was much greater than the variation due to altitude only (+/- 36 sec.). Even though this article is about maximizing climb height, the altimeter data does show the importance of maximizing the glide for best performance.

Since most of the glide data was measured in calm, cool and dry conditions, the standard sink rate for this analysis was increased from the average of 1.8 ft/sec to 2.0 ft/sec (.61 m/s) to allow for more typical contest conditions; i.e., higher temperatures and humidity.

Another source of climb data was the web site *eCalc* (Reference 8). It is primarily used for electric powered radio-controlled airplanes, helicopters, multi-rotors and ducted fans, but it can also be used for free flight models. Its data base has an extensive library of motors, propellers and speed controllers. The battery selection is somewhat generic, but there is an adequate variety of sizes and discharge ratings. After inputting model parameters and atmospheric conditions, the program computes a wide range of performance numbers. Since the analysis is based on R/C aircraft, the overall drag coefficient compared to free flight power models is not known, but the results seem to be reasonably accurate. Of interest to this analysis is the motor current, RPM, propeller static thrust at 100% power, and rate of climb. As a testament to the program's accuracy, it will warn you if a propeller is partially stalled when the forward velocity is zero. It will compute the reduced static thrust, called stall thrust, and will calculate the speed where the prop will become completely unstalled. For this analysis, a DYS MR2205/2750 Kv motor was chosen with a 450 mAh 2-cell lipo battery, a 25 A. ESC, and a variety of propellers. The resulting climb rates vs. motor currents are plotted in Figure 4. The rates of climb ranged from 44 to 77 ft/sec (13 to 23 m/sec), and this agreed well with the altimeter data listed previously. It also shows what climb rates are possible with current E-36/F1S models.

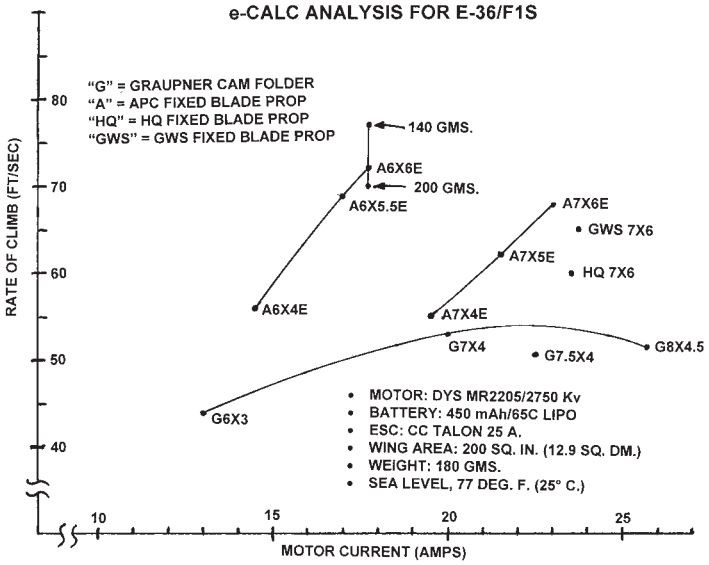


Figure 4. e-Calc analysis for E-36/F1S

Results

The chosen model velocities and spiral diameters along with the appropriate equations were input into two spreadsheets – one for spiral climbs and one for vertical/almost vertical climbs. The results are shown in the Appendix. The performance of spiral vs. vertical climbs is based strictly on trajectory when all model parameters are fixed. This article is not about how to find the best combination of model design, motor, propeller, battery and controller, although Figure 4 does show the effect of pro-

peller size and model weight on rates of climb. Reference 8 (eCalc.com) is a useful guide for showing the effect of different motors, props, batteries, controllers, weight, and atmospheric conditions on velocities and climb rates.

The calculated climb heights and flight times show the impressive performance that E-36/F1S models are capable of. In the vertical/almost vertical results, the lowest flight time was 120 seconds with a 5 second climb. The highest time was 6 minutes with a 10 second climb.

Assuming a 2 ft/sec. (.61 m/sec) sink rate, 230 feet (70 meters) is the minimum altitude to achieve a 2-minute max. For straight climbs, this height can be achieved with a 60 degree climb at 50 ft/sec (15 m/s) using a 5 second motor run. A vertical climb will increase the flight time to 130 seconds. For spiral climbs at 50 ft/sec, a 2-minute max with a 5 second climb requires a 30 ft. maximum diameter spiral and no more than one turn. Increasing the model's speed to 60 ft/sec (18 m/s) will increase the height another 53 feet which provides a 26 second safety margin.

For straight climbs, the flight path can be less than vertical without affecting the height much. However, for best results the angle should be between 70 and 90 degrees. When compared to a vertical climb, a 10 second motor run at

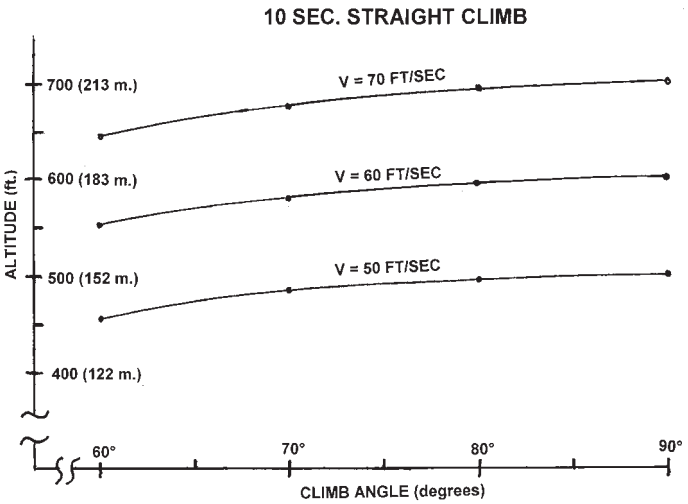


Figure 5. Straight climb for 10 seconds

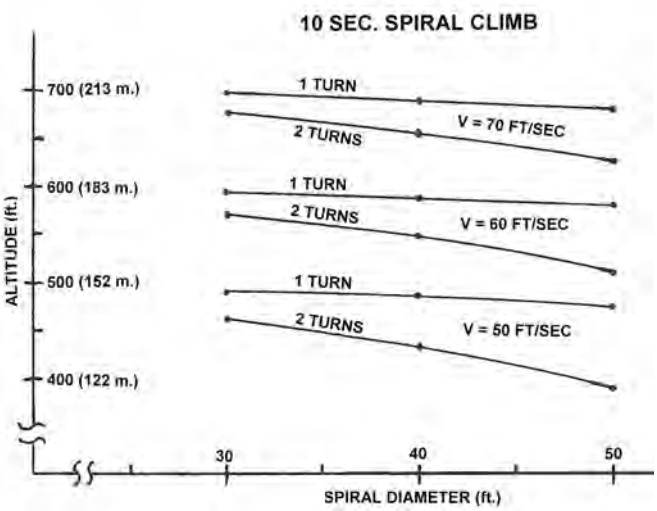


Figure 6. Spiral climb for 10 seconds

50 ft/sec and a 60 degree angle will reduce the final height by 39 feet and by 55 feet with a 70 ft/sec climb. Refer to Figure 5.

Spiral climbs are greatly affected by the number of turns on the way up. This increases the distance traveled. The differences in altitude between one and two turns in a 10 second climb can be seen in Figure 6. For 30 ft. diameter spirals, the difference can be 20-28 feet. For 50 ft. diameter spirals, the difference can be 57-86 feet! If the spiral diameter is kept to 30 ft. or less with a one turn climb, the altitude will only be 6 to 10 feet less than a vertical climb or about the same as a 75 degree straight climb. A 2-turn per 10 second spiral climb can still outperform a 60 degree straight climb as shown in Figure 7.

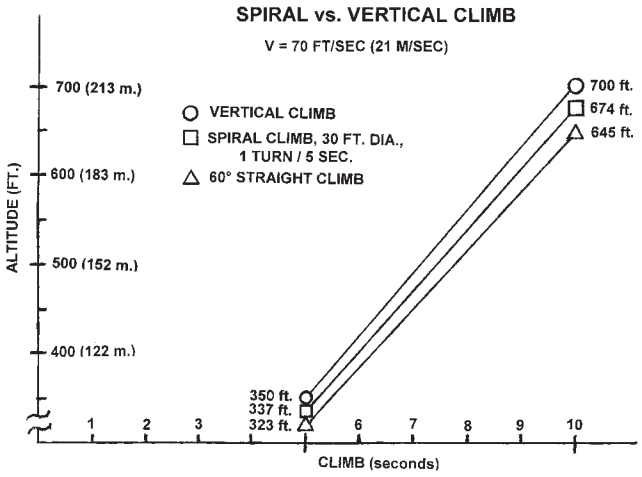


Figure 7. Spiral vs. vertical climb

Five second spiral climbs are affected by turning even more. At 50 to 60 ft/sec speeds, a model will not complete two turns in 5 seconds. The analysis had to resort to reducing the number to 1 ¾ and 1 ½ turns as shown in Figure 8. The model velocity has to be at least 60 ft/sec to exceed 120 seconds of flight. If the number of turns is reduced to ½, a 50 ft/sec speed will easily make a 2 minute max. Refer to Figure 9.

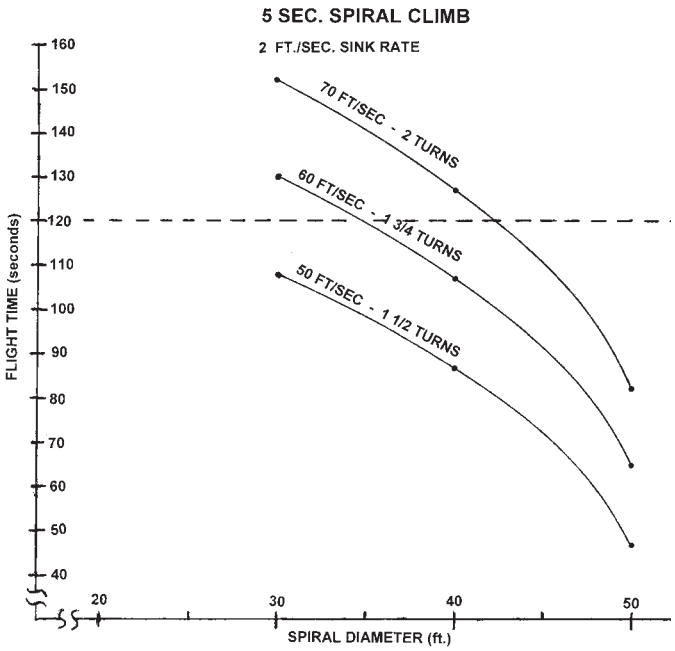


Figure 8. Spiral climb for 5 seconds with multiple turns

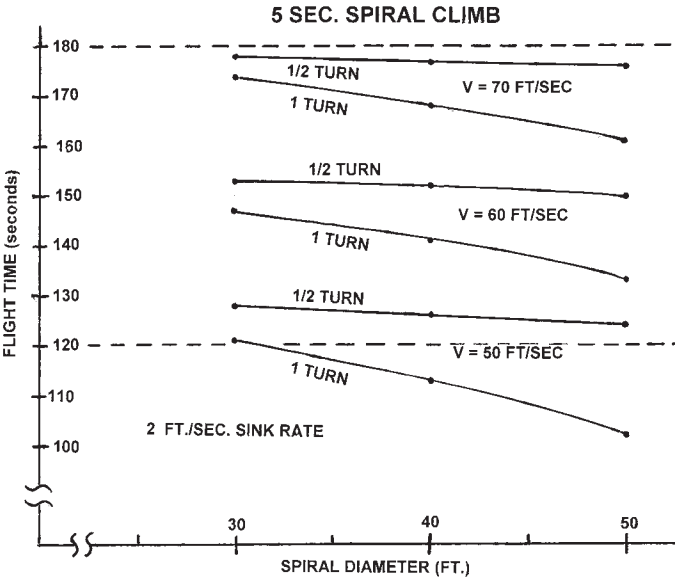


Figure 9. Spiral climb for 5 seconds with one turn and one-half turn

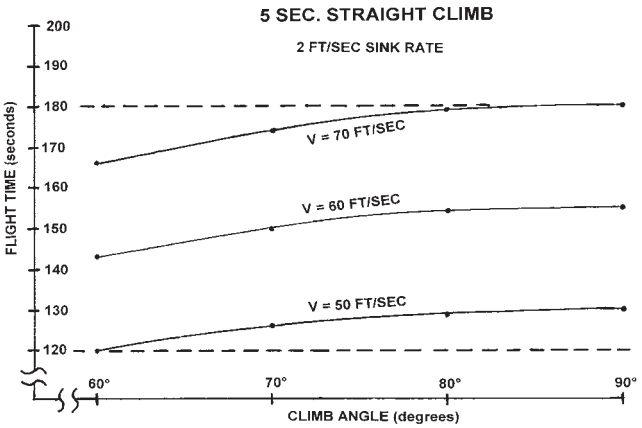


Figure 10. Straight climb for 5 seconds

In competition, the performance using a 5 second climb is what really matters. A two minute flight is an absolute minimum and a three minute flight is a desirable goal (2nd flyoff flight in the F1S event). If the model velocity is 50 ft/sec and does one turn, referring to Figure 9 it can be seen that the spiral diameter must be no more than 30 ft. to achieve a 120 second max. To come close to a 180 second max a flight speed of 73 ft/sec is required. If the model makes only a half turn, the altitude and resulting flight time improve considerably. At 70 ft/sec the model can obtain 178 seconds. This is very close to the performance of a vertical climb, as shown in Figure 10.

Conclusions

- A vertical climb will get higher than a spiral climb, but not by much. For a typical model velocity of 50 ft/sec, a 5 second vertical climb has an 18 ft. advantage over a one turn spiral climb at the same speed. The approximate 9 second glide advantage might be enough to win in ideal flyoff conditions.
- Near vertical climbs are best if the angle is at least 70 degrees.
- Spiral climbs can come close to vertical climbs if the number of turns is minimized. One turn in 10 seconds will reach close to the maximum altitude possible.
- Contemporary E-36/F1S models are capable of very high performance. Three minute flights with a 5 second climb are possible, as well as six minute flights in 10 seconds.

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8. Web site eCalc, https://www.ecalc.ch/

Appendix:

Straight Climb Analysis

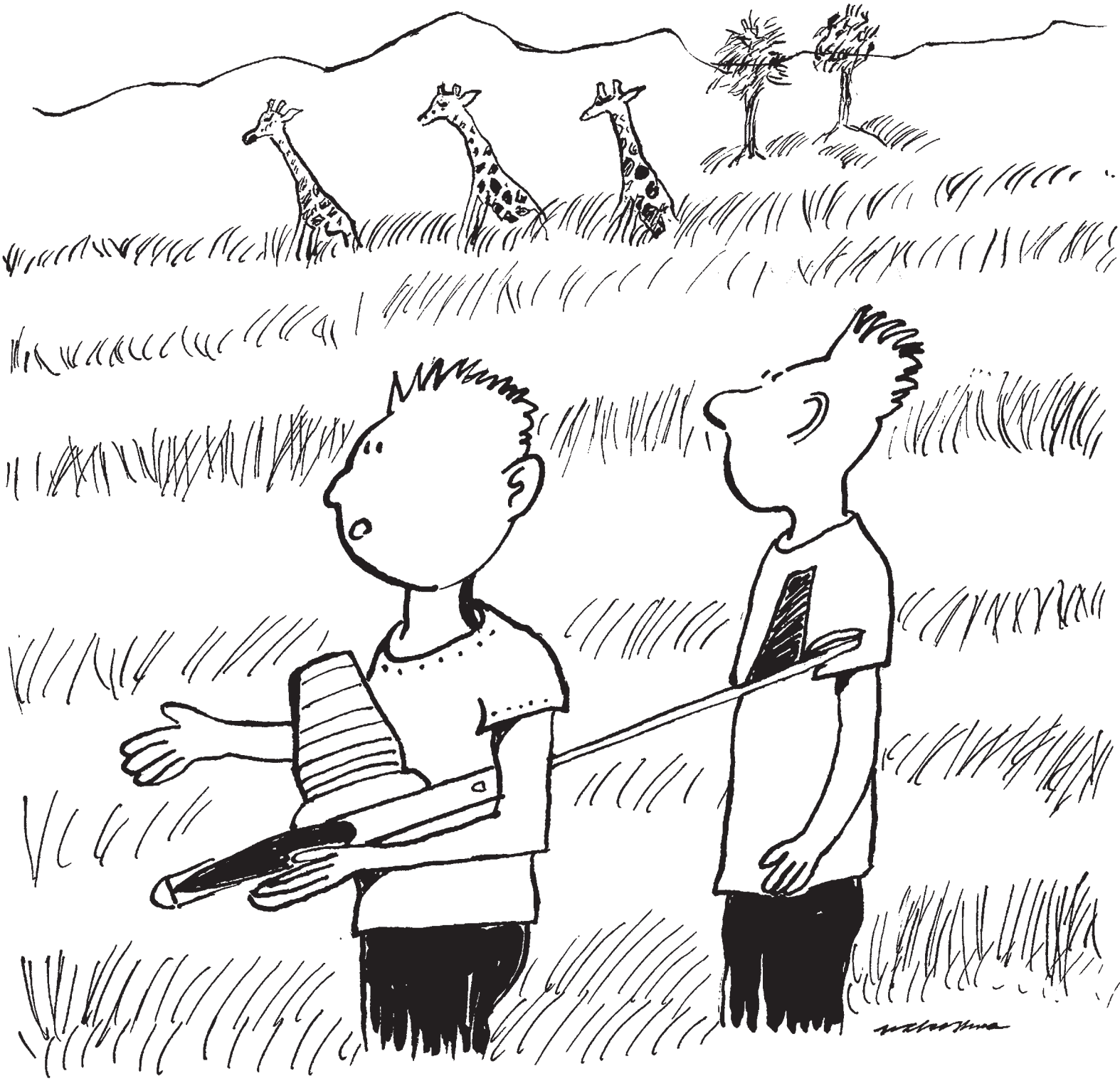
FLIGHT VELOCITY [ft/sec]	MOTOR RUN [seconds]	CLIMB ANGLE [deg.]	CORRECTED FLIGHT VELOCITY [ft/sec]	RATE OF CLIMB [ft./sec]	ALTITUDE [ft.]	MAX POSSIBLE ALTITUDE [ft.]	RATE OF DECENT [ft./sec]	CLIMB + GLIDE TIME [sec.]
50	5	60	53.2	46.1	231	250	2.0	120
50	5	70	51.5	48.4	242	250	2.0	126
50	5	80	50.4	49.6	248	250	2.0	129
50	5	90	50.0	50.0	250	250	2.0	130
60	5	60	63.9	55.3	277	300	2.0	143
60	5	70	61.8	58.1	290	300	2.0	150
60	5	80	60.5	59.5	298	300	2.0	154
60	5	90	60.0	60.0	300	300	2.0	155
70	5	60	74.5	64.5	323	350	2.0	166
70	5	70	72.1	67.7	339	350	2.0	174
70	5	80	70.5	69.5	347	350	2.0	179
70	5	90	70.0	70.0	350	350	2.0	180
50	10	60	53.2	46.1	461	500	2.0	241
50	10	70	51.5	48.4	484	500	2.0	252
50	10	80	50.4	49.6	496	500	2.0	258
50	10	90	50.0	50.0	500	500	2.0	260
60	10	60	63.9	55.3	553	600	2.0	287
60	10	70	61.8	58.1	581	600	2.0	300
60	10	80	60.5	59.5	595	600	2.0	308
60	10	90	60.0	60.0	600	600	2.0	310
70	10	60	74.5	64.5	645	700	2.0	333
70	10	70	72.1	67.7	677	700	2.0	349
70	10	80	70.5	69.5	695	700	2.0	357
70	10	90	70.0	70.0	700	700	2.0	360

Notes: *1. Altitudes (climb heights) do not include an initial launch height of approximately 6 feet (2 meters).*
2. Total flight times do not include the additional 3 seconds of glide time.

Spiral Climb Analysis

DIA. OF SPIRAL [ft.]	FLIGHT VELOCITY [ft/sec]	MOTOR RUN [seconds]	NUMBER OF TURNS	HORIZONTAL VELOCITY [ft/sec]	CLIMB ANGLE [deg.]	RATE OF CLIMB [ft/sec]	ALTITUDE [ft.]	MAX POSSIBLE ALTITUDE [ft.] (VERT. CLIMB)	CLIMB + GLIDE TIME [sec.]
30	50	5	1.5	28.3	56	41.2	206	250	108
40	50	5	1.5	37.7	41	32.9	164	250	87
50	50	5	1.5	47.1	20	16.7	84	250	47
30	60	5	1.75	33.0	57	50.1	251	300	130
40	60	5	1.75	44.0	43	40.8	204	300	107
50	60	5	1.75	55.0	24	24.1	120	300	65
30	70	5	2	37.7	57	59.0	295	350	152
40	70	5	2	50.3	44	48.7	244	350	127
50	70	5	2	62.8	26	30.9	154	350	82
30	50	5	1	18.8	68	46.3	232	250	121
40	50	5	1	25.1	60	43.2	216	250	113
50	50	5	1	31.4	51	38.9	195	250	102
30	60	5	1	18.8	72	57.0	285	300	147
40	60	5	1	25.1	65	54.5	272	300	141
50	60	5	1	31.4	58	51.1	256	300	133
30	70	5	1	18.8	74	67.4	337	350	174
40	70	5	1	25.1	69	65.3	327	350	168
50	70	5	1	31.4	63	62.6	313	350	161
30	50	5	0.5	9.4	79	49.1	246	250	128
40	50	5	0.5	12.6	75	48.4	242	250	126
50	50	5	0.5	15.7	72	47.5	237	250	124
30	60	5	0.5	9.4	81	59.3	296	300	153
40	60	5	0.5	12.6	78	58.7	293	300	152
50	60	5	0.5	15.7	75	57.9	290	300	150
30	70	5	0.5	9.4	82	69.4	347	350	178
40	70	5	0.5	12.6	80	68.9	344	350	177
50	70	5	0.5	15.7	77	68.2	341	350	176
30	50	10	2	18.8	68	46.3	463	500	242
40	50	10	2	25.1	60	43.2	432	500	226
50	50	10	2	31.4	51	38.9	389	500	205
30	60	10	2	18.8	72	57.0	570	600	295
40	60	10	2	25.1	65	54.5	545	600	282
50	60	10	2	31.4	58	51.1	511	600	266
30	70	10	2	18.8	74	67.4	674	700	347
40	70	10	2	25.1	69	65.3	653	700	337
50	70	10	2	31.4	63	62.6	626	700	323
30	50	10	1	9.4	79	49.1	491	500	256
40	50	10	1	12.6	75	48.4	484	500	252
50	50	10	1	15.7	72	47.5	475	500	247
30	60	10	1	9.4	81	59.3	593	600	306
40	60	10	1	12.6	78	58.7	587	600	303
50	60	10	1	15.7	75	57.9	579	600	300
30	70	10	1	9.4	82	69.4	694	700	357
40	70	10	1	12.6	80	68.9	689	700	354
50	70	10	1	15.7	77	68.2	682	700	351

Notes: *1. Altitudes (climb heights) do not include an initial launch height of approximately 6 feet (2 meters).*
2. Total flight times do not include the additional 3 seconds of glide time.
3. Assumes a rate of descent of 2.0 ft/sec (.61 m/sec).


"I think we're lost....."

THERMALS AND PICKING LIFT – AN UPDATE

AUTHOR
PAUL ROSSITER

There was a quite unusual occurrence at three World Cup events held consecutively at Narrandera in Western Australia in 2018: the Tui Cup, the AFFS Championships and the Widgiewa Cup. This was the unusually high number of F1A and F1B fliers dropping rounds in the mid-morning when rounds 3 and 4 were held, as shown in Tables 1 and 2 (the number of fliers who completed all rounds are shown in brackets):

F1A	Round 1	Round 2	Round 3	Round 4	Round 5
Tui Cup (5)	3	1	1	5	1
Widgiewa Cup (5)	3	1	2	0	2
AFFS Championships (5)	3	1	0	5	2
Total	9	3	3	10	5

Table 1. Number of F1A rounds dropped in the three events.

F1B	Round 1	Round 2	Round 3	Round 4	Round 5
Tui Cup (9)	1	2	4	4	2
Widgiewa Cup (11)	1	0	0	3	0
AFFS Championships (14)	5	2	2	6	3
Total	7	4	6	13	5

Table 2. Number of F1B rounds dropped in the three events.

With the exception of the F1A round 4 of the Widgiewa Cup, round 4 was generally a killer for most fliers in both classes, the most drastic being the Tui Cup and AFFS Championships rounds 4 in which all F1A fliers and many F1B fliers dropped. The F1C fliers seemed to be immune to this effect, possibly due to their ability to reach good heights whatever the conditions.

Having competed in F1B in these three events, I managed to drop all round 4 flights in the three competitions (a perfect record!) despite using a weather station to indicate lift and, where possible, piggybacking off the launches of the upwind F1A fliers, a very bad choice as it turned out! Thinking back, there were usually 3 or 4 F1B fliers waiting to launch, observing a drop in wind strength accompanied by a rise in temperature then launching as soon as the infill arrived, as was normal procedure. F1A fliers were similarly waiting to feel some lift for a circle or two then launching. While the conditions clearly indicated the passing of a thermal, most of us simply found the accompanying sink with a high degree of accuracy.

Now back home, after the pain has worn off and suitably lubricated by a glass of red wine, I went over the charts to try better to understand what went wrong and learn how it might be avoided in the future.

In all three cases, Rounds 1 and 2 exhibited typical early morning behaviour with the temperature slowly rising and the wind fluctuating up and down somewhat. By round 3, there were early indications of thermals coming through roughly every 5-10 minutes. However by around 11 o'clock, (round 3-4 Tui (90 minute rounds from round 3) and round 4 Widgiewa and AFFS) all three charts revealed a change in conditions with roughly an

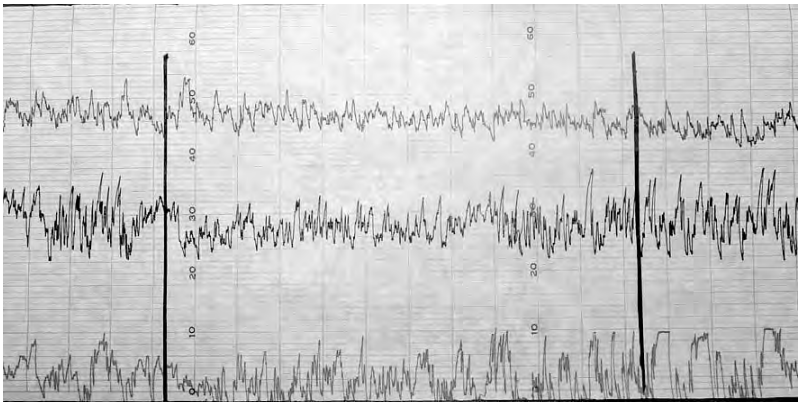


Figure 1. Top trace: wind speed, middle trace: temperature variation (upwind), bottom trace: temperature variation (at pole); all increasing upwards.

hour where the temperature and wind simply fluctuated more rapidly up and down every few minutes, with no real indications of strong thermals. After that, more normal thermal indications returned, as shown in Figure 1 above. The region between the two black lines corresponds roughly to the hazardous period around 50 minutes long (each horizontal division corresponds to 5 minutes):

This prompted me to re-read the article I wrote on picking thermals for the 2016 NFFS Symposium (Rossiter, 2016), particularly in relation to the mid –morning round 4 fiasco (from my original manuscript, somewhat abbreviated in the final published version):

2.2 Mid morning

As the moisture is driven off, the ground starts to heat up from the solar radiation and the air is heated by conduction and convection from the ground. Small thermals start to form and rise until they reach the inversion layer where they dissipate. However, as the thermal strength increases they will start to penetrate the inversion and the thermal air starts to rise to higher levels. These thermals cause mixing of the air and any winds from above are mixed in with the ground layer leading to increased turbulence, lift and sink. If the air is sufficiently warm it will lead to a destruction of the inversion.

The increasing temperature leads to a lower air density and, for the reasons discussed above, this in turn leads to a loss of model gliding performance, though the overall flight times will also be affected by changes in climb height resulting from improvements in rubber energy (F1B) or reduction in volumetric efficiency (F1C) as well as decreased drag during any vertical climb (F1A in the zoom, F1B in the burst and F1C).

This can be a hazardous period for max-hunters since model performance is dropping and yet the regions of lift are only starting to develop.

Traditionally one might have used the feeling on the face, neck or back of bare legs to detect changes in temperature and wind, and a few skilled fliers still manage to do quite well this way. Other aids like bubble machines or cattail/bulrush seeds can give a direct indication of what is going on and shouldn't be discounted either. **However, they both tend to go up in light lift that may be too weak to support a model and they can also give false indications in turbulent air.**

While this points to the difficulty of finding good lift in such conditions, I thought that my perfect record (together with many others) of missing the max pointed to something else going on. In searching for a possible answer I went back and had another look at the excellent presentations by that RC soaring guru Joe Wurts, available on You Tube (just search "Joe Wurts" on You Tube to find them). In commenting upon on the effects of inversion layers on thermals, he claimed that the size and spacing of thermal lift was dependent on the height of the inversion. The lower the inversion the smaller and closer together thermals would be. So in early morning there would be many small light thermals rising to the inversion height, and building up against the main inversion. This height would lower as the air collected under it, and slowly kill off lift until sufficient buoyancy was created to break the inversion up and penetrate the layer. Then big but widely spaced thermals would begin.

Wurts' observation was that thermals typically pull air in towards them, so any model near a thermal will usually be pulled in - except near the top of a thermal encountering an obstructing inversion where the thermal after climbing is stifled by the layer of warm air above, and spreads out horizontally under it before sinking back to earth - he had a sketch showing a classic mushroom pattern with air rising in the stem, and then spreading across the top and sinking back along the perimeter of the mushroom head. According to him a model will typically climb well up to the layer, then be pushed out into sink. So presumably if there is an inversion at say 120 metres, and an F1A or F1B climbs in a thermal to 110 metres, it is then in the dispersion zone under the inversion and will be actively pushed out into sink. As the thermals build in strength, they finally break through the inversion layer and normal lift conditions prevail. This would seem to provide an explanation for the round 4 dilemma: prior to that the thermals are weak and so there is no strong dispersion at the bottom of the inversion layer. A max results simply from model performance. As they build in strength the dispersion layer grows and throws the models out into the surrounding sink. Then by round 5 the thermals are strong enough to break through the inversion layer and good lift is found.

He also describes conditions around midday (he describes as a "boiling pot") prior to the establishment of regular strong lift, where strong thermals start to form but break up at low heights.

With this in mind and looking over the charts with the benefit of hindsight, it is clear that the lift the F1B and the F1A fliers were trying to pick around round 4 had actually become quite weak and narrow and not building progressively as might be expected from the Wurts explanation. However, it occurred to me that if the build-up of warm air below the inversion layer was sufficient to reduce the effective height of the layer, the thermals could indeed become quite narrow, as Wurts suggests. It is then possible that as the inversion starts to break down due to the build-up of that warm air, the cold air above the layer descends producing the observed sink. This is most likely to occur where the narrow thermals rise and would explain how my meticulous picking of the narrow lift at ground level from the indications on the charts led to completely consistent failure: all I was doing was consistently picking the triggers for the localised breakup of the inversion layer and subsequent sink associated with the falling colder air.

Under those conditions, a better strategy for F1B fliers, at least, was probably to wait for a relatively **stable** period of wind and temperature and rely on model performance for a max in generally neutral conditions. This avoids finding the sink around scant thermals, as so many of us did. Otherwise, wait until there are clear indications of a large thermal, but that might not occur for some time after the inversion layer breaks down (something like 40 – 50 minutes at the Narrandera competition!). So I think the main message for the chart-watchers is to be very alert to changes in the pattern of lift coming through and, when this occurs, maybe wait to see what happens to the other fliers.

Of course, the nature and behaviour of any inversion layer and the subsequent effect on thermals will be dependent upon local meteorological and geographic conditions and so the behaviour noted above may or may not be observed at a different time or location. Nevertheless, it acts as a caution to be continually on your guard for any significant changes in the conditions.

Acknowledgements.

I thank Neil Murray for many interesting discussions on the topic and reminding me of Joe Wurts' presentations.

References.

Rossiter P.L., 2016, 49th Annual Report of the National Free Flight Society, Symposium 2016, page 113.



Guy Menanno at 2018 Issacson – Photo by Brian Furutani

TRIMMING A MODEL'S CLIMB WITH AN ALTIMETER

AUTHOR
ALEX ANDRUIKOV

Altimeters are buzz word in free flight lately. A very good article regarding the use of altimeters was presented in the 42nd NFFS Symposium 2019, by Ken Bauer [1]. This article is to present how I use an altimeter to aid in trimming my models.

However don't assume that you make one flight with an altimeter and get all the data you need. Like money never sleeps the air is never still.

An Important thing is how you use your altimeter and how much attention how much effort you need to put to operate it.

My timer is designed in such a way that you don't do anything with Altimeter. You just fly your model. The altimeter records about 25 flights by itself. It starts recording when you launch. You can download and analyze data at your convenience in the evening.

Once again about statistics; If you use altimeter only occasionally or you need to switch it on and off, that makes it inconvenient and you do not record all your flights.

Sensitivity of Altimeter is also important. Best pressure gauges may have a resolution of about 10 cm while cheaper ones would have accuracy of plus - minus half a meter. It may be good for Altimeter timing, but not for your model glide adjustment

References: [1] "An Altimeter Glide Trim Method" by Ken Bauer, the 42nd NFFS Symposium, 2009

Testing

The best time of the day to check your glide is early in the morning before sunrise or first hour after. In the evening, even if the air looks really nice and calm, there is often some thermal activity.

I usually prepare two or three models for glide tests. I wind all motors to 250 turns. This lets the models climb to 40 – 50 meters. Then launch them within a few seconds of each other. This way I can compare the glide. I can usually do 3 or 4 flights in the morning before thermal activity is too high and then summarize the data. See Figure 1

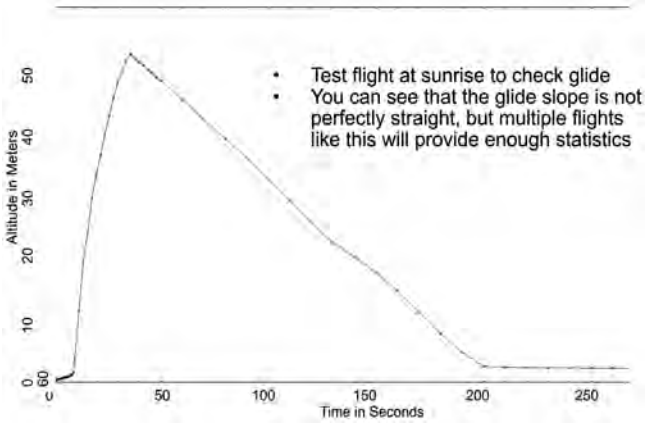


Figure 1 – Typical Test Flight

You can clearly see this with a graphical representation of your flight. Interestingly enough even if your glide line looks very straight all the way from the highest point to the ground, it doesn't necessarily

mean that you are gliding in a clean air. Sometimes the air may be better or worse and you definitely need a lot of flights to get enough meaningful statistics.

Here is How I Practice the Launch

I set the VIT for one second. Then I attach the VIT line but do not attach DT. This way in one second tail plane goes into DT position. You can now throw the model into the air without winding your motor. At one second it is at 5 m altitude and DT is activated for safe landing back on the grass. You can practice launch in your backyard.

When I check the climb I let the model glide for one minute after the climb. If the sink rate was significantly different than 0.3 m/s is then the climb data is not good. If the sink rate he is close to 0.3 m/s and glide is nice and straight on the graph, then the climb data are useable.

I Usually Look At a Few Points in Time During the Climb.

My first point of interest is 0.5 seconds. It shows how hard you throw the model. My normal altitude at half a second is around 6 m. Anything more than that is really good. I did see fliers capable of 8 m but many people have only 4 or even less. If your altitude at half second is less than 5 m, that means you have room for improvement in your launch technics.

Second important point in the flight is five seconds after launch. It shows you how good your initial burst is. With good rubber motor you can get over 50 m of altitude by five seconds.

Point number three is 10 seconds into the flight. It is the most important for the overall performance as it shows how nicely you model transitions from the vertical climb into

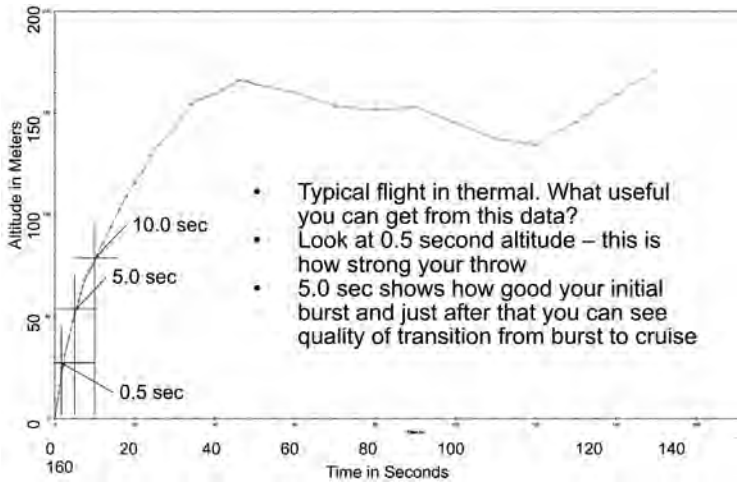


Figure 2 – Initial First Seconds of Flight

the spiral. Anything close to 70 m is really good. See Figure 2.

And the final number obliviously is your motor climb the total altitude.

Presented are additional Figures 3 through 6 showing typical flight profiles and what they look like.

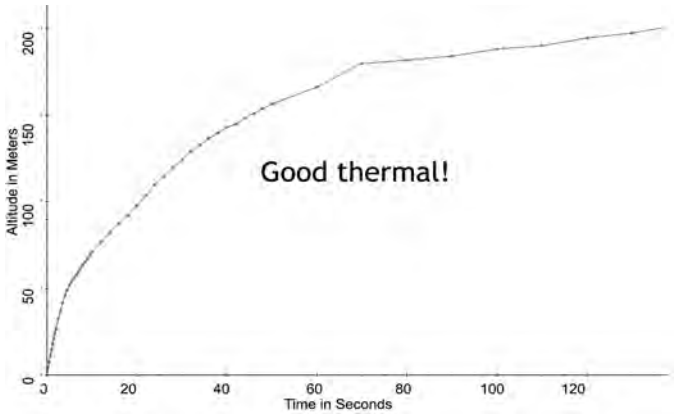


Figure 3 – The Profile of a good Thermal Flight

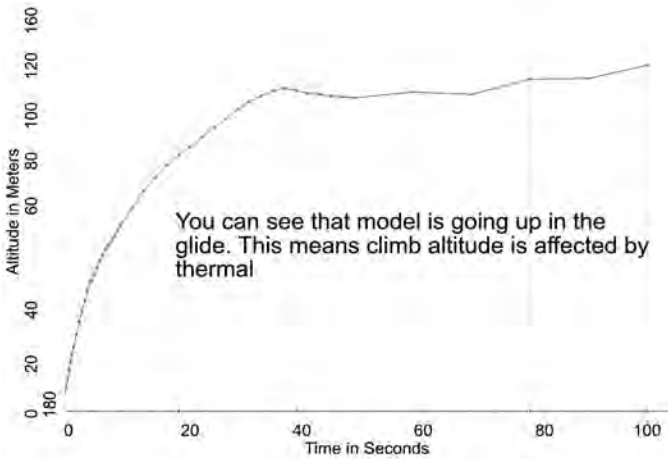


Figure 4 – The Profile of a Thermal Aiding Climb

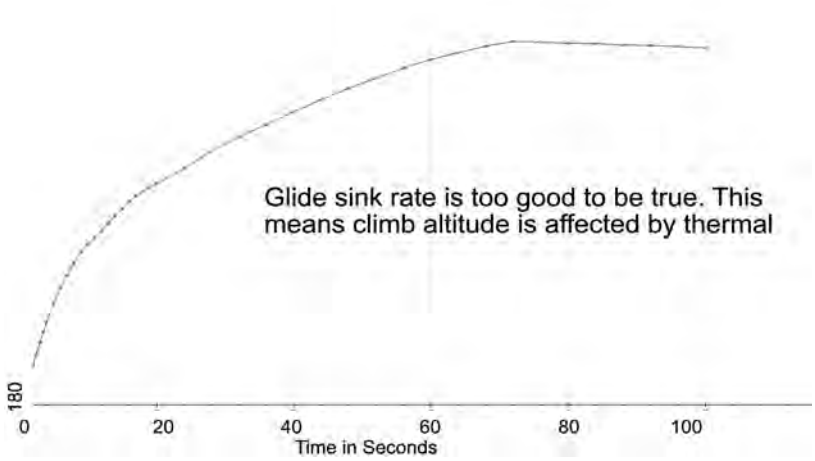


Figure 5 – Another Profile of a Thermal Aiding Climb

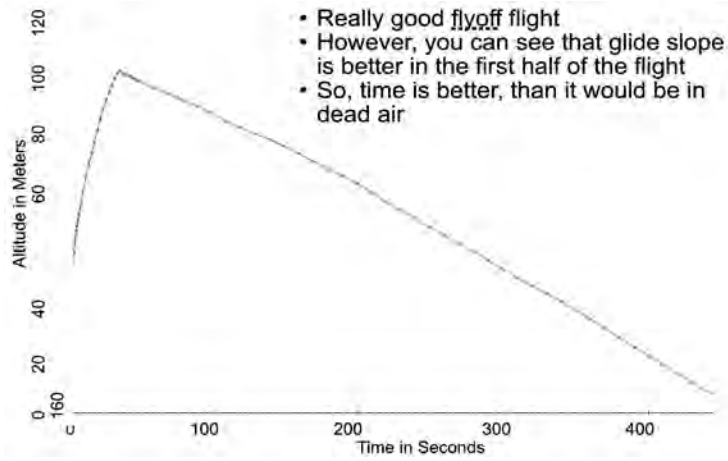


Figure 6 – The Profile of a Good Flyoff Flight



2019 Indoor NATs P-18 Mass Launch. Photo-Bruce Brawberg.



Tom Ioerger with F1Q and Mike Richardson nearby at 2018 Nats — Photo-Rick Pangell

USE AND ABUSE OF GPS MODEL TRACKERS

AUTHOR
CHRIS EDGE

Prologue

20 years ago on these very pages Julian Pennington wrote that 'Integration of Walston or Biotrack with GPS, as a one stop package, would surely be an aero-modeller's dream' (Ref .1). In fact things moved quickly as the technology developed with some FF systems being available around 2003, but the initial trend to provide GPS model tracking as an integral part of a timer with the inherent cost and reliability issues (what happens when the GPS stops, do you buy a new timer ?) limited take-up. Step forward another 15 years or so and stand-alone systems became available that you could quickly install in any model; it is these systems that have now transformed the tracking and retrieval of our models with many dozens being used at recent Championships. This paper, updated from one presented in the prestigious 2018 BMFA 'Free Flight Forum' (Ref. 2), gives an overview of available systems along with my practical experience of using GPS tracking; I hope it's of use.

In the beginning

GPS model tracking has been available for over 10 years but until recently only integrated in to timer systems and at great expense. That all changed when Optimal Tracking introduced their stand-alone commercial iCare2 product which provided a simple lightweight means to replace radio trackers such as the Biotrack, Walston or Pim Ruyter units. In 2019 there will be three stand-alone systems commercially available with others in prototype development so now is a good time to review what's available and describe practical experience of using GPS tracking in FF models.

Why bother?

Radio trackers were a game-changer when introduced over 35 years ago. No longer did you have to worry about a model going in to tall crops, you just tracked it with a receiver and a directional 'Yagi' aerial made that easy. The problem came if you had long flights or flyaways where the signal was lost or the terrain was difficult and/or you had interference from power lines, fences etc; these have been well documented. In the limiting case, if you had no signal you had no information as to where the model was, er, except it was not in range of your receiver at that given point and at that given time.

With GPS tracking you now have the situation that if you have a signal from the model then you know exactly where it is at that moment to a tolerance of ~5m. What's more you know accurately which direction and how far to go to get it, with some systems even displaying this information on a map of the area, and all within a model package of similar size and weight to a standard 'bug'. All this enables quicker retrievals even in difficult circumstances; what's not to like ?

How does it work ?

In simple terms both the transmitter (model) and receiver (with you) gathers positional and time data from GPS satellites and, via a radio link, transmits the model data to the receiver which in tern calculates a distance and, via an integral electronic compass, a direction to the model. Each of the three systems discussed here displays information in a different way but all provide real-time bearing, distance and altitude values. Where mapping is available, the model's position is shown superimposed with the map on a suitable display.

Like a traditional 'bug', the radio link used to transmit the model's positional data is the limitation in terms of data range, but is similar to a Yagi-equipped unit at ~20kms airborne. However, unlike a simple bug that is giving you just a modulated tone that needs to be interpreted, the GPS data is accurate to typically 5m in 3-D space.

All this capability requires some set-up time of course. As a minimum you need to set your receiver to listen for the particular transmitter and the process for doing that is perhaps easier with some systems than others, but none are difficult. You also need to calibrate your receiver's compass which is a process of following screen instructions and typically rotating around on the spot; re-calibration is also recommended if you travel a long distance between contests. When complete you will basically see a symbol to show where you are and another to show where the model is with information via text or arrows as to which direction and how far away it is. If mapping is available then that is shown as a backdrop on the screen which helps plan the best route to the model.

Specification Time

Most flyers are used to adding a radio tracker to a model, just plug in the battery, slip in to the model and fly. Now you have three suppliers for the equivalent system using GPS, the basic details of which are summarised on the Facing page. ⟶



Figure 1, From Left - Pim Ruyter Tracker (for comparison), iCare2 Transmitter, iCare Receiver' - Photo Credit Chris Edge



Figure 2, 'Pyxis Receiver with Transmitter' - Photo Credit Ken Faux

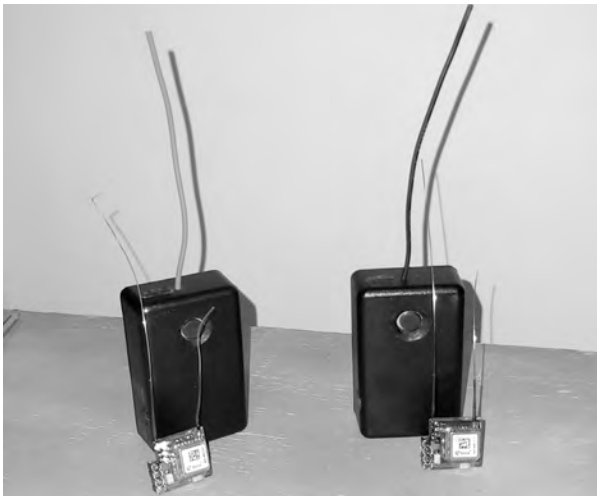


Figure 3 'Hershkoviz Ground Stations with Airborne Modules' - Photo Credit Liav Hershkoviz

Supplier	Optimal Tracking	Liav Hershkoviz	FF Electronics
Product name	iCare2	None	Pyxis
Price for 2 transmitters + 1 receiver	Euro 620	TBD available late 2019 (+ phone or tablet)	Euro 440
Model Transmitter			
Size (without antennas)	37x16x6mm	19x17x8mm	29x16x5.4mm
Weight	4.8grms	3grms	2.3grms
Supply Voltage Range	3.0 > 5.5V	3.7 > 8.4v	3.7v Nominal
Range - Ground/ Airborne	>0.5kms/>20kms	unknown/>10kms	unknown/>2.4kms
Minimum battery capacity for 12 hrs use	300mAH	120mAH	170mAH
Transmit interval	Variable: based on speed, distance, altitude; all user definable	14s average in flight, 60s on ground, on request after DT	Constant when moving, lower frequency when stationary
Additional functions	None	RCDT (BMT, M&K, etc compatible)	None
Ground Receiver			
Type	Custom	Custom to Android App	Custom
Size	115x56x22mm	65x35x20mm	~100x50x25mm
Weight	106grms	40grms	~100grms
Battery life	~14hrs	~10hrs	>20hrs
Mapping options	Hand drawn, uploaded from Google Earth	Google Maps interface with model track overlay	None
Data download	Position, time, speed for all recorded transmitters via PC software	Positional data can be shared with other App users	No

Slipping it in

Unlike a radio transmitter with a small coin cell or fishing float battery, you need greater battery capacity to run a GPS transmitter so gone are the days of slipping in a small cell and off you go. The Pyxis unit has a connector integrated on to the bottom of the units, so in principle you could incorporate an appropriate connector in each model and just plug in the units as required, with internal wiring taking power from a dedicated battery or an electronic timer battery.

The iCare2 unit has a trailing wire with dedicated connector which does make plug and play a little more fiddly but there is an after-market modification from Lucca Aringer with which it is a simple plug-n-play to use in any model more like the Pyxis unit.

To switch on the Hershkoviz GPS unit (figure 3) it has to be connected to an electronic timer via a servo connection plus, if you want to use the integral RCDT functionality, to the timer's RCDT signal connection as well. So to swap between models you would need a 4-pin con-

nector from the timer to be available; simple soldering will facilitate this.

Needless to say that no unit has connectors compatible with any other !

All the units are a little bigger than the Ruyter transmitter so you'll likely need to ensure you have the space available. Very important is to have the top 5-6mm of the unit and all the wire aerial length clear of the model as this ensures the in-built GPS antenna has clear line-of-sight to satellites. Orientation shouldn't be too critical, I've seen vertical and horizontal installations, but in the latter case I find that acquisition of the GPS satellites will take longer. See Figure 4.

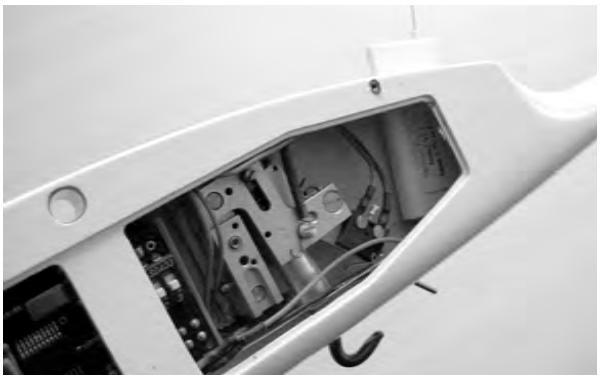


Figure 4 'Typical GPS Tracker Installation in F1H' - Photo Credit Chris Edge

In use

For the majority of flights, retrieval is not a problem even without a tracker but it is those extreme cases described earlier where GPS systems really come in to their own. Having used a GPS tracking system for 4 years I have subtly changed how I approach the problem flights, including those that haven't DT'd (or have DT'd but won't come down !). The pre-requisite for the following is that you have checked your GPS system is fully working before you let go of the model; you always do that don't you ?

So let's say that I've just launched a model, it isn't coming down (assume DT failure), it's gone OOS BUT it has a GPS tracker on-board, and it's working, this is what I'd do :-

1) Stay put. Each transmission is giving you the model's position in 3D space to within 5m, so as long as you get a transmission you know exactly where it is and you can navigate to it. Chasing risks loosing the transmission (ie it suddenly DTs as you start driving/riding off and the transmission ceases).
2) Watch the numbers. Rather than just a beep from which you can only get direction and a poor estimate of distance, the numbers are very useful. They tell you how far it is and, more importantly, if it is still going up or not. If still going up then relax, just enjoy the ride, if coming down then do 3). Note that testing shows typically 20kms range at 80m altitude, likely more if the model is higher but there will be a limit on range based on the power of the transmitter, this could be 30, 40 kms however; experience will eventually show what is achievable.
3) Hold the receiver above your head. Like a Biotrack or Walston receiver, every extra foot in height is a benefit in keeping the data coming. As with a traditional bug, as the model gets closer to the ground you will eventually loose line-of-sight to the transmitter and the data will cease. Review the numbers after each transmission, is it coming down or not ?
4) The last transmission will likely be at some finite altitude. If the model was descending quickly (you've followed 2) right ?) then it will have landed close to the position shown on the receiver. In this case plot the last transmission position on a map (you carry a paper map of the site with you, right ?) and navigate to it.

If the last transmission showed the model was still high, say a few hundred meters, and was descending slowly then you need to extrapolate a landing position/area. If your receiver has a 'sight and go' function then use that to plot a line through the last transmitted position to aid this, and/or use a map to achieve the same.

5) You're now downwind at the last transmitted position. If the model is within 500m or so then you'll get another transmission and you'll know where the model is to within 5m - go and get it !

If you are at the last transmitted position and don't get a signal then you need to get one. Clearly the model is further along it's flight line (as per the sight-and-go and/or map heading) so head downwind in ~500m steps, trying to gain height to increase transmission range to the model. You'll eventually get to a point where you'll get another transmission and hence you know where the model is.

If you still don't get a transmission after heading downwind in steps then frankly I'm in uncharted territory. If using the iCare2 unit I would likely plot the flight on GoogleEarth (GE) and extrapolate more accurately the likely landing position from the altitude/direction data. The only positive is that, assuming it hasn't been picked up, you know where it isn't so maybe at this point you start phoning land owners.

6) If you've got a signal and the model is in a trees you have a slightly different issue. Here the GPS accuracy can be insufficient to spot the model but you now use the signal strength meter on the receiver (iCare2 and Pyxis systems only). This displays the signal strength with the maximum typically being within inches of the transmitter; it's best to do some testing beforehand to get used to what the numbers mean. You can use body shielding for direction but you are obviously limited to the longer period of transmissions compared to a bug. The one occasion I had to use this method was when my model landed in a tree but was not immediately visible from ground level. It took a few minutes but I eventually saw it using the signal strength information - note that you can use the altitude value to tell how high it is, very useful.

In normal use the availability of mapping (iCare2 and Hershkoviz only) is a great benefit as it aids your decision on how to fly and how to get the model back. At my usual flying site of Newbigging in Scotland there are some major hazards such as trees, rivers, the haggis farm, buildings etc which you really don't want to land in. By tracking the model on the GPS display against a map you can make objective decisions as to when to DT to under or over-fly these hazards, noting that models can be strangely attracted to obstacles that you really want to miss (Murphy's Law #94) - beware ! And it is now much easier to follow practical tracks to the model than a direct route hence you can use maps to get the model quicker, which personally I find the biggest strength of these systems.

Simple maps are added the the iCare2 receiver using the line and polynomial drawing options within GE; a good tutorial for showing the method is given in (Ref. 3). Simply, you zoom in to your area of interest and draw over the areas of the satellite image that you need. For me this would include local roads, buildings, trees and the like. You can go further and add in all field boundaries if you wish but it all takes time and many will not want to do this. The good news is that Optimal Tracking provides some UK and overseas maps on its website for downloading; see Ref. 4. An example of a map of the UK flying site at RAF Sculthorpe is shown in Figure 5.



Figure 5 'Typical Google Earth Overlay Map as used in iCare Units' - Photo Credit Chris Edge

In comparison, the Hershkoviz system plots the model's track and your position directly on a phone or tablet using Google Maps, so no need to create anything beforehand but accessibility to the mapping data must be possible at your flying site of course. See Figure 6.



Figure 6 'Hershkoviz App Display Showing Tracking Information on Google Maps' - Photo Credit Liav Hershkoviz

Elephants

So that's all good then ? Well needless to say nothing is without risk and consequences and for GPS trackers the biggest issue is with battery life. Gone are the days of a week or weeks of transmissions with a radio tracker, typical batteries noted above will only give 12 to 24 hours of useable function so you have to tread carefully.

If you think about it, if you can run your transmitter at a lower transmission frequency (ie longer period) when stationary then you can save quite a lot of power, after all the model is maybe flying for 3mins or so every hour so most of the power is used up when the model isn't moving; all three systems noted have this capability. For more flexibility the iCare2 unit allows the user to set the stationary transmit period from a default of 30s - so using 60s instead will practically double the battery life from the default value. The Hershkoviz system switches off the GPS module after DT to save power but cleverly allows you to switch it back on via the 'RCDT' button to obtain the current positional data at regular intervals.

In the comparison table you'll see that the manufactures suggest a battery capacity for a 24 hours life of the transmitter. Some of these are quite large and therefore heavy for small models so an alternative is to use a smaller battery, say 160mAh, then re-charge or swap out every few flights - not ideal in my experience but an option; I personally use as large a battery as I can fit in as it runs both the GPS and electronic timer. For a single-servo model I use 300mAh and for a 2/3-servo model I use a minimum of 500mAh and prefer the circular Turnigy 900mAh batteries when practicable. You can of course switch the GPS off between flights as you'll never forget to switch it on again will you...

Each supplier's ground receiver battery is good for 10 hours or so and even if it goes flat it will retain all the flight data, so when re-charged it will still show the last transmitted position - this is amusing when you travel to or from an overseas event; I've had 3500kms shown as a distance to my model before!

There are also reports of servos 'twitching' when data transmission happens. This is known to affect the iCare2 system with at least one servo type (Dymond 4.7 or equivalent, eg Ripmax S100) but when only connected via a common battery; I have models that show this effect but it has never affected the trim. Optimal Tracking show a simple modification to the servo wire

on their website that completely alleviates this problem if you have any concerns. In general RF transmissions can cause strange interference so best to check everything works to your expectation before flight.

You also have to be very careful to connect up the GPS transmitter with the correct battery polarity as you can wreck the transmitter if you don't. Don't ask me how I know this...

Toys

As with many electronic goods there are additional 'toys' on offer. In this context the best toy is the ability with the iCare2 unit to download your flights, with the option to show a pseudo 3D altitude, on to GE; I have to admit to liking this and having most (all?) of my GPS flights available to display.

The iCare2 receiver also records all other operating transmitter's data for perusal as shown on the (in)famous 'Szentes Spider' plot of F1A day at the 2017 World Championships, see Figure 7.



Figure 7 "The Szentes Spider' - a plot of iCare2-equipped flights at the 2017 World Championships' - Photo Credit Chris Edge

So this way you can switch from one model to another in either tracking (or in GE display mode) as mentioned earlier. You might think that having all this data would allow you to determine model climb heights and sink rates and even allow remote model timing in competitions but remember that the data is not at a resolution or accuracy that currently allows this. Besides there are better ways to perform alternative model timings - see the 2019 'Free Flight Forum' for a discussion on this very subject !

The Hershkoviz system is a very versatile beast that requires a further look. As well as the GPS tracking facility it has an interface to RCDT that uses the same transmit/receive system as for the GPS data and hence it can operate as an alternative to Bauer, Bodnar, Aeries, and M&K RCDT systems. The ground receiver has a central button that operates the RCDT function, you just need to connect the transmitter unit to your timer's RCDT connection to provide this. The whole in-model package is much smaller and lighter than having two separate units; other suppliers are prototyping similar combined units.

Currently the Pyxis unit has no toys.

Maintenance

There is not too much to do to ensure reliable operation above that of a traditional bug system, keeping the batteries charged is the most important but the iCare and Pyxis systems tell you the voltage of the transmitter battery (and so the timer battery also if common, a very useful feature) as well as the receiver's. As noted the compass in the receiver (or phone/tablet in the case of the Hershkoviz unit) should be calibrated a few times a year, especially if you travel abroad, and there is the option to correct for any magnetic declination errors which are minor unless you go somewhere like Mongolia.

For the Hershkoviz and Pyxis systems that don't save data there is no filling up of memories but remember that iCare2 saves all the model tracks and that of the receiver and so it is wise to delete model and receiver 'trajectories' as they're called after each day's flying or after downloading your flights to display on GE. The issue is really only if you travel to big contests with many users of this system as it will pick up every flight from every transmitter and save

it, useful if you ever need to help someone but otherwise data you don't need; at least it tells you when the memory is getting full and it's a couple of button presses to empty.

Other than that I've found my system very reliable and I know others have as well - they have even survived the odd model crash intact !

Suits you Sir

So I hope I've convinced you that GPS model tracking is the way to go and you've looked at the table earlier, so which do you choose ?

Well to be honest they're all so much better than a traditional bug that anyone is worth having. As all provide the basic positional data to the same accuracy the tradeoff is really down to cost v's added functionality. I personally think mapping is essential as you can use it to avoid hazards via careful use of RCDT and it helps you navigate efficiently to the model, but you don't 'need' it.

The Hershkoviz unit is arguably the best value as you also get a RCDT unit as well but you also need a suitable Android phone or tablet and take that with you along with the ground receiver, but then you do get all the advantages of the Google Maps database when tracking. It can only be used with an electronic timer as the GPS is switched on and off using a servo connection and similarly it needs to be connected to the timer's RCDT signal connection for that functionality to operate. As a new product it doesn't have much user base at present but I expect it will be very popular and reliable. As of writing this I know of no users in the UK or USA.

The iCare2 has a greater user base through longer availability and some UK and USA flying site maps are available from the Optimal Tracking website to avoid duplication and extra work. It will pick up any transmitter automatically so you can help or obtain help from other users if required; this is very useful if on international duty for example. There are quite a number of users in the UK and Europe as well as other countries who can provide support if needed.

The Pyxis unit has the smallest transmitter and has been designed to integrate with the Sidus timer so is an obvious choice for those users. Currently it has the simplest interface with no mapping but this may be added latter as this also is a young product without extensive knowledge of reliability. I know of many users in the UK and USA as well as other countries.

Nudge

If you're still not sure if GPS is the way to go there here are a couple of examples that emphasised the advantages to me.

First, in Hungary at the World Champs 2017 I had a flight in a huge thermal that did over 5mins despite an early DT and which travelled over 2kms. The retrievers didn't hear the walkitalki call that I had flown but heard and saw the flight on a receiver, knew when the model was overhead and subsequently picked it up in the air. I knew when the model had landed, when it had been picked up and when it was time for me to collect it and from where. Overall less stress for me knowing where the model was at all times.

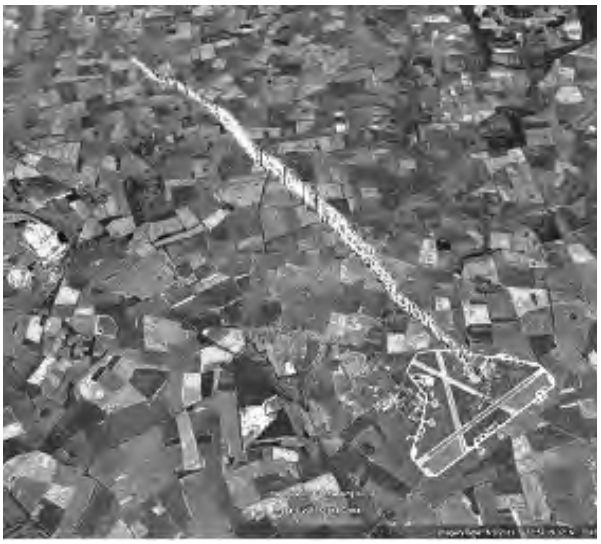


Figure 8 'Google Earth Track of Mark Benns' 14kms flight from Sculthorpe, September 2017 - Photo Credit Mark Benns

Second, at the GB Team Trials at Sculthorpe in 2017 Mark Benns had a flight that wasn't coming down despite a definite DT occurring. The model was tracked for over 14kms to within 23m of the ground, with Mark retrieving the model within 30 minutes; the track of the model being shownin Figure 8. *(previous page)*

With a Biotrack or Walston on board, neither flight would have been retrieved without considerably more effort and greater time, perhaps hours, being expended. So what are you waiting for, order now !

Contact Details for Suppliers

Optimal Tracking :- Frederic Aberlenc, www.optimaltracking.com, contact@optimaltracking.com

Liav Hershkoviz :- https://www.facebook.com/LiavsElecProjects/, liav.he@gmail.com

FF Electronics :- Massimo Ursicino, www.ffelectronics.com, info@ffelectronics.com

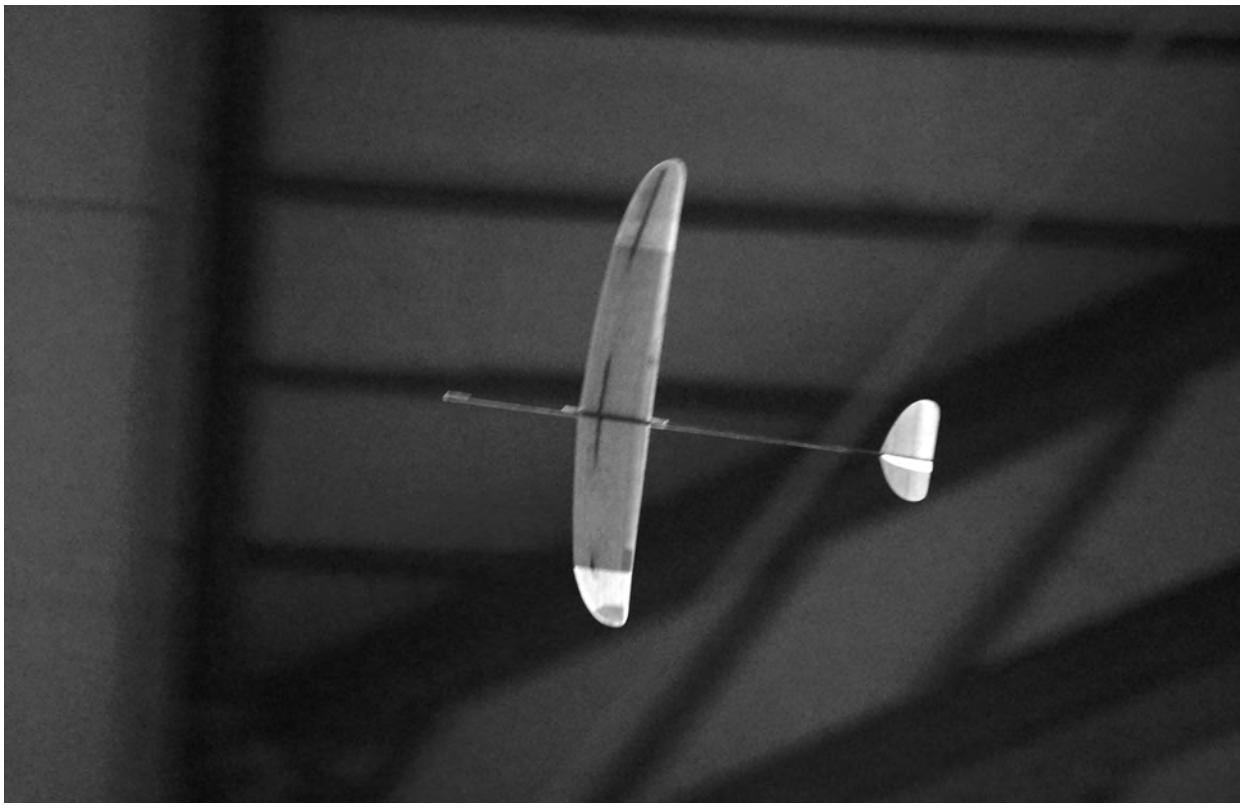
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(1) Baron Julian Pennington - 'GPS - A Position Paper on use in Retrieval', 32nd Annual Report, NFFS, 1999

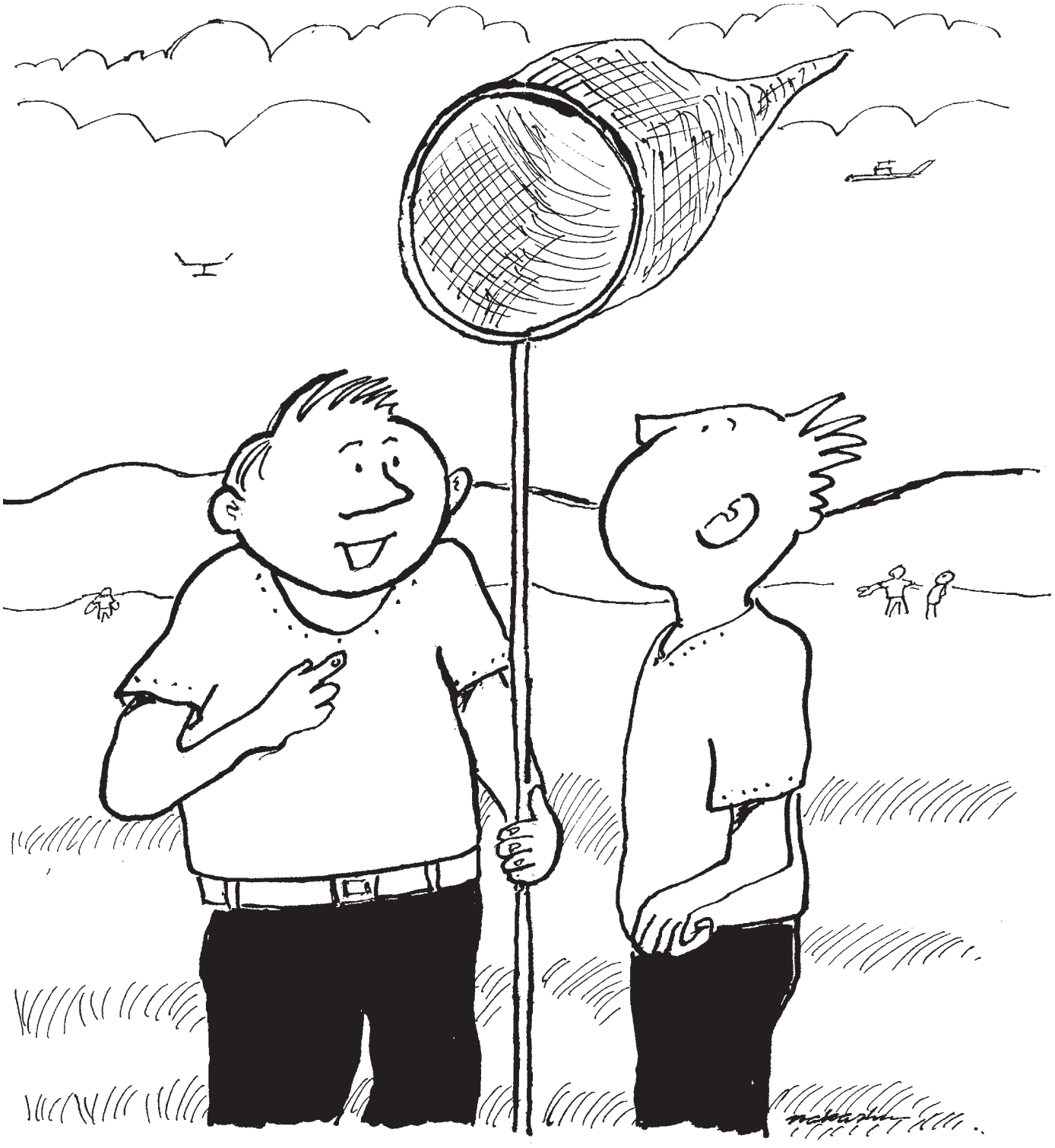
(2) Chris Edge - 'Use and Abuse of GPS Model Trackers', BMFA Free Flight Forum Report, 2018

(3) Map Creating using GoogleEarth - https://www.youtube.com/watch?v=yF68CO-HXig

(4) iCare2 Mapping Database - https://www.optimaltracking.com/en/content/12-downloads



DiscusLaunch Glider 2019 Indoor NATs



"I use it to catch my ideas...."

FLYING F1E

AUTHOR
ROBERT SIFLEET

Class F1E slope soaring glider is a popular class of free flight modeling in Europe. At many of the competition venues, frequently there are 40 or more competitors. Many juniors as well as entire families enter in F1E competitions.

F1E in the United Sates is a relatively under-participated in event that is somewhat overlooked, but it is challenging nonetheless and US flyers should take notice. Gladly, participation in recent years has increased.

The F1E model is basically a free flying glider that has a passive steering mechanism on the front, and it is more challenging than meets the eye. All that is on the flight line are models and the flyers within a specified time limit. One has to be well aware of the flying conditions and the models performance to be adaptive and competitive.

Those who have not seen F1E competitions, usually have the opinion it is a simple hand glide contest. F1E flying, technologically speaking, is simple in comparison to other F1 free flight classes, but one has to be well aware of the flying conditions and the models performance to be adaptive and competitive. In comparison to the support equipment required it is a bit simpler, no starter boxes, fuel, winders, stooges, towlines and helpers are needed. To make a flight, an anemometer (wind speed indicator) and if required, a tool to adjust a magnet powered Steering Fin on the nose of the model, called the "Pilot" (this is not to be confused with the flyer but the mechanism). Yes it is event jargon, but the terms used are the only equipment required at the flight line to make a flight. Much of what is presented has been said before but for purposes of this article it is included.

Part of the attractiveness of flying F1E, is just about any model that glides well can be fitted with a Pilot mechanism and fly competitively. Converted A-2 glider wings make an excellent choice and one notable flyer converted an F1B..

The Pilot and its Parts

See Figures 1, 2 and 3

The nose pod on a typical F1E model is usually a teardrop-shaped unit that contains the steering mechanism, commonly called the "Pilot."

A jewel bearing is used as a pivot located in the bottom center of the nose pod.

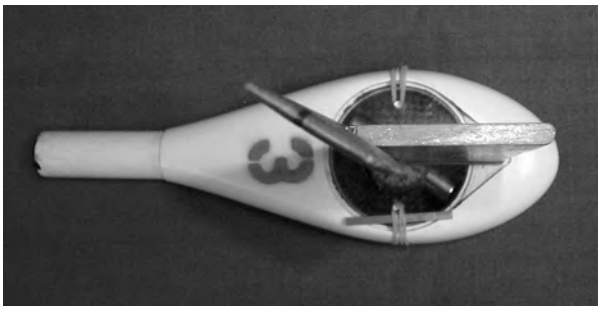


Figure 1. Complete Autopilot

The forward fin is attached to a keyed flat plate that is affixed to the top of the nose pod with rubber bands. This allows the steering fin and the magnet to detach during a hard landing to avoid damage.

The hinged steering fin is attached to the forward fin and the magnet housing is attached

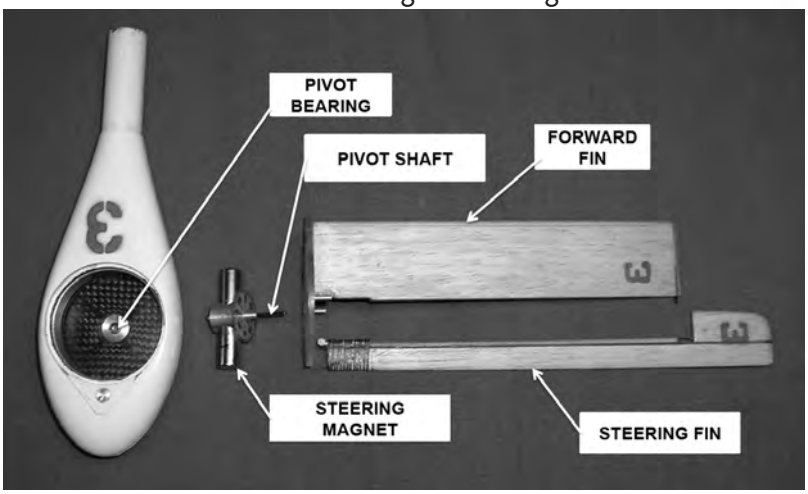


Figure 2. Pilot Pieces: A teardrop-shaped Magnet Housing, Magnet with Pivot Shaft, Forward Fin and Steering Fin

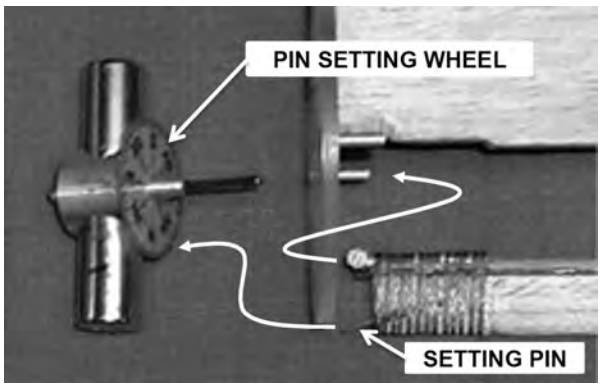


Figure 3 Pilot setup features

to the lower part of the forward fin. A pointed pivot shaft is located on the lower end of the magnet housing and rests on the bearing in the teardrop housing.

How the Model Flies

Setting the pilot relies on understanding how the pilot affects the model. The steering concept relies on the magnet "N" Pole always wanting to point north. The Steering Fin / Steering Fin arrangement creates and "airfoil"

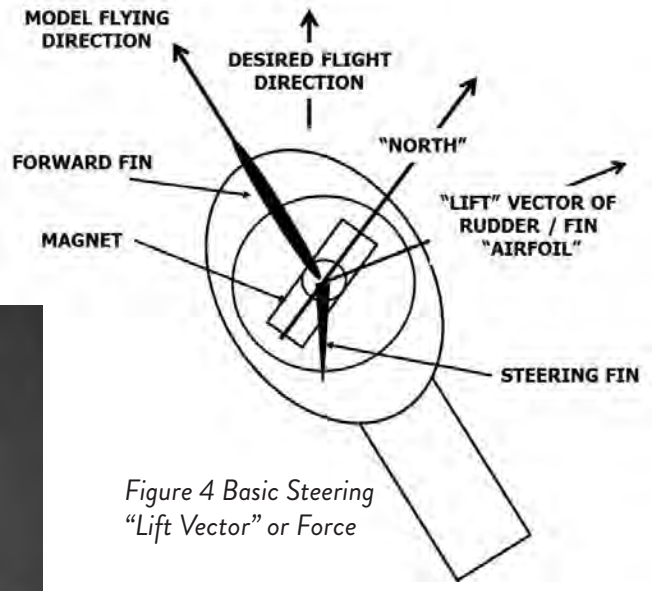


Figure 4 Basic Steering "Lift Vector" or Force

shape and the lift force creates a torque, or moment about the center of gravity hence pulling the nose and "steering" the model back on course. See Figure 4

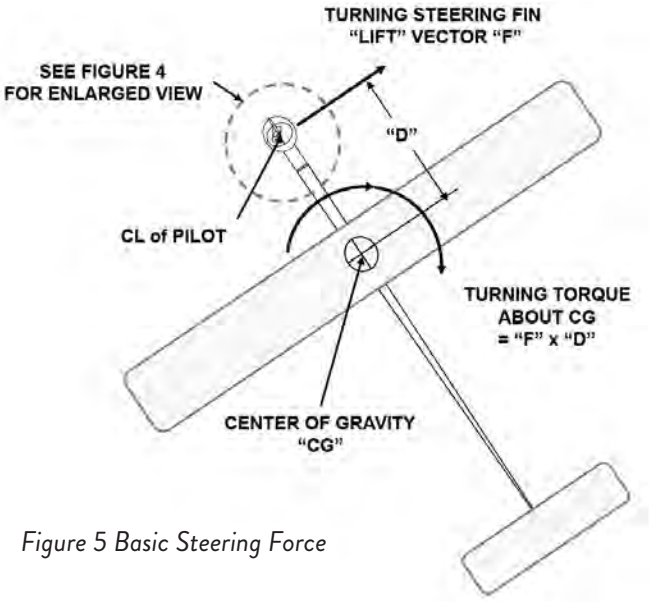


Figure 5 Basic Steering Force

When the model veers off the desired flight direction left or right, the steering magnet will want to "find north" again. The force vector wants to pull the nose of the model back to the desired flight path with a moment arm "D" about the center of gravity creating a turning torque. This is a bit different than the conventional rudder effect of trying to turn the model, but the force effect is the same. See figure 5

Setting the Pilot

The steering concept relies on the magnet "N" Pole always wanting to point north. For Neodymium magnets this force is substantial, more than your basic hardware store magnet, and it acts just like the needle on a compass. Fixing the steering fin to this magnet using a setting wheel and a pin on the fin aligns the magnet with the fin direction relative to the model.

The steering fin is adjusted to be straight with the forward fin with the model oriented in the desired flight direction by holding the magnet assembly in position with a tool and moving the steering fin to be in alignment with the forward fin.

The steering fin wants to be aligned with the desired flight direction of the model and along the model's axis. NOTE: Staying away from ANYTHING magnetic is key to setting the steering fin. Standing near a metal vehicle, motorcycle or auto will affect the pointing. At a recent team selection finals, a flyer just could not get his fin to set properly only to discover a bottle cap stuck to the underside of his nose piece! Point the model in the desired fight direction, free the fin from the magnet setting wheel, let the magnet find "north." Hold the magnet assembly in position, orient the model in the desired flight direction and set the fin.

Various devices can be used to set the steering fin to the shaft, wheel hub collars, screws, but to set the fin on the steering wheel, I use an adjustment tool. The adjusting tool cannot be made of any material that is attracted by a magnet. The tool I use is made of a 2" long piece of 1/8" square bass wood with one end carved to a blunt chisel point. See Figure 6.

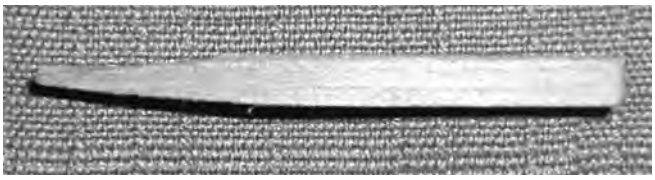


Figure 6 The Steering Adjustment Tool

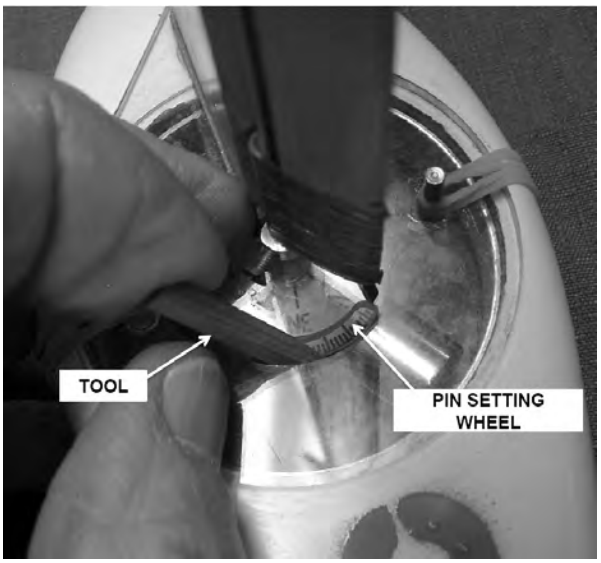


Figure 7 Using the Steering Adjustment Tool to hold the Magnet Assembly

The tool is inserted into a slot in the flat plate and is jammed against the Setting Wheel / Magnet Assembly to hold it steady while the steering rudder is being positioned. Move the steering fin to be in alignment with the forward fin. See Figure 7.

The desired final alignment of the Steering Fin to magnet should be "free" and aligned as shown in Figure 8 when pointed in the desired flight direction.

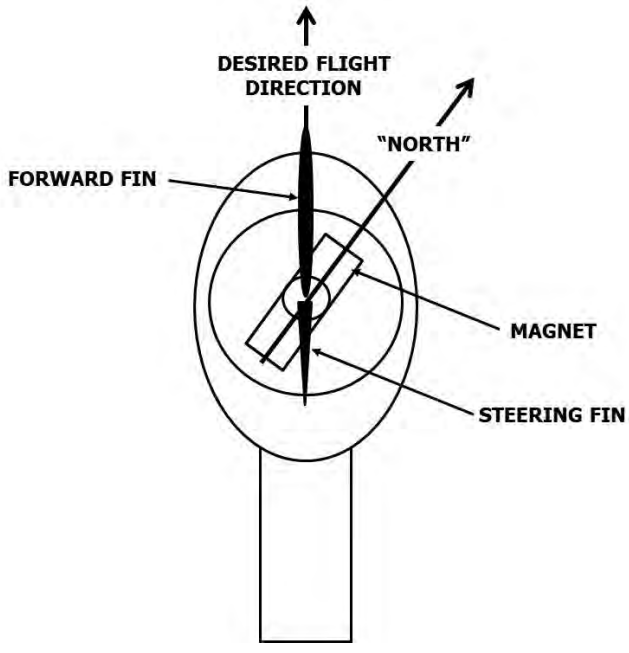


Figure 8 Pilot Steering Fin Setup

Flying F1E

When an F1E model is launched for a flight, it enters a complex environment. The wind velocity and direction to the slope, the slope shape, and the amount of lift over the slope, the upwind terrain as well as the thermal activity are the dynamic influences on the flight duration. This is the challenge of F1E. Knowledge of these influences on the flight and the ability to analyze the models flying upwind is required to achieve the desired flight time.

English Units					
Model Type	For Wind Speed (mph)	Wing Area (sq-in)	Weight (oz)	Wing Loading (oz/in-2)	Glide Speed (mph)
Large, Slow, High duration	0-2	930	21.89	0.0235	4-6
medium Speed	2-10	665	19.42	0.0292	8 - 9
High Speed	9+	650	21.18	0.0326	12
Metric Units					
Model Type	For Wind Speed (m/s)	Wing Area (dm2)	Weight (grams)	Wing Loading (grams/dm2)	Glide Speed (m/s)
Large, Slow, High duration	0-.9	60.0	620	0.0968	1.8 - 2.7
Medium Speed	.5-4.5	42.9	550	0.0780	3.6 - 4.0
High Speed	4	41.9	600	0.0699	5.4

Figure 9. Suggested Model configurations for Flying Conditions

At a Contest

To start, one needs to know what models are in a contestant's model box. Most competitors have 3 to 5 models. As the FAI rules allow 5 models for a 5 flight contest, each model could be for specific flying conditions. There are 3 basic types of models:

1. Slow speed high duration for use in calm and light breeze.
2. Medium speed for 3 to 10 mph. Wind.
3. High speed for 10+ mph wind.

The current FAI rules for F1E are:

Characteristics of Gliders with Automatic Steering F1E		
Maximum surface area (St)	150 dm2	2325 in-sq
Maximum wing loading	100 g/dm2	0.225 oz/in sq
Maximum flying weight	5 kg	176.37 oz (11#)

For various flight conditions, Figure 1 shows configurations of the 3 commonly models flown.

Know Your Model

To determine the glide speed of a model, launch it from a low hill of about 10 ft height on a calm evening and time the flight. Then measure the distance flown and calculate the glide speed by dividing the distance flown by the duration.

Choosing the correct Model to fly

The large model with a low wing loading is the best to use in calm and slight breezes. Some modelers use larger models as described in fig. 1 to fly in calm conditions. The typical max of 300 seconds is easy light thermal activity achieved on a slope of 200 feet in height.

Turbulence on the slope from a breeze of 2 mph or greater and light thermal activity is problematic for the large models. The pilot can be overpowered by a large model that encounters wind shifts or turbulence resulting in in the model turning, and recovery to the desired flight direction is a slow process. When this happens, a 90 to 180 degree turn can occur and the model can land on the slope before it can return to the desired flight direction.

A medium speed model can also be flown in calm conditions but is normally flown in turbulence and wind velocity of up to 9 mph. If a medium speed model cannot make forward progress from the slope, adding ballast will increase the glide speed slightly.

With the wind speed exceeding 10 mph. A high speed model should be flown. These models commonly use semi symmetrical airfoils, and can fly in a wind speed of 10 to13 mph without adding ballast.

Analyze the Slopes Before the Competition

Test flying on the competition slope to learn the lift characteristics of the slope and surrounding

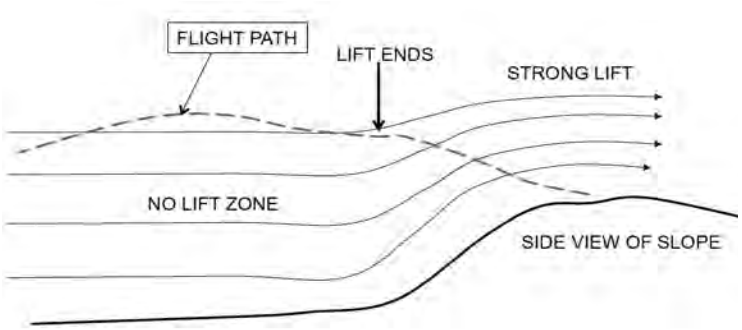


Figure 10. F1E Simple slope

terrain is important to learn how to fly on the site. Observing other flyers, particularly local modelers to see how they handle the flight conditions is always good practice.

1) A simple slope is a hill 200 ft high with a slope angle of 30 to 40 degrees with no hill within ½ mile directly up wind. See Figure 10
2) Should the wind come from a direction other than perpendicular to the slope, the model should be flown at an angle between the wind direction and the slope. This is necessary as the lift ends a short distance from the slope, and flying the model directly into the wind will result in the model eventually being forced into the slope. This is a tactic that must be practiced to learn the proper angle to the wind that will achieve the desired result. See Figure 11
3) If there is another hill a short distance upwind of the launch site, the band of lift could be narrowed and possibly blocked by the wind following the contour of the hill. This may make it necessary to fly to the side of the wind similar to figure 11 to stay in the lift. Figure 12 shows the dynamics of lift when this occurs.

Organization of a Competition

The flight line is usually located 50 or more feet down from the top of the slope and is placed parallel to the slope. This is done to avoid starting flights in the turbulence that frequently occurs at or near the top of a hill. There are usually 10 or more pole positions each with 2 dedicated timers. These timers are frequently well trained and are experienced at timing F1E models. At one end of the flight line there is a table for scoring and has a clock and information on the start and end of rounds. The max for each round is clearly posted there.

An official who has the score cards is stationed near the scoring table. Before a round starts, the contestants form a line starting at the official's location. At the start of a round the contestants are assigned to a pole position and the flight cards are given to the timers.

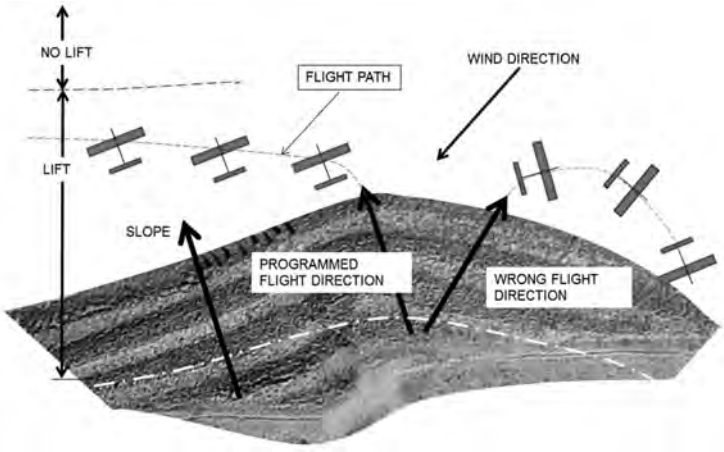


Figure 11 Variable Slope Wind Directions

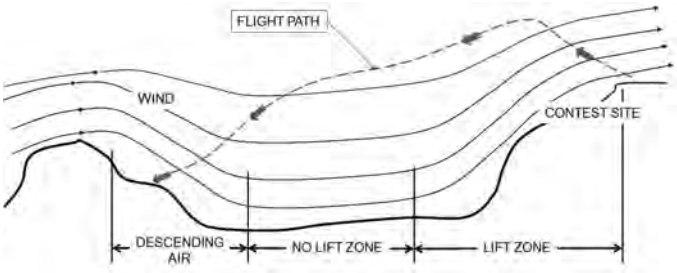


Figure 12 Front Hill Profile

The contestants proceed to their assigned pole and upon arriving the 5 minute window to launch their models starts. If a contestant chooses not to fly in the time allowed, he returns to the back of the line and the flight card is returned to the official and the next contestant in line is assigned to that pole position. No attempt is charged to the contestant unless he launches his model. Then the contestant waits in line for his turn to be assigned to a pole position again. The maximum time for each flight is

normally 300 seconds, but if flying conditions are less than desirable, the max time can be reduced to 240 or 180 seconds etc. as required. Scoring is done in a special manner. For each flight the score in seconds is divided by the max time in seconds. If a max time is 300 seconds and the flight time is 300 seconds the score is 100. If the flight time is 150 seconds then the score is 50, etc. This allows for changing the max times without an advantage or disadvantage for any contestant.

Starting a Flight

Before getting in line to fly there are several things to consider instead of using the 5 minute flight window to prepare for the flight. Using an anemometer, check the wind velocity and choose the proper model to fly. Then carefully determine the desired flight direction and set the pilot accordingly.

If the wind velocity is higher than a large model should be flown, then use a medium speed model.

A medium speed model may require ballast if the wind is within 2 mph of it's flying speed. A small amount of ballast, 35 to 50 grams may be enough if the wind speed and the model speed are nearly the same. A short test flight should be flown to determine the proper ballast required to have the model fly into the wind. If the model cannot make forward progress away from the launch location, more ballast is needed to increase the glide speed.

Ballast weights of 100, 150 and 200 grams are commonly used. The weights are easily attached or changed using hook-loop tape fasteners on the weights and boom under the center of gravity. Adding more than100 grams of ballast to a model will make it fly faster but the glide sink rate will also increase when the ballast increases the models weight by 20 percent or more. Now, a high speed model should be flown.

If ballast required for a high speed model to prevent it from flying backwards in the wind, the same procedure for adding ballast as for medium speed models applies.

On the Flight Line

With only 5 minutes to fly, there are other important considerations before launching the model.

On a calm day watch streamers for evidence of light thermal activity. If there the streamers are showing evidence of light lift and if there is a soft varying breeze, it should be a good time to fly. At that time models upwind should be holding altitude or rising slowly. With a steady breeze of 3 mph or more there should be good consistent lift present.

If the breeze is not steady, there may not be good lift in the calmer periods. When good lift is present, models will proceed slowly forward and attain altitude until flying beyond the lift created by the breeze being forced up the slope.

A thermal upwind can be found by watching other models. If a model or models flying upwind suddenly starts rising rapidly and experiencing some turbulence, it is in a thermal. When the model flies beyond the thermal, it will dramatically loose altitude until it flies beyond the downdraft behind the thermal. The challenge here is to set the pilot to steer the model to the thermal.

Before launching, check the pilot to be sure the flight direction for the conditions at that time, and determine the need for ballast needs to added or removed. Finally, be sure there are no other models are too close by before launching.

What Type of Launch

A simple hand glide has been used since the beginning of F1E flying. However, if the slope is shallow or is uneven, turbulence and cross currents of wind low to the ground can defect a low flying model into the ground shortly after launch. To prevent such an occurrence, there other launch methods recently developed. Three are presented here.

Bunt Launch

For a bunt launch, the models are set up with a small amount of positive incidence in the stab. The model is launched quite hard at a steep angle. After a programmed time of 1.5 to 2 seconds, more angle of attack is applied for 1 to 2 seconds. At this time the model is at a normal glide attitude and the stab goes to the normal glide setting. Yes, a model of over 950 square inch wing area that weighs 1 ½ pounds can be thrown nearly vertically with enough speed to bunt. A bunt launch with a middle speed model can attain 15 feet or more of altitude. This height is enough to get the model above the ground turbulence.

Arc Launch

A bunt launch not executed properly can have undesirable results. So the arc launch evolved. The models stab is set for high positive incidence. The normal amount is 3/8 to ½ inch down at the stab trailing edge. The launch is a hard throw to 30 to 45 degrees up. The model flies an arc up and over to a level position normally taking 3 seconds then the stab returns to the glide setting, and the model glides away. If there is good lift on the slope, launches of 20 or more feet can be attained.

High speed Launch

For high speed models, there is a different approach for a launch to quickly get the model away from the turbulence and strong wind close to the slope. The stab is set for a small amount of positive incidence, about 1/16 to 3/32 down at the trailing edge. The model is launched fast and flat or slightly down directly into the wind. This makes the model fly faster than normal and a little down to get the model away from the slope into smoother air. The stab ts is allowed to return to normal glide trim after a preset time. Normally, 5 to 15 seconds is enough, but under high wind and strong turbulence 1 minute or more may be required.

The Flyoff

Should 2 or more contestants achieve the same high score, a fly off is required to determine the winner. As with other F1 FF classes a longer flight is scheduled, but the task becomes more difficult for F1E models. The flight line is moved ½ the distance or more toward the bottom of the slope. This makes the challenge of obtaining the max usually quite difficult. If a 2nd fly off flight is required, the flight line is moved further down toward the bottom of the slope.

Conclusion

F1E flying is a rather relaxing low stress event.

Imagine flying a model airplane from the top of a hill in a low alpine setting where the skills required to master competitive flying in this environment are more complex than for other free flight models.

The first round of a contest usually starts at 10 AM. Each of the 5 rounds can present a unique set of challenges to be mastered to achieve the desired flight results. To achieve a perfect score is quite rewarding and if necessary, a fly off will occur.

For competition F1E flying there is a handicap used for fly offs that presents different challenges by moving down the slope to a lower starting height. This challenges the actual glide duration capability of the model as well as the modelers' choice of what flight path is desirable. By 5 PM the contest is finished, awards presented and the competitors are sipping wine and discussing what the correct tactics of the day were.

(1) Portions of this article were extracted from Robert Sifleet Introduction to F1E Model Aviation, June 2006 pp 45-47.



PERFORMANCE TESTING OF F1C PROPELLERS.

AUTHORS
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JAMES DELAURIER

Introduction

The direct drive propellers on F1C models typically operate about 30,000 rpm statically and may gain a further 10% or more at the top of the climb. Airfoils near the tips of the propeller blades will experience high local airspeeds resulting from the combination of propeller rotation and forward flight. The local Mach numbers can become greater than 0.8 and are high enough for flow on the airfoil surface to become transonic i.e. Mach number >1 and shockwaves will arise. The airfoils used on today's F1C propellers were not designed to be efficient at transonic conditions and as a result the shockwaves will be very strong causing increased drag and significant losses in propulsion efficiency.

The purpose of this article is to describe wind tunnel testing to measure the performance of three carbon folding propellers, two obtained from Babenko and the other Sychov. The data collected will be used as benchmarks for evaluating the performance improvements from future new propeller designs using supercritical airfoils.

It is essential to have access to a suitable wind tunnel for such work. Fortunately for us, retired Prof. James DeLaurier who is an ex free flight aeromodeller, has one in his basement that could be adapted. He generously allowed us ready access and he is also providing valuable experience and test support for the project.

The second crucial need for propeller testing is a reliable balance for measuring torque and thrust simultaneously, along with related software for processing the data. The recent surge of interest in small civilian drones using propellers has brought to market a suitable propeller test stand. The RC1870 thrust/torque balance is made by RCbenchmark, ref. 1, and it also provides the motor control system and data logging capability needed for testing.

The paper describes the modifications made to adapt the DeLaurier wind tunnel for F1C propeller testing. Examples are provided of the measured thrust, power and efficiency obtained for the three F1C propellers as propeller rpm and airspeed are varied up to their respective maximum values of 30,000rpm and a wind tunnel airspeed of 18.9 m/s.

DeLaurier Wind Tunnel

The wind tunnel uses an open jet type of test section with the airflow returning to the front entry via the space between the tunnel exterior and the basement walls. The model testing is done downstream of the exit nozzle in an unobstructed area that provides easy access for model setup and adjustments, see figure 1

The tunnel has a 30" (0.76m) diameter two bladed fan at the front in a 31" (0.79m) diameter duct, see figures 1and 3, followed by a settling section and a fine honeycomb screen to straighten the flow and reduce turbulence. There is some further flow conditioning followed by the final nozzle which is 22" (0.56m) high by x 25" (0.64m) wide in cross section.

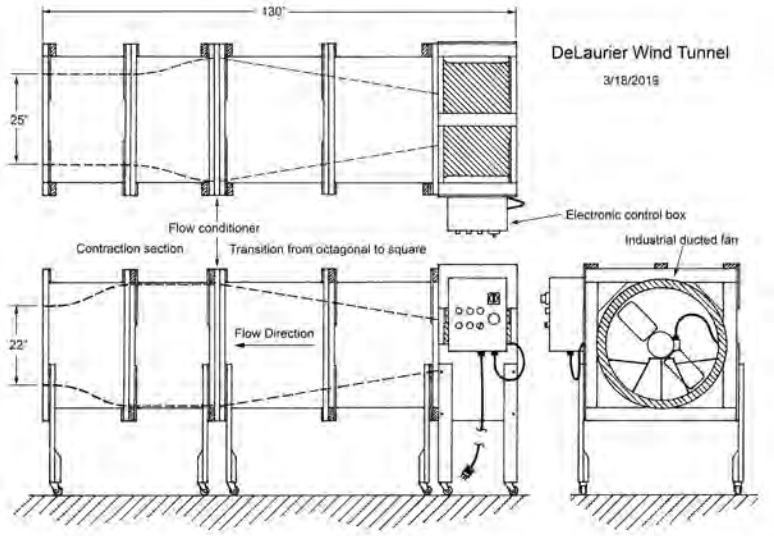


Figure 1, Layout of DeLaurier Wind Tunnel

The fan motor is rated at a maximum of 2.0 shp at 1750 rpm. The fan uses two blades with near constant width that are simply made from untwisted sheet metal with a uniform curved arc profile for the airfoil. Pitot survey mapping the exit velocity profile from the standard nozzle show that good uniformity is achieved . The maximum speed for this configuration is about 12 m/s. No turbulence measurements have been made but they are unlikely to be good enough for extensive laminar flow on airfoils at low Reynolds numbers.

In order to increase nozzle speeds for propeller testing a contraction was made that gives a nozzle diameter of 1 ft. which results in a contraction ratio of 4.2:1. An image showing the contraction in place on the tunnel exit is given in figure 3. The large area reduction should reduce turbulence levels in the jet significantly. The maximum nozzle speed with this configuration only increases to about 19 m/s as the fan becomes overloaded and it is operating well beyond its' design condition.

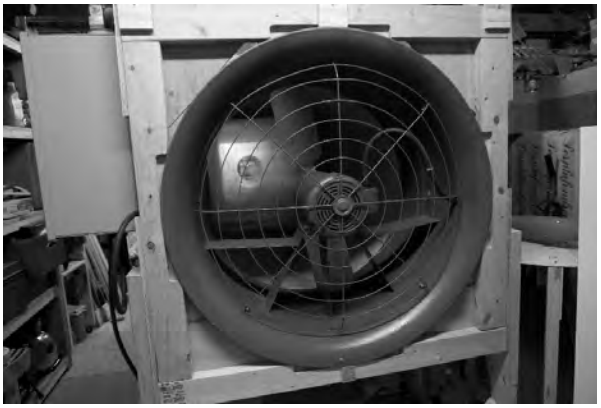


Figure 2, Front Fan Mounting



Figure 3, New Exit Nozzle

Thrust/Torque Balance, Motor and Power Supply

The motor and balance installation used for the tests is shown in figure 4. The motor is mounted on extensions that stand out well ahead of the balance to avoid any interference from the rig on the flow through the propeller disk.

The thrust/ torque balance used is the Series 1580 made by RCbenchmark , reference 1, and it is shown in figure 4 with the motor and test propeller mounted. It uses a single vertical straingaged beam in bending for measuring the thrust while the torque is measured using two fore and aft horizontal beams disposed equidistant from the thrustline. The data acquisition board sits on the stand behind the propeller/ motor. It collects data on the torque and thrust outputs, motor rpm, the supply amps, volts

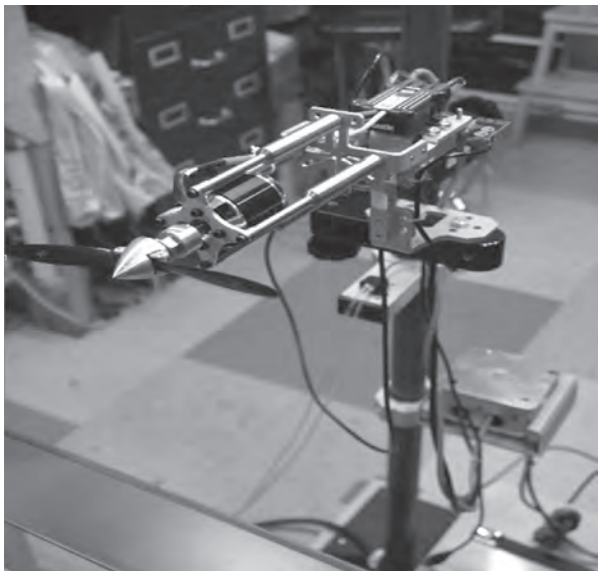


Figure 4, Motor and Balance Test Rig Installation

and motor temperature. These data outputs are passed to a PC via a cable and a USB port for analysis and recording. The software package provided for analyzing the data is comprehensive and it was found to be reasonably user friendly.

The motor and balance installation is uncowled and quite irregular in shape so it creates considerable aerodynamic drag which in turn reduces the apparent thrust shown by the balance. As a result the raw thrust measurement has to be corrected for the test stand drag and the procedure currently used will be presented later in the discussion of results.

Modern F1C motors are supposed to develop about 1 hp at 30,000 rpm. After surveying the available outrunner motors the Scorpion HK-4015-1070 was selected for powering the propeller. A Mastech HY3080 switching power supply rated at 30 volts and 80 amps is used as the power source. The motor rpm is controlled using a Castle Phoenix Edge Lite unit rated at 75 amps. Control of the rpm can be done manually via the PC or by using the software to set the up and down rates for ramp changes in the rpm.

It is found that operation at rpms greater than about 30,000 can run into problems with premature shutdown of the motor. This appears due to electrical noise from the leads of the switching power supply interacting with the balance's circuit board when operating at high power/rpm. Several ferrite choke coils were inserted in the power leads which attenuated the noise signal by a factor >10 but the shut-downs still persist. Work continues on looking for solutions.

Balance Installation Drag and Thrust Corrections

The aerodynamic drag of the balance without the propeller in place was established by tests with the motor in place and the propeller off. The following chart shows the test stand drag values measured as tunnel speed is varied from 5 to 18.6 m/sec. The drag results closely follow a quadratic relationship with airspeed as given by

$$D_b = 0.0007.V^2 - 0.0002.V + 0.0006 \quad (1)$$

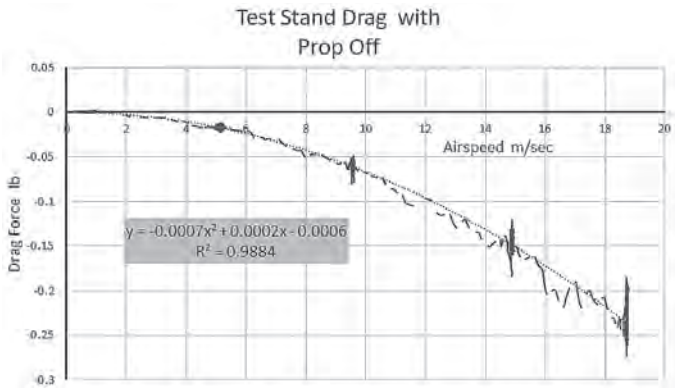


Figure 5, Balance Installation Drag Test Results

The other source of test rig drag comes from the increase in velocity within the slipstream created by the prop thrust. Propeller momentum theory shows that the average slipstream velocity, Vs, in the fully contracted slipstream behind a prop having a thrust loading of T/A (actual prop thrust/disk area) in a freestream velocity of V, is given by

$$V_s = ((T/A)/(\rho/2) + V^2)^{0.5} \quad (2)$$

The value of the propeller's actual thrust is then found using

$$T = T_{stand} + D_b \quad (3)$$

The raw value of thrust from the stand is used

to calculate the first estimate of slipstream velocity from equation (2) which enables an updated balance drag to be found using equation (1), then using equation (3) to update the first estimate of the actual prop thrust. The procedure is iterated three times to obtain a converged value of the actual thrust.

However, note that this method of correction is a simplification as the prop thrust will not be uniformly distributed over the whole disk, also there is swirl present in the prop slipstream flow and also the drag producing features of the rig are irregular in their shape and location.

In the more sophisticated test arrangements used by industry the balance and test stand are usually tightly enclosed inside smooth cowlings. They give low external drag and minimize the thrust losses arising from the installation. Prior experience shows that the test stand drag can be reduced to 2-3% of the measured thrust when using well streamlined nacelle arrangements. Most probably cowlings will be needed in the proposed future testing at higher airspeeds.

Propeller Performance Comparisons

Three propellers were tested, two by Babenko (#1 and #3) and the other by Sychov . The #1 Babenko propeller has been found to give the best climb performance so far by Shvedenkov in his flying and it is preferred. The Babenko #2 propeller has yet to be ground or flight tested.

The detailed test results obtained here are tabled in Appendix 1. The airspeeds tested were about 5, 10, 15 and 18.9 m/s at a prop rpms of 28,000 and 30,000. The variation with airspeed of the corrected propeller thrusts, the power required and the corresponding propeller efficiencies are shown the following figures.

The propeller thrust data in figures 6 and 7 show the Babenko #1 prop gives the lowest thrusts at both the 28.000 and 30,000 rpm conditions while the Babenko #3 prop was the highest and the Sychov propeller has intermediate values. The corrections applied to the raw balance thrusts are shown in the Appendix and they are typically about 1.1 lb in value which is about 25% increase in thrust at the highest airspeed tested.

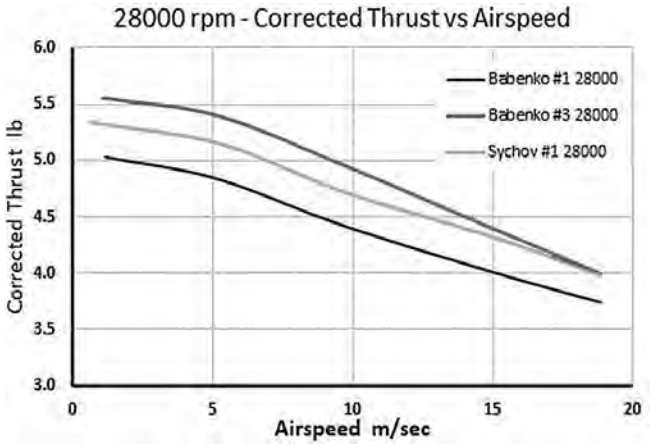


Figure 6, Comparison of Propeller Corrected Thrusts vs Airspeed at 28,000 rpm

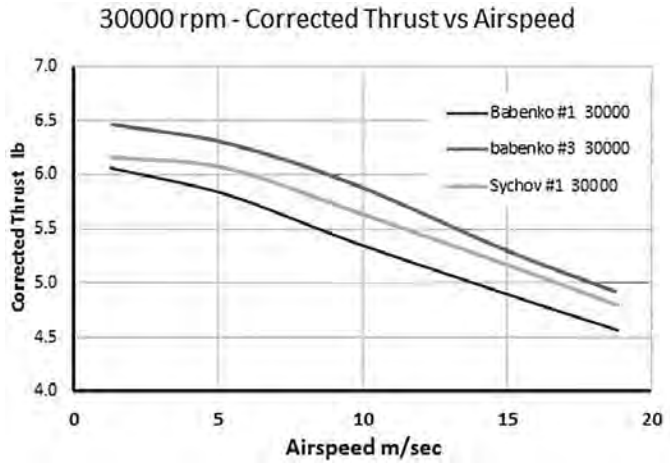


Figure 7, Comparison of Propeller Corrected Thrusts v's Airspeed at 30,000 rpm

The propeller power requirements are plotted in the following figures 8 and 9. The Babenko #3 prop requires substantially more power than the other propellers which readily accounts for its' greater thrusts. At static conditions it requires 20-25% more power than the Babenko #1 and about 10% more at the highest airspeed tested. Consequently in an F1C model the static rpms could be reduced by about 2000 and in flight about 1000 depending on the engine.

The power data for the 30,000 rpm shows anomalous behavior for the Sychov propeller as it does not reduce with airspeed as expected. Its

power required falls intermediate between the Babenko #1 and #3 at the static condition and also at the top airspeed tested but the power increases at intermediate speeds. This anomaly will require repeat testing to be done.

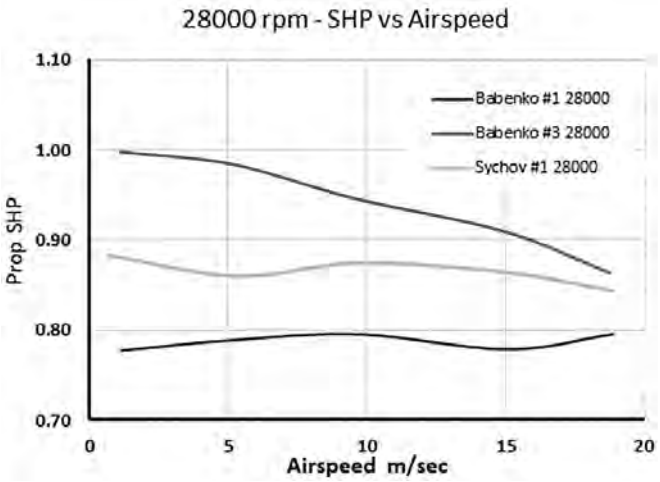


Figure 8, Comparison of Propeller Power required v's Airspeed at 28,000 rpm

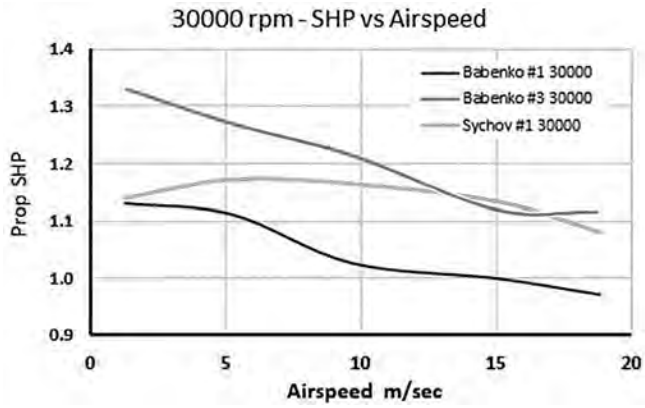


Figure 9, Comparison of Propeller Power Required v's Airspeed at 30,000 rpm

The corresponding propeller efficiencies are presented in figures 8 and 9. The Babenko #1 propeller shows significantly greater efficiencies than the other two propellers. It is found that the propeller efficiencies do not reduce dramatically at the highest airspeeds and rpms tested here so it appears the high tip speeds and local Mach number effects are not yet having an impact in this range of conditions. Future tests at 10% higher rpms are proposed to explore such effects once the test rig issues with premature shut down are resolved;

The corrected thrusts and the raw balance data tabled in the Appendix show that the balance drag corrections are 15-20% of the corrected thrusts which is a very high proportion. This indicates that future tests planned at airspeeds up to 40 m/s and at 10% higher prop rpm will require the balance system to be enclosed in fairings to reduce the drag penalty and corrections involved.

Thrust Performance in an F1C Model

The front end of an F1C folder model is quite untidy for drag even with a cowled engine. With a folded wing the airfoil section in the slipstream is very thick and at the wing junction with the body side there are untidy gaps from the wing folds. Also downstream the tailplane lies in the slipstream creating added drag. Accordingly it is conceivable that the thrust loss created by drag in the slipstream represents more than 10% of the corrected thrusts that are given here.

Future Plans

It is planned to upgrade the wind tunnel so that tests at speeds up to 40m/s are possible. A new three blade fan is being designed using airfoils similar to current F1A designs. The motor rpm will be increased and a modern inrunner motor giving about 5 shp output will be used. The tunnel airspeed is currently being controlled by hand, taking significant time. An airspeed controller is required so speeds can be preset and controlled automatically.

Closing Remarks

A new propeller test rig has been created that allows measurements of thrust, torque and efficiency of F1C propellers to be made in a small wind tunnel at airspeeds up to 19 m/sec. Preliminary tests on propellers by Babenko and Sychov gave encouraging results. It was found that :

1). The present test set up experiences large drag losses from the bluff shape of the exposed test stand. The resulting thrust corrections

required are quite large, approaching 20% and they reduce accuracy of the measurements.

2) This may be acceptable for initial comparisons at the airspeeds tested here but at the higher airspeeds planned of 40m/s the test stand will require cowlings to improve accuracy.

3) The efficiencies measured for the Babenko #1 propeller are the highest and its power requirements are the lowest of the three types tested. A selection of the best propeller option for F1C will be based on obtaining the best match with the power curve of the engine being used and thus far the Babenko # 1 is found the best for climb height.

4) At the top airspeed and rpm tested there was no sign of prop efficiency falling off so transonic effects are not yet significant.

Nomenclature

ρ	air density
A	propeller disk area
D	propeller diameter
D_b	drag of balance
rpm	propeller rotational speed per minute
RN	Reynolds number
T	propeller thrust
V	wind tunnel airspeed
Vs	propeller slipstream airspeed

References

1. RCBenchmark link:
https://www.rcbenchmark.com

Appendix #1

Note the following table also includes a Babenko #2 propeller that was only tested statically and at the maximum wind tunnel airspeed conditions.

Table of Results and Analysis

	rpm	Airspeed m/s	Thrust lb Uncorrected	Power W	Power SHP	Thrust lb corrected	Prop Efficiency
B-1-Static-28000	28011	1.17	4.076	579.7	0.777	5.036	0.045
B-1-5-28000	28000	5.10	3.895	588.5	0.789	4.846	0.187
B-1-10-28000	27893	9.69	3.506	593.7	0.796	4.421	0.321
B-1-15-28000	27937	15.07	3.078	580.7	0.778	4.003	0.462
B-1-19-28000	27967	18.86	2.775	608.7	0.796	3.736	0.528
B-1-Static-30000	30082	1.25	4.888	843.0	1.130	6.057	0.040
B-1-5-30000	29991	5.23	4.677	828.9	1.111	5.817	0.163
B-1-10-30000	30012	9.66	4.277	766.1	1.027	5.376	0.302
B-1-15-30000	30027	14.95	3.805	746.7	1.001	4.901	0.437
B-1-19-30000	30047	18.84	3.443	725.5	0.973	4.563	0.527
B-2-Static-28000	27951	1.28	3.787	603.1	0.808	4.691	0.044
B-2-19-28000	28027	18.67	2.456	537.3	0.720	3.334	0.515
B-2-Static-30000	29946	1.40	4.407	740.3	0.992	5.461	0.046
B-2-19-30000	30016	18.71	3.127	705.2	0.945	4.167	0.492
B-3-Static-28000	28058	1.10	4.489	744.0	0.997	5.562	0.037
B-3-5-28000	28043	5.17	4.347	733.6	0.983	5.406	0.170
B-3-10-28000	28065	9.56	3.957	705.2	0.945	4.977	0.300
B-3-15-28000	27994	14.90	3.410	678.1	0.909	4.410	0.431
B-3-19-28000	28006	18.74	3.000	643.5	0.863	4.010	0.519
B-3-Static-30000	30065	1.34	5.221	992.3	1.330	6.470	0.039
B-3-5-30000	30027	5.28	5.064	946.9	1.269	6.297	0.156
B-3-10-30000	30075	9.65	4.715	906.4	1.215	5.920	0.280
B-3-15-30000	29925	15.04	4.118	835.5	1.120	5.292	0.424
B-3-19-30000	30041	18.73	3.732	833.2	1.117	4.918	0.492
S-1-Static-28000	27962	0.62	4.310	659.3	0.884	5.338	0.022
S-1-5-28000	27924	5.29	4.136	641.4	0.860	5.147	0.189
S-1-10-28000	27938	9.65	3.749	652.5	0.875	4.722	0.311
S-1-15-28000	28010	14.98	3.336	644.7	0.864	4.320	0.447
S-1-19-28000	28035	18.83	2.973	629.0	0.843	3.980	0.530
S-1-Static-30000	29917	1.27	4.970	850.0	1.139	6.158	0.041
S-1-5-30000	29987	5.20	4.874	874.1	1.172	6.061	0.160
S-1-10-30000	29953	9.76	4.502	868.3	1.164	5.657	0.283
S-1-15-30000	29969	15.05	4.018	845.3	1.133	5.168	0.409
S-1-19-30000	29925	18.86	3.634	804.9	1.079	4.801	0.500

A NEW F1Q DESIGN WITH GEARED MOTOR AND F1B PROPELLER*

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Preface

In this article I want to describe my new F1Q model.

In 2018 I made my first F1Q with a geared motor. The experience of Israeli modeler Omri Sirkis has shown that a geared motor with F1B blades has a great advantage in F1Q. I designed and flew with a non-geared model in 2017 and can therefore compare my results with his models. Usual non-geared model can reach 120-130m altitude using 3 Joules per gram of its weight; geared models have a height advantage of 20-30 meters. In regular 5 or 7 rounds the non-geared model can stay in the competition, but in a fly-off with 2 Joules per gram, the higher efficiency of the geared propeller is an advantage that makes the geared motor unbeatable.

Introduction

I have been making F1Q models since 2007. My first models were straight climb, bunt models... small "electric" F1C. But when rules were changed with extension of motor time to 40 seconds, the age of straight climb models was over. It became obvious that using all that 40 seconds of motor run for climb would give better results. Well known from model aerodynamics, decreasing climb speed yields decreasing total drag of the model.

Lowering the models speed implied to me that this could be done by lowering propeller RPM with increasing propeller size. A bigger propeller with lower revolutions is more effective on the low speed flight.

This was demonstrated in a detailed article by Aram Schlosberg and Dave Lacey in the NFFS 2016 Symposium Report2.
In 2017 I began to design a model with geared motor and a big propeller. Previously I did not make F1B models, so I decide to make my own design of propeller blades. It have more usual shape and reinforcement root part that make possibly to use "early" mechanical stop. Early fold of the blade make some advantage and make possible to reach additional altitude after motor stop. This models test flights had very encouraging results.

New front end

Main parts of this model are a new front end and a new propeller. I decided to use the well-known German Reisenauer 5:1 ratio gearbox with the widely-used 2212 stator size outrunner motor of 55-58gr weight and 1000kV. I chose the Sunnysky X2212 980kV outrunner motor, as it has good quality and a realistic price. Also it can be easily found in online stores.

(Portions of this article have been excerpted from an article published in Free Flight Quarterly, Issue 69, October 2018 and reprinted with permission)



Figure 1 Front view of the Sunnysky motor and Reisenauer gearbox, with the adjustable mounting ring



Figure 2 Rear view of the Sunnysky motor and Reisenauer gearbox, with the adjustable mounting ring

Propeller

For definition of propeller size I used eCalc, a well- known online program. Propeller blades were made using standard F1B technology, balsa core reinforced by 80g/m Textrem carbon cloth.



Fig 3 View of the propeller blade, built with a balsa core and carbon cloth covered

The root part of the blades were reinforced by carbon rowing, and the blades have standard joiner size: 8mm wide and a 3mm axle diameter. An adjustable hub makes it possible to change blades angle. Default diameter is 580mm (23") and pitch 580mm (23") which can be increased to 650-680mm (26"-27"). Connection of motor tube with front end was made adjustable too. It is possible to change the motor angle to 2-4 degrees right and 3-4 degrees down.



Fig. 4 A light alloy hub with adjustable pitch facility and stylish spinner.

The propeller can be stopped by an electric and mechanical brake in that order. The mechanical brake has a 2mm steel pin that stops the blades in the correct position 0.3 sec after the electric brake. The steel pin is controlled by a nylon line which connects with the "F1C' style timer. This timer controls the stabilizer and rudder position via nylon lines too. An extra servo operates on left wing to decrease wing angle by 0.6-0.8 degrees during climb.

The front end is made from 2 layers of 160g/m Textrem carbon cloth with some reinforcements. I use Castle Creation Talon 15 ESC and 2 cells GensAce 850mAh battery. The Servo used was Blue Bird BMS-101

Adjustments

Main adjustments of this model are made by adjusting the thrust angle of the motor. The front end and motor tube joint has basic 3deg down thrust setting and an extra conical spacer ring can be added between the two main parts. This conical spacer can add from 2 to 4° additional slant. It can add 3-4° right and 3-4° down thrust adjustments. The model needs 3° right motor thrust for stable right circles and 3-4° down for high climb speed. Less down thrust results in less climb speed.

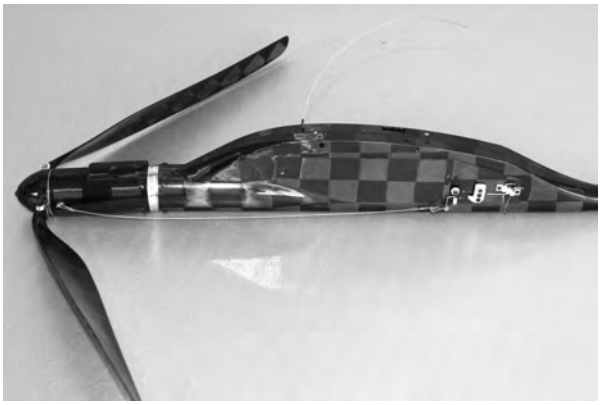


Figure 5 Front fuselage with front end and folding propeller



Figure 6 Front fuselage with front end and propeller folded

During the climb the main method for adjusting correct right circle diameter is matching side thrust of the motor with wing's angle difference. This difference is nearly 0.5-0.8°, right wing has a larger angle of attack, the left less. Rudder setting has very small impact on the climb and is not used to control it, or rudder is just set with a small left deviation to prevent right circles tightening as the model increases its speed. During the glide the rudder has a small right deviation and wings stay at the same angle.

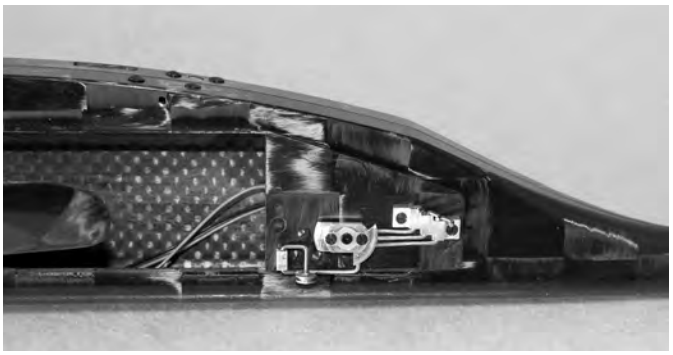


Figure 7 Timer installation controlling prop brake, VIT, Wing Wiggler and Auto Rudder

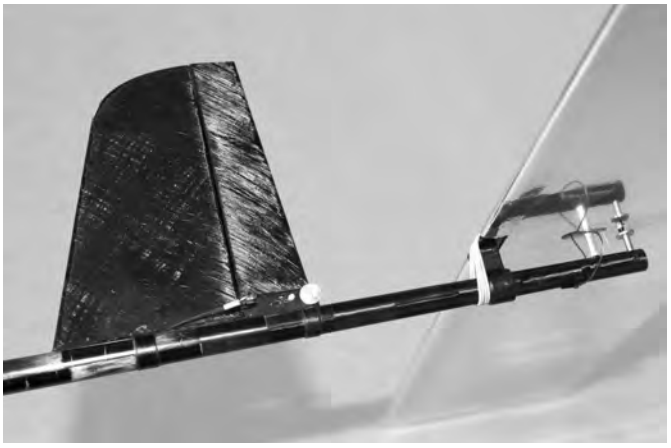


Figure 8 Fin, Stab and Rudder. Rudder and Stab have a fine thread screw adjustment.

Wing/stab decalage during the climb is 3°, during the glide 4-4.2°.

Conclusion

I want to share my opinion about big propellers. From the first I did not know what to expect about the operation such a big propeller. There is a very big difference regarding on "ground" and "in flight" conditions. "Stall" thrust on the ground makes it impossible to test on the ground. As example, this motor with propeller turn 5500rpm with 65W power on the ground. In flight the power drops to 50-52W and RPMs rise to 6000rpm.

Test flights of such model in 2018 shown very hopeful results.

My non-geared model 2017 with 2810(3530) sized outrunner with 13x10 propeller can reach 130-135 meters during a 25-27 seconds climb. An altimeter showed 4.8-5 m/sec vertical

speed. In real daytime conditions my non-geared model reached 120 meters.

My geared model with a big propeller showed 5.5-5.8m/sec vertical speed and obtained 150-160 meters in altitude. Climb is more stable, model better fly in windy weather.

In regular 5 or 7 rounds non-geared model stay competing, but in fly-off with 2 Joules per gram multiplier advantage of geared motor is unbeatable. This model gave 100-105 meters in calm weather using a 2 Joules/gram multiplier.

Model Construction features

The model is of similar design to my previous F1Q's, but all dimensions were increased. The primary goal was minimum weight of the wings with sufficient strength.

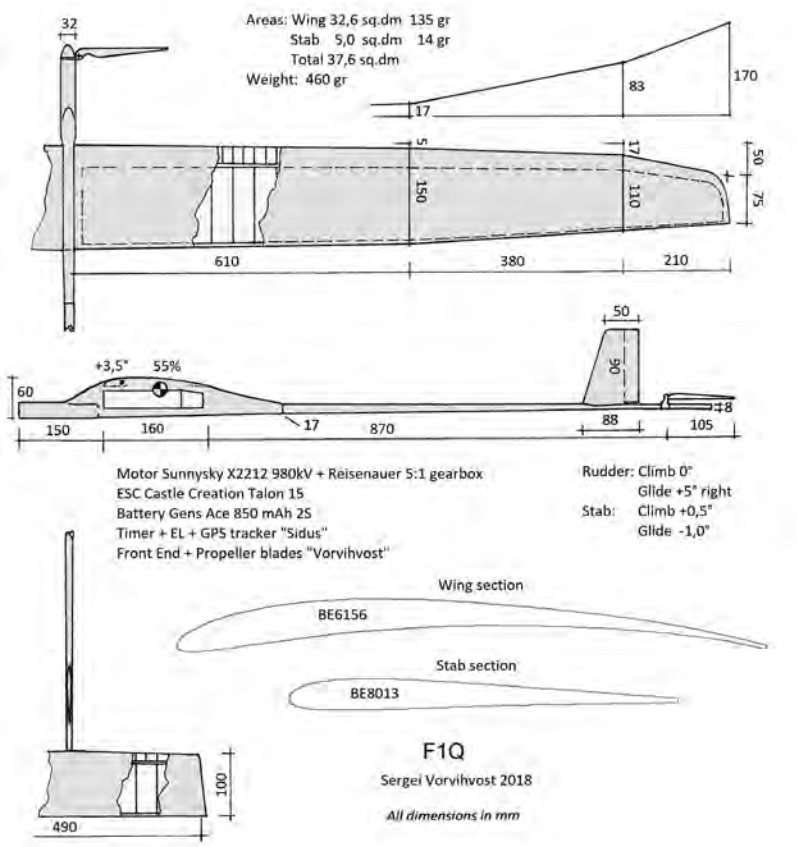


Figure 9 Plan of model drawn by Matti Lihtamo

Wings

- Area 32.6 sq. dm wings
- Wingspan - 2380 mm.
- Airfoil - BE6156.
- D-box from 160 g/m carbon, 32mm-27mm-20mm wide
- Spar size 7mm-3mm- 1.5mm x 0.6mm
- L.E. 1.5mm x 0.6mm
- T.E. 3mm x 0.6mm.
- Wing joiner is made of steel wire 4mm diameter
- Weight of uncovered wings 110gr (when covered with "Icarex" the wings weigh 135gr)

Stabilizer

- Area 5 sq.dm
- Airfoil is standard with a flat lower surface, 7.5% thickness.
- D-box from 80g/m carbon 15mm wide and 1.5mm-0.7mm x 0.6mm
- T.E. 2mm x 0.6mm
- Stabilizer when covered by silver "mylar" weighs 14gr



Figure 10 The Model

Reference

Free Flight Quarterly, Issue 69, October 2018, Sergio Montes Editor

Aram Schlosberg & Dave Lacey - FIQ Commentary – 49th Annual Report NFFS, 2016

OPTIMIZATION OF GLOBAL FACTORS IN INDOOR MODEL DESIGN

AUTHOR
DAVID ARONSTEIN

1. Introduction

This article deals with the optimization of 'global factors' in model design, specifically the relative sizing of the lifting parts vs. the propulsive parts. The results presented are not dependent on any improvement in the performance of the individual components. The conclusions are applicable in conjunction with all of the excellent past and ongoing work by many others on the optimization of individual parts, such as propellers, airfoils, use of materials, selection & handling of rubber, etc.

The conclusions of this article are applicable to unlimited Indoor models and to some, but not all, limited classes of Indoor models. Specifically, the conclusions are most applicable when one or both of the following factors exist:

a) Freedom to vary the sizes and weights of the 'lifting system' (wing, stab) and/or the 'energy system' (motor, motor stick, prop) with a meaningful benefit to the total aircraft; and/or…

b) Limited ceiling height.

For classes such as Mini Stick, F1D, F1L, or Limited Pennyplane, with regulatory maximums to the wing & motor stick size, and readily achievable minimum weights, the information in this article will be of little benefit. The path to improvement in those classes lies in the continued optimization of the individual components, and in the hope of yet higher energy capacity in the rubber.

Section 2 of this article reviews the previously published rubber duration equation and its implications. Section 3 examines some successful Indoor competition models in light of these implications. Section 4 introduces consideration of ceiling height. Section 5 presents a path to increased performance solely by reproportioning the 'energy system' relative to the 'aerodynamic system', and shows the predicted performance when this method is applied to the example models introduced previously. Duration improvements are predicted to be possible, with a concurrent **reduction** in the required ceiling height.

2. The Rubber Duration Equation, the Aerodynamic System and the Energy System

The Duration Equation

The duration of a rubber model can be estimated using the principle that energy equals the capacity to do work, and work = force x distance. The energy available is equal to the energy capacity of the rubber motor times the efficiency with which that energy is converted. The net work

performed during a flight is equal to the drag x the distance flown, which in turn is drag x speed x time. (The net work performed by or against gravity is negligible, assuming the model lands at essentially the same height from which it was launched.)

The equation has been published previously in various forms, for example in References 1 -4. The equation is stated below as the starting point for this article:

$$t = k * \eta_p * [\sqrt{(\rho/2)}] * L/D * [\sqrt{(C_L)}] * Wr/W * [\sqrt{(S/W)}] \quad \text{(Eq. 1a)}$$

Where:

t = flight time

k = rubber energy output

η_ρ = (greek letter 'eta') propeller efficiency (nondimensional). Always less than 1.

ρ = (greek letter 'rhō') air density, 0.00238 slug / ft^3 at sea level standard day conditions

L/D = Lift-to-drag ratio of the model (nondimensional)

C_L = Lift coefficient of the model (nondimensional), value usually close to 1

Wr = Rubber weight

W = Total weight including model and rubber

S = Area. Note, some authors use wing area only and some use wing+stab area. Either way is valid as long as it is used consistently. In this article S=wing+stab area.

Applying conversion factors for the units commonly used in the U.S., and replacing $\sqrt{(\rho/2)}$ by its numerical value on a standard day at sea level:

$$t = 0.00102 * k * \eta_p * L/D * [\sqrt{(C_L)}] * Wr/W * [\sqrt{(S/W)}] \quad \text{(Eq. 1b)}$$

Weights are in grams, 'S' in square inches, 'k' in ft-lb per lb of rubber, and time in minutes. (Yes, grams are actually mass, not weight. But if we assume standard Earth gravity then the equation is valid.)

If you want to use this equation to guide your own design efforts, it is good to calibrate any assumptions (such as typical values of k and η_ρ) against the performance of your own and other known models in the classes of interest. Some authors have grouped all of the factors besides [Wr/W * $\sqrt{(S/W)}$] together into a factor F, called the 'duration factor':

$$F = k * \eta_\rho * [\sqrt{(\rho/2)}] * L/D * [\sqrt{(C_L)}] \quad \text{(Eq. 2)}$$

F is what Kang Lee has tabulated as 'Efficiency' on the Indoor Construction Group website (Ref. 5), for a number of recent competition models. Using F to simplify the equation:

$$t = F * Wr/W * \sqrt{(S/W)} \quad \text{(Eq. 3a)}$$

If we introduce Wm, the model weight excluding rubber, then:

$$W = Wr + Wm$$

$$t = F * Wr/(Wr+Wm) * \sqrt{(S/(Wr+Wm))} \quad \text{(Eq. 3b)}$$

This form makes it easy to look at the effects of three key items that are easy to understand, easy to measure, and easy to influence by our design choices, and which in turn have a very great effect on performance: the rubber weight (Wr), the model weight (Wm), and the lifting surface area (S).

It is important to remember that **F is not a constant**. It is just a label for a group of quantities that are more difficult to measure. Rubber performance, propeller efficiency, and the aerodynamic efficiency of the model are all wrapped up in 'F'. To be competitive, these factors also need to be maximized.

The Misleading Optimum

For a fixed model, the duration equation predicts that the optimum motor weight is twice the model weight. This result is **true, but must be taken in context**. There are at least 2 important qualifiers:

- First, to reach this optimum the model has

to be able to carry that much rubber and use it efficiently. As we all know, most models cannot do so.

- If the motor is too long, it bunches. This takes away from the rubber energy output (k) in the full-length form of the equation. Recall that 'k' is hidden in the duration factor (F) in the short form.
- If the motor is too thick, the model is overpowered and does not fly as efficiently. This diminishes the prop efficiency (η_ρ) and/or L/D, both of which are also buried in 'F'. Or the motor stick breaks.
- I am being extra careful to point this out, so you can see that the equation is not wrong. These considerations do not invalidate the equation, but they do put practical limits on some of the terms in the equation.

- Second, this is the theoretical optimum motor weight **for a fixed model**. It comes from varying Wr in the equation above, while holding everything else (F, S, and the weight of the rest of the model) constant.

Therefore this result is only applicable when the wing area and the model weight are fixed. They can be fixed by class rules, or because you are already at the meet and your model is built. In either of these scenarios, you may never get to 2X the model weight, but the duration equation tells us correctly that the more rubber we can carry and effectively use, up to 2X the model weight, the longer our flight times will be.

Figure 1 shows the estimated flight time vs Wr/Wm for a hypothetical Intermediate Stick model having 1g empty weight, 140 sq in of area (total wing + stab) and an efficiency factor of 9:

The theoretical maximum duration, given these inputs, is 41 min. But it takes a 2g motor to reach this maximum. Suppose our 1g model



Figure 1. Flight time vs Wr / Wm.

can only practically carry 1g of rubber. Then it achieves 37.6 minutes instead of 41 minutes.

But if we tried to 'optimize' the model by designing it to carry 2g of rubber, we would actually design an inferior model! Specifically, we would alter the other parameters in the equation in such a way that even when we carried the 'optimum' motor weight on the new model, that combination would give lower performance than the original model.

What would this model look like? The wing would be too small and the motor stick would be too long. Not only would it have less duration potential than the original model; it would need a higher ceiling to achieve even its reduced potential (more about that in Section 4).

Suppose we traded some wing area for motor stick length in order to increase Wr while keeping Wm constant. Suppose we achieved the 'optimum' when we had reduced the area to 100 sq in (wing+stab). We still have the same 1g empty weight. The curve for the 2nd model is added in Figure 2 (next page). Even though we have 'optimized' the rubber weight fraction, we have lost duration because the theoretical optimum duration of the new model is only 34.6 minutes. In engineering this is called 'sub-optimization' - finding an 'optimum' solution to an incompletely or incorrectly stated problem. In striving to reach the top of the mountain, we have inadvertently made the mountain smaller.

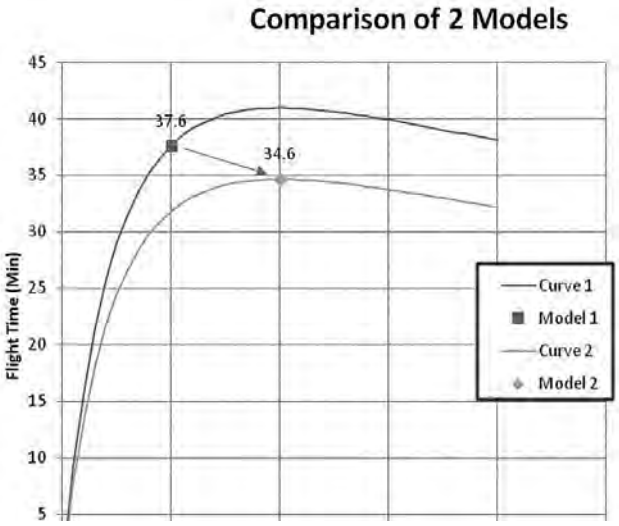


Figure 2. Comparison of 2 hypothetical Intermediate Stick models.

So what good is all this analysis? How does it help us design a better model? Especially in events where the wing area, the model weight, or both, are unconstrained? What is the best model design in that scenario?

A "Systems" Approach

Max Hacklinger (Ref. 1) stated, back in 1963, that if one takes into account the increase in structure weight that is needed to support a heavier motor, the optimum rubber weight is much less than 2x the model weight. He provided a graph to illustrate the point, but did not present the development or discuss the consequences in any detail.

Martyn Pressnell, in the 1977 NFFS Sympo (Ref. 2), presented a concept that enables the effect to be quantified, at least approximately, and used for practical guidance in model design. The concept is to break up the model into an 'Energy System' and an 'Aerodynamic System'.

The Energy System includes not only the rubber, but also those parts of the model whose primary purpose is associated with the rubber motor – specifically, the motor stick and the propeller. The Aerodynamic System includes the parts of the model whose primary purpose is to provide lift and stability (i.e. the wing, stabilizer, fin and boom). (Arguably the need for the vertical fin comes at least partly from the destabilizing effects of the propeller. A valid argument, but the fin is often grouped with the stabilizer in published weights, and it is very small relative to everything else, so for simplicity I am including it in the Aerodynamic System.)

Pressnell made the approximations that the weight of the Energy System is proportional to the weight of the rubber being carried, and the weight of the Aerodynamic System is proportional to the wing area. These are approximations; but we can learn from them. They are reasonable for small variations around a 'baseline' design, such as an existing model that you want to improve.

To apply this logic, 2 factors of proportionality are used, kr and ka:

kr = (prop + motor stick weight) / rubber weight (Eq. 4)

ka = (wing + tail + boom weight) / wing area (Eq. 5)

The group weights and total weights can now be expressed as:

We = weight of Energy System = Wr*(1+kr) (Eq. 6)

Wa = weight of Aerodynamic System = S*ka (Eq. 7)

W = total weight = Wr*(1+kr) + S*ka (Eq. 8)

Figure 3 shows the duration, expressed relative to the optimum (maximum) achievable duration, plotted against the fraction of total weight which is devoted to the energy system. It can be shown using calculus, and is apparent from the graph, that the optimum energy system weight is 2/3 of the total weight, and the optimum aerodynamic system weight is the other 1/3 of the total. This result is similar to the earlier result (varying rubber weight only, with the entire model weight fixed). In fact, if one re-plotted Figure 1 with Wr/W on the horizontal axis instead of Wr/Wm, it would be the same shape as Figure 3. But now it is the entire 'energy system', and not just the rubber, which should come to 2/3 of the total.

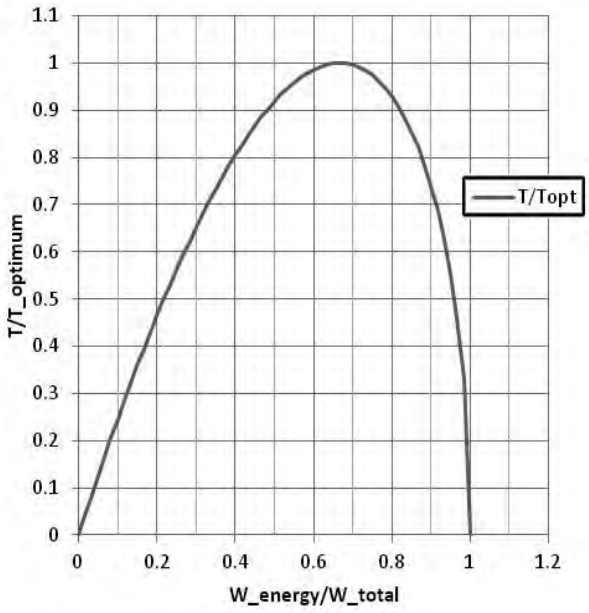


Figure 3. Normalized flight time vs. W_energy / W_total.

There is also a fairly broad range around the optimum where the performance is still very good. Specifically, any energy weight fraction from slightly below 50%, to slightly above 80%, will give at least 90% of the theoretical maximum duration.

Figure 3 is 'normalized', meaning the performance is shown not in absolute terms, but relative to the best performance that can be achieved with the given values of the weight efficiencies (kr and ka) and of 'F', which in turn is the product of several other efficiencies.

Pressnell presented this result in 1977 but did not apply it to Indoor models. The present article applies Pressnell's logic to the improvement of Indoor models, including the consideration of ceiling height.

3. Real-Life Examples

The previous section reviewed previously published theoretical results. This section examines some successful, mostly recent, competition Indoor models, relative to the results described in Section 2.

The models listed below were selected for:

- Adequate data available to determine the weights of the 'energy system' and the 'aerodynamic system' as defined in the preceding discussion
- Classes in which there is opportunity to trade between the 'energy system' and the 'aerodynamic system' in a meaningful way

For example, with a Limited Pennyplane (LPP) one can trade weight between the motorstick and the wing all day, and still have a 3.1g model with a 90 sq in wing, a 10" motorstick and a 12" prop. Trading in this manner does not actually improve any of the inputs to the duration equation. As far as the duration equation is concerned, the LPP is a 'fixed' model and the earlier result applies: the optimum motor is 2x the model weight, or else as much as the model can carry. Therefore I have not shown any LPP's or similarly limited classes, in spite of plenty of available data.

I have included one old (1963) F1D from Hacklinger (Ref. 1). Remember that at time of that publication, F1D was not limited as it is now. There was a wingspan maximum (90cm) but no weight minimum. Although most of the example models are traditional indoor 'stick' classes, I have included 3 of my own Coconut Scale models because they provide further illustration of the principles being presented.

Table 1 presents the basic identifying data for the selected models, ordered alphabetically by competition class. Table 2 presents more detailed data, including the reported component weights; groups the weights into the 'energy system' and 'aerodynamic system' as defined previously; and shows where each model falls relative to the optimum balance between these two groups.

Gray-shaded cells are estimates. When stick and boom weights were not listed separately, I used an average split of 77% stick / 23% boom based on those models for which separate stick and boom weights were listed. For models with 'miscellaneous' weight (landing gear and/or ballast), this was allocated to the energy sys-

Builder	Model	Class	Source (ref. no.)	W_r g	W_m g	W_total g	S_wing in^2	S_horiz in^2	S_total in^2	Duration min	Duration Factor 'F'
Andy Taliafico	Baby Blue	A-ROG	Winning Indoor Designs 2002-2005 (6)	0.40	0.44	0.84	29.9	14.4	44.3	19.5	5.7
Don Slusarczyk	Rota (Cat III)	Autogyro	INAV April 2017 (7)	1.25	1.02	2.27	142.5	61.0	203.5	21.7	4.2
Don Slusarczyk	Rota (Cat II)	Autogyro	INAV May 2018 (8)	1.13	1.02	2.15	142.5	61.0	203.5	15.6	3.1
David Aronstein	Cessna Caravan (40")	Coconut	Personal notes	16.0	32.8	48.8	169	51	220	2.8	4.0
David Aronstein	Miles M-18 (36")	Coconut	Personal notes	12.7	34.9	47.6	245	71	316	3.1	4.5
David Aronstein	ANT-25 (65")	Coconut	Personal notes	13.1	35.4	48.5	325	51	376	4.8	6.4
Chuck Markos	1989 USIC Winner	EZB	Winning Indoor Designs 1987-89 (9)	0.95	0.82	1.77	52	20.0	72.0	22.0	6.4
John Marett	Teardrop VII	EZB	Winning Indoor Designs 1987-89 (9)	0.96	0.91	1.88	54	20.6	74.6	20.6	6.4
Jerry Nolan	Serendipity	EZB	Winning Indoor Designs 1987-89 (9)	0.91	1.13	2.03	54	20.0	74.0	23.4	8.7
Mike Palrang	#12a	EZB	Winning Indoor Designs 2002-2005 (6)	0.55	0.46	1.01	49	18.4	67.4	28.4	6.3
Yuan Kang Lee	BS-6 (USIC)	EZB	Hip Pocket Builders' Forum (10)	0.33	0.34	0.68	50	21.2	71.0	28.2	5.6
Yuan Kang Lee	BS-6 (Lakehurst)	EZB	Hip Pocket Builders' Forum (10)	0.43	0.38	0.81	50	21.2	71.0	34.4	6.9
Yuan Kang Lee	Donna's Dragon Fly	EZB	INAV April 2013 (11)	0.28	0.24	0.51	50	20.4	70.4	37.8	6.0
Max Hacklinger	(not named)	F1D (1963)	Theoretical and Exp. Investigation... (1)	1.20	0.88	2.08	144	58.0	202.0	45.0	7.9
Nick Ray	Cat IV Record	F1R (35cm)	INAV June 2018 (12)	0.55	0.40	0.96	75	36	111	33.7	5.4
Nick Ray	Cat III Record	F1R (35cm)	INAV April 2017 (13)	0.44	0.40	0.83	75	36	111	28.7	4.7
Nick Ray	Cat II Record	F1R (35cm)	INAV October 2017 (14)	0.48	0.40	0.88	75	36	111	27.4	4.5
Tom Sova	Cat II/III Record	F1R (35cm)	INAV April 2016 (15)	0.43	0.41	0.83	66.9	25.9	92.8	27.1	5.0
Josh Finn	Girder Grabber III	F1R (35cm)	INAV June 2016 (16)	0.45	0.44	0.88	58	35.4	93.4	26.6	5.1
Manuel Angel Diaz	QuasiTandem	F1R (35cm)	INAV June 2016 (17)	0.45	0.41	0.86	50.6	39.2	89.7	17.0	3.2
John Kagan	Safat	HL Stick	Winning Indoor Designs 2002-2005 (6)	2.10	1.72	3.82	356.4	138.2	514.0	61.5	9.6
Jim Richmond	Film Star	HL Stick	Winning Indoor Designs 1987-89 (9)	1.40	1.40	2.80	300	133	433	51.5	8.3
Don Slusarczyk	Lumber Yard	HL Stick	Winning Indoor Designs 1987-89 (9)	2.42	1.73	4.15	340	150	490	35.4	5.6
Jim Richmond	Starwalker	HL Stick	INAV 1979 (month unknown) (18)	1.42	1.34	2.76	274	116	390	52.2	8.5
Steve Brown	(not named)	HL Stick	Record Flight Efficiencies (5)	1.84	1.12	2.96	?	?	432	63.9	8.5
John Kagan	Immediate Stick	Int Stick	INAV September 2016 (19)	0.80	0.86	1.66	99.5	45.4	145	47.6	10.6
Larry Coslick	Phoenix	Int Stick	Winning Indoor Designs 2002-2005 (6)	0.94	0.76	1.70	95	38.7	133.7	41.8	8.5
Mike Palrang	I.S.#2.4	Int Stick	Winning Indoor Designs 2002-2005 (6)	0.72	0.73	1.45	100	39.3	139.3	29.6	6.1
Ron Ganser	Mylar Doll	Int Stick	Winning Indoor Designs 1987-89 (9)	1.50	1.17	2.67	99	37	136	25.2	6.3
Earl Hoffman	Symphony	Int Stick	Winning Indoor Designs 1987-89 (9)	1.16	0.80	1.96	95	39	134	31.3	6.4

Table 1. Example models – identification and basic data.

		Component Weights (g)									We Energy System	Wa Aero System	kr g/g	ka g/in2	We Wtot	% of theoretical potential	Reported Time min	Optimized Time min	Improvement min
Builder	Class	Rubb	Prop	Mot Stick	Boom	Wing	Tail	Misc	Model	Total									
Taliafico	A-ROG	0.396	0.108	0.135	0.040	0.102	0.034	0.023	0.441	0.84	0.66	0.18	0.66	0.0041	0.78	94.6%	19.5	20.6	1.1
Slusarczyk	Gyro-Cat III	1.250	0.123	0.255	0.075	0.362	0.204	0	1.019	2.27	1.63	0.64	0.30	0.0032	0.72	99.1%	21.7	21.9	0.2
Slusarczyk	Gyro-Cat II	1.130	0.123	0.255	0.075	0.362	0.204	0	1.019	2.15	1.51	0.64	0.33	0.0032	0.70	99.6%	15.6	15.7	0.1
Aronstein	Coco-Cessna	16.0	3.2	7.3	2.1	7.7	2.9	9.6	32.8	48.8	32.9	15.9	1.06	0.0723	0.67	100.0%	2.8	2.8	0.0
Aronstein	Coco-Miles	12.700	3.200	6.948	2.052	11.000	3.000	8.7	34.900	47.60	27.96	19.64	1.20	0.0622	0.59	98.0%	3.1	3.2	0.1
Aronstein	Coco-ANT	13.100	3.200	6.022	1.778	13.700	2.600	8.1	35.400	48.50	26.80	21.70	1.05	0.0577	0.55	96.0%	4.8	5.0	0.2
Markos	EZB	0.949	0.226	0.211	0.062	0.240	0.080	0	0.819	1.77	1.39	0.38	0.46	0.0053	0.78	94.7%	22.0	23.3	1.2
Marett	EZB	0.964	0.245	0.256	0.075	0.240	0.096	0	0.912	1.88	1.46	0.41	0.52	0.0055	0.78	95.0%	20.6	21.7	1.1
Nolan	EZB	0.906	0.232	0.324	0.096	0.379	0.096	0	1.126	2.03	1.46	0.57	0.61	0.0077	0.72	99.0%	23.4	23.6	0.2
Palrang	EZB	0.550	0.112	0.159	0.039	0.114	0.028	0	0.452	1.01	0.82	0.18	0.49	0.0027	0.82	90.5%	28.4	31.4	3.0
Lee	EZB-BS6-US	0.334	0.065	0.106	0.035	0.102	0.033	0	0.341	0.68	0.51	0.17	0.51	0.0024	0.75	97.5%	28.2	28.9	0.7
Lee	EZB-BS6-LH	0.431	0.102	0.106	0.035	0.102	0.033	0	0.378	0.81	0.64	0.17	0.48	0.0024	0.79	94.1%	34.4	36.6	2.2
Lee	EZB-DDF	0.275	0.065	0.061	0.021	0.067	0.024	0	0.238	0.51	0.40	0.11	0.46	0.0016	0.78	94.9%	37.8	39.8	2.0
Hacklinger	F1D (1963)	1.200	0.160	0.270	0.080	0.300	0.070	0	0.880	2.08	1.63	0.45	0.36	0.0022	0.78	94.7%	45.0	47.5	2.5
Ray-Cat IV	F1R (35cm)	0.552	0.098	0.118	0.046	0.092	0.050	0	0.404	0.96	0.77	0.19	0.39	0.0017	0.80	92.6%	33.7	36.4	2.7
Ray-Cat III	F1R (35cm)	0.437	0.088	0.118	0.048	0.092	0.050	0	0.396	0.83	0.64	0.19	0.47	0.0017	0.77	95.8%	28.7	29.9	1.3
Ray-Cat II	F1R (35cm)	0.480	0.090	0.118	0.048	0.092	0.050	0	0.398	0.88	0.69	0.19	0.43	0.0017	0.78	94.7%	27.4	28.9	1.5
Sova	F1R (35cm)	0.428	0.083	0.120	0.040	0.104	0.058	0	0.405	0.83	0.63	0.20	0.47	0.0022	0.76	96.9%	27.1	28.0	0.9
Finn	F1R (35cm)	0.445	0.091	0.134	0.039	0.127	0.046	0	0.437	0.88	0.67	0.21	0.50	0.0023	0.76	96.8%	26.6	27.4	0.9
Diaz	F1R (35cm)	0.450	0.086	0.128	0.044	0.084	0.066	0	0.408	0.86	0.66	0.19	0.48	0.0022	0.77	95.6%	17.0	17.8	0.8
Kagan	HL Stick	2.10	0.25	0.35	0.10	0.76	0.26	0	1.72	3.82	2.70	1.12	0.28	0.0022	0.71	99.5%	61.5	61.8	0.3
Richmond	HL Stick-FS	1.40	0.22	0.39	0.000	0.52	0.27	0	1.40	2.80	2.01	0.79	0.44	0.0018	0.72	99.1%	51.5	52.0	0.5
Slusarczyk	HL Stick	2.42	0.23	0.37	0.11	0.65	0.37	0	1.73	4.15	3.02	1.13	0.25	0.0023	0.73	98.7%	35.4	35.8	0.5
Richmond	HL Stick-SW	1.42	0.23	0.38	0.11	0.47	0.15	0	1.34	2.76	2.03	0.73	0.43	0.0019	0.73	98.3%	52.2	53.1	0.9
Brown	HL Stick	1.84	(not included in this reference)					0	1.12	2.96	2.28	0.68	0.24	0.0016	0.77	95.8%	63.9	66.7	2.8
Kagan	Int Stick	0.80	(not included in this reference)					0	0.86	1.66	1.20	0.46	0.50	0.0032	0.72	98.8%	47.6	48.2	0.6
Coslick	Int Stick	0.940	0.160	0.215	0.085	0.220	0.076	0	0.756	1.698	1.315	0.381	0.40	0.0028	0.78	95.5%	41.8	43.8	2.0
Palrang	Int Stick	0.720	0.146	0.200	0.053	0.270	0.070	0	0.74	1.45	1.07	0.39	0.48	0.0028	0.73	98.5%	29.6	30.0	0.4
Ganser	Int Stick	1.50	0.25	0.29	0.08	0.41	0.14	0	1.17	2.67	2.04	0.63	0.36	0.0046	0.76	96.4%	25.2	26.1	0.9
Hoffman	Int Stick	1.160	0.125	0.232	0.054	0.306	0.088	0	0.80	1.96	1.52	0.45	0.31	0.0033	0.77	95.7%	31.3	32.7	1.4
											Average - Indoor Stick models		0.43	0.0029	0.76	96.4%			1.2
											Std Dev - Indoor Stick models		0.10	0.0014	0.03	2.2%			0.8
											Average - Scale models		1.10	0.064	0.60	98.0%			0.1
											Std Dev - Scale models		0.07	0.006	0.05	1.6%			0.1

Table 2. Example models – balance between Energy System and Aerodynamic System.

tem and the aerodynamic system in the same percentage that resulted from the other components. For Steve Brown's HL Stick and John Kagan's Intermediate Stick, having no component weights, I estimated the model parts of the aerodynamic and energy systems, as a fraction of total model weight, based on the averages of the other models in each of their respective classes.

Figure 4 adds the example models to the curve shown previously. Key results are:

- All models are in the range which yields at least 90% of their theoretical maximum potential.
- All models except for my 3 Coconut Scale models are to the right of the peak. Therefore, they are on the 'energy-heavy' side of the balance.
- Among the Indoor Stick models (i.e. the entire population except the Scale models):
  - Average We/W is 0.76 with a standard deviation of 0.03; vs theoretical optimum of 0.67.
  - Average % of theoretical maximum duration is 96.4% with a standard deviation of 2.2%.
  - The average potential improvement of the Indoor Stick models surveyed is 1.2 minutes, with a standard deviation of 0.8 minutes.

One could legitimately question whether this result is significant, or merely an artifact of the approximations that were made. It might be claimed that the competitive community has found the true optimum by experimentation, except for 2 further considerations:

- As will be shown in the next section, if ceiling height is taken into account, most models should be on the low side of the optimum We/W, not the high side.
- There are some real-life examples which suggest that the opportunity is not only real, but that it can lead to synergies as one moves to lower energy system weights - that is, favorable and compounding effects that are outside of the analysis presented here, which cause the improvement to be greater than predicted. Examples include the revolution in EZB that took place after Larry Coslick pioneered very short motor sticks; and my own experiences in Coconut Scale.

What the optimum means and how to change the design to get there

As a closing reminder for this section, the variation represented in Figure 4 is the balancing between the 'energy system' and the 'aerodynamic system'. If a model is on the energy-heavy side of the optimum, one moves it closer to the optimum by reducing the weight of the motor stick and propeller, accepting the con-

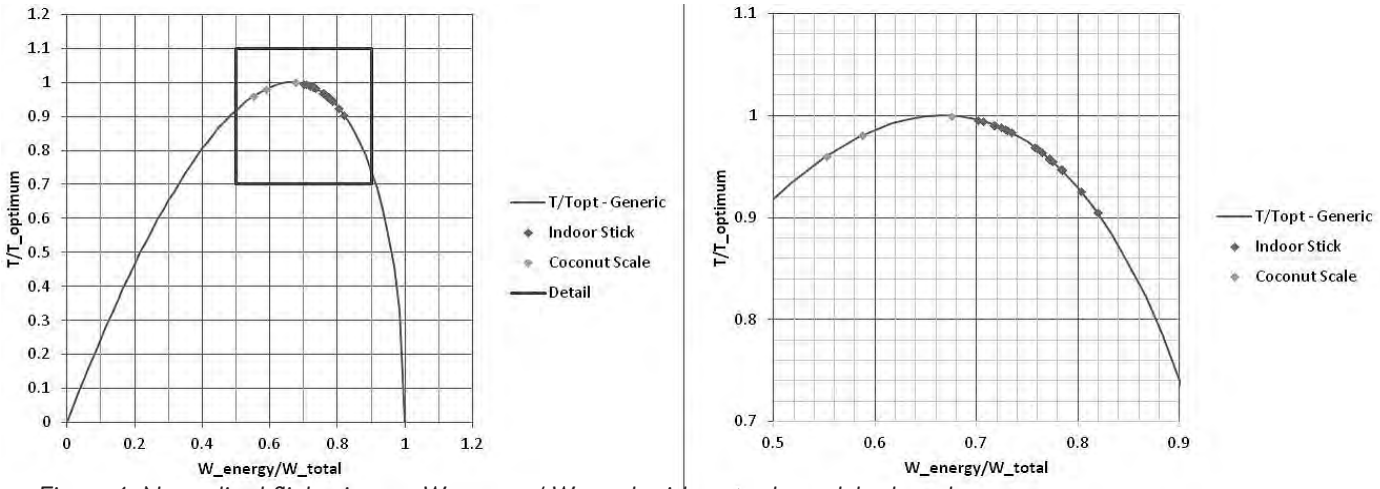


Figure 4. Normalized flight time vs. W_energy / W_total, with example models plotted.

sequent reduction in motor weight; and/or by enlarging the wing. The benefit of the resulting wing loading reduction outweighs the loss of motor weight fraction. If the model is to the left of the optimum, the opposite is true. The optimum is the point where the sensitivity to wing loading and motor weight fraction are balanced.

4. Ceiling Height Matters: How Rubber Weight Fraction Determines 'Natural' Climb Altitude

Now consider the effect of torque variation as a rubber motor unwinds, as shown in Figure 5. We have all seen many similar illustrations. Assuming the torque is measured while unwinding, the area under the curve is proportional to the energy released by the motor. (The differences between torque in, and torque out, are very real but are outside the scope of this article.)

If one draws a horizontal line, representing the torque required for level flight on a given model, then the area under the torque curve, but above the level-flight line, represents excess energy. Assuming the model and its propeller are rigid, and the model is well trimmed, the excess energy is converted into climb altitude. It is a fair approximation (better at small climb angles, worse at very large climb angles) that this conversion takes place with the same efficiency that the model achieves in level flight. This is not a new result. It was recognized at least as far back as 1963 (Ref. 1).

Similarly, the altitude that a model loses in the descent phase is proportional to the area that is below the level-flight line and above the torque curve. When the model is trimmed to land just as the last useful winds are expended, and assuming it does not strike the ceiling during the flight, then the climb altitude is equal to the descent altitude and these areas will match.

Natural Climb Height

To find the 'natural' climb height, H, of a model, recall that the total energy provided by the rubber is k*Wr. If R is the ratio of the area above

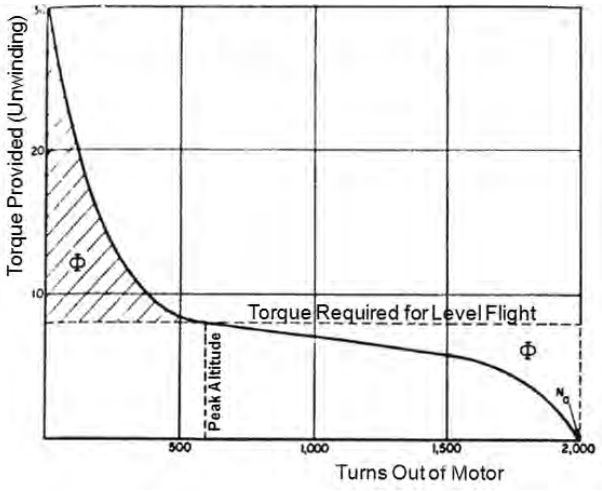


Figure 5. Torque vs turns (Ref. 1).

the level-flight line (Φ), to the total area under the curve, then the excess energy above the level-flight line is R*k*Wr. Converting this energy into gravitational potential energy (weight x height), and taking the propeller efficiency into account:

$$(Wr + Wm) * H = R * k * \eta_\rho * Wr$$

$$H = R * k * \eta_\rho * Wr / (Wr + Wm) = R * k * \eta_\rho * Wr/W \quad \text{(Eq. 9)}$$

Hacklinger reported that typical values of R, at the time, ranged from 0.15 to 0.28. Modern rubber probably has a slightly different range of values. Lower values are clearly more favorable for flight in low ceilings, as the 'natural' climb altitude is directly proportional to R.

Consider as an example the Intermediate Stick model of Figure 1 with Wr = Wm = 1g. Suppose k = 3,000 ft-lb/lb and η_ρ = 0.75 (realistic, competitive values). Further suppose that R = 0.20, meaning that the area above the level-flight line is 20% of the total area under the torque curve:

$$H = 0.20 * 3{,}000 \text{ ft-lb/lb} * 0.75 * 1g / (1g+1g) = 225 \text{ ft}$$

This shows that even in a dirigible hanger, one must manage altitude with some classes of models.

Looking at the other factors involved, the important observation is that **the natural climb height of a model is directly proportional to its rubber weight fraction, Wr/W.**

Reducing the Natural Climb Height

Modelers have devised many ways to reduce the climb height of indoor models, including:

- Flaring propellers
- Variable-pitch propellers
- Backing-off
- "Torque burner"
- Deliberate mistrim at high torque
- Letting the model bump on the ceiling

The first two methods increase the torque required for level flight, when the torque available is high. The level-flight line is no longer a horizontal line on the plot; it now varies as a function of rubber torque. The area above the level-flight line and below the torque curve is reduced; hence the climb height is reduced. Furthermore, the model gets more time out of the early winds because the propeller RPM is slowed. With a lot of skill (and arguably some luck also), a VP prop can divide the flight into an initial climb to the ceiling, initial descent almost to the floor before the prop 'kicks' into low pitch; then a 2nd climb right back to the ceiling; cruise; and final descent.

Backing-off flattens the torque curve via a phenomenon known as hysteresis. This reduces R, but it also reduces the effective value of k because the total area under the curve is reduced. It is the easiest method to employ but it definitely wastes energy.

The "Torque burner" consists of a wire hook partway along the motor stick, and an extra O-ring in the motor, arranged to restrain the aft portion of the motor from unwinding at all, until the forward portion unwinds to some level. When the torque difference is sufficient, the hook lets go and allows the aft portion to unwind as well. Some energy is lost in the sudden adjustment of torque levels between the forward and aft parts of the motor. Torque burners were popular in some classes during the 1990s; I am not aware of any current usage.

Deliberate mistrim in the form of a prolonged stall will suppress climb and slow the prop somewhat, although usually not as much as an increase in prop pitch. If a dive (i.e. fast flight with near-zero climb angle), then the opposite is true - RPM is increased in the early part of the flight. Both of these methods waste some energy, the dive more so. Mistrim can also be difficult to achieve consistently.

Letting the model bump on the ceiling also wastes energy, because it sacrifices the gravitational potential energy that would otherwise be gained during the phase when the model is climbing. It is more or less risky depending on the flying site.

It is an interesting and useful exercise to show how the each of the above methods changes the torque required line and/or the torque available line on the torque-turns plot; but time and space preclude doing that here.

Whatever combination of methods is used, with a given level of skill and daring, there is still a practical minimum value of R, call it R', which corresponds to the minimum practical climb height of the model & motor. Because most methods of reducing R' also sacrifice energy, there is also a reduced value of k, call it k', that is consistent with the methods used to reduce the climb height. The modified flight time and climb height are given by:

$$t' = k' * \eta_\rho * [\sqrt{(\rho/2)}] * L/D * [\sqrt{(C_L)}] * Wr/(Wr+Wm) * [\sqrt{(S/(Wr+Wm))}] \quad \text{(Eq. 10)}$$

$$H' = R' * k' * \eta_\rho * Wr/(Wr+Wm) \quad \text{(Eq. 11)}$$

To see how to minimize climb height while also minimizing the adverse effect on duration, height and duration are plotted together in Figure 6.

The combined graph shows that as one moves slightly off the optimum duration in either direction, the sensitivity of flight time to We/W

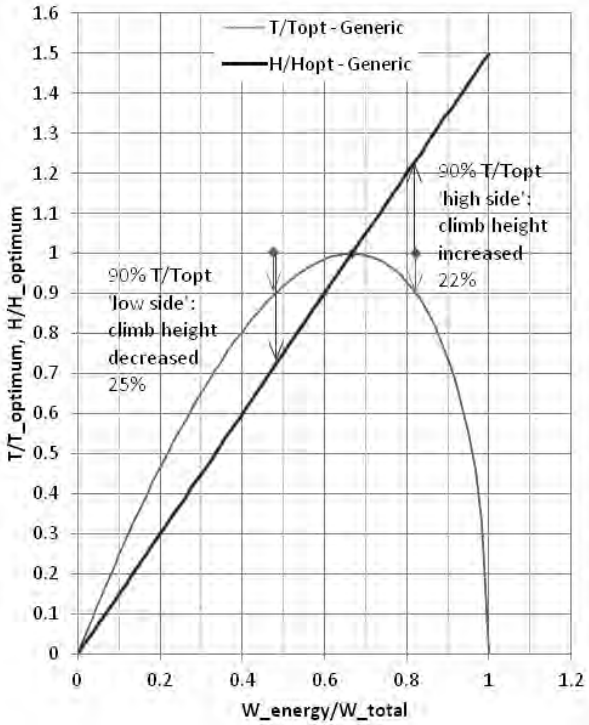


Figure 6. Combined graph of ceiling height and duration.

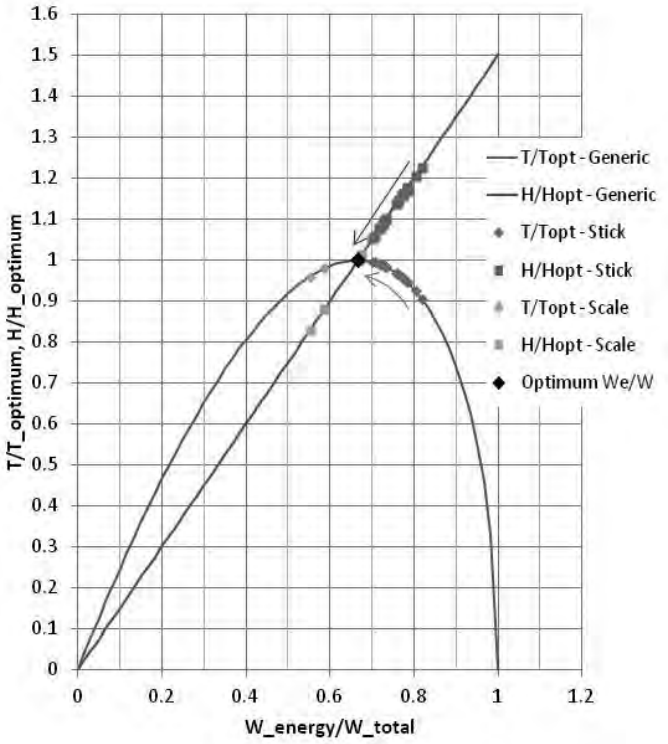


Figure 7. Combined graph of ceiling height and duration, with example models plotted.

is initially flat. But the variation of climb height with energy weight is not flat; in fact it is a straight line of constant slope. Thus, the loss of flight time is not appreciable until one has moved a fairly significant distance off the optimum; but the change in climb height is immediate. The added arrows show that in the range of energy system weights where the duration is within 10% of the optimum, the climb height can vary from 25% below that of the 'optimum' model on the low side, to 22% above that of the 'optimum' model on the high side.

It stands to reason that we should 'tweak' our models off the optimum, in the direction of a lower energy weight fraction, if we wish to minimize our interaction with the ceiling. But recall that all of the Indoor Stick models from Section 3 are actually on the high side. Adding the data for these models to the combined graph results in Figure 7:

What are the implications? The entire set of Indoor Stick models on the graph, though successful, could be improved by designing them with reduced rubber capacity. Flight times generally ranging from 1% to 10% longer could be achieved in **lower** ceiling heights, ranging from 5% to 20% lower. There is also a significant range of We/W to the left of the optimum where even greater reductions in ceiling height can be achieved while maintaining the duration at least great as that of the original models.

5. Real-Life Opportunities

This section develops two hypothetical families of models, based on the example population introduced previously. The first family is optimized purely for duration without regard to ceiling height. Reduction in ceiling height is achieved in this family, but is purely incidental. The second family moves farther to the left (i.e. lower We/W) in order to achieve a greater reduction in ceiling height, while matching the duration of the original model.

For all of the Indoor Stick models, the target ratio of We/W is lower than that of the original model. Therefore the required change consists of reducing the weight of the motor stick and propeller, with consequent reduction in motor weight that can be carried; and/or increasing the wing area. The intent is to maintain the same ratios of stick+prop weight to motor weight (kr), and of wing+stab+boom weight to

			Scaling Factors											Target	Predicted	Duration	Height
		Method	Energy	Aero	Target Component Weights (g)									S_Total	Duration	Increase	Change
Builder	Class	of change	System	System	Rubber	Prop	Mot Stick	Boom	Wing	Tail	Misc	Model	Total	sq in	(min)	(min)	(% of orig)
Taliafico	A-ROG	Decrease We	0.55	1	0.218	0.059	0.075	0.040	0.102	0.034	0.015	0.32	0.54	44.3	20.6	1.1	-15%
Slusarczyk	Gyro-Cat III	Decrease We	0.79	1	0.985	0.097	0.201	0.075	0.362	0.204	0	0.94	1.92	203.5	21.9	0.2	-7%
Slusarczyk	Gyro-Cat II	Decrease We	0.85	1	0.961	0.105	0.217	0.075	0.362	0.204	0	0.96	1.92	203.5	15.7	0.1	-5%
Aronstein	Coco-Cessna	None	1	1	Not applicable. Original model is already at the optimum.											0.0	0%
Aronstein	Coco-Miles	Increase We	1.41	1	17.8	4.5	9.8	2.1	11.0	3.0	10.8	41.1	58.9	316	3.2	0.1	14%
Aronstein	Coco-ANT	Trade	1.27	0.79	16.7	4.1	7.7	1.4	10.8	2.0	8.5	34.5	51.2	296	5.0	0.2	21%
Markos	EZB	Decrease We	0.55	1	0.523	0.125	0.116	0.062	0.240	0.080	0	0.62	1.15	72.0	23.3	1.2	-15%
Marett	EZB	Decrease We	0.56	1	0.542	0.138	0.144	0.075	0.240	0.096	0	0.69	1.23	74.6	21.7	1.1	-15%
Nolan	EZB	Decrease We	0.78	1	0.707	0.181	0.253	0.096	0.379	0.096	0	1.00	1.71	74.0	23.6	0.2	-7%
Palrang	EZB	Decrease We	0.44	1	0.243	0.049	0.070	0.039	0.114	0.028	0	0.30	0.54	67.4	31.4	3.0	-18%
Lee	EZB-BS6-US	Decrease We	0.67	1	0.225	0.044	0.071	0.035	0.102	0.033	0	0.29	0.51	71.0	28.9	0.7	-11%
Lee	EZB-BS6-LH	Decrease We	0.53	1	0.229	0.054	0.056	0.035	0.102	0.033	0	0.28	0.51	71.0	36.6	2.2	-16%
Lee	EZB-DDF	Decrease We	0.56	1	0.154	0.036	0.034	0.021	0.067	0.024	0	0.18	0.34	70.4	39.8	2.0	-15%
Hacklinger	F1D (1963)	Decrease We	0.55	1	0.66	0.09	0.15	0.08	0.30	0.07	0	0.69	1.35	202	47.5	2.5	-15%
Ray-Cat IV	F1R (35cm)	Decrease We	0.49	1	0.270	0.048	0.058	0.046	0.092	0.050	0	0.29	0.56	111	36.4	2.7	-17%
Ray-Cat III	F1R (35cm)	Decrease We	0.59	1	0.258	0.052	0.070	0.048	0.092	0.050	0	0.31	0.57	111	29.9	1.3	-14%
Ray-Cat II	F1R (35cm)	Decrease We	0.55	1	0.265	0.050	0.065	0.048	0.092	0.050	0	0.30	0.57	111	28.9	1.5	-14%
Sova	F1R (35cm)	Decrease We	0.64	1	0.274	0.053	0.077	0.040	0.104	0.058	0	0.33	0.61	92.8	28.0	0.9	-12%
Finn	F1R (35cm)	Decrease We	0.63	1	0.282	0.058	0.085	0.039	0.127	0.046	0	0.35	0.64	93.4	27.4	0.9	-12%
Diaz	F1R (35cm)	Decrease We	0.58	1	0.263	0.050	0.075	0.044	0.084	0.066	0	0.32	0.58	89.7	17.8	0.8	-14%
Kagan	HL Stick	Decrease We	0.83	1	1.75	0.21	0.29	0.10	0.76	0.26	0	1.62	3.37	514	61.8	0.3	-6%
Richmond	HL Stick-FS	Decrease We	0.79	1	1.10	0.17	0.31	0.000	0.52	0.27	0	1.27	2.37	433	52.0	0.5	-7%
Slusarczyk	HL Stick	Decrease We	0.75	1	1.81	0.17	0.28	0.11	0.65	0.37	0	1.58	3.39	490	35.8	0.5	-8%
Richmond	HL Stick-SW	Decrease We	0.72	1	1.03	0.17	0.27	0.11	0.47	0.15	0	1.17	2.20	390	53.1	0.9	-9%
Brown	HL Stick	Decrease We	0.59	1	1.09	(component weights not available)					0	0.94	2.03	432	66.7	2.8	-14%
Kagan	Int Stick	Decrease We	0.76	1	0.61	(component weights not available)					0	0.76	1.37	145	48.2	0.6	-8%
Coslick	Int Stick	Decrease We	0.58	1	0.54	0.09	0.12	0.09	0.22	0.08	0	0.60	1.14	133.7	43.8	2.0	-14%
Palrang	Int Stick	Decrease We	0.74	1	0.53	0.11	0.15	0.05	0.27	0.07	0	0.65	1.18	139.3	30.0	0.4	-9%
Ganser	Int Stick	Decrease We	0.62	1	0.92	0.16	0.18	0.08	0.41	0.14	0	0.97	1.89	136	26.1	0.9	-13%
Hoffman	Int Stick	Decrease We	0.59	1	0.684	0.073	0.137	0.054	0.306	0.088	0	0.66	1.34	134	32.7	1.4	-14%
														Average - Indoor Stick		1.2	-12%
														Std Dev - Indoor Stick		0.8	4%
														Average - Scale		0.1	11%
														Std Dev - Scale		0.1	9%

Table 3. Sample models modified for maximum duration.

wing area (ka), as on the original model. For most of the example models, enlarging the wing is not an option (within the limits of the class), but reducing the weight is. Thus, the available avenue of change is to reduce the energy system weight.

For the Coconut Scale models, the hypothetical change is different in each case. This class is defined by a wing span of at least 36 inches and a weight of at least 1 ounce (28.3 grams). The Cessna Caravan is already right on the optimum ratio of We/W; no change is needed. (My first Coconut. Brilliant? Lucky? But then why do other 2 fly longer...? Read on.) The Miles needs more rubber or less wing to reach the optimum; but the wing is already at the minimum span for the class. Therefore the energy system is scaled up. The ANT-25 is also energy-light, and is well above the minimum wing span. There is freedom in this case, and I chose to split the scaling between both systems. Because this is a Scale event, each of the above changes implies the selection of a different subject aircraft whose proportions match the new target.

Modified component weight targets are shown for all models in each family. To define in detail the specific design changes to reach the new weight targets, for the entire family of models, would be a lengthy exercise. One example is presented in detail at the end of this section to show that the changes are achievable and to illustrate the general logic that should be used.

Sample models modified purely for duration

The target for this family is for the energy system weight to be 2x the aerodynamic system weight. For each model, a scale factor was applied to We and/or to Wa in order to achieve the target ratio. All component weights that are part of the affected system are then scaled by that factor. Table 3 shows the results of this exercise. It is assumed that kr, ka, F and R' are unchanged from the original models.

The average improvement (for the Stick models), as noted previously, is 1.2 minutes with a standard deviation of 0.8 minutes. Now we also

see that this change comes with a **decrease** in the required ceiling height, averaging 12% with a standard deviation of 4%.

Furthermore, synergies may be achieved, for example:

- Lighter wings are possible, even at the same wing area, when the energy system weight is reduced, because the forces on the wing are reduced. This effect is very real, but hard to quantify; otherwise it would have been included in the equations to begin with.
- The lift-to-drag ratio (L/D) is likely to increase as the propulsive components shrink relative to the lifting components. L/D is hidden in 'F', but the relationship is linear: 'F', and consequently the duration, will increase 10% for every 10% that the L/D increases. Differences in L/D are most likely responsible for the largest variations in 'F' seen in Table 1. The HL sticks, having large wingspan and the advantage of higher Reynolds number, generally have higher values of 'F' than the 35cm models, for example. Also note the nearly 50% increase in 'F' from my first two Coconut models to the ANT-25.
- Models with lower We/W will typically need less backing-off. This is true whether the back-off is to avoid launch antics, or to control altitude. The result of less back-off will be an increase in k' (which is also hidden in 'F') and consequently an increase in duration. In other words, one may trade back some of the reduction in climb height, for a gain in usable energy density of the rubber.

Samples models modified to match original duration with lower ceiling height

For the second family, the target We/W is determined individually for each model, to be just as far below the optimum flight time on the low We/W side, as the original model is on the high We/W side. Otherwise the method is the same as in the first family. The Coconut Scale models

			Scaling Factors											Target	Predicted	Height
		Method	Energy	Aero	Target Component Weights (g)									S_Total	Duration	Change
Builder	Class	of change	System	System	Rubber	Prop	Mot Stick	Boom	Wing	Tail	Misc	Model	Total	sq in	(min)	(% of orig)
Taliafico	A-ROG	Decrease We	0.31	1	0.125	0.034	0.043	0.040	0.102	0.034	0.010	0.26	0.39	44.3	no change	-32%
Slusarczyk	Gyro-Cat III	Decrease We	0.63	1	0.782	0.077	0.159	0.075	0.362	0.204	0	0.88	1.66	203.5	no change	-14%
Slusarczyk	Gyro-Cat II	Decrease We	0.73	1	0.821	0.089	0.185	0.075	0.362	0.204	0	0.92	1.74	203.5	no change	-10%
Aronstein	Coco-Cessna	None	1	1	Same as original model ==>>										no change	0%
Aronstein	Coco-Miles	None	1	1	Same as original model ==>>										no change	0%
Aronstein	Coco-ANT	None	1	1	Same as original model ==>>										no change	0%
Markos	EZB	Decrease We	0.32	1	0.300	0.072	0.067	0.062	0.240	0.080	0	0.52	0.82	72.0	no change	-32%
Marett	EZB	Decrease We	0.33	1	0.316	0.080	0.084	0.075	0.240	0.096	0	0.58	0.89	74.6	no change	-31%
Nolan	EZB	Decrease We	0.62	1	0.557	0.143	0.199	0.096	0.379	0.096	0	0.91	1.47	74.0	no change	-15%
Palrang	EZB	Decrease We	0.21	1	0.115	0.023	0.033	0.039	0.114	0.028	0	0.24	0.35	67.4	no change	-40%
Lee	EZB-BS6-US	Decrease We	0.46	1	0.154	0.030	0.049	0.035	0.102	0.033	0	0.25	0.40	71.0	no change	-23%
Lee	EZB-BS6-LH	Decrease We	0.30	1	0.127	0.030	0.031	0.035	0.102	0.033	0	0.23	0.36	71.0	no change	-33%
Lee	EZB-DDF	Decrease We	0.32	1	0.089	0.021	0.020	0.021	0.067	0.024	0	0.15	0.24	70.4	no change	-31%
Hacklinger	F1D (1963)	Decrease We	0.32	1	0.38	0.05	0.09	0.08	0.30	0.07	0	0.59	0.97	202	no change	-32%
Ray-Cat IV	F1R (35cm)	Decrease We	0.25	1	0.140	0.025	0.030	0.046	0.092	0.050	0	0.24	0.38	111	no change	-37%
Ray-Cat III	F1R (35cm)	Decrease We	0.36	1	0.157	0.032	0.042	0.048	0.092	0.050	0	0.26	0.42	111	no change	-29%
Ray-Cat II	F1R (35cm)	Decrease We	0.32	1	0.152	0.029	0.037	0.048	0.092	0.050	0	0.26	0.41	111	no change	-31%
Sova	F1R (35cm)	Decrease We	0.42	1	0.179	0.035	0.050	0.040	0.104	0.058	0	0.29	0.47	92.8	no change	-25%
Finn	F1R (35cm)	Decrease We	0.41	1	0.183	0.037	0.055	0.039	0.127	0.046	0	0.30	0.49	93.4	no change	-26%
Diaz	F1R (35cm)	Decrease We	0.35	1	0.158	0.030	0.045	0.044	0.084	0.066	0	0.27	0.43	89.7	no change	-29%
Kagan	HL Stick	Decrease We	0.70	1	1.46	0.17	0.24	0.10	0.76	0.26	0	1.54	3.00	514	no change	-11%
Richmond	HL Stick-FS	Decrease We	0.62	1	0.87	0.14	0.24	0.000	0.52	0.27	0	1.17	2.04	433	no change	-15%
Slusarczyk	HL Stick	Decrease We	0.56	1	1.37	0.13	0.21	0.11	0.65	0.37	0	1.47	2.84	490	no change	-17%
Richmond	HL Stick-SW	Decrease We	0.53	1	0.75	0.12	0.20	0.11	0.47	0.15	0	1.05	1.81	390	no change	-19%
Brown	HL Stick	Decrease We	0.36	1	0.67	(component weights not available)					0	0.84	1.50	432	no change	-29%
Kagan	Int Stick	Decrease We	0.59	1	0.47	(component weights not available)					0	0.69	1.16	145	no change	-16%
Coslick	Int Stick	Decrease We	0.35	1	0.33	0.06	0.07	0.09	0.22	0.08	0	0.51	0.84	133.7	no change	-30%
Palrang	Int Stick	Decrease We	0.55	1	0.40	0.08	0.11	0.05	0.27	0.07	0	0.58	0.98	139.3	no change	-18%
Ganser	Int Stick	Decrease We	0.39	1	0.58	0.10	0.11	0.08	0.41	0.14	0	0.84	1.43	136	no change	-27%
Hoffman	Int Stick	Decrease We	0.36	1	0.416	0.045	0.083	0.054	0.306	0.088	0	0.57	0.99	134	no change	-29%
															Average - Indoor Stick	-25%
															Std Dev - Indoor Stick	8%

Table 4. Sample models modified for same duration, lower ceiling.

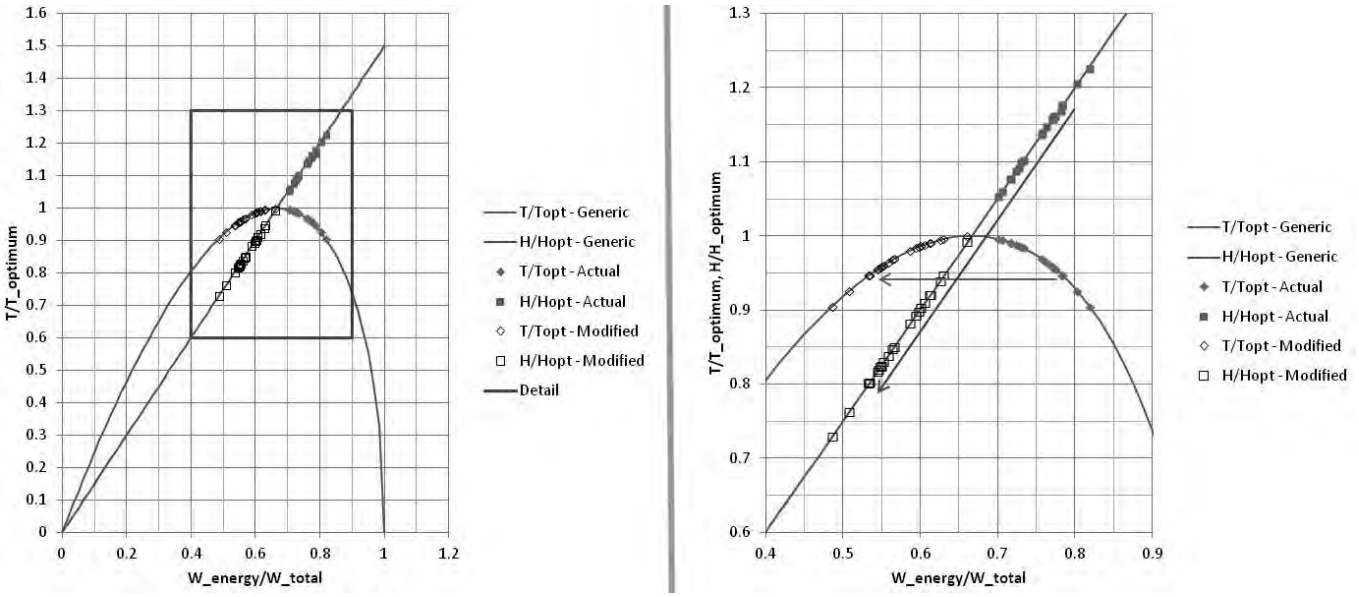


Figure 8. Modification for reduced ceiling height, while matching original duration.

are omitted from this family because they are already on the low We side of the optimum.

Figure 8 shows these results graphically.

The average reduction in ceiling height is a very significant 25% with a standard deviation of 8%. Although the predicted flight time is the same as the original model, one may actually see improvements for the same reasons discussed in regards to the previous family (i.e. lighter wings possible as the total model weight is reduced; and higher lift-to-drag ratios).

Evidence

Larry Coslick demonstrated this principle, and transformed the EZB event, with his short-stick designs in the late 1990s / early 2000s. He built them initially for 'no-touch' competitions in low ceiling venues; and found that the models were also competitive - even dominant - in regular contests. This revolutionized the event; weights dropped quickly from ~ .8g to .5g, and eventually to .3g and below. Times went from the low 20s (Ref. 9) to the mid 30s (Ref. 5, 10).

(Incidentally, when one is constrained to fly no-touch at a height that is much lower than the 'characteristic' height R' * k' * η_ρ / (1+kr), the optimum energy system weight becomes 1/3 of the total instead of 2/3 of the total. The proof and further discussion of this is beyond the scope of this article.)

I have included EZBs from before this transition (Markos, Marett, Nolan) and after (Lee) in the tables. Motor stick lengths were all 8" to 10" for the earlier models, and 6.2" for Kang Lee's; see Figure 9. Palrang's is somewhat transitional, having an 8" stick but being fairly light, attributable in part to his rigorous testing of the wood for every piece, and in part to Coslick having proved that you can make an EZB from such light materials.

The immediate weight reduction was the direct savings from the shorter, and slightly thinner, motor sticks. The subsequent, and equally large, weight reduction came as the reduced loads on the model from the lighter all-up weight and the smaller motor allowed everything else to be reduced as well. It was the classic 'weight spiral' in reverse. The end result was a duration improvement much greater than that predicted in Figure 7 and Table 3, i.e. more than just moving closer to the top of the hill. **The hill got bigger.**

The progression of my first three successful Coconut Scale models gives another example of radical improvement from reducing the energy system relative to the lifting system, even when the starting point was already right

at the theoretical optimum (and very successful in competition, having won the USIC Coconut Scale mass launches in 1990 and 1991). With each step, the fuselage dimensions were generally reduced and the wing area was increased. The Caravan and the Miles both fit within the conventional concept of good rubber scale subjects. The ANT-25 is very similar in proportions to the Miles when seen in a side view; but the wingspan is huge relative to everything else. I built the ANT at a scale which made the fuselage roughly 85% as long as the Miles; this resulted in a 65" wingspan (Figure 10).

All 3 of these models were built between 1989 and 1995, using similar techniques throughout. (And all are still in flying condition.) The motor base was reduced progressively from 20", to 14.5", to 13.5". The propellers are all of similar construction (although the Caravan has a 4-blader to compensate for very short ground clearance). The Miles and the ANT-25 propellers were made on the same form and are virtually identical except that the propeller on the ANT-25 is cut down about 1" in diameter for ground clearance. Competitive times in Coconut Scale are typically in the upper 2-minute range. My ANT-25 has come very close to 5 minutes and won the Coconut Mass Launch at the USIC and/or Indoor Nationals in 1995, 1999, 2011, 2014 and 2019 (all the ones I attended in that time span).

This is again more than the few percent predicted by the duration curve. What happened? 'F' increased by almost 50% from my first 2 coconuts to the ANT-25. Recall from equation 2 that:

$$F = k * \eta_\rho * [\sqrt{(\rho/2)}] * L/D * [\sqrt{(C_L)}]$$

My winding technique did not change. All of the models have similar propellers and similar airfoils on the wing. Of all these terms, the one most likely to see large variations is L/D. A large increase in L/D is consistent with the huge wingspan of the ANT-25. (I suppose I should conduct glide tests of these models to measure the L/D.)

Regardless of cause, the effect of the increased 'F' is shown in Figure 11 which plots the actual flight time (not normalized) vs We/W. The effect is the reverse of Figure 2. Instead of making the model worse by striving to reach the supposed optimum, **we are moving away from the optimum but the hill gets taller with every step.** The ground shifts as we walk on it, like something in Alice in Wonderland or a C.S. Lewis story. The natural mind wants to reject it and say that it is not real. But it is real; it just does not submit itself to our limited understanding. Each curve corresponds to the values of 'F', kr and ka that were achieved by each of the 3 actual models. But the curves are hypothetical. The only point on each curve that is totally real is the point where each model is. An aircraft is a very integrated thing. We cannot change just one parameter and make all others stand still. Everything we do affects many things, sometimes unfavorably, and sometimes favorably.

Application

This section presents practical steps to apply the findings that have been presented, with an example.

First pick a model to improve. Weigh the components, calculate We/W, and see where you are on the duration curve (Figure 12).

Then decide where you want to be. You can pick a specific target ratio of We/W as in the example below; or you can just scale down the following items as much as you think you can, aiming to scale them all by approximately the same factor:

- Motor width
- Motor length
- Motor stick cross sectional area
- Motor stick length
- Propeller spar cross sectional area
- Propeller diameter

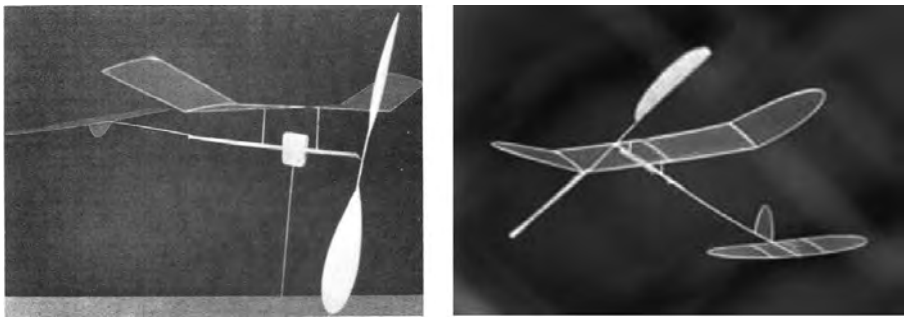


Figure 9. Long- (Markos, Ref. 9, left) and short-stick (Lee, Ref. 20, right) EZB models; both USIC winners.

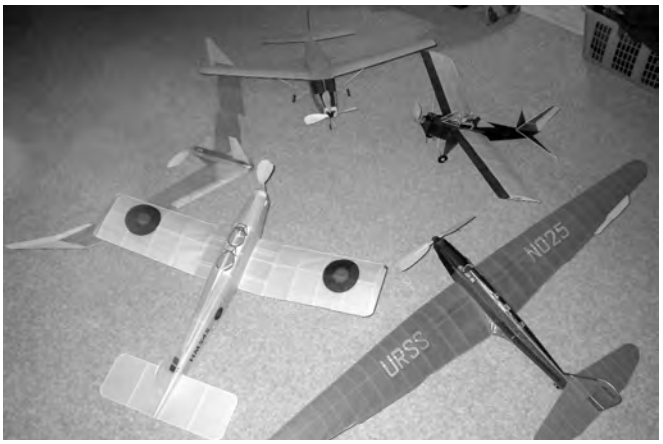


Figure 10. Coconut models, clockwise from top: Caravan, Mini-Max, ANT-25, Miles, non-scale Flying Wing (photo: Aronstein).

If you pick a specific target We/W, then any point between the peak of the curve in Figure 12, and the point directly to the left of the original model, should give you a duration improvement AND a climb height reduction. The farther left you go, the more you will reduce the climb height.

Design and build the new motor stick and propeller. As a first approximation, you should be able to scale down the motor stick cross sectional area and the prop spar cross sectional area by the same factor as the target motor cross section. After you have scaled down the motor stick in both length and cross section, take another inch or so off its length, if the configuration permits and if the original model could have accommodated more slack in the motor.

Use your original wing as-is, and boom and tail if they are transferrable. If you build a new tail, make it at least as light as the original. Alternatively, make it lighter in anticipation of the loads being reduced because the new model (including motor) will be significantly lighter than the original model.

Some reduction in propeller diameter will be needed to make the weight target. (If you can't believe that your model will fly longer with a smaller prop, take note of John Kagan's "Safat" 61.5-minute HL Stick with a 44" wingspan and only a 20" propeller; Ref. 6. Yuan Kang Lee's 37 minute, 2012 EZB has a smaller, lower pitch propeller than his 34 minute, 2011 EZB, which in turn used a smaller copy of a propeller design from Larry Coslick; Refs. 9and 10.) I also suggest a slightly lower P/D ratio (90% to 95% that of the original model) and do not scale the blade chord down quite as much as you scale the diameter. Both of these measures are intended to avoid overloading or stalling the blades of the new, smaller diameter propeller.

Reduce the weight of the secondary parts of the propeller and motorstick as much as possible. The thinner motor will put less stress on everything. Therefore you can use thinner wire for the thrust bearing and rear hook; the next smaller size of VP hub (if you buy it) or just smaller materials throughout (if you make your own); thinner Tungsten for the bracing wire; etc. Simplify the bracing system if possible; if you have "V" bracing, change it to a single overhead. The shorter motor stick will be less susceptible to buckling. Use thinner and/or fewer boron strips, if you used them on the original motor stick.

Fly it. Weigh your new prop and motorstick. Aim to use a motor weight that maintains at least the same ratio of motor weight to {prop + motorstick weight} as on the original model; and you should see an improvement in duration along with a significant reduction in ceiling height needed.

Now build a lighter Aerodynamic system - and do it all again! You will have made the whole model considerably lighter, which should enable you to follow up with a lighter Aerodynamic system. When you have done that, you might be energy-heavy again, and you can repeat the cycle! The benefits the 2nd time around may be smaller than the first (that's why it is called a spiral). How far you go just depends how badly you want the last bit of performance.

Detailed Example

As a detailed example, we will use Larry Coslick's Intermediate Stick model "Phoenix" (Ref. 6, pp. 56-57). From Table 2, We/W = 0.78. This puts the original model at 95.5% of the theoretical maximum duration that can be obtained without any improvement in its duration factor (F) or its component weight efficiencies (kr and ka).

Let's aim for a point to the left of the peak that gives 99% of the theoretical maximum duration.

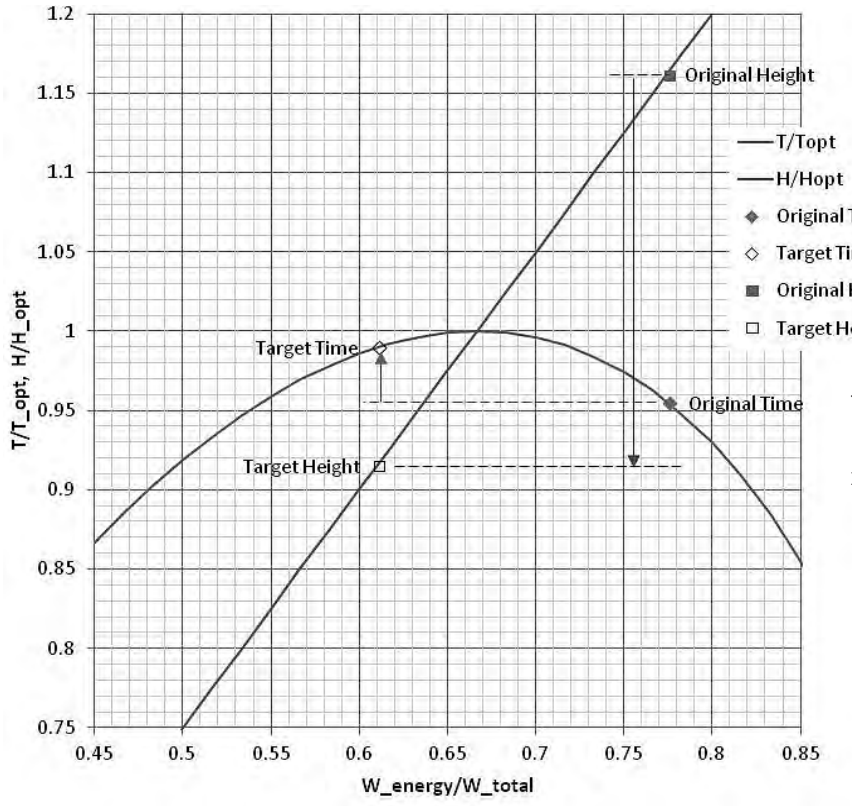


Figure 12. Chart for finding target We/W.

As shown in Figure 12, the target We/W is 0.61. The blue arrow shows the predicted increase in time, and the red arrow shows the predicted reduction in climb height, from the original model to the target.

The We/W target is known, but W is not fixed. Wa is known: 0.38g, same as on the original model. Therefore, use Figure 13 to translate We/W into We/Wa. For our target We/W = 0.61, the corresponding We/Wa = 1.57. Then:

We_target = 1.57 * 0.38g = 0.60g

Now we can see how much to scale down the energy system weight, to reach the target:

Energy system weight scale factor = We_target / We_original = 0.60g / 1.32g = 0.45

(1.32g is the weight of the original energy system; this and the other original weights from Table 2.)

W_prop_target = 0.45 * W_prop_original = 0.45 * 0.160g = 0.073g

W_motorstick_target = 0.45 * W_motorstick_original = 0.45 * 0.215g = 0.098g

We could achieve the target motor weight by scaling the length and the width equally by the square root of the energy weight scale factor, which would be 0.67. However, it will be easier to make a light propeller if we make the motor even a little bit thinner. Let's aim for a motor that is 0.57 x the original width and 0.80 x the original length. 0.57 x 0.80 = 0.45, preserving the desired weight factor.

Original motor = 0.045" x 16.5"

Target motor = 0.026" x 13.2"

Remember this is only a target to guide the next step. We will power the finished model with whatever it needs.

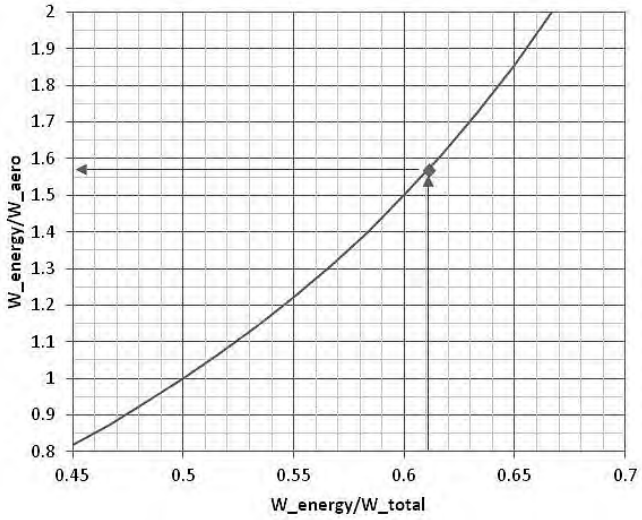


Figure 13. Chart for translating We/W to We/Wa.

Table 5 shows the proposed propeller and motor stick details, along with some general data. (For reference, Figure 14 shows the original plan). The motor stick length is scaled by 0.80 and then reduced another 1.75" for a little extra weight savings. This benefits not only the balsa tube but also the boron and the bracing wire. It leaves an 8.5" stick for a 13.2" motor, which is not too much slack in my experience. Also, I propose reducing the number of boron strips from 4 to 2, located 45 degrees either side of bottom center. This provides both compressive and lateral strength and stiffness. With the bracing wire overhead, I do not think a top boron strip is needed.

At the lower left of Table 5 are the weights I would expect to achieve if we actually built the new parts as well as Larry Coslick built the original parts. Although the propeller spar weight (scaling by length x cross section area) matches the target ratio, many of the detail parts do not, and I estimate that the propeller will be approximately 25% above the target weight, or 0.09g instead of 0.07g. With the tube on target, the boron and tungsten below target, and some of smaller parts above, I expect the entire motor stick to be on target. So in this hypothetical example, we come out 0.02g above target. We tried to take 210 mg out of the prop and motor stick, and we only took out 190 mg. What do we do about it? Fly the model!

Now that the model is designed and built, more rubber is OK, and we can use a little extra rubber to compensate for missing our weight target. Using the simplified duration equation 3b, with the same value of 'F' as the original model, the predicted performance of the modified model with the target motor is 42.1 minutes, not appreciably better than the original model. If we can up the motor weight from the original target of 0.43g to 0.47g, we should be able to match the target duration of 43.4 minutes. Suppose we end up with 0.028" x 13.5" instead of 0.026" x 13.2". This is a little bit more than the new prop and motorstick were design for; but the ratio of actual {prop + motorstick} weight to rubber weight, kr, is still higher than on the original model. In other words, we are not assuming a higher energy system weight efficiency than on the original model.

Table 6 and Figure 15 illustrate these steps. The overweight model with the upsized motor should achieve the target time. Instead of the target 21% reduction in climb height, it achieves a 19% reduction - still very helpful. The new model is below the original duration curve, but above the absolute duration and below the ceiling height of the original model.

Furthermore there is another step to take. Even with the overweight prop and upsized motor, the all-up weight is now 1.04 g, only 61% of the original 1.70 g. And it has exactly the same wing. The original wing may have been the lightest possible wing for the original model, but it is over-built for the new model. If we can build a new aerodynamic system - wing, boom, tail - even 10% lighter than the original, we will have the model represented by the last row in Table 6 and the last point in Figure 15. The predicted duration is increased by 4.1 minutes from the original model, from 41.8 min to 45.9 min, while using only 84% of the original altitude!

Review of opportunities by model class

This section discusses the opportunity for improvement beyond current performance levels,

General:	Original	Target		Motor:	Original	Target	
We	1.32	0.60	g	Width	0.045	0.026	in
Wa	0.38	0.38	g	Length	16.5	13.2	in
W	1.70	0.98	g	Width Factor		0.57	-
W/Wo:		0.58	- (ratio)	Length Factor		0.80	-
Speed Factor V/Vo = /(W/Wo):		0.76	-	Turns/Inch Ratio TPI / TPIo = 1 / /(width fac)		1.33	-
Power Fac. = (V/Vo)*(W/Wo)		0.44	-	N/No = (L/Lo)*(TPI/TPIo)		1.07	-
(assumes same L/D as original)				RPM Factor W/Wo		1.03	-
				(for required power at new torque)			
				Time Ratio T/To = (N/No)/(W/Wo)		1.037	-
				Time	41.8	43.3	min

Prop:	Original	Target	Item Weight Ratios
Diam	16.5	13.5	
Max Chord	1.80	1.80	0.82 covering
Spar hub	0.07	0.053	
	0.08	0.060	0.46 spar
Spar tip	0.020	0.020	
	0.020	0.020	
Outline	0.020	0.018	
	0.020	0.020	0.74 outline
Ribs	0.018	0.016	
	0.020	0.020	0.67 ribs
# of ribs	4	3	
Hi Pitch	55	41	?? VP hub
Lo Pitch	28	21	
			?? Shaft

Weight Summary:	Original	Target	Estimate	Delta
Prop Overall	0.16	0.07	0.09	+0.02
Stick Overall	0.22	0.10	0.10	0.00
Prop+Stick	0.38	0.17	0.19	+0.02
	g	g	g	g

Stick:		Original	Target	Item Weight Ratios
Balsa Tube	wall thk	0.011	0.009	
	ID	0.22	0.1875	
		(7/32)	(3/16)	
	L	12.75	8.5	0.46 tube
Front web	w	0.018	0.016	
	L	0.75	0.625	0.63 F web
Rear web	w	0.014	0.014	
	L	0.5	0.375	0.64 R web
Rear solid plug - L		0.1875	0.15625	
		(3/16)	(5/32)	0.61 R plug
Bracing post	diam	0.05	0.04	
	length	1.6	1.06	0.43 post
Rear hook	wire	0.010	0.009	
	standoff	0.17	0.125	0.60 hook
Thrust bearing	wire	0.012	0.010	
	standoff	0.17	0.125	0.51 bearing
Boron	#	4	2	
	clock positions	3, 6, 9, 12	4:30, 7:30	0.33 boron
		*see explanation		
Bracing wire	diam	0.0015	0.0012	0.43 bracing
	# wires	1	1	

Table 5. "Phoenix" Intermediate Stick modification design and construction.

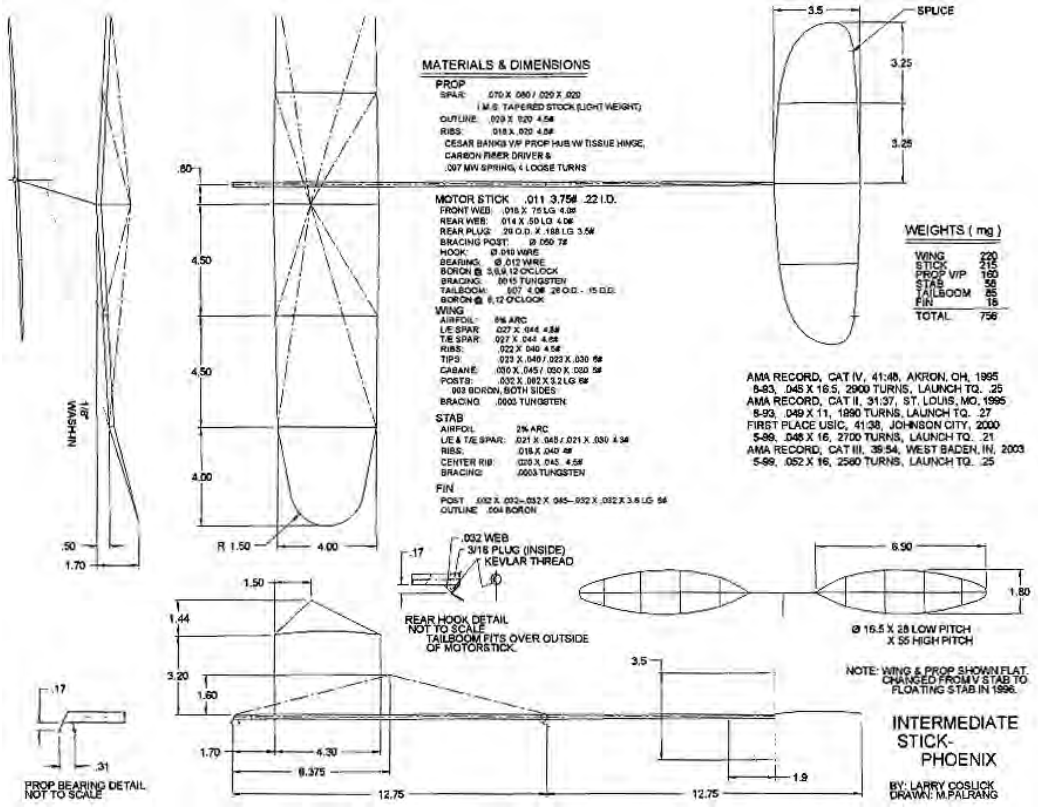


Figure 14. "Phoenix" original plan (Ref. 6).

	Motor			Model			Total	Energy	Aero	(lower is better)			Predicted	Time	Height
	Width	Length	Weight	Prop	Mot Stick	Model	Weight	System	System	kr	ka	We/W	Time	Increase	Change
	in	in	g	g	g	g	g	g	g	g/g	g/in2	(ratio)	min	min	%
Original Model	0.045	16.5	0.94	0.160	0.215	0.758	1.70	1.315	0.381	0.40	0.0028	0.77	41.8	0 (ref)	0% (ref)
Target	0.026	13.2	0.43	0.073	0.098	0.552	0.98	0.598	0.381	0.40	0.0028	0.61	43.4	1.6	-21%
20 mg over weight	0.026	13.2	0.43	0.091	0.100	0.572	1.00	0.618	0.381	0.45	0.0028	0.62	42.1	0.3	-23%
Adjust motor size	0.028	13.4	0.47	0.091	0.100	0.572	1.04	0.659	0.381	0.41	0.0028	0.63	43.4	1.6	-19%
10% lighter Aero System	0.028	13.4	0.47	0.091	0.100	0.534	1.00	0.659	0.343	0.41	0.0026	0.66	45.9	4.1	-16%

Table 6. "Phoenix" Intermediate Stick modification performance summary.

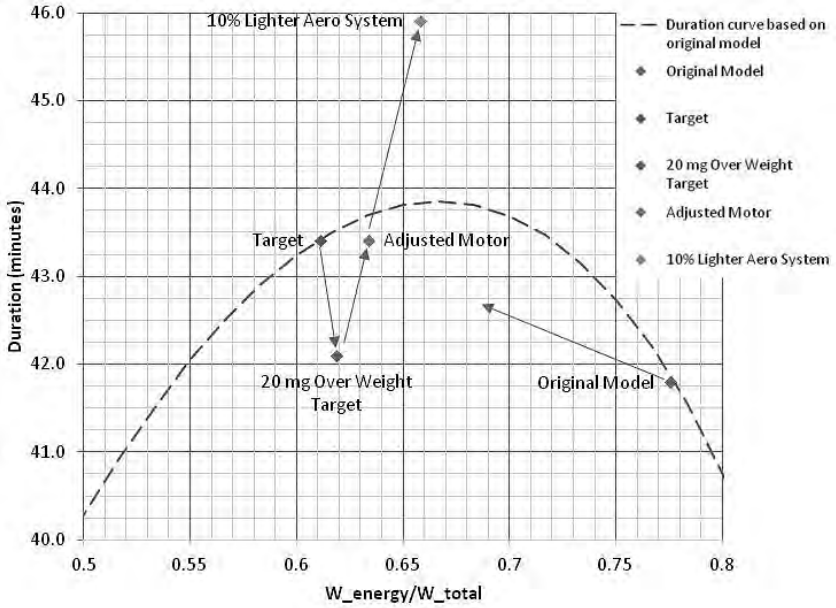


Figure 15. Performance of hypothetical modifications of the "Phoenix" Intermediate Stick.

for several classes of Indoor models, by applying the methods of this article. Applicability is not limited to these classes.

- **Intermediate Stick.** This class is ready to follow the EZB revolution, as suggested by the preceding detailed example.
- **A-ROG.** A very interesting class with great opportunity. It should appeal to the F1R (35cm) crowd. There is room to shorten the stick significantly. Reducing prop diameter will allow the takeoff gear to be shorter and lighter. I believe this event will also benefit from retracting gear; the drag reduction would be worth the weight. Stan Chilton tried this but did not perfect it.
- **ROG Cabin.** Although I did not include any examples, this is an elegant class and I believe the opportunity is similar to A-ROG, with an added benefit. As the motor base is decreased, the tailboom can also be decreased slightly, both of which contribute to a reduction in the required cabin cross section. A higher aspect ratio wing, similar to current Intermediate Stick models, would work well with these changes, and provide further improvement in L/D.
- **EZB.** A revolution has already happened, but maybe not finished? The new EZBs still have We/W ~ 0.75. The sticks are shorter than the older EZBs, everything is lighter, and We/W has come back to the same place! Is there another step to take? 4.5" motor stick? 40+ minutes?
- **F1R.** There is opportunity here too, but more challenging to capture because the motor sticks are barely longer than the wing chord. The scaling-down would have to be mostly in thickness rather than in length; the benefit might be smaller.
- **Let's not forget Scale.** Although only a few Scale subjects were analyzed, the results suggest that long-winged subjects deserve more attention than they have generally received.
- **New events.** It is my hope that as we introduce new events every now and then to stimulate the little grey cells, some of them will have meaningful design freedom to make tradeoffs between the major elements of the model.

- **HL Stick.** Best for last. Even though I do not fly HL Stick, I was inspired by Jim Richmond's 52:14 which happened very early in my modeling years, and stood as the absolute record throughout my youth and well into adulthood. He is a giant. I still have the pages from INAV with his plan and description of the flight. I am intrigued by the question of how much duration is ultimately possible.
    - This class has the same challenge as F1R, in that the motor sticks are not greatly longer than the wing chord. But it also has an intriguing opportunity: there is no limit on wingspan or area.
    - Steve Brown's HL Stick shows opportunity. Although I do not have his component weights, his ratio of rubber weight (1.84g) to model weight (1.12g) is higher than any other HL stick. With all that rubber counting toward We, his We/W must be high; and 3% to 6% improvement should be possible just by optimizing We/W. Considering he has already done 63.9 minutes, another 2 to 4 minutes would be an epic flight by any standard. And that is without any consequent reduction in the weight of the aero system.
    - The other HL Sticks are very are already very close to the optimum We/W. There does not seem to be much opportunity in optimizing the weight ratio. But the total weight comes down considerably as one moves left even a little bit on the We/W scale. The all-up weights of the optimized HL Sticks (Table 3) average 81% of the weights of the original models (Table 1), reducing the loads on the aero system. If one is willing to step a little farther to the left and aim for the point where the predicted duration is 99% of the maximum, the average all-up weight comes down to 69% of the original models. You risk 36 seconds duration (the difference between 99% and 100% of a nominal 1-hour capability) but now you have a very significant 31% reduction in all-up weight of the model. In HL Stick this can benefit the aero system in multiple ways:

- First, reduction in weight of the aero system, as previously discussed.
- And/or, improvements in aerodynamic efficiency:
- Reducing the amount of bracing
- Increasing the wingspan (with or without increasing the area)
- **The increase in flight time due to L/D improvement is 1 to 1.** A 15% increase in L/D would yield a 15% increase **- 9 minutes** - in duration; and this is a very reasonable expectation with a slight increase in span and area, and/or some aerodynamic clean-up of the draggy parts (posts and bracing).
    - Therefore the real prize is not necessarily in getting to the top of the mountain (the exact optimum We/W), but in the synergies that can make the mountain taller. I think John Kagan's "Safat" is on the right track. In spite of being a fairly crude model (by Kagan's description; not crude by my standards!) built partly from F1D components and with a lot of bracing, "Safat" has an 'F' that is higher than Brown's 63.9 minute model. "Safat" has a large wingspan, 44", and a small 20" prop. Brown's has a longer time due to better weight efficiencies. I believe that someone should build another model like "Safat" but cleaner and lighter. Purpose-built, no more F1D parts. Do not increase the prop or stick at all. Make the wingspan at least as large as "Safat", larger if you can, and see what happens. Combine Brown's weight efficiencies, near-optimum We/W, and Kagan's 'F' value (or better) in one model. **To 70 and beyond!**

6. Conclusion

If one decomposes an Indoor model into an "energy system" (motor, motor stick, prop) and an "aerodynamic system" (wing, boom, tail), nearly all Indoor Stick models have a heavier than optimum energy system relative to the aerodynamic system. Taking ceiling height into account, it would be preferable have a slightly lighter-than-optimum energy system.

It is predicted that most of these models can be improved by more or less uniformly scaling down all parts of the energy system, and/or scaling up the aerodynamic system. **Duration can be increased and the required ceiling height can be decreased, simultaneously.** This conclusion is applicable to any class which has design freedom to make meaningful trades between the energy system and the aerodynamic system. The advancement of the EZB class, from 0.8g models having typically 10" long motor sticks and achieving durations in the low to mid 20s (minutes), to 0.3g models having 6" long motor sticks and flying in the mid to upper 30s, lends evidence that the benefit is not only real, but that it can be significantly greater than the predictions presented here. This is due to the initiation of a downward weight spiral; and to favorable variation in other factors that were treated as constant in this analysis.

A method for applying this principle was presented, with a hypothetical detailed example. Although hypothetical, the example accounts for the likelihood that design targets will not be achieved exactly. The resulting model is still predicted to achieve an improvement in duration with a simultaneous reduction in required ceiling height. **The improvements do not depend on any increase in component efficiencies.** The same builder, who built the original model, can build the optimized model, using similar techniques.

Thank you for your attention. If you would like some help applying these concepts to the improvement of your model, or would like to share your results with me, please contact me at: davidcaronstein@gmail.com

Symbols and Abbreviations

η_ρ	(Greek letter 'eta') propeller efficiency
ρ	(Greek letter 'rhō') air density
Φ	(Greek letter 'phi') area under torque curve that is above the level-flight line
Ω	(Greek letter 'omega') propeller rotation rate
C_L	Lift coefficient of the model
D	Propeller diameter
F	Duration Factor = $k * \eta_\rho * \sqrt{(\rho/2)} * L/D * \sqrt{(C_L)}$
ft	Feet
g	Grams
H	Climb altitude
H_opt	Climb altitude of model optimized for duration only
in	Inches
k	Rubber energy density output
k'	Rubber energy output modified by altitude management techniques
ka	(Wing + tail + boom weight) / wing area
kr	(Prop + motor stick weight) / rubber weight
L	Length
L/D	Lift-to-drag ratio
LB	Pounds weight
N	Turns
o	(as subscript) Original
P	Propeller pitch
Q	Torque
R	Fraction of total rubber energy that is above the level-flight line
R'	R, modified by altitude management techniques
S	Total area (wing + horizontal stabilizer)
Sh	Horizontal stabilizer area
Sw	Wing area
t, T	Flight time
T_opt	Flight time of model optimized for duration only

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TPI	Turns per inch in motor
w	Width (when lowercase)
W	Total weight including model and rubber (also W_total)
Wa	Weight of 'aerodynamic system' (wing + tail + boom)
We	Weight of 'energy system' (rubber + motor stick + prop)
Wm	Model weight (excluding rubber)
Wmisc	Miscellaneous weight (not specific to aerodynamic system or energy system)
Wr	Rubber weight

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THE DEVELOPMENT OF ELECTRONIC STEERING FOR F1E MODEL AIRCRAFT

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Introduction

The F1E Free Flight event is for competition free flight models which fly down a slope into the wind. The performance desired is flight durations of from three to five minute maximums for five rounds of flying plus fly offs. The models are permitted some autonomous steering to maintain their heading down the slope.

Persons interested in flying f1E in the USA are not hindered by lack of information or resources. There are large amounts of information publicly available in magazines or commercial outlets. Many F1E articles have been published in past Symposia and the AMA Model Aviation magazine. In Europe, F1E is flown extensively and complete ready to fly F1E models, kits and parts are available from European sources.

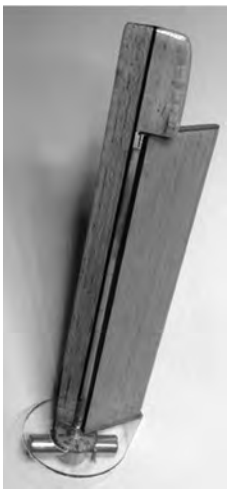


Figure 1. Conventional Steering Vane Assembly

The Conventional Magnet Steering System

The usual method of automatic steering is to attach a very powerful magnet, usually a Rare Earth Neodymium bar magnet, to a steering vane on the nose of the model. The magnet intercepts the magnetic lines of force of the Earth and aligns with them similar to a ships compass. The steering vane is a snug but movable fit on the axial shaft of the magnet so that it may be set to the desired slope direction when the magnet is pointing to magnetic north. If the model deviates in heading, the magnet will hold the steering vane on the desired heading which will appear as a nose rudder offset and push the nose back to the desired heading. See Figures 1 and 2. This system functions acceptably provided there is little air turbulence.

The Steering Problem

The problems with magnet steering are three fold.

First, while the magnet is very powerful, the magnetic lines of force of the Earth

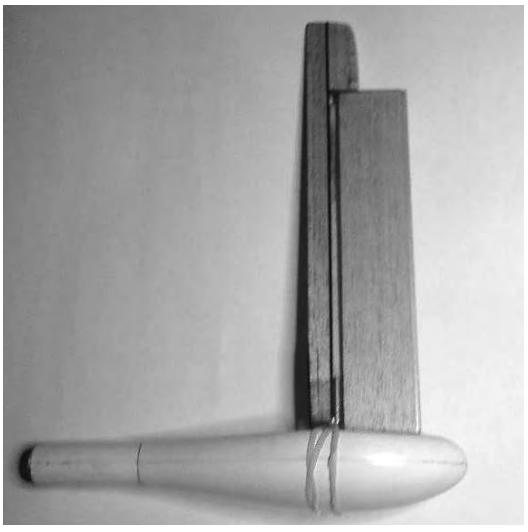


Figure 2. Conventional Steering Vane showing connection to Magnetaa

are not, so the magnet can only exert a weak force on the steering vane causing steering corrections to be slow.

Second, the powerful magnets needed for steering are heavy and the steering vanes they operate need some leverage so they are both located some distance from the center of gravity toward the nose of the model. This fact gives the F1E models a large moment of inertia which is compensated for, but not minimized, by a long tail moment arm and a large stabilizer.

Third, these model aircraft encounter side wind gusts and thermal updrafts as they fly without radio control down the slope into the wind. F1E models pitch, roll, and then yaw to a different heading in response to these disturbances. Since the pitched or rolled steering magnet no longer intercepts the magnetic lines of force of the Earth it has no corrective force. The aircraft must return to pitch and roll level overcoming its large moment of inertia before the steering magnet can start turning the model back to the desired heading. This lengthy process causes major deviations in flight path including turning back into the slope or shifting sideways to an undesirable part of the slope such as into trees or water.

Possible Solutions

The problems associated with magnet steering incentivized me to try to find another way to steer the models that is quick acting and works when the model is pitched or rolled or both.

I had observed other modelers attempting to implement electronic steering for F1E models but with no real success. Their approaches were based on either steering by gyroscopes or by magnetometers. The gyroscopes available to model experimenters drifted in heading and by my observation one or two degrees per second, even though the manufacturers claimed much better performance.

The electronic magnetometers performed even worse that the normal magnet steering. When upset by a side gust, they would turn back into the slope, spiral dive or lock up. I determined to see if I could do better.

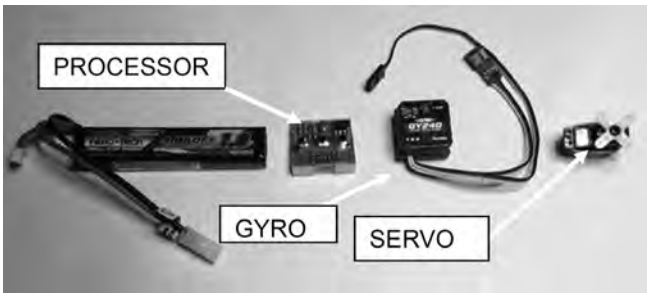


Figure 3, First electronic steering system using a gyro

1) In late 2010 I found a gyro stabilization device which claimed a maximum drift of two degrees per minute. This was from a reputable radio control manufacturer. I designed a steering system comprised of a flight battery, a power switch, a servo testing circuit board, the gyro stabilizer and a steering servo operating a rear rudder. See Figure 3

The servo testing circuit board could generate a servo centering output of a 1.5m sec. 5 volt pulse at a frequency used by servos. The concept was to point the model in the desired direction, switch on the system, and allow everything to stabilize. Then to set the test board to output the servo centering pulse, send this pulse through the gyro stabilizer to the steering servo and thus steer the model.

The gyro stabilizer was to modify the steering pulse to correct the model heading if it moved off course. This system actually worked, but the gyro stabilizer was not anywhere near as good as claimed. Flight tests revealed that although the system did function as designed, the performance of the gyro stabilizer had been misrepresented. The heading drift was closer to one degree per second than two degrees per minute. This gyro stabilizer was subsequently taken off the market.

2) Next, I found an RC gyro stabilization set from China which claimed stabilization in pitch, roll and yaw. See Figure 4.

I substituted this device into my system in place of the gyro above. The result was a similar failure.

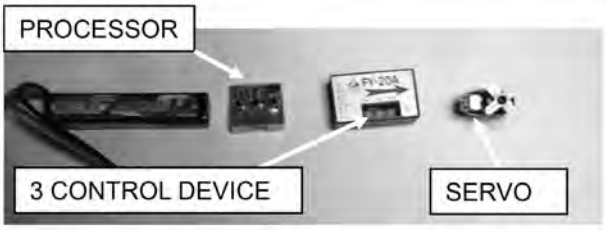


Figure 4. Steering System using a Three Control Stabilization Device

About this time, around 2011 I received some feedback that gyros of the performance I needed were not available on the open market because they could be used to steer cruise missiles. Then the FAI banned the use of the Global Positioning System for F1E steering because they could possibly take your model to a way point rather than just maintain heading. Given this situation and my negative flight test results, I decided to see what full size practice was for autopilots.

The answer is they use a full gyrocompass for heading control. This means a combination of three axis accelerometers, three axis gyroscopes and three axis magnetometers and some very complex filtering to figure out the best heading information to use.

The desired heading is set in the auto pilot and the magnetometers are given priority unless the vehicle is pitched or rolled in which case the gyros are given priority until the vehicle returns to level flight or sailing. It seemed to me that something similar could be used for our purpose of steering an F1E. I even found an AHRS (attitude heading reference system) available on a development circuit board of a size that would fit, but it was going to require starting from scratch in a new programing language.

This system would probably have worked but the time and effort required to get there was too much. As I searched the Web, I found a few RC model autopilots but they were all GPS based and ran on Arduino computers with yet another language.

3) Finally, late in 2012, I contacted an RC autopilot maker named Tom Pycke who made Gluon Pilots and asked him if he could modify one of his autopilots to use a magnetometer instead of GPS to steer an F1E. He said yes.



Figure 5. Autopilot mounted in Protective Shell

I told him that the AHRS should be able to react to changes in aircraft heading immediately and send an output to the steering servo connected to the aircraft rudder. This approach should correct the aircraft heading before it deviates very far, and thus maintain the flight path close to nominal.

To achieve this electronic steering, the AHRS mounted on the aircraft needs to have a way of being told the selected heading. This may be done by aligning the aircraft on the desired heading and pressing a switch. Once the AHRS has memorized the correct heading it can detect deviations from that heading and send an output to the steering servo to correct the heading by moving the rudder.

I also told him that the signal i.e. pulse width sent to the servo should be proportional to the deviation from the desired heading to give both quick reactions and smooth steering around zero deviation.

Lastly, I told him that the AHRS needs to use the magnetometer for steering when the aircraft is flying wings level and pitch nominal and switch to gyro steering when the model rolls or pitches or both beyond a limited amount and then switch back to the magnetometer as soon as the model returns to level flight.

Tom found a three axis magnetometer and plugged it into his autopilot in place of the GPS receiver. See Figure 5

He changed his software to meet my needs and sent me a test article early in 2013. The system showed some promise, but the calibration was

laborious and required a laptop in the field. It did however seem to eliminate the two failure modes (1) of gyro only steering drift and (2), magnet only steering drop out when pitched or rolled. Tom produced another test article which could self-calibrate if held still. I was running out of time so I took this test article to the World Champs in Slovakia in August of 2013. The system was bulky and heavy but it steered the model. Unfortunately, in the World Cup event before the World Champs, the model de-thermalized into a tree and the steering system was damaged beyond local repair.

I next flew the model with repaired electronic steering at Lost Hills in February of 2014. Again, it worked as desired. This caused Bob Sifleet and I to ask Tom Pycke to make some additional systems in preparation for the World Championship in Serbia in 2015. When we began to work with the new systems, we began to encounter problems with the magnetometers.

I flew models using the electronic steering systems at the World Champs, but they failed to operate correctly. The failures were inconsistent and it was not clear whether the failures were due to faulty components or proximity to the powerful steering magnets of other models or both. I ordered more magnetometers and selected the best ones for flight use, but most of them seemed to be deteriorating. I also learned that Honeywell had stopped production of these magnetometers.

Further testing seemed to show that some selected magnetometers were operating correctly so we asked Tom Pycke to change the software to operate the circuit board on edge so that we could package the systems for lower drag on the models. See Figure 6.

This was a mistake! It is now apparent that while the magnetometers, gyros and accelerometers are described as being three axis, i.e. they will work in any orientation, they are not symmetrically three axis. They apparently require biasing



Figure 6. Autopilot on edge in Pylon Mount

to use them other than horizontally.

Anyway, this electronic steering system never worked consistently again! When we tried to return to a horizontal orientation they still did not work. Finally, we abandoned this system after years of effort and asked Tom Pycke if he thought he could do a new design based on our accumulated knowledge and using the newest and most reliable components. He said yes again.

The resulting configuration is shown in Figure 7.

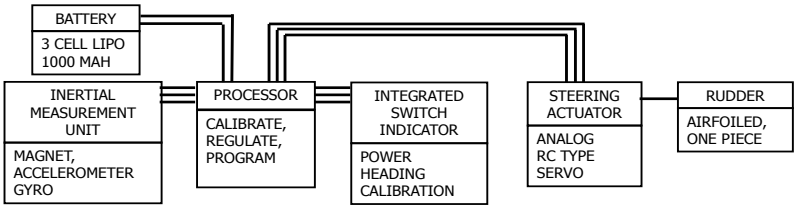


Figure 7. System Schematic

Tom found a SPARCFUN IMU (inertial measurement unit) circuit board that is meant for use flat only, but contains all of the three needed components 1) accelerometers, 2) gyroscopes 3) magnetometers and is small enough that it may be used flat without causing excess drag. He was also able to use a small control board and a combined steering switch and signal light. See Figures 8 and 9.

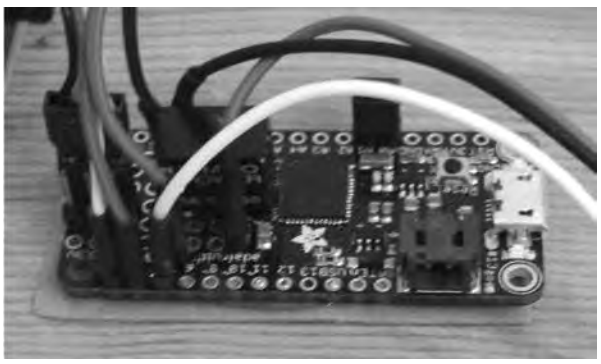


Figure 8. New Control Circuit Board

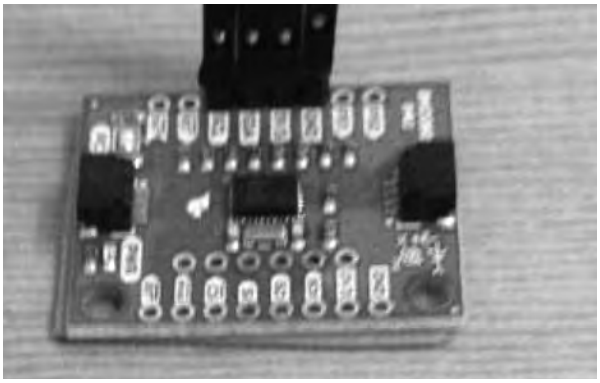


Figure 9 New Inertial Measurement Unit

This makes the whole system much smaller and lighter than before and easier to use. It also conducts continuous calibration and signals its state of calibration through the lighted switch.

To test the new system, I built up a new "brass board" test fixture using the new steering system from Tom, a LIPO battery, an on/off switch, a steering servo and an actual aircraft rudder set. Then I tested the whole "brass board" sequentially in my shop, outside in the clear, with an ICARE GPS tracker on board and with a FFELECTRONICS GPS tracker on board, as well as a Walston style tracker from F&L Electronics.

I did pitch, roll and yaw and permutations of all of them both indoors and out. The system worked very well except with the GPS trackers on board. The ICARE tracker appeared to interfere with the steering servo so I would be wary of both of them until ferrite beads can be added to the connecting leads and thoroughly tested.

Since the new F1E steering system worked at my home, an F1E was prepared with the new system and the steering servo was placed twelve inches removed from the IMU to get its magnets away from the magnetometers and a clock work timer was used. Both of these things were done to prevent interference with the IMU.

This F1E was tested at home successfully and then was flown in competition at Lost Hills in February. It completed test flights and all five competition flights correctly. No particular effort was made to keep the model away from its magnet steered competition. The model finished fourth, but the main emphasis was on observing its steering which met our requirements of quick steering and steering when the model was pitched and or rolled.

Future Flying

More steering systems are on order from Tom Pycke and those new systems will be thoroughly tested before installation into more F1Es. The publication of this article will be ahead of 2019 contest flying, but if all goes well then electronic steered F1Es will be flown at the 2019 Wendover, AZ contest and the 2019 Denver F1E World Cup contest in preparation for the World Championship in Slovakia in August, 2019. The Denver contest should provide some variable wind speeds to exercise the systems more thoroughly than Lost Hills.

If time permits, ferrite beads will be added to the servo input wires and the IMU connecting wires to see if this will fix the GPS interference and allow use of the more sophisticated trackers.

Latest Test Results

The systems that we ordered came in and two were forwarded to Bob Sifleet for his testing. Bob's tests were even more encouraging than mine were. Bob found that his steering units were not affected by his cell phone, his GPS tracker, or one of the powerful magnets previously used for steering. He also found that the system did not creep or jitter while sitting still and provided steering signals to the servo when pitched or rolled or both. The latest system flies much better than any others. The self-calibration of the system also appears to be functioning better than before.

Sources mentioned in this article:

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FFELECTRONICS FFelectronics.com

F&L Electronics, Huntington, WV 25701



"Every one is interested in airfoils.
I'm interested in being a machinist
This frontend has 28 parts!"

BUILDING AND USING LASER TECHNOLOGY

AUTHOR
JOHN LORBIECKI

It seemed only a few years ago that laser cutters were only for the high end user. However, as with all electronics, the prices of these machines have continued to decline and capabilities have increased. Almost all modelers have either heard of or have constructed kits containing laser cut wood. And, as these prices of laser cutters dropped, more and more modelers have one in their shop.

This article is going to introduce the use of lasers to show what the laser is, how it works, changing the thought process when using one, and building using laser produced parts. The hope is that more will see the usefulness and capabilities of producing better fitting, more complicated parts for the average user.

What is a laser?

The term laser has been around for many years. Using Wikipedia, it introduces the term laser as " a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. The term "laser" originated as an acronym for light amplification by stimulated emission of radiation." In simpler terms, think of a light beam that is highly focused into a very narrow beam and uses the power of it to produce an intense light. This light has energy associated with it and can be used for many uses. From the old laser disk audio systems to a powerful beam of light that can destroy a missile in space, it has many practical applications.

These beams of light can be produced in multiple ways. One early method was the ruby laser. A ruby laser most often consists of a ruby rod that must be pumped with very high energy, usually from a flashtube, to achieve a population inversion. The rod is often placed between two mirrors, forming an optical cavity, which oscillate the light produced by the ruby's fluorescence, causing stimulated emission. Ruby is one of the few solid state lasers that produce light in the visible range of the spectrum, lasing at 694.3 nanometers, in a deep red color, with a very narrow linewidth of 0.53 nm (Wikipedia). This produced a lower power beam and was the beginnings of a laser that the tech savvy experimenter could make.

However, it was low power and awkward. Technology continued and soon there were laser diodes. The semi-conductor laser diode was developed and commonly used for audio and communication systems. It, along with fiber optics, is still used today for sending signals over long cables with very fast speeds. Again, it is fairly low power.

As technology increased, so did a variety of laser types. Soon lasers were devel-

oped that could easily cut various metals and non-metallic materials. These are commonly referred to as CO2 and fiber optic lasers. They can produce high power outputs and by changing the wave length of the light, can be used for many materials. The speed and accuracy of these systems made them commonplace in many manufacturing facilities. The fiber optic lasers are used by sheet metal houses to make various types of parts. They are quite powerful but also very expensive.

However, CO2 technology has proven to be relatively low cost and readily available to the hobbyist. The most basic form of a CO2 laser consists of a gas discharge (with a mix of gases) with a total reflector at one end, and an output coupler (a partially reflecting mirror) at the output end, all contained within a glass tube. The beam is reflected internally until it reaches a desired power level and is then transmitted through a series of mirrors leading to the final lens in the traveling head. The glass tubes are relatively long and water cooled. The beam in the tube is blue to purple in color but after it leaves the tube is invisible. Because the beams cannot be seen, every commercially available laser is equipped with safety interlocks to permit cutting to occur only when the top of the unit is closed. It is very important to use great care when working with a system that has been modified in any way. CO2 lasers are available in ranges from 5 to 100 plus watts. The higher powered lasers can cut thicker materials faster. However, like all things, higher powered machines are more costly. The wavelength of the normal CO2 laser will cut woods and plastics but not metals.

What Does a Typical Hobby Laser System Consist of?

The basic laser construction is a tube, power supply, and electronics to read the code which turns the laser on and off and moves an x/y drive system. The x axis and y axis of the system are driven by stepper motors and belts. This positions the head (which has a mirror and lens system) in its proper location for the cut. The beam is reflected from the tube's output by two other mirrors to the main head.

There are basically two things that set the cost of the unit, the wattage of the tube and the size of the cutting area. These vary model to model. Also, the country of manufacture will affect the cost. The lower cost units are Chinese made and vary greatly in quality and service.

The most common Chinese system is the K40. It available on eBay and they have sold many of them. The quality is such that many will be delivered that do not function. However, there is a large group of experimenters that provide a wealth of information- everything from how to make them work to reworking the mechanics and electronics to improve the operation. Costs for these are in the $500-$1000 range. The cut size is 300mm by 200mm (11.8" x 7.8"). One major problem is the lack of customer service.

The American made units are more costly but many times the user gets what he pays for. These systems typically function out of the box. There are many manufactures, such as Full Spectrum (the unit used for this article), Epilog, Boss, Universal, and others. These typically start in the $3500 range and go from up from there. This increase in price gets the user improved mechanical and electronic systems, better programs for running them, and easier access to customer service. The usable table is normally bigger, with 20" x 12" being on the small size. The unit used for this article is the Full Spectrum H-Series (Hobby). It has a 40 watt tube and a 20" x 12" cutting area.

The laser needs a few other things to make it usable. The first is a vent system. It consists of a blower that draws the fumes from the laser enclosure and pumps it out. This fan is normally a centrifugal style and vents via a 4" dryer style tube to the outside. Many people will use a

dryer vent system to the outside of their work area.

Next, because the tube is water cooled, there is the need for a chiller system. The simplest cooling system is a 5 gallon bucket of distilled water that is pumped thru the tube. It relies on ambient temperature to chill the tube. This will work with the lower powered systems but as the units get bigger, there will be the need for a dedicated chiller. A chiller consists of a radiator and fan or possibly a refrigerator style device. It is important to keep the temperature constant for best performance.



Figure 1: The all-in-one laser cart

It is not uncommon to use an air assist system. This is a small blower that blasts air towards the cut area. It uses a small compressor that will help the cut by keeping the immediate area clear of smoke and debris. Some folks will use a bigger compressor to help improve the process. The manufacturer of the machine will provide recommendations to what is needed.

Finally, it is best to have a dedicated computer or laptop to run the machine. This can be a very basic unit, as the files sent to the laser are simple print files, effectively.

Setting Up the Laser System

The units tend to be relatively large (the Full Spectrum dimensions are 32" x 20" x 8.5") and there is the need for space for the chiller and computer. Some will use a work bench or table but the author made a movable cart. It has a top section that holds the laser as well as space for a laptop. The bottom shelf is used for a mounting area for the exhaust fan as well as an area for the cooling bucket. Plus there is additional storage for supplies. See Figure 1.

The vent system should be run outside using the 4" vent tube. This can be done with flexible corrugated dryer tube (metal is preferred) and a vent thru the wall. There are available stand-alone filtration units to permit inside-the-house discharge, but these may require regular maintenance.

A power strip of some type will be needed. It is very important in the set up that when the laser is turned on that the chiller pump is functioning as well as the vent fan. These two units use the most power but it has been found that a good, high quality power strip will function well. Failure to turn on the chiller when using the laser can result in destruction of the tube.

Whatever system is used, it is important that the unit is stable. If not, there is the possibility that misalignment of the internal mirrors may take place which will affect the operation of the laser (possibly poor cutting and loss of cutting power).

Laser Operation

From this point on, many things stated will be in regards to the use of the Full Spectrum laser system. Details will vary system to system, but this will show a method in which to laser cut parts.

Please note that the materials that can be cut on the laser are important. Of course, most of this discussion will be using balsa and plywood but it will also acrylics cut very easy. It is important to know that the system should never be used for plastics that are chlorinated, in particular PVC. The gases that are produced

when PVC is cut will destroy the internals of the machine in hours. Plus, it is poisonous to the operator.

The power of the machine will dictate the maximum thickness and speeds that can be cut. The laser beam is focused onto the upper surface of the material. At this point, the user should realize that the beam will create a kerf cut (kerf is the shape of the beam when it leaves the focusing lens- it is not a straight beam but is actually cone shaped). Because of kerf, the thicker the material and the quality of the focus will cause the cut not to have vertical sides. There will be a slight taper to every cut. When cutting thinner materials the kerf will be quite small, but as the material gets thicker expect more of an angle.

There are two types of operations that all lasers do: raster and vector. A raster cut is used for engraving. A common example of raster cutting is engraving glass cups. Raster consists of the carriage moving rapidly in the x axis (left to right) and advancing in small steps in the y axis (fore and aft). The cuts tend to be very shallow and will easily do images and lettering. This process has been used for making trophies and plaques in wood and acrylic (note that polycarbonate is not recommended in any laser operation).

All cutting of parts is done with a so-called vector cut. It is easy to think of this as a band saw cut. The beam is turned on with relatively high power and the head moves to produce a through cut. By a combination of turning the laser on and moving the head via the x and y axis stepper motors, any shape can be cut. Because of these capabilities, anything that can be drawn in a 2D system can be cut

Creating a Cut File and Sending it to the Laser

Probably the hardest part of the laser operation is producing the files to make the part. Many CAD programs can be used to produce a usable file. The more expensive systems like SolidWorks or Pro-E will work, as well as the classics, like AutoCAD or TurboCAD. However, there is a freeware CAD program called DraftSight (https://www.draftsight2018.com/) that will make very usable files. It is a 2D program that replicates AutoCad Lite and allows the user to design simple to complex parts. Inkscape is another free and open source vector graphics editor; it can be used to create or edit vector graphics such as illustrations, diagrams, line arts, charts, logos and complex paintings- https://inkscape.org/release/inkscape-0.92.4/). See Figure 2.

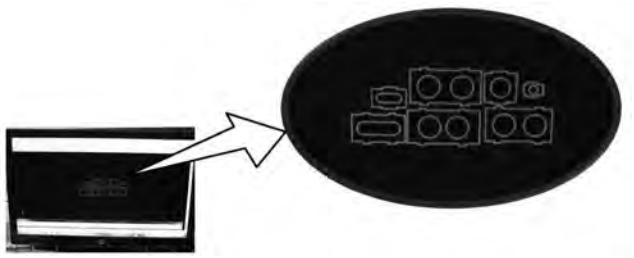


Figure 2: With a CAD program, features like alignment tabs, lightening holes, and interlocking geometry are possible

Once the design is made the user will go to the print portion of the CAD program. There is a selection made for the print driver to the Full Spectrum machine. It is important that the parameters are properly set, particularly making sure that the file will be printed 1:1 (full scale). Then the button is pushed and the file is sent to Retina Engrave, which is Full Spectrum's laser controller software. In this program the operator sets up the speed and power as well as setting the actual size of the part. All of these parameters can be modified relatively easily and quite accurately.

At this point, the cutting process is nearly ready to begin. The material is placed on to the table in the laser. The user shall verify that it is in the proper location. The Full Spectrum software will allow it to traverse the outer most perimeter of the cut. This will verify that the material is in the proper location and is big enough to make the cut. Many systems employ a smaller pointing laser on the head for aiming. The user

can set the speed and power of the machine to match the material type and thickness. These numbers vary from machine to machine and it will take some experimentation to determine what is needed for any combination of material, thickness and density. Once these steps are completed, all that is done is to push the start button and watch the magic.

From a safety standpoint, it is very important that the operator watches the cutting process. There is the possibility that a fire could be started inside the box. This is particularly important when cutting small, complex parts. Smoldering or scorching could occur as a result of incorrect focus, too high a power setting, or two low a speed setting. Virtually all machines have an interlock built into the cover. If something happens (or any time the cut needs to be stop instantly) simply raising the cover will stop the laser process and the problem can be remedied. A squirt bottle of water nearby is a good idea.

Designing and building concepts for the Laser

This is the fun part. The more imaginative the designer is at this time, the easier it will be to build a strong, accurate model.

The user will need to set the project up so that it fits the machine table parameters. This means that (again, using the Full Spectrum H Series) no piece can be longer than 19.75" and no deeper than 11.75". We know that models many times will have parts longer than these dimensions so a splice must be made.

There are various methods to perform this. A common way is to use a jagged, non-symmetrical design. The shape looks like a saw tooth. See Figure 3. This will make the parts fit together precisely and by making it not symmetrical, the parts can only be put together one way. By doing this, it will be impossible to put them together incorrectly. This process can be used for fuselages pieces, trailing and leading edges, or any other piece that exceeds the machine dimensions.

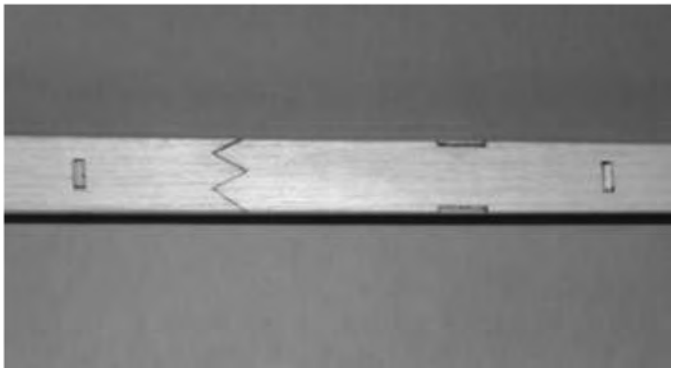


Figure 3: The sawtooth joint

When the design is being done, it should be kept in mind that the laser does remove some material on each side of the cut. This is the aforementioned kerf. If an accurate dimension needs to be maintained (such as spar fits), then the feature should be designed slightly undersize. With this machine, about .005" per side will usually allow a tight fit. This dimension change will be done when designing the part.

The designer can locate parts wherever needed on the material. For instance, if your material is a 4" x 18" plank of balsa, place the parts inside a 4 x 18" rectangle in the CAD software before sending the file to the laser. However, the direction of the grain of the wood needs to considered. There only needs to be about 3/32" between the parts, so if there are small parts like formers or gussets, use whatever area is available to minimize waste.

When cutting ribs (especially flat bottomed sections) they can be set up bottom to bottom. If this is done, make sure that any lines that are joined have only one line. If there are two lines stacked on top of each other, the laser will cut that line twice which could cause a problem.

Many models incorporate tapered wing structures. That means that the ribs change in dimension chord-wise. The CAD system will allow the modeler to simply scale each rib and it will maintain the same airfoil shape. One method to do this is to scale the rib. In CAD, the length of the rib can be determined. The measured dimension is then scaled by a percentage of

change (rib to be cut divided by the main rib). These then can be cut and will be a perfect taper. However, it must be remembered that any spar notch in the rib will also shrink. These dimensions can be modified in CAD or the spar can be cut with the appropriate taper.

One thing that can be done when doing tapered ribs (or any other part) is to laser in a number. These numbers will then allow the builder to know which part goes where. When the wing has a narrow taper, it helps to make sure that the proper rib is placed in the proper place.

Many models have under cambered ribs. With a bit of work, a tab can be added to the bottom of the rib to allow the structure to be built on a flat board. These tabs can also be designed so that the structure could have wash in or wash out built in. See Figure 4



Figure 4: Ribs! Note the undercambered rib with temporary fill tab on the bottom at right. Once the wing's built, remove the fill.

If the design incorporates sliced ribs, these can very easily be cut. There are indoor fliers that use the laser to cut their ribs. Models such as the Ram Rod will be greatly simplified by using this technique.

One problem that the laser may have is when there is a very sharp point (like a sharp diagonal or possibly a narrow rib trailing edge). The point may be burn or smolder as the section is very thin. Minimize these features whenever it is possible.

The laser can very easily cut internal features in a part. If the design has an internal spar (like a Viking wing rib) these can be readily done. It makes things simple to do and very accurate. Also, lightening holes can be cut very easily to minimize structural weight.

In the design process, use as many self-locking features as possible. It is possible to assemble many parts without plans. Wings can be simplified and strengthened by notching both the leading and trailing edges for the ribs. If the design allows, the builder can set the trailing edge in place, parallel to the edge of the building board. Pin this in place. Add the ribs to the trailing edge and slide the leading edge in place, aligning the notches to the ribs. Take a machinist's square, place it on the edge of the building board and push the leading edge against the square. Pin the leading edge in place and now the builder has the basic outline completed. Diagonal ribs and spars can be added and the wing is complete. All this is done using no plans, just the accuracy of the laser cut pieces.

Many planes use geodetic construction. The laser or CAD software can help tremendously in making these ribs. Once the main wing rib is designed, it can be modified to the dimension of the diagonal rib. Let's say that the diagonal rib extends from the leading edge to the main spar. This dimension can be found on the original layout. In the CAD software, trim the rib to the spar. We now have a half rib but it is too short (the length diagonally will be much bigger). Save this rib design and move it to the laser software. The software will allow the rib to be stretched in either the x axis, y axis, or both. In this instance, stretch the rib in the x axis. Note that this will not change the overall height but just stretch it. The airfoil shape is not changed when viewed from the side, but the rib is now longer. Add approximately .09" to the dimension previously determined from the CAD drawing and cut the part. The builder now has an accurately cut diagonal rib that will need some final sanding to fit. Of course, if the CAD software allows it, the stretching process can be done there as well.

Many times there is a requirement for a tapered spar. The laser makes this very simple. Draw the tapered spar and simply cut it. They tend to be quite straight and accurate. Also, if the modeler doesn't have the proper strips of balsa, they can readily be cut from sheet stock to any dimension needed.

Fuselage construction can be simplified by doing some initial design magic. There are many parts to a fuselage that require accurate alignment- pylon and fin locations, firewall or front end angles, stab locations, etc. With some thought initially in the design, there can be features added that will make construction easier and self-aligning. Tabs can be added to formers that fit into slots located in the fuselage sides and top and bottom. A slot cut in the fuselage top and bottom can be added to align the pylon and fin in a built up fuselage design. Alignment tabs can be designed into the nose to accept the firewall for both strength and thrust. The timer cutouts can be figured out and also added to the design. Slots can be cut into the fuselage to simplify alignment features of the stab mount. See Figures 5 and 6.

Fuselage sides are quite long and normally will not fit the table dimension. In the initial design process, the designer must decide early on where to put the splices. It is best to have the splices for tops and bottoms in different locations than for sides for maximum strength. If the fuselage is a standard box style, the sides and the top and bottom can have tabs and cutouts added to them to self-align the structure. These tabs and slots will allow the builder to very easily dry fit the entire structure to insure that all pieces fit.

Any doublers or braces can easily be cut. These parts can also be designed to be self-aligning. Holes can be added so that thin CA can be wicked into them for gluing the structure together. . See Figure 6.

Summary

The laser, like anything else, is only as good as the designer and operator. It excels in doing complex parts and is very fast. The accuracy and ability to make self-aligning features can produce models that are much easier to build.

However, the parts are only as good as the design. The user will need to learn various software packages but many of these can be quite simple. Some may be put off by this but with a few nights of training they can be mastered enough to begin making use of the laser.

Another feature of the laser-plus-CAD system is that, because of the speed with which small changes can be made to a part's design, iterations of parts can be tried rapidly if needed. Also, if the model is to be reproduced more than once, it's as easy as loading the files and cutting more parts.

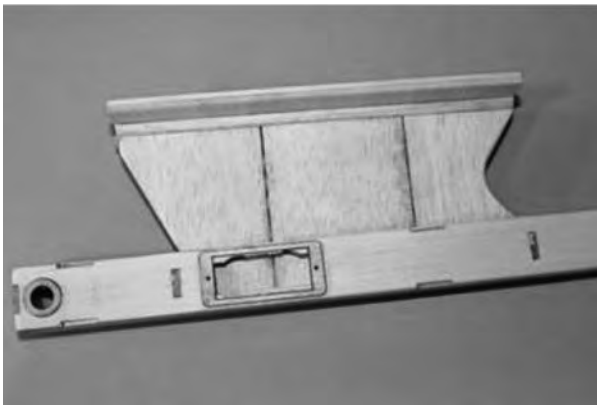


Figure 5: F1P Astro-Star front end, showing wing-mount, timer mount and fuselage.

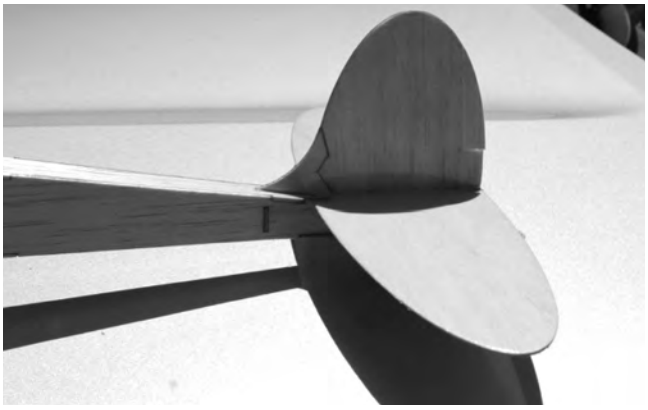
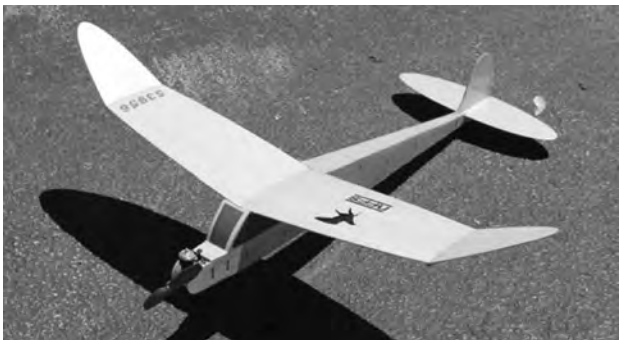
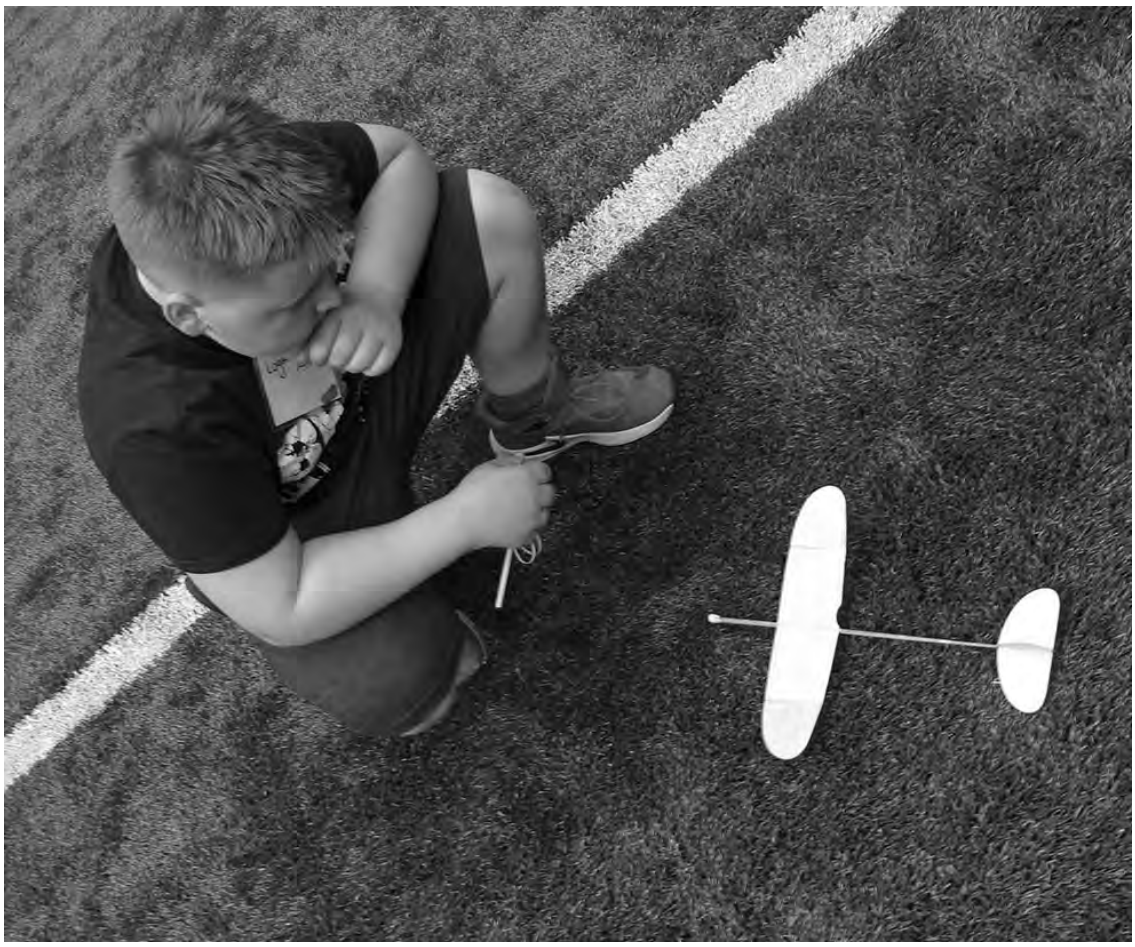


Figure 6: Interlocking and self-aligning stabilizers.

Technology is cool and with the prices decreasing and capabilities increase, the laser cutter soon may be a tool in many a modeler's repertoire. It will never replace the X-Acto knife or sandpaper but can make life a lot easier!



The all laser-cut .020 powered "JD"



Junior Logan Alves Pondering CLG at 2019 Indoor NATs - Photo Bruce Grawberg

3D PRINTING – A PATH TO CUSTOM PARTS THAT ANYONE CAN WALK

AUTHOR
PAUL BRADLEY

Introduction

3D printing technology has been around since 1986. In the beginning 3D printing was on the expensive side so its application was limited to businesses with deep pockets. Like so many technologies, 3D printing has evolved and some really nice much less expensive options have emerged. The lower cost options for 3D printing just happen to be perfect for application to the world of model airplanes.

It is hard to be among a bunch of model builders these days and not see models sporting 3D printed parts, hear about a 3D printed building aid, or see a field support item that has been 3D printed. While knowing how to develop a computer 3D model for 3D printing gives you the most flexibility, today's trends are making that much less necessary. There has never been a better time to think about incorporating 3D printing into your model airplane hobby.

Like so many tools that we use in our hobby, adopting 3D printing technology has a learning curve. Understanding what is involved along with the potential rewards is important in making a decision to jump in or pass. This article is intended to help the reader make an informed decision regarding adopting 3D printing.

Why Consider 3D Printing?

Have you ever had a situation when building a new model that would have been much easier or more accurate if you had a special fixture available? The problem was building such a fixture was either impractical or would have been difficult to do with the level of accuracy needed. Perhaps you like scale models and have avoided certain subjects because some of the details would be hard to make with the scale fidelity desired. What about those times when you have struggled with finding something in your field box that would benefit from its own custom storage container or storage slot insert?

Each of the preceding scenarios represents ways 3D printing can help change your modeling for the better. The use of 3D printing is ideal for creating custom one of a kind parts that can be incorporated in a model, be useful building aids, or simply make life easier when out flying. To be a bit more specific, here are a few examples.

Items That Can Be Incorporated In The Model

- Spinners
- Wheels
- Accurate motor side and down thrust wedges

- Rubber power props
- Nose blocks
- Cams and gears
- Scale details

Building aids

- Drilling jigs like those used for folding rubber power propellers
- Fixtures to hold parts in accurate alignment when being glued
- Molds for vacu-formed parts
- Balsa prop forming fixtures

Flying field support items

- Rubber motor stuffing stick ends
- Winding stooge parts
- Custom tool box inserts
- Brackets for mounting things to tripods

This list of possible 3D printing applications is a very small sample of what can be done. The core factor is items that we may have long wished for but have avoided making due to cost, complexity, or simply an inability to construct with the necessary accuracy are very doable using 3D printing.

Just What 3D Printing Technology are We Talking About?

The basic concept of 3D printing is simply developing objects by creating thin layers of material stacked on top of each other. The ways for doing that vary quite a bit. The process that began it all in 1986 is known as sterolithography (and its equipment--sterolithography apparatus--SLA.) That process involves the use of lasers that fuse a special liquid resin to form the stackable layers during the printing process.

As you might expect, SLA based 3D printers are on the expensive side due to the equipment involved. This type of 3D printer does offer several nice advantages. 3D printers that can create very thin layers produce much better tolerances and surface smoothness. Printers

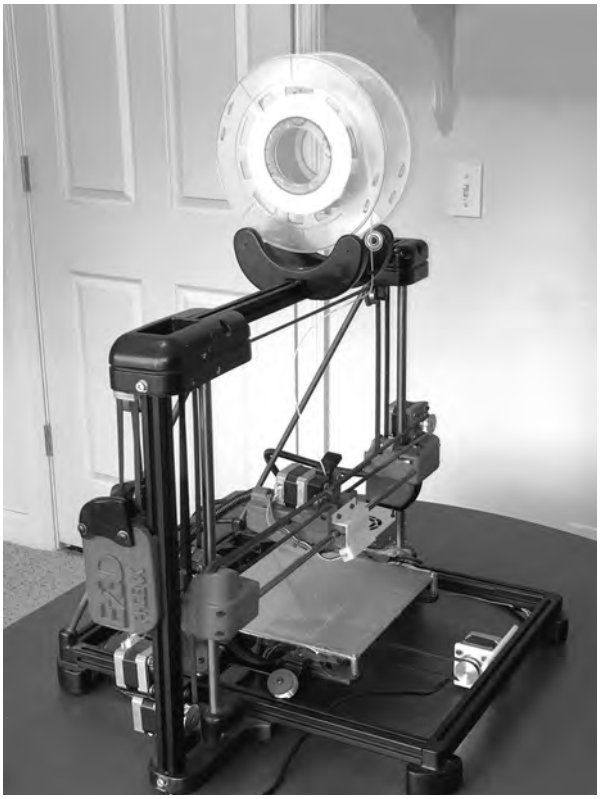


Figure 1. A typical FDM type 3D printer.

that use SLA technology can produce very thin print layers.

Fortunately, the desire to make 3D printing more affordable has resulted other process being developed. One in particular is of interest to the model airplane builder. It is also the process used by the vast majority of 3D printers being sold in today's market. Known as Fused Deposition Modeling (FDM) or Fused Filament Fabrication (FFF), this type of printer uses a plastic filament wound on a spool. The printer melts the plastic filament and extrudes the melted plastic through a small orifice moving nozzle on to a moving print bed. The combined motion of the extruder nozzle and print bed allow the creation of the object layers. As each layer is completed, the nozzle is moved up a tiny bit and a new layer is created. Fairly simple in concept.

Printers based on the FDM technology can't produce print layers as thin as those of an SLA based printer, but the parts they produce are plenty adequate for our needs. You will see

some surface roughness, and to get holes with a good fit you need to print them a bit under size and then drill them out. Certainly nothing that prevents a low cost FDM printer from serving us quite well.

There are several very nice advantages of FDM printers when it comes to supporting the model airplane hobby. First and foremost is their cost. You can find many that sell for under $500. If you are willing to do a little assembly, they can be purchased for under $300. In addition to printer cost, there is a nice variety of materials available to use with FDM printers. Another plus for FDM printer is the presence of a very large community of users around the world. That large user community translates into a very good support group. Many on-line forums exist that are very helpful when it comes to learning the ropes of operating a 3D printer.



Figure 2. A rubber model winding stooge made with 3D printed components.

Photo 1 provides a look at a typical under $500 FDM printer. Such printers have a frame to hold the print bed and extruder components. The print bed and extruder are controlled by stepper motors that get their instructions from a main control board. A power supply is also part of the package. The printer is connected to a computer via a USB cable. The printer in the photo has a foot print of 20" x 21". A size that fits well next to a computer monitor on a typical desk. Photo 2 is an example of what can be done with a low cost FDM printer. The major parts of the winding stooge have been created using the 3D printer in photo 1.

Ok, so there are some affordable 3D printers that are viable for the model airplane builder. That is fine, but what is involved in actually having one produce model airplane parts? The infamous bridge that connects theory to reality can some times be a "bridge too far".

There are two major factors involved in exploiting 3D printing. The first is having a computer generated 3D model for the item to be printed. The second is learning the ins and outs of operating a 3D printer. The sections of this article that follow look at these factors.

Developing 3D Models

One very nice aspect of 3D printing within the model airplane community is the number of people adopting the technology is growing at a nice pace. This growing community of 3D printing users includes people who are skilled at developing the computer based 3D models needed for creating an object with a 3D printer. Many of these people are sharing their 3D models via the Internet. As repository 3D models grows, more and more model airplane relate parts are being included. This makes it possible to own and operate a 3D printer without having to create your own 3D model. The downside is you are limited to the 3D models that are included in the public access repositories. Here is a list of sites offering 3D models:

thingverse.com

grabcad.com

pinshape.com

cults3d.com

instructables.com

Author's web site parmodels.com

While it is possible to use a 3D printer to produce model airplane parts without knowing how to create a computer based 3D model, to

get full advantage of a 3D printer you really will benefit from developing some computer 3D modeling skills. As you start using 3D printing you will quickly begin to see many new possibilities that are not sitting in the repository of already created 3D models.

Fortunately, you can do quite a bit with a fairly basic set of 3D modeling skills. Just about all software used to develop 3D models makes it easy to create 3D objects from a two dimensional drawings. If you can create a 2D drawing of the object you want to 3D print, you can for the most part create the needed 3D model with a basic knowledge set of 3D modeling.

To help illustrate how some basic 3D modeling tools can be used to create a functional 3D printed part lets use some simple examples. The first is a tool for shaping leading edges. I know that shaping balsa leading edges is a pretty straight forward task when using a sanding bar, but have you ever wanted to be sure the leading edge shape is the same along its entire length? A simple shaped sanding tool is a great way to make that happen. The nice thing about 3D printing is making such a tool is both easy and involves surprisingly little time.

Figure 3 provides a 2D drawing of the leading edge shaping tool profile. Included in that drawing is an allowance for the thickness of the sandpaper that will be glued to the face of the shaping tool. Picture yourself reaching into the piece of paper that holds the 2D drawing and pulling the drawing up toward yourself. The base of the drawing stays attached to the paper as you pull and suddenly the flat drawing has a third vertical dimension. It now has thickness. A standard 3D modeling software tool allows us to actually pull a 2D shape to its thickness dimension. That function is called extruding an object. Figure 4 is an illustration of what we get after the flat 2D drawing has been extruded. Without any further drawing effort, the 3D model of the leading edge shaping tool can used with a 3D printer. Printing time for such a part would be about 30 minutes. Not a bad investment in time and effort to produce a handy tool for making more accurate leading edges.

Another very handy basic 3D modeling function is revolving a 2D object. 3D models for things like wheels and spinners can be quickly developed using the revolve function. To illustrate how this function works, a 2D wheel and spinner profile have been provided in Figure 3. Those drawings represent one half of the target objects. The 2D drawings are then simply rotated around their center axis in the 3D modeling software. The result is a nice 3D model of a wheel or spinner as shown in Figure 6.

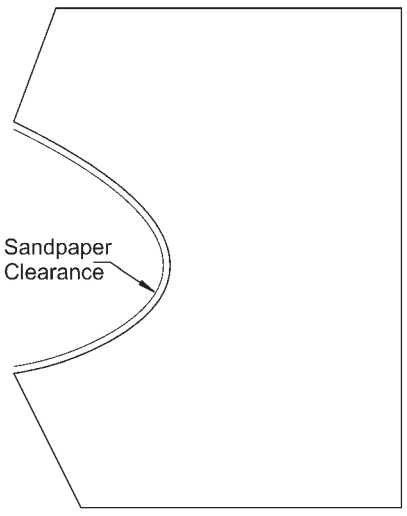


Figure 3. Two dimensional drawing of a leading edge shaping tool.

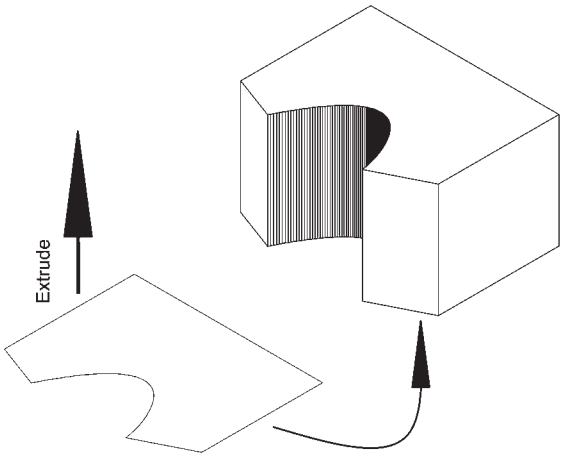


Figure 4. Conversion of the 2D leading edge tool to a 3D model using the 3D modeling extrude function.

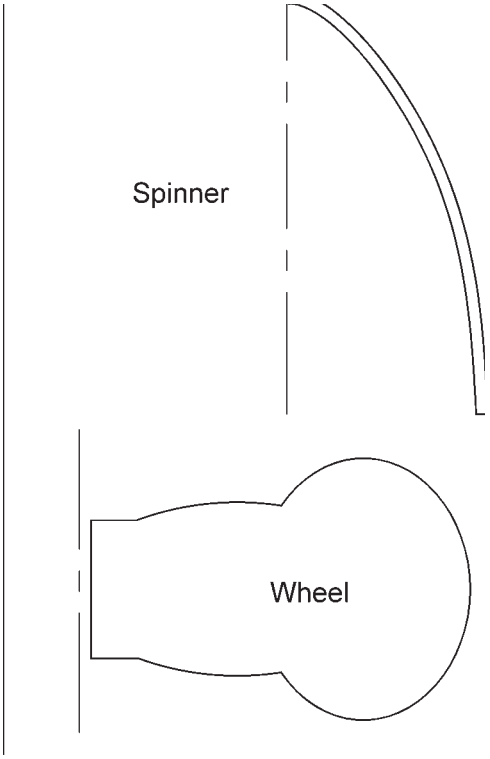


Figure 5. Rotating a 2D profile around an axis is another easy way to produce a 3D object.

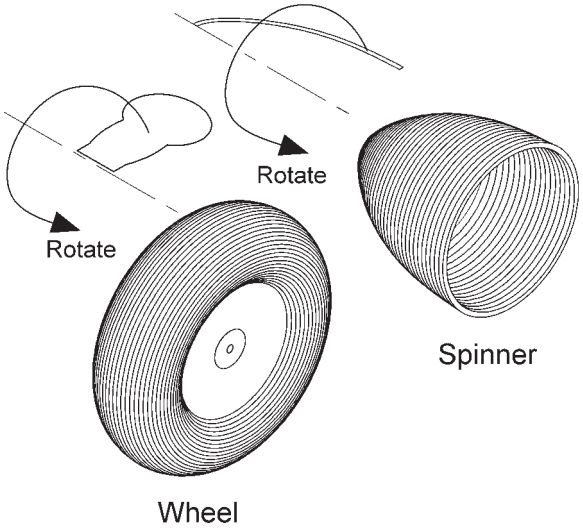


Figure 6. What happens when the profiles in Figure 5 are rotated.

Needless to say, there are many more functions available in 3D modeling software. Those functions allow you to make much more complicated 3D models, but the process of learning to use them can be incremental. You don't have to know all of them to be able to start making useable 3D models of items you want to create with a 3D printer.

Here are some additional 3D modeling functions that you will likely want to learn along with a description of how they work:

Lofting - This function allows you develop more complicated shapes like cowlings, propeller blades, and canopy molds. You develop 2D cross sections of the item to be modeled and then the software builds a solid shape based on the cross sections. Figure 7 illustrates the process for a rubber power propeller blade.

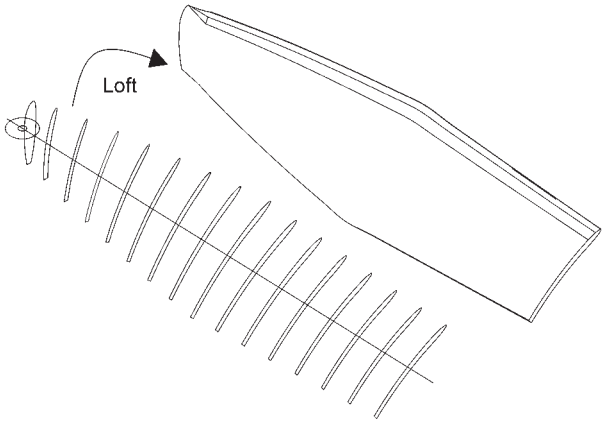


Figure 7. Lofting connects cross section segments to form a solid compound 3D shape.

Boolean operations - This function allows you to add one object to another, subtract an object from another, or intersect two objects. This function is very useful for creating holes, notches, adding a boss, and related 3D modeling tasks. Figure 8 offers some illustrations.

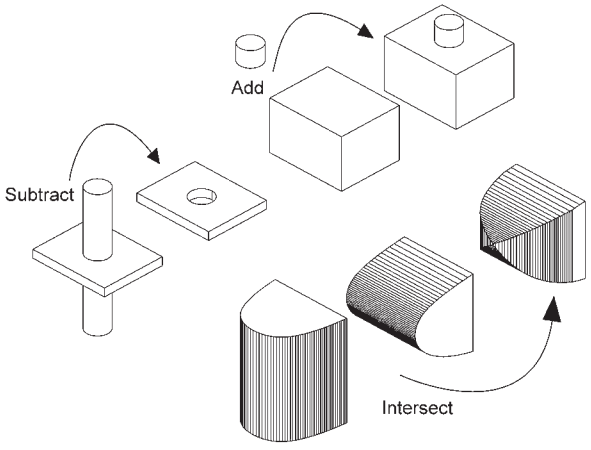


Figure 8. Adding, subtracting, and intersecting 3D shapes using Boolean functions allows creation of more complex shapes.

Sweeping - This function lets you drag a 2D shape along a path to create a compound shape. Figure 9 illustrates this function.

There are a number of 3D modeling software products on the market. Some are a bit pricey

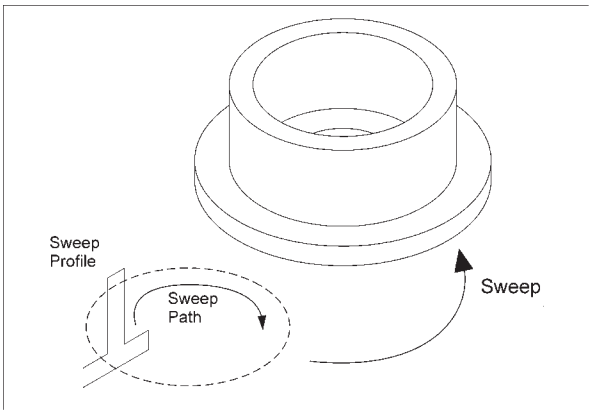


Figure 9. Using the sweep function to drag a 2D profile along a path is one more useful way to create a complex 3D object.

and some are free. Happily, the free options are quite adequate for the needs of modelers. Each has its own set of learning challenges, but they do for the most part have decent user communities that can assist. One product that offers a good mix of functionality and user support is FreeCAD. You will find it for free download at https://www.freecadweb.org/downloads.php. It can be used to develop both the foundation 2D part drawings and then the 3D model.

The goal of this part of the article is not to teach 3D modeling, but to help you understand that 3D modeling does not have to be a hurdle. By investing a little time in learning the basic functions of a given 3D modeling software package, you can prepare quite a number of 3D objects suitable for 3D printing.

One other possibility exists for developing 3D models suitable for printing is the use of a 3D scanner. That is outside the authors' personal experience, so that avenue will have to be researched by the reader. The cost of 3D scanners, like 3D printers, is coming down so it is an avenue worth examining if you don't think learning the CAD tools is something you are likely to pursue. Especially if you have a desire to duplicate an existing part where you have an example on hand.

Operating a 3D Printer

Getting the 3D model ready to print

Once you have the 3D model for the part, or parts, you want to 3D print, there are a few decisions that need to be made. Those decisions relate to how the printed item will be used and the capabilities of the 3D printer you will be using.

There are a surprising number of filament materials available to the user of an FDM 3D printer. The two most common and probably the best suited for the vast majority of any 3D printed model airplane related objects are PLA (Polylactic Acid), and ABS (Acrylonitrile Butadiene Styrene).

PLA is the easiest printer filament to use. It melts at a lower temperature than ABS and does not shrink as it cools during the printing process. The latter characteristic is important as parts are not prone to warp during the printing process. The disadvantages of PLA are a lower mechanical strength and tendency to lose strength when exposed to heat like that of a sunny day at the field.

ABS is a bit more demanding when it comes to getting good print results. It does shrink very slightly as it cools. That can lead to problems with parts warping during the print process. To combat part warping, when printing with ABS it is necessary to use a heated print bed. The print bed needs to be held at a temperature around 100°C during the printing process. As long as the printer is able to do that, very good results can be obtained when printing with ABS. Printing with ABS has several notable advantages. First is the mechanical strength of the material. It sands well, and can be glued with acetone. If the part needs a smooth finish, sanding and then brushing on a coat of acetone will deliver a

nice gloss finish. Parts printed with ABS will also stand up to direct sun exposure.

The first decision in preparing a 3D model for printing becomes "what material will be used for the item being printed?". PLA is the easiest material to work with but the lower strength and temperature tolerance make it best suited for items that will be used as tools or fixtures. You can create some very good fixtures and building aids using PLA filaments.

For items that need more strength or will be subject to direct sun exposure, ABS is the better choice. ABS is also a better choice if the item you are creating will be several 3D printed items that get glued together. ABS bonds very firmly by brushing acetone in the joints. ABS is also the better choice if the item being printed will need a good finish. As long as the printer being used supports a heated print bed, ABS is often the best choice.

Another factor to consider is the internal structure of the part being printed. While the 3D models used to create 3D printed parts are normally solid, the printed part does not have to be solid. One of the really great features of the software that prepares parts for 3D printing is an ability to create internal structures that range from hollow to a specified percentage of solidity. That means what might be a very heavy plastic part can actually be a relatively light plastic part.

A key step in the 3D print process is one that takes the 3D model and slices it into the many thin layers needed to actually print the part. Software called the slicing engine handles that tedious task with very little input from the user. During the slicing process you can control how dense the printed part will be. The term used is infill. You tell the slicing software if you want the part to be hollow, or have an infill that is something less that solid. Say something like 10 percent infill. The slicing software will then create a solid shell that is filled with structure that looks like an egg crate. The density of the infill determines how tight or lose the egg crate structure becomes. For most of our modeling parts, an infill of 10 to 20 percent is more than adequate. You end up with parts that are very strong but also surprisingly light.

The decision of what infill to use not only affects the weight of the printed part, but also the print time. Using just enough infill to give the part adequate strength also greatly reduces the amount of material that gets printed. That in turn reduces the print time. For that reason, infill values in the 10 to 20 percent ranges are good not only for parts that will fly, but also bench and field support items.

The next decision factor when setting up a part to 3D print is print speed. While you can set detailed print speeds, generally three choices are available. Fast, medium, or slow speed. As speed increases, most 3D printers lose print resolution. For simple shapes without a lot of curves, higher speeds are good to use. As parts become more complex, it is better to use slower speeds. For most parts the medium speeds work quite well.

There is one more factor in play that may or may not get attention when setting up a print job. That factor is layer height. The software that slices the 3D model into layers can set the layers to many different thickness values. Generally setting the layer height is not something the user has to worry about. You just pick a print quality level. Something like fine, medium, or coarse print quality. Thicker layer heights (more course) will reduce print time, but will also result in a rougher surface finish. Thicker layer heights can also result in a slightly weaker part. With FDM printers, as each layer is printed it is slightly squeezed. That helps make sure there is a good bond between layers. As layer height is increased, the amount of squeeze is reduced. That can produce parts with reduced inter layer bonding strength. Here again, using a medium quality level produces reasonable layer bonding strength and print times.

To briefly summarize this part of the discussion, once a 3D model is ready to print there is a pre-print preparation process that takes place. The 3D model is fed into a slicing software engine. The slicing software does just that. It slices the 3D model into many, many layers. By setting several parameters in the slicing software, the density of the printed part is set, the speed at which the part is printed is set, and finally part surface print quality is set. These slicing parameters influence part weight, part strength, how much post print clean up might be required, and finally how long it will take for the part to print.

Printing the 3D Model

When the slicing software has finished with the 3D model, a file is prepared that contains the information needed by the printer to actually print the object. The printing instructions contained in that file are called G-Code. You don't have to do anything with the G-Code file other than know it exists. Once you tell the printer to do its thing, it will read the G-Code file and faithfully perform the included instructions.

While you don't need to mess with the G-Code file, there are a few pre-print operations that have to be completed before you tell the printer to start. In order for the fist layer to the part to stick to the print bed when printing begins, the print bed needs some preparation. The preparation will vary depending on the type of filament being used. For PLA filaments the common practice is to cover the print bed with blue painter's tape. The PLA filaments have been found to stick nicely to the blue painter's tape. For ABS filaments a common practice is to cover the print bed with Kapton tape, an electronic insulation tape that becomes tacky when heated. An application of Kapton tape normally lasts for a number of prints. Kapton tape will also work well as a print surface for PLA filaments. When printing with ABS the print bed is heated to 100ºC.

The next operation is to check the distance between the print bed and the extruder nozzle. That distance needs to be the same at all locations. The distance value is also important relative to the ability of the printer to create the first layer of the part being printed. Some printers can handle the task of bed leveling automatically, but those in the lower price ranges normally do not. Bed leveling is not difficult to perform. The instructions vary by printer, and the process normally is only required at the start of a given print session regardless of the number of items being printed.

With the print bed prepared for the type of filament being used and leveled, printing can begin. The printing process normally begins with the printer creating a skirt or perimeter around the area where the part will print. This is done to provide a quick visual check that the print bed to extruder nozzle distance is good, and that the filament will stick to the print bed. If things do not look correct, you can stop the print process and make corrections. This helps save time and material.

The first print layer is important to the overall success of a given 3D print operation. It is always a good idea to monitor the development of the first print layer. When that layer has been fully printed and things look good, you can do other things while the printer is creating your object. Occasional checks are good, but for the most part you can do other things on your computer while the 3D printer is running. You don't want to leave the printer completely unattended, but you can certainly do other things on your computer while the 3D print progresses.

Things to Consider When Selecting a 3D Printer

While talking about the creating 3D models and then bringing them to life using a 3D printer, we should spend a little time looking at what features should be considered when purchasing a 3D printer. Like buying any new item for the first time, looking at the features of possible candidates can be a challenge to digest.

When looking at low cost (under $500) FDM 3D printers that will do a good job of creating model airplane parts, there are some basic factors to consider. These are listed below for your review.

- Does the printer have a heated print bed? Having a heated print bed will make sure you will be able to print a wider range of filament materials. The print bed needs to be able to support temperatures up to 100°C.
- The print bed size. Print bed dimensions in the area of 200mm x 200mm (roughly 8"x8") should be considered the minimum. Smaller print beds can either limit the items you can print, or will require your printed objects to be broken into multiple parts that will have to be assembled after printing.
- Make sure the printer does not use pre-packaged filament reels. You want the printer to be able to accept filament reels from any manufacturer. This will keep filament costs down and will increase the material options.
- Dual or single extruder. Some printers have more than one extruder. That allows multiple materials to be printed at the same time. That feature can be helpful when temporary supports are needed for the item being printed. Temporary support structures are needed to hold up the filament as it is being laid down in an open space. An example would be a flange that extends from a part and is above the print bed. The heated filament is soft when it is extruded and can't support itself as the filament is extruded in a region with no underlying support. Using a dual extruder printer, It is possible to print the slicing software generated temporary supports with a water soluble material. Single extruder printers print the temporary supports using the same material as the part. They are easily removed from the printed part when the printing is complete. Dual extruders are more expensive and require additional operation skills. Single extruder printers are more than adequate for printing model airplane parts that include temporary supports.
- Print bed material. The standard print bed material is aluminum plate. That works well but is prone to warp very slightly when heated. That can make leveling the print bed relative to the extruder nozzle problematic. For a relatively small additional cost, some of the low cost printer manufactures will provide a print bed made from borosilicate glass. That is a very good option as the print bed will remain flat cool or heated.
- If you are willing to perform some assembly, it is possible to save $150 to $200. Assembly of the printer should be no problem for a model builder. Especially with the on-line help available from the manufacturer.
- Purchase price features continue to improve with time. At the time this article was written automatic bed leveling is a feature included with printers above the $500 price point. Check to see if automated bed leveling might be included with any of the printers under consideration. This is not a critical feature, but does make life easier.

Conclusions

We are now back to that bridge that carries us from the theory of 3D printing to actually creating 3D printed parts. Two major hurdles in crossing that bridge have been discussed; having a 3D model of the item to be printed, and operating the 3D printer.

As is the case with just about any tool, operating a 3D printer requires some knowledge. Fortunately the steps involved in operating a 3D printer are not difficult to learn and there is a very large user community that is available to help.

Being able to develop your own 3D models provides the maximum benefit for 3D printing, but is not totally necessary to start using 3D

printing. A growing repository of public access 3D models is available that includes model airplane items.

Some very good free CAD/3D modeling software is available. Learning basic 3D modeling techniques can make it possible to develop a nice variety of 3D models suitable for the model airplane hobby. Learning basic 3D modeling skills and expanding on them can be done while honing 3D printer operation skills using 3D models developed by others.

The marketplace now offers a number of very good low cost options for owning a 3D printer. The number of people who do own 3D printers is increasing daily, and that user community is a terrific support resource.

So now I guess the question becomes "Is 3D printing worth the effort?". For me I can say that 3D printing truly has changed the way I approach the hobby of model airplanes. It is hard for me to think of a project in the past three years that has not included a 3D printed item. Parts have been made that have been integrated in airframes, many building aids have been created, and some very helpful field items have been added to my take along gear.

I am finding that as I start the planning phase of a new project, my first thoughts are about what 3D printed items will enhance the build, will become part of the airplane, or will help when the new model is taken out to fly. By way of some specific examples, I recently completed building the BMJR Model Products WACO CG-4A troop glider. This was a kit build and I did make some 3D printed items for the project. Those items fell in to the categories that have been discussed in this article.

Items that became part of the model.

- A set of scale wheels were created to replace the kit supplied wheels. The kit wheels were actually very adequate, but I was looking for wheels that looked more like the wheels used on the full scale airplane.
- A custom cam to use on the viscous timer that handles the DT function. That cam compensates for the reduction of spring tension as the timer is running.

Items that aided construction.

- Leading edge shaping tool
- Pin clamps for holding parts during construction

Field support items

- Hi-Start system tow line storage reel
- Hi-Start pole head that allows a quick emergency release of the tow line

The preceding list varies by model project, but represents the type of things I find myself creating on my 3D printer for each new model airplane build. It seems every new project presents new ways to have the 3D printer earn its keep.

One final thought needs to be shared. If you do decide to enter the world of 3D printing, be aware that 3D printing can become addictive. You may find yourself printing more than just model airplane parts. That could lead to a reduction in your available model airplane building time... just saying.

FREE FLIGHT FROM A YOUTH PERSPECTIVE

AUTHORS
BOB STALICK AND ADELAIDE MACHADO ULM

Introduction:

"Getting to the point, we always talk about the junior issue from the perspective of the adult.

What do you think of putting together an article for the Sympo from the youth perspective?

- What got them into FF?
- Did they have a mentor?
- What turned them on?
- How difficult was it?
- etc?

I think this has some merit. Going to all of the available former junior team members would be a start. These kids, some are now adults, are pretty astute and have some great insight. Plus recapturing some of them and where are they now?

Any feedback?

So, this is how it all started. Rick Pangell, editor of the 2019 Symposium, posed this question to me in December 2018.

As you will see in the following report, the feedback was that the "article" in question became a study similar to that conducted by college students for their master's degree. How to conduct this study was an initial question that needed to be answered. Then, thinking back just prior to Rick's email, he and I recalled a short article that appeared in **the Southern California Aero Team Electronic Newsletter (SEN)** edited by Roger Morrell, from Adelaide Machado Ulm. Adelaide is a bright young woman who was a member of the 2018 US Junior Team that competed in Bulgaria. I had met Adelaide there and was impressed with her maturity. The SEN article suggested a good partnership that would combine an older free flight veteran with someone who has a youth perspective. A perfect combination for this purpose, I asked, Adelaide agreed, and we were on our way.

Procedure:

Over a period of a few weeks, each of us posed questions that would be useful and productive to ask the target group. Since Adelaide suggested that we use an internet device called Survey Monkey to conduct the survey of our youth, and since she knew how to do it, she became the survey operator.

Since I knew many of the names of the potential target group members, I took on the task of locating them and their email addresses.

So who are these young people?

I went to the NFFS website, and I copied down the names of the Junior Team Members from the captions under the pictures online. This was the initial list.

I then went back to the NFFS website and checked the names of Junior fliers who had competed for the National Cup. Since many names appeared only once, I decided that if a name appeared two or more times in a row, this person could be a candidate for the survey. As I saw it, the flier must have been interested enough to continue participating.

Now, with about 50 names on the list, I constructed a request that was presented in the NFFS Facebook page, asking for anyone who might be interested in participating. To my surprise, I received several candidates. A request for participants that was sent to the FreeFlight magazine was never printed, so no results came from that source. I also consulted the NFFS directory for the names of members whom I knew to be parents of some of the young folks in question. They, in turn, were able to provide contact information not only for their sons or daughters, but also for some of the others on the big list. I discovered that emails are not as commonly in use with the younger generation as I had thought. However the system we were using was an email based program, so we were on our way for better or worse.

Over time, usually by contacting the parent or a friend of the person, I was able to obtain an accurate email address. In two cases, I had contact US Postal addresses, so I sent letters and got responses, too. After nearly two months of on again, off again, searches. I was able to submit fifty-one names and email addresses to Adelaide for her Survey Monkey work. I was unable to locate addresses for only 6 of the names on these lists, so the results was better than expected.

We wanted to find out what got these young people interested in free flight initially. What kept them interested? Who helped them along the way? Why they stopped flying, if they did, and why they continue, if they still do? We also wanted some information about when they got started and what kinds of events they built and/or flew.

So, what was the list of questions? We started by brainstorming via email and developed more questions than we could use. The Survey Monkey format could accommodate a maximum of 10 questions, so we had to hone it down to get to the magic number. Over time, we developed this basic list of questions, ready for the actual survey. The following questions were that survey:

1. If are willing to be quoted, please include your name in the space below.
2. At what age did you first fly a Free Flight model?
3. What Free Flight events have you flown?
4. Have you built any of the models that you've flown? What were the models you've built?
5. At what level of competition have you flown?
6. Who or what was it that got you interested in Free Flight?
7. Who were your supporters, mentors, or inspirations for your interest in Free Flight? Please list all.
8. If you no longer participate in Free Flight, what is it that caused you to stop?
9. If you still participate in Free Flight, what is it that keeps you interested?
10. If NFFS or AMA could do anything to improve youth participation, what would it be?

The survey questions were refined, and then the survey was distributed primarily by email to all of the participants. A note: two sets of surveys were actually sent via USPO where email seemed to be unresponsive. We received USPO responses, too.

The email survey was sent out initially on March 12, then a followup was sent out on March 17 and a final was sent out on March 29. Each iteration was productive, resulting in more responses. In all, we had 26 participants out of a total of 51 possible. Not a huge turnout, but it was a good representation of our young flyers.

I am told that a 51% response rate is excellent even with a targeted audience as we had.

The Survey Responses:

Question #1 - If you are willing to be quoted, would you include your name in the space below.

(22 responded. 4 skipped) Those who responded (in alphabetical order) :

Logan Alves, Hayden Ashworth, Peter Barron, Michael Davis. Kyle Gerspacher. Chinmay Jaju, Sevak Malkhasyan Hailey Mattson, Ed Pelatowski, Jace Pivonka. Elliott Plantner, Wes Reuter, Oliver Sand. John Shailor, Alex Stalick, Roman Stalick, Connor Vucovich, Dan Vucovich, Nathan Vucovich, William Wicks, Joel Yori

Question #2 - At what age did you first fly a free flight model? (Best guess).

(26 responded. 0 skipped) **See Table 1**

Demographics	Number of Respondents	Percentage
Under age 10	17	65.38%
Ages 10-12	8	30.07%
Ages 13-14	0	0.00%
Ages 15-16	0	0.00%
Over age 16	1	3.84%
Total:	26	100.00%

Table 1 – Respondent Summary

Question #3 - What Free Flight Events have your flown?

(26 responded. 0 skipped) **See Table 2**

Note: This question was open ended and included 23 different outdoor and 10 indoor events in the response grid. The most mentioned in order, were:

Outdoor HLG	17
Outdoor Catapult Glider	16
P-30	11
AMA/1/2A Gas	9
F1A	8
F1G	4
F1B	5
Rubber/Mulvihill	4
Electric/E-36	3

Table 2 – Events Flown

- The following events received two mentions: F1C, Classic Towline.
- The following outdoor events received one mention: Golden Age, Nostalgia Gas, A-1 Towline Glider, Scale, OT Rubber, ROW, F1B, Flying Aces, F1H, F1Q, Rubber Stick, Dawn Unlimited.
- The following Indoor events received one mention: HLG, CLG, Peanut Scale, Pistachio, A-6, EZB, Pennyplane, Dime Scale, P-18, No Cal Scale.

Question #4 - Have your built any of the free flight models you have flown? (yes, no) What were the models you have built (gliders, rubber models, gas models, electric, etc.)

(26 responded. 0 skipped) See Table 3

Note: This was an open ended question and produced 14 different responses. The most mentioned were:

Gliders - (non specified)	8
Rubber models (non specified)	8
HLG	5
CLG	5
P-30	4
Gas/ 1/2A	4
Electric	2

Table 3 – Type of Models Built and Flown

The following received one mention: Mulvihill, F1A, F1Q, F1P, A-1, Coupe, Indoor Models.

Question #5 - At what level of competition have you flown?

(26 responded. 0 skipped) See Table 4

Local	18	69.23%
Regional	17	65.38%
National	19	73.07%
International	14	53.84%
None	0	0.00%
Total	26	100.00%

Table 4 – Competition Level

Question #6 - What or who was it that first got you interested in free flight?

(26 responded. 0 skipped) See Table 5

It turns out that this question and the one that follows (Question # 7) have nearly identical answers. Listed in order:

Dad	12
Granddad	6
Club members	2
Bought a kit	2

Table 5 – First Interest

Others mentioned once: Mom, online forum, brother, scouts, family, myself.

Question #7 - Who were your supporters, mentors or inspirations for your interest in free flight? (dad, mom, granddad, grandmom, friend, club member, etc.) Please list all.

(26 responded. 0 skipped)

This was an open ended question and elicited 12 different responses. They also mentioned a number of individuals by name. I have listed these names separately below. Several free flight clubs are also mentioned, and I have included them as well (Listed in order of most mentioned).

Dad /Stepdad	15
Granddad	13
Club members/friends	10
Family	5
Mom	2

Table 5 – Supporters and Mentors

Others mentioned once: Classes taught, Boy Scouts, Cousin, Grandma.

Several clubs were mentioned as well as members of these clubs who were instrumental: The Oakland Cloud Dusters, The MMM Club, The Detroit Balsa Bugs, FAC, Wilbur and Orville Club.

It is important to mention the individuals who were the mentors of these respondents. Although the question asked for responses by class or group, many added the names of individuals. The following people were mentioned by name (presented in alphabetical order):

Tim Batiuk. Paul Crowley, Bill Davis, Don DeLoach, Robert Donnelly, Art Ellis, Chuck Etherington, Jim Finley, Walt Ghio, Charley Jones, Chuck Markos, George Morris, Dick Myers, Jim O'Reilly, Rick Pangell, Jim Parker, Bill Reuter, Bob Sifleet, Greg and Evan Simon, Roger Simpson, Hank Sperzel, Bob Stalick, Tom Stalick, Bill Vanderbeek, Brian VanNest, Al Yuhasz.

Question #8 - If you no longer participate in free flight, what is it that caused you to stop? (please list all reasons). Again, this is an open ended question. Comments are quoted directly without editing.

(15 responded. 11 skipped)

- I do it less now because of a busier schedule.
- I couldn't find the time to dedicate to constructing and flying airplanes. Baseball and school take up the majority of my time during the summer.
- Business, Relational, Cost.
- Life, School. work, relocation for work. Proximity to flying site. Available time.
- Family no longer need my support on the field.
- College and jobs. When I first quit (flying), it conflicted with baseball which helped me get into college.
- I don't participate much in free flight. There were a few reasons but frankly time is the largest one. In college I didn't have much time to do activities outside of school. It was tricky to make it out to a field to fly, and the amount of prep work that would need to happen, especially flying power, made it prohibitive to participate in those categories. I flew some catapult gliders for fun just to be out of the field but I only attended a

handful of competitions throughout college. Space is another factor that prevented me in college and now from participating. I live in SF now, and a college dorm room before then. Neither space has nearly enough room to build models (which can be messy) and definitely not enough space to store them. I miss flying free flight a lot, but working a fast paced job and attending a college where academics were very important have shifted my priorities away from hobbies.

- I have not participated in free flight recently due to college and my location. I currently moved to NYC post college and have not been able to find time to enter events. I also do not have space in my apartment to build or store airplanes.

Question #9 - If you still participate in free flight, what is it that keeps you interested? (please list all the reasons). Open ended question. Comments are quoted directly without editing.

(22 responded. 4 skipped)

- The new technology bringing new challenges that I like to overcome.
- The accomplishment of building and flying
- I like to build and watch my creations soar in the heavens above!
- The planes, the fun, and the thought of winning
- Travel to go flying in Indiana, Lost Hills, Romania (potentially).
- Watching your model in a thermal. Competing in a contest. Riding a motorcycle to retrieve a model.
- Love to build and fly.
- Community, passion for building and flying.
- I do it for the competition and friends.
- Freeflight forever!
- I like competition and seeing others fly. It keeps me interested.
- I do it because it gives me time to be with my grandfather.
- I like the competition.
- I enjoy flying. I like to compete in the NFFS program which I receive the National Cup in 2016.
- International competition. I am very interested in the US team. I also really enjoy state of the art models like F1Bs.
- Still interested because some family members still fly.
- I go to an event a year, sometimes less. The people are what keeps me the most interested. As a 15 year old, I learned so much from older flyers who were always sharing stories and talking to me about all sorts of topics. I think that's the part I miss the most. I really enjoy just going out to the field and chasing planes and timing so I can say hi to all my friends and mentors.
- I like to get out and have a fun weekend beating the old guys in F1A.
- Spending time with my dad and with my family is the strongest reason for me continuing to fly. This is a sport that has brought us closer together and something special that we will share and remember for our entire lives. -I have acquired many long-lasting friendships through free flight, and use free flight as an avenue to continue strengthening those relationships. -The excitement of flying is another thing that keeps me motivated. The friendly competition in events, the drive to succeed in each event that I fly in, and the truly awesome experience of putting something that I built hundreds of feet into the air is a surreal experience, each and every flight.
- I am still interested in Free Flight because I get to be around the great people of the community and the hobby provides great competition. Also, having been able to represent the USA on the Junior Team was one of the most exciting things I have done.

- Free flight for me is twofold, both intense international competition, and the breathless awe and beauty of a slowly gliding model as it flies over head. I both strive to be on the top of my game and sit back and marvel at a beautiful flight.
- The satisfaction of seeing models fly and the thrill of competing against people just seconds behind you. Also the people and the Opportunities presented.
- The humbling aspect of the sport, the community, and the understanding of how much Free Flight has given me and all I have learned from it. Free flight can be hard to walk away from as so much time and effort goes into the sport and watching a hobby slowly diminish is truly tragic and it is our duty as members of the community to do the least we can even if it means showing up at competitions. Also free flight allows you to create a bond with competitors, mentors, and friends that is hard to replicate in other aspects of life. The sport itself is unique and something that not all individuals can comprehend as there is no cash prize, we're under the sun all day and get super burnt, and spend a decent amount of money to run around after planes and get super dirty.

Question #10 - If NFFS or AMA could do anything to improve youth participation, what would it be? (please list all the programs or support that you think would be helpful). Again, an open ended question. Quoted as presented without editing.

(24 responded. 2 skipped)

[The first 3 entries are important because they affect all youth. It behooves all Free Flighters, Clubs and anyone else concerned about the "junior problem" to read these. Ed].

- Time: it takes time to build planes and building planes is a skill that takes a mentor to learn In order to get a young person invested in the sport to a point where they are willing to devote the time and energy. They need to have awareness for the sport and develop an interest (likely from observing a competition). It could be interesting to have "demo days" where kids are able to try to fly pre-built planes while being supervised by an AMA member.
- Money: since competitions are far away, it can be costly for some kids to get to flying fields. Additionally, though inexpensive to buy materials for a basic glider, the cost can seem daunting for someone who has never flown before. It could be helpful to have prepackaged kits that include all materials needed (including glue, dope, paint, clay, etc) To get kids to latch on.
- The biggest hurdle, however, is captivating potential flyers. Many kids love the instant gratification that can only be provided by video games, etc. Flying model airplanes, however, is more akin to a sport as it requires practice and failure in order to succeed. Getting the word out to potential flyers takes advocates and advertising. The sport is one that truly takes mentorship and spreads through word of mouth. I think the biggest thing is for members to do what they can to find potentially interested youth and help them along the way.
- Cash prizes and model kit prizes. A large America's cup for youth. A youth "plane camp" would be a cool idea, meaning a week or weekend of building and flying.
- I think that build space is really hard to come by. There's many tools needed and if there was a way to link young participants to mentors who would open their garage or shop to them, that would eliminate many of the hurdles to building models. Having clear, good kits would help people who are less experienced. One thing that I found also helped was local competition. Deeper integration with school events such as Science Fair might help draw in younger par-

ticipants. Building simple kits (Delta Darts) and gliders may be good ways of teaching 30 kids what free flight is, and maybe 1/30 will stick, and like me, get hooked immediately. Indoor events in a high school gym, for example, can often be easier to get to than driving hours to a large field.

- I think a program to reach out to kids in schools would be helpful. A mentorship program would also be good. I think there are plenty of kids interested in engineering and by informing them in school about opportunities and scholarships many people may join.
- Bring more attention to the hobby and show the opportunities and benefits it opens up.
- More flying locations (mentioned three times).
- Most of the junior flyers come from family members that fly. Junior participation is difficult as we all know.
- Need more regional competitions.
- Need places to fly that are closer.
- Recognize the younger generation that do fly freeflight...went to his first Nats and did really well last year and nothing was mentioned in NFFS or AMA congratulating him? I just thought something about the grand junior champ should have had something in the magazines.
- Market the hobby effectively using relevant platforms. Hold events in relevant people group arenas. Set up a program that those interested but have no clue can access to get started.
- Easily accessible kits, school programs, straightforward events and flying sites that kids can easily get to.
- I think getting the word out to the public about free flight contests taking place would draw youth spectators out to the field. That would allow them to see what is taking place, which could get them interested.
- I like it when models are donated to us because I can't always build them as good. and they fly well.
- In a few years, when I am older, I plan on building all of the planes that I will fly.
- I think that the junior FAI team is really important and could definitely be promoted more. Also, ensuring that the open US team selection process is accessible to youth and younger college age flyers.
- It's 6 hours for me to the nearest field. Having something within an hour would have me back out there. But that's near impossible to do for everything on a national scale.
- Regular school programs!

Support of local club who could then do outreach in their local communities.

- I would think to target schools and try and start programs through that.
- I know that I was exposed to it through word of mouth so either using different methods (internet/social media) or by increasing exposure through more interactions. Advertising in schools more, maybe.
- More promotion of the programs that they have.
- The AMA as an organization puts no effort into advertising free flight. It makes sense that they would shift their direction towards drones and other RC planes as it is popular and a greater economic opportunity. It's easier for an individual to pay a hundred bucks and walk out a store and be able to fly something immediately, but there's no longer term satisfaction. Its hard to advertise the joy in watching something you built and designed fly. It's hard to convince a child in a era of instant gratification and participation awards that working towards something is actually rewarding. Free Flight is only

discovered through word of mouth, and we can't expect participation to increase if competitors who are our only form of advertisement are depleting. And to point fingers and say its a certain organization's fault is also incorrect, as we need to look toward ourselves, the free flight community, to understand where we are lacking. And to say that as a country of over 300 million people we couldn't find 9 children who are willing to represent our country is a joke. Even though I have had amazing supporters and mentors in our sport who have helped me become the competitor I am today, I have also experienced individuals who have been very inappropriate towards myself and many other juniors who have shared the same experience. Our community is not at a point where we have the leeway to allow juniors to be pushed away from our sport by being mistreated or scolded because of old mindsets and rules. Every junior that shows up to a competition should be provided with the equipment, models, and support that they need to be able to experience success. It's difficult to sustain a junior's attention if they are constantly underperforming and not provided guidance.

Two Summaries of the Survey:

Bob's Summary:

A 65% majority get started in free flight under the age of 10, and all but one of the respondents was active by age 12. This means a true Junior who lives with family and is helped either by dad, granddad or a friend is most likely to become a free flighter for more than just a year or so.

The events most often flown by the respondents were handlaunch glider, catapult glider, P-30 and 1/2 A gas. Since a large number of the respondents have been members of the Junior FAI program, F1A, F1B and F1P are mentioned in more than one example. Since these are the events flown at the Jr. World Champs, this result is not unexpected. However, even these fliers got started on the more basic events.

When it comes to building their own models, the number of responses decreases noticeably, but the events stay the same. They built catapult and hand launch gliders, rubber models/P-30, and 1/2A gas models.

Who introduced them to the hobby and who were the most often mentioned mentors:

Dads and Grandads lead the list, by a large margin. I was also pleasantly surprised that family played a part in a number of responses. The value of clubs, club members and friends were also important factors. Certain clubs are mentioned as having been influential, with the names of specific club members mentioned in some cases.

What are the reasons some of the respondents are no longer active?

It seems that getting started in life after school and college is a large deterrent to continued modeling activity. Having a place to build and store models, a shop with the needed tools, proximity to flying sites, and having the needed financial resources are factors. Having time to build and fly is a major factor.

For those who are still participating, the reasons are: the competition, the personal interaction with others on the field, the Junior FAI program, being with family and friends.

What should we do to encourage participation?

Here the answers are more varied. In brief:

- Cash prizes
- Free Flight Camp - build and fly week with a mentor.
- Making kits and built models available
- Flying sites that are accessible within a reasonable distance
- Support for clubs to do outreach to scouts, schools, libraries, etc.
- More publicity about events using multiple platforms.

- Public recognition for achievements. Photos, magazine articles, etc.
- Mentorship programs.

Adelaide's Summary:

Young free flighters initially got into free flight with all but one respondent being age twelve or under, and there is a generally equal distribution of competition levels with a slightly larger emphasis on the Nats (73%). The Nats is a family friendly competition with an abundance of people who support Juniors.

Dads and grandads are listed as the top most mentors and supporters to Juniors, and some acknowledged the fact in their comments: "The sport [must] be "passed down" as it only truly survives through its members," Dan Vucovich said. Enticing the younger generation was a commonly held concern. Nine people suggested school programs, seven mentioned accessible flying fields, two proposed increased social media, and there was an overall suggestion of more easily available competition for school aged Juniors. Word of mouth simply wasn't enough to get Juniors into free flight.

The most popular event among Juniors were hand launch and catapult gliders (thirty-three people mentioned them), despite that neither of them are World Champ events. Reasoning for this include their convenient size and straightforward nature. They are uncomplicated to learn and easy to transport, proving younger fliers need simplicity. Complicated models are difficult to learn and are often more expensive to fly which takes the fun out of learning a complex model.

Most often the reasons for discontinuing free flight were time and proximity to flying sites. Most often the reasons for continuing free flight were love of the competitive atmosphere with the people they meet on the field, the accomplishment they feel, and simply getting out on the field to have fun. Numerous suggestions of keeping Juniors and obtaining new fliers vary, but most Juniors come to a general consensus about needing closer fields to fly on, school programs, or recognition.

Conclusions:

A preponderance of the targeted Juniors said they started flying at quite an early age, and they were mostly influenced by their dads and grandads. Twelve years old and under provides just enough thrill of flying, competition, and bonding moments with family.

"I do it because it gives me time to be with my grandfather." — Elliot Plantner

Since that age, most have been flying at all different levels of competition: local, regional, national, and international, with heavy emphasis on the Nats. Only after Juniors get into college and begin working do their schedules restrict time for Free Flight.

Aside from the Nats, there is a tendency to hold contests at times that are not convenient for all ages. For example, the 2019 US Team selection contests were held in October 2018, making it difficult for students or working-age adults to compete. If local or regional contests were available both geographically and seasonally, more young adults would have easier access to a flying site which would motivate them to find time to work on constructing and trimming models. Besides the logistical challenges presented by time, storage space, and money, young people truly enjoy flying. They fly for the people they meet, the feedback they receive, and the competition they love. Their passion shows by their willingness to engage other young people in free flight, expanding the number of participants to better share their love of the sport.

"Having been able to represent the USA on the Junior Team was one of the most exciting things I have done." — Kyle Gerspacher

A few Juniors mentioned they had first delved into the world of free flight via model kits which initially sparked their interest when they

were young. They then elaborated this, saying that school programs would be a beneficial way to attract younger flyers; some students may be interested, but have no clue how to start, one Junior mentioned in the survey. A simpler option of this idea would be to extend advertisement to schools, using social media or other programs similar to Science Olympiad to attract student interest. The majority of the Juniors thought that targeting schools would be effective in obtaining Junior support for free flight. Another Junior mentioned getting spectators out to watch a contest would garner interest, and although he thought more about targeting youth spectators, there is no reason that this technique would not work for passers-by as well. Flying fields are the second most talked about issue in the survey. Seven people mentioned more flying fields would get people started flying or back into it.

"It's 6 hours for me to the nearest field. Having something within an hour would have me back out there." — Anonymous

Some Juniors believe that more social media and internet advertisement directed towards newcomers would garner attention for the better of the sport. "Likes" on Facebook have always proved that photos are worth more than a thousand words; humans have a visual nature. We rely more on sight than any other sense. Instagram is another platform of social media that has grabbed the attention of young people; there are little words and plenty of images to like, comment, and keep up with. Thus, perhaps a photo based campaign that would prove effective in bringing attention to free flight is worth pursuing.

Young people thrive on support from both peers and mentors. Whether it is a simple congratulations from a grandfather or "great job" from a friend, Juniors need recognition to strengthen their love of the sport, no matter how embarrassing a shout out may be. Similarly, one respondent said that an acknowledgement for the Juniors who do fly may help them keep with free flight as a sport, and less as a hobby they could scrap at any given time.

Personally, I believe including "non-retired" people in helping with the NFFS, and by extension the AMA, would help in acquiring more youth participation. Who knows Juniors better than actual Juniors? A new perspective of the younger generation by the younger generation would be so much more beneficial to the NFFS than simply taking surveys or asking around for suggestions, and it would be more likely to have lasting, positive effects on the future of the sport. Free flight is dependent on the next generation to carry forth the traditions of the past.

Recommendations:

1. One of the surprises from the survey was the age at which the large majority of respondents became involved in free flight. All but one was involved at age 12 or less. As important a discovery is the importance of dad or granddad as a mentor. A large majority not only had dad as the one who introduced the youngster into the hobby, but it was also dad who was the mentor in the majority of cases. The apparent target for any programs then would seem to be youngsters at or below age 12 and his or her father. Involving dad (or granddad) in the activity seems to be a good formula for a successful youth experience.
2. Free flight Camp. One of the novel ideas that the survey revealed was the idea of free flight camp. Based on the idea of sports camps, this camp would provide youth the opportunity to go to a place and learn how to build and fly free flight models. The camps could be located at different areas of the country and be staffed by volunteer free flighters (perhaps taking advantage of our cadre of expert retirees). The end result would be a flight competition among the campers with models they built. This concept needs further investigation.

3. School based programs. The current emphasis on STEM programs in the schools of the country are tailor made for the introduction of model aviation activities. The AMA has invested some time, finances and energy into providing model aviation materials and advice to school districts who inquire. The NFFS should consider piggy-backing on the AMA efforts. It is also true in some communities organizations such as the Boys and Girls Clubs, Scouts or community library programs are offering STEM programs. It is likely that such organizations would be receptive to prepackaged free flight programs.
4. Flying sites. Flying sites are a bugaboo issue. As noted by several respondents, living far away from a flying site is a major issue. Since the availability of free flight sites in the future seems problematic, it is time to face the music. The large free flight sites that cater to F1C flyoffs, D Gas behemoths and Dawn Mulvihill flights are not going to increase. These will remain few and far between. So, what do we do?

   Small field free flight is one answer. Events that can be flown at public parks seem a good direction to move toward. This fits with the idea that many of the youth in our survey build and flew Catapult and Hand Launch Gliders as well as P-30 models. Electric also provides a quiet opportunity, especially E-20 and scale size models. Models like these can be tailored to take advantage of large community parks. Another avenue to explore is indoor free flight. Sites abound in nearly every community. The schools have gyms and gyms are good locations for indoor model flying. Granted, some gyms are better than others, but tailoring the event to the space is a way to provide competition on a small scale. Sometimes, providing building and flying instruction to students at the school provides an "in" for using the gym for indoor contest events at no cost other than time. On other occasions, simply asking the principal for time in the gym on non-school days is an entree.
5. Scholarships to attend contests and financial aid for those who help youth. This is a two fold concept. A system to provide financial assistance to individuals or clubs who agree to locate and mentor youngsters who exhibit an interest in free flight is one part of the idea. The other part is to provide some support to adults to bring youngsters to compete in contests. The cost of the contest is not so much the cost of entering but all of the other expenses, such as lodging, travel, meals, etc. A financial incentive to encourage youth participation would be one step to help out. Such expenses are currently covered for Junior FAI Team members, so a version of this concept could be a starting point. Concurrently, contest should feature Junior only competitions in Catapult Glider, HL Glider, P-30, etc.
6. Publicity: This one seems easy. A comment from our survey contends that a youth champion at the Nats did not even receive a picture or notice in the NFFS magazine. We should extend ourselves to make sure every youngster who competes gets noticed. Pictures or articles should be an expectation Other forms of notice would be needed, too. Local level club members should just take some pictures of youth action in their area and send them to Free flight Magazine. AMA would be advised to establish a youth page in Model Aviation. NFFS could do the same. Families who fly could be a feature article. Our survey indicated that family is not too far behind granddad as a source of support. Let's look at featuring families as well.
7. Consider establishing a youth advisory panel to recommend free flight programs, ideas and the like to the NFFS (and AMA?) leadership. Some of the respondents to our

survey gave a great deal of thought to their answers and provided cogent reasons for their ideas. It seems appropriate to form a youth committee from among these young people to advise NFFS (and AMA?) on the kinds of programs and services that would enhance youth participation and long term involvement in free flight activities. Meetings of the group could be done in a virtual setting and be cost effective. Membership in the youth advisory committee could be on an ad hoc basis or for a term of a couple of years. Our suggestion is that this group be made up of the older cohort (those 18 to 25, for example).

Finally:

As with most studies, this one scratched the surface of the issue. Further study needs to be conducted to determine if any of the recommendations can be implemented from an organization that is literally all-volunteer.

Another area of investigation is to look into the financial and manpower implications of some of these recommendations.

We should not lose track of our youth as they grow older and move on to other aspects of their lives. A connection between NFFS and these young people will, in the future, pay off as they become parents and have their own children to mentor into future free flighters. The Reuter family sent along a note to Adelaide and me. I liked it so much, I decided to include it for everyone to enjoy:

"Thanks for taking the time to help the kids with the survey. All the kids mentioned are all fourth generation free fighters that started with their great grandfather who started flying back in 1942. They enjoy flying but we have nowhere local to go and practice or to show others how their planes fly. So we will continue to take them to Muncie as long as we can and hopefully they will continue to fly in the future."

I want to thank all of the young people who took the time to answer the questions we posed. This is a tribute to the kind of people these young free flighters are. A tribute to their dads, moms, granddads, friends, family, and everyone who helped them grow up to be the thoughtful and responsible people they are and are growing to be.

It was a privilege to have this chance to interact with them.

Resources:

1. **Southern California Aero Team Electronic Newsletter (SEN)** edited by Roger Morrell
2. NFFS Website/Competition pages. Junior FAI Teams.
3. NFFS Website/Competition pages. Junior National Cup listings.

Some of the USA Jr Team Members who participated in this survey:



2016 Junior FAI Team: (Left to Right): Cade Fedor, Jace Pivonka, Troy Davis, Jim Parker (team manager), Sevak Malkasyan, Joel Yori, Alex Stalick. In front is our Macedonian guide.



2019 Junior FAI Team: (L to R): Sevak Malkasyan (Asst. Team Manager), Hayden Ashworth, Roman Stalick, Adelaide Ulm, Joel Yori, Kyle Gerspacher, Jim Parker (team manager).

F1E HISTORY AND DEVELOPMENT

AUTHOR
GEORGE ARGHIR, PHD

At the end of the fifth and beginning of sixth decade of XX century [late 1940's through the 1950's] there were air model gliders in national and international competitions for plains [level field] and slope flying.

There was a Volunteer Association for Helping Country Defense (Asociatia Voluntarilor pentru Sprijinea Apararii Patriei) in Romania during the 1950's. It had different branches to develop some sports. Aviation was one of them, including aeromodels. Groups of aeromodelers were organized in many cities. It was an organized Airmodel National Center (Centrul National de Aeromodele) in Bucharest. The program was a militaristic one. The students wore aviation civil uniforms. There were many lectures presented on applications, aerodynamics, materials, technology, and rules. After three months of training, each graduate received the title of instructor of aeromodelling. I had the privilege to be one of them, see Figure 1.

The wings and horizontal stabilizer had a combined area of 40 to 60 dm2. The fuselage cross section had to be minimum 1 % of the area. The wing was of one piece held on with rubber strip on the fuselage. The horizontal stabilizer was fixed on the fuselage. No dethermalization.

The plain gliders were launched with a 50 m cable on the flat ground. The slope gliders were launched by hand on a slope into the wind. Both gliders flew in a straight line or circled. No guidance in their flight.

The best flying time of three flights in three rounds were considered for classification.

They were built of resonant wood [spruce] for the leading edge, longeron (main, second), and trailing edge and plywood for ribs. All were covered with lapping laid (natron) paper. Casein glue was used to stick wood and paper. Paper on the skeleton was wetted, it became smooth by drying. Then the paper was nitro-lacquered with enamel. Balancing was done by adding lead in the nose.



Figure 1. George Arghir and Florian Romanu. Airmodel National Centre. Bucharest. November 1955.

Some information about the magnetic steering of aeromodel flights appeared in some magazines. It started before 1950. I saw them. Mr. Hans Gremmer (~1920 – 1991) of Landshut, Germany, reference 1, pioneered this effort. So I adapted an F1A glider with a steering magnet pilot and flew it at Sibiu International Airport, in June 1970. It was a hot windy day. I launched with a 50 m cable against the wind. I caught a thermal and released the glider. The steering device did not work properly and the glider flew 2 miles and landed safety. Two team mates Eugen Pop (International Maestro of Sport - IMS) and Francisc Rimoczi (Maestro of Sport - MS) retrieved the glider. Anyway, the first steering glider flight took place in Romania in the presence of the people who attended the National Free Flight Championships. Mr. Ioan Bobocel, Secretary General of Romanian Modeling Federation, was at hand and retained the idea of a magnetically steered flight. The dethermalization was done by using dry tinder or cotton wick impregnated in ammonium nitrate to burn the rubber band fixing properly the stabilizer. The direction and flight was established by visual contact, sometimes using binoculars.

Mr. Hans Gremmer wrote on F1E flight, see figures 2&3. He mentioned in reference 2, I was an F1E active flier as was Dr. Trevor Faulkner of Great Britain, in 1983. Hans expressed his thanks for my drawings in reference 2

However, the steering device did not work properly, so I did aerodynamic calculations to establish proper sizes of all elements.

International Championships of Romania in F1E class was in San Petru, Brasov in 1972, 1973, and 1974. A magnificent hill is in a flat zone of San Petru, Brasov. It is excellent for slope flight, close to Carpathian Mountains. Mr. Laszlo Hobany of Budapest, F1E pioneer in Hungary, attended all Championships, see Figure 2. He presented his classic model. The pilot is not seen in the picture, it was affixed later in the nose.



Figure 2. Laszlo Hobany and George Arghir. San Petru, Brasov. 1972.

In all three contests the result was: 1. George Arghir; 2 Laszlo Hobany, 3. A gentleman from Sacele, Brasov. People got the titles and diplomas from the Romanian Modelling Federation.

In the following years, the Romanian Modeling Federation organized every year a three days Conferences for Club coaches. In these conferences presented were the news in the field, rules, and I presented a glider with a magnetic steering device. I explained how the steering device – automatic pilot – works and distributed the design of the pilot to interested people, see Figure 3.

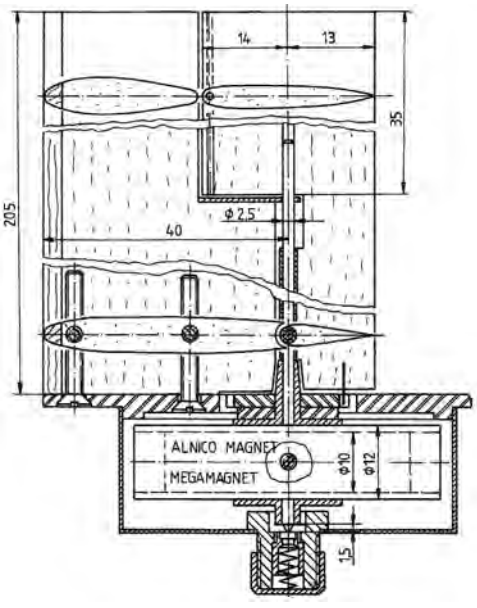


Figure 3. F1E pilot. Dimensions are in mm. Original drawing in China ink on tracing paper.



Figure 4. Ioan Nicodim, George Arghir, and Eugen Pop. San Petru, Brasov. October 1979.

The Airomodel Club of Brasov organized a few events as "F1E Brasov Cup". Attending people of the 1979 Cup are in Figure 4. Graupner dethermalizers started to be used for retrieving the gliders from the sky. We used our eyes to establish the direction of flight.

We, Romanian citizens, could not attend the international contests at that time (1978 – 1990).

I prepared for attending the future contests and designed the "OLYMPIC 8" an F1E special slope soaring glider for low wind (2 m/s) and another for strong wind (6 m/s). All models were built of resonance wood, plywood, paper, and some balsa wood. For high wind the aeromodel had 2.7 m wings, (a small) horizontal stabilizer, fuselage, and pilot. For low wind, the wing was elongated to 3.5 m wingspan by adding a rectangular part on left and right of fuselage to the wings. The horizontal stabilizer was a big one. It was done the same balance point for both configurations. The glider for low wind is in Figure 5.



Figure 5. Ioan Bobocel – Secretary General of Romanian Modelling Federation – with "OLYMPIC 8" George's elongated wing F1E glider. 1981.

F1E class is getting new people, see Figure 6. "Cup of Transylvania" started in Dezmir, Cluj, 1985 and had many editions. It caught F1E fliers from Romanian and abroad like a magnet [no pun intended...ed]. It was like a grammar school for beginners and for advanced fliers. In 1986 edition there were six fliers, latter up to 40 fliers.

The F1E National Championships for seniors and juniors started in 1990, see Figure 7.

At the FAI Congress in Paris, in April 1990, I proposed, representing Romania, to organize



Figure 6. Cup of Transylvania, 2nd edition, Dezmir, Cluj. April 1986. From right: Mihail Cune (Craiova), Eugen Pop, George Arghir, and two sportsmen.



Figure 7. National F1E Championship of Romania, Dezmir, Cluj. May 5, 1990. From left: Eugen Pop, Cringu Popa, people from Austria.

next World F1E Championships, in Dezmir, Cluj, Romania. It was accepted.

The model designed and built for 1991World F1E Championship is in Figure 8.

"The Swallow" F1E glider, had the following specifications: flying speed – v: 5.5 m/s; wing: 34.5 dm2, 320 g, MVA 173 airfoil; stabilizer: 6.2 dm2, 20 g, Clark Y 7 % airfoil; total area 40.7 dm2, total weight 614 g; load: 15.09 g/dm2. To increase the flying speed is added: 110 g for v = 6 m/s, 380 g for v = 7 m/s, and 689 g for 8 m/s.

As a result of 1991 World Championship organized in Romania many sportsmen of Romania started this class to build and fly. It was spread between seniors and, most important, juniors, see Figure 9.

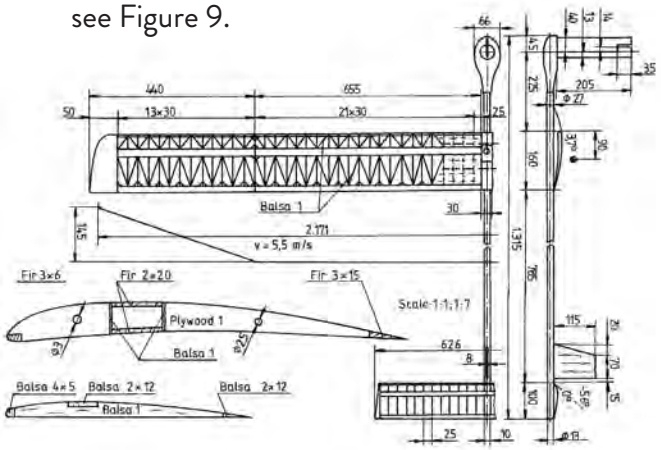


Figure 8. "The Swallow", F1E glider – Slope soaring glider, with automatic steering. Dimensions are in mm. 1991. Original drawing in China ink on tracing paper.



Figure 9. The first F1E Junior Team of Romania. 1991.



Figure 10. Tehnofring F1E Cluj Napoca flyers. From left: Adrian Bot (MS), Ionut Craciun (MS), George Arghir (MS), Eugen Pop (IMS), Cristian Faur (MS), and Stefan Razman (MS). 1992.

Many clubs organized contests. Romanian Modelling Federation organized National Championships, National Cup, and National Cup contests. All competitions were organized for selecting the best people for national team.

One of the most dedicated to F1E flight was team of Tehnofrig Sport Club of Cluj Napoca, shown in Figure 10. The juniors were excellent and the seniors very good.

Tehnofrig Sport Club presented its very gifted and promising juniors, and excellent seniors as shown in Figure11.

Romanian sportsman attended all World and European Championships since 1991. Seniors and/or juniors were champions many times, so the team of Romania is shown in Figure 12. This is a result of very strong domestic contest program and due to attending the World Cups.

Some buzzes were used to establish the direction where the glider was landed. During the



Figure 11. National F1E Championship, Cluj County Contest: from left: Ionut Craciun, Tudor Nicolae Barlea, Adrian Bot, Stefan Razman, Cristian Faur, and George Arghir. Turda. 1998.



Figure 12. F1E World Championship, Nowy Targ, Poland, September 2001. From left: Dan Petcu, *Marian Popescu (coach), George Arghir, and Florian Draghici – Romania team, placed 3.*

flight the direction was established using only your eyesight and eventually using binoculars. Later, for direction of flight we used small radio emitters, lighthouses, as receivers and to establish the direction and distance we used a trans-receiver. It was of a great help. Visual tracking, helped by a binoculars, remained the main method to locate the glider. The use of GPS was extended after 2000 when it was of a great help in finding the gliders after flight. Electronic and mechanical dethermalizers were primarily used and later, some radio dethermalizers were introduced.

Use of new materials including carbon fiber, kevlar, and others, needed a new design which resulted in the "STRONG CLIMBER" design shown in Figure 13.

The "Strong Climber", F1E glider, had the following specifications: flying speed – v: 6 m/s; wing: 29.2 dm2, 260 g, B7406f airfoil; stabilizer: 7.39 dm2, 29 g, Clark Y 7 % airfoil; total area 36.59 dm2, total weight 526 g; load: 14.38 g/dm2. To increase the flying speed is added: 190 g for v = 7 m/s, 410 g for v = 8 m/s, and 665 g for 9 m/s.

The flying site, where many contests took place, is St. George's Hill nearby Cluj Napoca. George

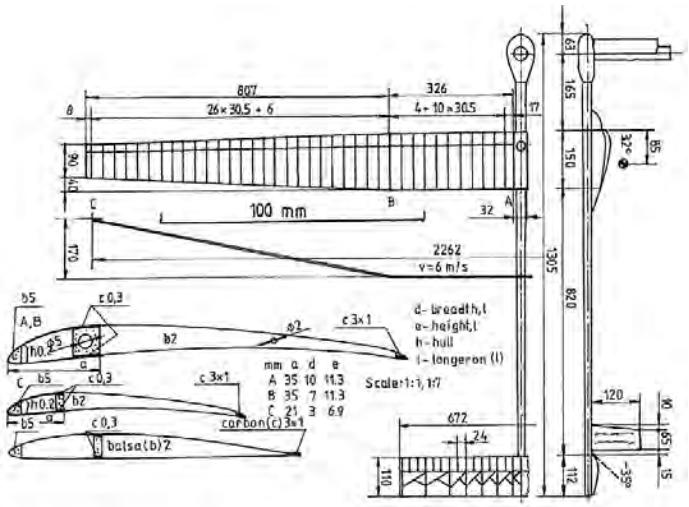


Figure 13. "STRONG CLIMBER", F1E slope soaring glider. Dimensions are in mm. 2014. Original drawing in China ink on tracing paper.

is flying his gliders every Sunday, when weather is not bad. See Figure 14.

I did research into two directions: one to improve aerodynamics of the glider and another one to improve its steering. Improved aerodynamics is by selecting proper wing profiles and high wing aspect ratio for low wind (2 – 3 m/s). Improving steering is by proper automatic pilot, proper wing profiles and low aspect ratio for high wind (7 – 8 m/s). For average wing (5 m/s) everything should be in between.

Many gifted and talented F1E fliers are: Cringu Popa, Eugen Pop, Dr. Dan Petcu, Dr. Marian Popescu, Florian Draghici, Stefan Razman, Daniel Baldea, Viorel Salisteanu, Dr. Paul Bere, Ionut Craciun, Cristian Faur, and Sandor Litomiczky (Hungary) appeared. They developed new techniques and tactics, dynamic launching and new ways to track and find their gliders. They were national, european, and world champions.



Figure 14. George Arghir and "Strong Climber" glider in flight over Cluj Napoca. October 2015.

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REMEMBERING BILL GIESKIENG – ONE PERSON'S AFFAIR WITH A HOBBY

AUTHOR
RICK PANGELL

Marion William "Bill" Gieskieng,
March 27, 1931 - January 14, 2019

Prologue

I originally conceived this article long before I became an editor of this year's Symposium. I sent out a blanket email to those who remembered Bill and perhaps his influence on them, if any. The response was sort of lackluster and I was a bit puzzled, and then Ken Phair hit it on the head:

"We can be disappointed by the lack of response to your request for input but maybe not too surprised. From my experience with the NFFS and FAI community in the US and internationally, Bill Gieskieng is less revered than we believe he has earned. We are the fortunate sons to have lived close enough to him to truly benefit from him."

Ken Phair

As Ken indicated, Bill's contributions to Free Flight are significant but not well recognized. I don't want to say I had some trepidation about this article, but then again I had a bit of hesitancy about an article regarding Bill because of appearing to over-praise him versus telling the story of what motivated Bill in his youth, the affect he had on the hobby and his contribution to Free Flight. And, to let readers know where a lot of what is taken for granted came from.

Much of this article uses Bill's own words in what one could consider an autobiography of one avid Free Flighter's life.

Bill's innovations and creativity have been documented many times, most recently in the 2016 NFFS Symposium in an article F1C: A Technological History by Louis Joyner, featuring three of his early designs. Featured were his "Sour-Cream" from 1973, which the name was a take-off from Thomas Koster's "Cream" which was the name of a Rock group; "Siren-Dipity" which was from his "Siren" he designed for his wife Annie, and his first folder that had a pop up linkage for lifting the wing from a tucked down climb position.

He was elected to the NFFS Hall of Fame in 1991 describing Bill as:
"An experimenter in the area of advanced technology. Bill has been a pathfinder in variable geometry surfaces. Included are his flapped wings and folded/extendable wing surfaces. Bill always figure better ways to solve the challenge when failure presented itself"

And in that same year his Siren-Dipity and the flapper story was NFFS Model of the Year. That article in the 1991 NFFS Symposium is a good read also.

Coupling Bill's experience with the article appearing in this Symposium, "Free Flight From a Youth Perspective" does make one realize that things have changed regarding what motivates the youth of today.

I first met Bill back in about 1970 when he and his notable wife, Annie, were editors the NFFS Digest. By then he and Annie were well known. Bill had NFFS member #99 and Annie had #100. Annie is a major part of his story.

"I was dragged kicking and screaming back into free-flight in 1963 but it was Annie, whom I married in 1964, that made my modeling possible — she was understanding enough to let me go with Bob Lynch, Ed Collins, etc. off to Kansas to fly in the team finals of 1964. (Here is a typical wrong-thing memory...this occurred during the middle of our honeymoon. Shame!!!)"

Bill became a close friend to me in his later years. I was tasked by him to aid him in "relinquishing" much of his "collections" whether it was modeling hardware or writings. To say the least, there were plenty. As we sorted out much of his belongings, most of which were model aircraft related, he said: "You know of course, this is most of my life."

I knew Bill from our early (1950's) High School days in Denver. His parents' home was right across the street from South High. We've flown together endless times since then. Of special memory were the times when he and Annie were a Team.

Bill had an inherited, inventive ability which lasted throughout his active free flight career. Such things as VIT and variable CG were among his earlier innovations. He was an incredible innovator. Most active fliers have no memory of those early days.

Bill Lovins

Bill grew up in a time when model airplanes were bigger than video games are now. He was an excellent writer and more than willing to discuss thoughts on model design. And, many prominent folks took notice. He was very prolific. He wrote under a few pseudonyms... Mr. Max, Billy Bob Butterball, Skykieng, Billious G, and the list goes on.

He truly had the "modeling gene" and much of this article is in Bill's own words:

"Back in the thirties aviation was the great romance. Young or old, every kid on the block made model airplanes. The local [movie] theater ran some really nifty movies...In particular I remember "Only Angels Have Wings" "Dawn Patrol" "Test Pilot" etc. Next door to the theater was a seductive model airplane store, filled with airplanes hanging from the ceiling... Wow! Then there were the radio serials...one stood out –"Captain Midnight! bong, bong, bong,—12 times!

I talked my mother into sending 25 cents to get a Little Orphan Annie swing-wing catapult glider. This was the beginning of an event that placed me onto a futile path. I got just one flight with the glider...It zipped way up into the sky, the wings snapped open up for the glide...It caught a little lift and ended up across a vacant lot onto the roof of a four story apartment house... it lay helpless in the gutter — unrecoverable. This glorious flight produced a thrill that I've been chasing ever since — hoping to experience once again that wondrous thrill.

There were so many things reinforcing models...My father took us to a business contact for dinner...There were model airplanes in the basement...I showed my father the neatly constructed swing panel that gave access to the rear motor peg. I was shocked that he was shocked! Dad was embarrassed... he apologized for my crime and told the father that I would fix it!!! ME!! a little kid? I tried to explain that it was meant to be that way.

The early contact with planes left its mark. I remember the 1933 World's fair...my mother promised me that we would take a sky ride.... some bright colored airplane looking things traveling across the sky high overhead on a horizontal wire. She lied. About the same time I remember trying to make a monocoupe (sp?) [monocoque, ed.] fuselage by rolling paper...It was pretty neat! But, I had no way to add wings, etc. For years it remained the highpoint of my modeling craftsmanship.

But that is a whole different story!!"
Billious G

Trial and Error

"I was in 8th or 9th grade... There were about 5 of us who belonged to the Denver Model Airplane Club. I had built four free flights...one of them I had designed, and before that I had screwed up my version of the Playboy Senior by changing the wing dihedral to Gull. A bad idea...

The 'Super design' came next and was the first of about 4 of that series. The 8' wing had six feet of straight [no] dihedral capped off by two, tapered, polyhedral tips...12" each. It surprised everyone when it actually flew! I heard the grownup club leader's talking about it and when one guy claimed that "It out-glided a Sailplane... "Wow! That was heady praise indeed!"

Learning through failure

"When I flew it next it ended its life via a powered spiral dive to the right. What I should have done was to key the wing and stab... Rather I had a pin sticking out of the tail that I aligned with a groove in the end of the fuselage.

I had a new model ready to go. The night before a contest I test-glided it under the street lights on the South-High school lawn. It was nose-heavy! To get it to glide I had to put a quarter inch balsa shim under the wing. Next day I put in a test flight...only using a short 15 sec engine run. Just as I launched the shim fell out!! The ship thundered up straightaway at 50 degrees — like it was on rails! My friends hollered and yelled with excitement... "You got it Bill!" The engine quit... The ship made a beautiful transition over the top!...Then it came down the same way it went up... scrambled parts littered the ground."

ok...end of the writing jag! But, easier to write about it instead of doing. Bad. bill g

2/23/2016 My Interview of Bill Gieskieng

I went to see Bill as a thought for the 2016 F1C Sympo article by Louis Joyner. I presented Bill with some questions. Approaching his 85th birthday I wanted to get his story in his own words as he remembered them. Of course, in his usual mode everyone was treated as an essay question, but I took notes. I obviously took paraphrased quotes and typed this up using a lot of my notes to fill in the blanks.

Q: Why did you start work on flappers? When?

First, back when I was say 12 or 13 years old I had one of those folding catapult gliders... an AJ Interceptor I believe. I was in grade school at the time but what always impressed me is how high it got and then the wings unfolded. That always stuck with me.

Second, as a teenager, my dad, who was a pilot, told me one time that wings of higher aspect ratio glided better. He looked at a full-sized plan that I was drawing, and pointed out that I needed to make the wing long and skinny...He called it, "Aspect Ratio"... That was the secret to high performance...so my Herkimer .60 got an 8 foot wing with a 7 inch chord!

That always stuck with me too. What I did figure out was the models with high aspect wings glided better but they didn't climb as fast. It became my idea to figure out how to climb with low aspect wings and glide with high aspect wings.

The third thing that always stuck with me was the discussion of single blade versus double blade propellers that was big among the rubber flyers.

Most of us kids back then were all building models whether rubber or gas, but I built mostly gas models.

About that time the DT was invented. I had never used a DT and of course my models either flew away or we managed to chase them pretty far.

They used fuses and some other contraptions. About that time too I imagined that if the model didn't have as much decalage in the power part it climbed faster but I had to add weight. There was this game to be played with maybe having the stab do two things. I dreamed of an auto stab but all I had to work with was those old pneumatic engine timers so I rigged a release to release the stab with a line from the timer. This worked about as well as the timer. Not too accurate, but it sort of worked, and I could use a fuse DT. My first real attempt was a high aspect model with no DT that flew over an hour and a half! There were 3 cars that chased that model and it made a perfect landing in the middle of a street. I never flew it again because I didn't want to lose it. I was still in my late teens!

Just prior to going into the Navy in the late '40's, and while still in the service, my thoughts wandered into that AJ Interceptor and its folding wing to a model that would have a symmetrical airfoil and maybe less drag than the undercambered ones everyone was using. And, I had always been into "gimmicks" and those sorts of things.

The main thing issuing from all this drama was this: while stewing in the Navy I kept thinking about ways to push and pull balsa shims in and out. I found some ways to do it.

The Bunt

The end of this story is that I suspect that I was probably one of the very first pioneer's to champion Auto-Stabs and Auto-Rudders, quick D.T's etc. Then in 1964 I flew an FAI ship in the team selection finals that had not only an auto stab but boasted a special gimmick that produced a fancy transition maneuver—which Bill Hartill later described as "the Bunt."

Q: In those days before the internet, how did you research? Were any particular correspondents or newsletters helpful? Were you corresponding with Koster at the time? With anyone else working on flappers?

Flappers were not the issue at that time because the auto stab was just in its infancy. Even so I had built a flapper model prior to the Kansas Semi-finals ('63 or so?). It did get a lot of attention, I remember Pete Sotich coming over and asking me about it. I put the flapper on the shelf for a while thinking that when the undercambered wings were folded, they made a symmetrical airfoil for climb. It wasn't until the late 80's or so, that I did make some

I joined the MMM club when I moved to Colorado in 1975. Bill was already a legend by then - given credit for many innovations in FIC (the first flapper I heard of or saw was his). His regular flying seemed to fall off not long after that, which was a pity since his planes were so elaborate and interesting to see. In spite of that, he was almost always at our regular club field events. Even if he wasn't flying, he always had some intricate auto-mechanism to show us; masterpieces of plywood and metal. About [30] years ago, he was in on the early development folders and he wasn't shy about building test beds - I probably would have started with a .049 powered model but Bill showed up with an ST 65 powered monster! Starting the engine was scary enough for me; to Bill, no big deal.

Bill was a pleasure to be around; he always had kind words for everybody and their models, even for us innovation-challenged modelers. He had an easy-going personality, and I never saw him in anger, although he liked to tease my good buddy and fellow modeler, Dean Carpenter. I was fortunate to have known Bill as a person and as one of the outstanding free-flighters of our time; I will certainly miss his positive aura on the field.

Dave Wineland, Nobel Laureate Physics (2012)

test panels with foam and carbon where the aft portion of the wing squashed when folded to a thinner symmetrical airfoil and then went into full camber when unfolded. See Figure 1

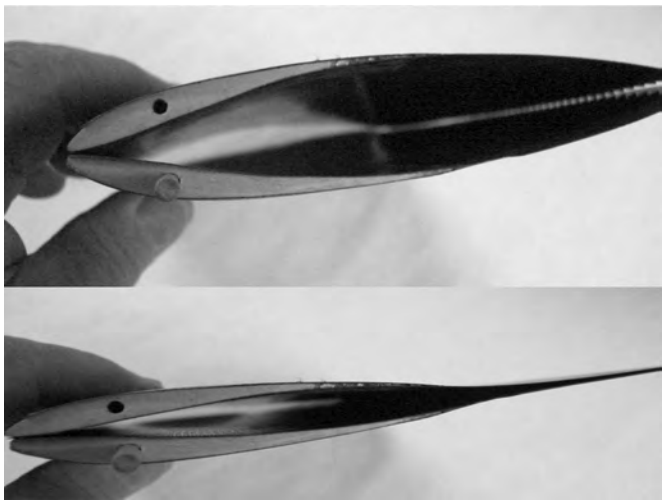


Figure 1 – Compressed Folded Wings Test Panels

OH! PAY ATTENTION YOUNG GRASS-HOPPERS – Memo by Bill regarding the aforementioned "idea"

I thought I should document this for modeling posterity just in case I drop dead or get lost, etc.

I made a quickie mockup of the hold down and release cams for the folder/flapper wing project for the Shifty Eagle F1C. I learned a bit. It turns out that I can simply run the line through an eyelet on the bottom of the cam. There is enough mechanical leverage to secure it in a hold down position...and it is free enough to swing to the release position from the rubber band tension as centered in the 22" inner wing panel (s). A rubber band from each cam goes around the folded wing to not only hold it in the folded position, but to compress the symmetrical airfoil formed naturally as an un-squeezed 20+% section down to a low drag version of 13%) See Figures 1 & 2.

One aspect of the release sequence surprised me; the first cam must release before the second can activate!! The sequence is thus: the cam pulls out a loop of line long enough to release the rubber band along with its tension.

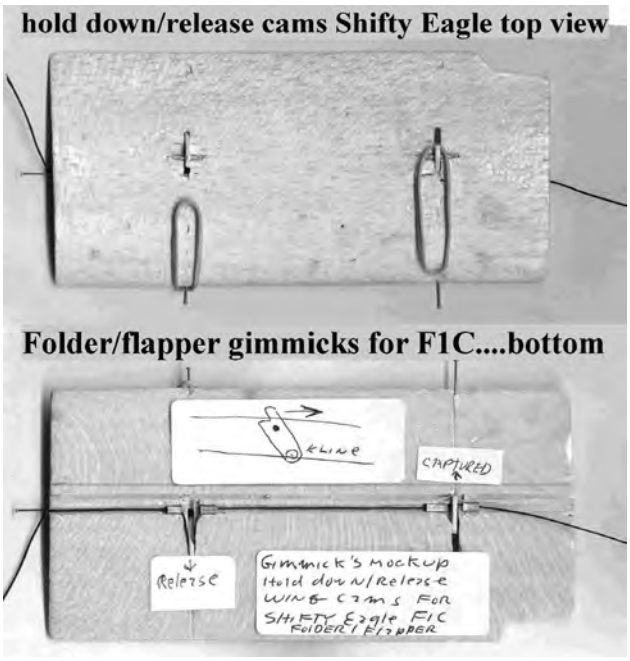


Figure 2 - Bill's proof of concept for folding wings and compressing them

With the loop no longer in tension the second cam takes up the resulting slack and thus releases in turn. This complication does bother me. Too many things hanging on one thread, so to speak. I will see about running a second line in the same channel—one dedicated to each cam.

I am concerned about securing the wing root area. This is the problem: I use a band from each enfolded winglet tip that exits the wing root area and goes down to the bottom of the fuselage...(this is an auxiliary initial opening assist) I would imagine that this downward component will severely counteract the inner-wing hold-down gimmick... So I think it necessary to plan on running a simple band around the wing 5 root area back to the release lever protruding from the fuselage rearward of the wing root. That will also guarantee that the lever will turn as it is supposed to do when released by its line to the timer...anyway the line from the wing cams is not very "stretchy"...in fact it calls for some kind of in-line spring to fences mounted above and below the wing chord that determine the climb and glide settings. So, the cams are virtually hidden...though I imagine the templates will cause a major disruption in the

airstrip. Oh, well...nothing is perfect. I guess a better way could be found, but I don't know if I could design it much less construct it.

— Bill "Skykieng" Gieskieng

At the semi-finals in 1965(?) Tomas Koster and I had a lot of conversation. His "Cream" model was on the road to wanting to be a multi-function folder flapper and we exchanged many ideas. Of course we had to write letters back and forth and I made a ton of sketches. It was a big trial and error effort. There were always a lot of questions from observers and they did show a lot of interest.

After the contest I came back to Denver and built a rather complicated model with all sorts of gadgets on it. It had too many gadgets. I was a victim of my own imagination. I always kept coming up with newer ideas before completing the prior one and would always confuse myself. Reducing drag was a big influence. I had created a rocking type of pylon to set the wing lower in the climb mode a release system using lines and heavy hinges. See Figure 3.



Figure 3 – Wing Lifting Linkage on "Shifty Eagle"

The [wing] hinging system was a big issue using torsion springs, rubber sheet flaps over the top of the wing, but eventually ended up using a wing joint rib with hooks and rubber bands. I built everything from wood and epoxy, very few machined parts, a lot of epoxy. [Note here: Bill spent a lot of time fabricating things in his own shop... ed] See Figures 4 and 5

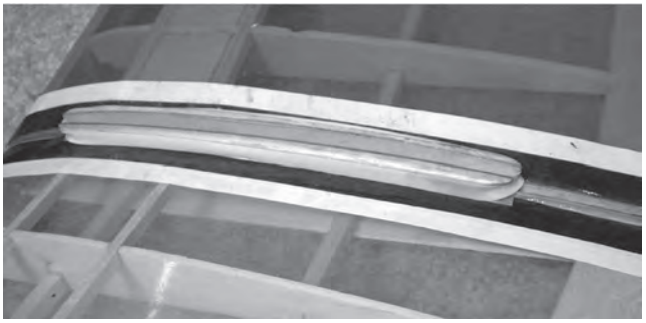


Figure – 4 Closed Wing Hinge

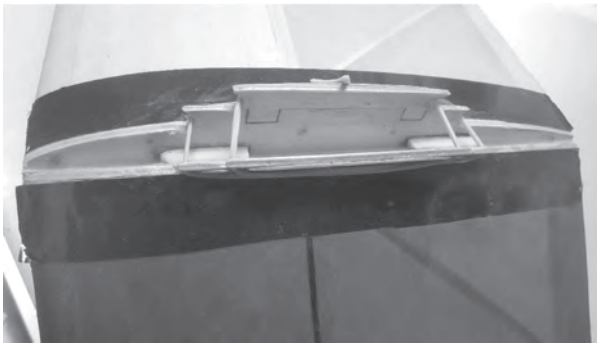


Figure – 5 Open Wing Hinge

Bill was a genius at model airplane design. I attended a FAI team selection qualifier in Denver, 1987. Bill was flying the first ever folding wing FIC - his invention. He missed a few rounds but he proved the viability of the folder. Now it's common. Rest in Peace, Bill. We will miss you mightily.

-Gilbert Morris

Needless to say, timers and triggering mechanisms were a big issue. There just weren't enough levers on available timers to do everything I wanted to do and I invented a ton of mousetraps, totally too complicated. I had a lot of modified Seelig timers (See Figure 6) and even tried using those [Plastic] timers [as slaves]. See Figure 7.

My first folder was in the early '60's. It took me a while to get around to actually doing it, although I had built a 1/2A test model with a V-wing with symmetrical airfoil. My whole process ended up with the "SkyZilla" multi folding 120 inch span, 1000 in-2, OS 65 powered monster. See figures 8 & 9.

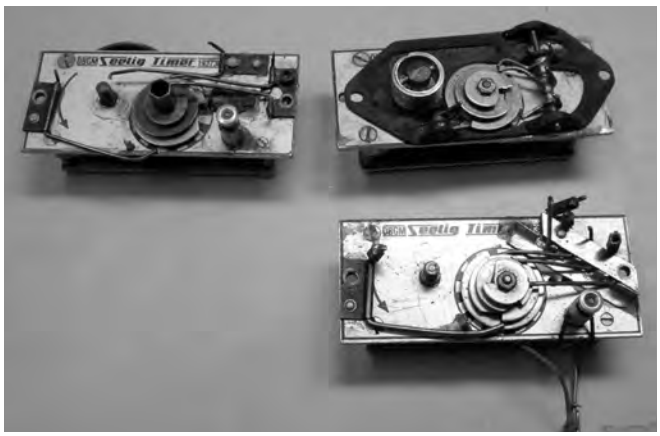


Figure 6 – Multiple Seelig Timer Mods

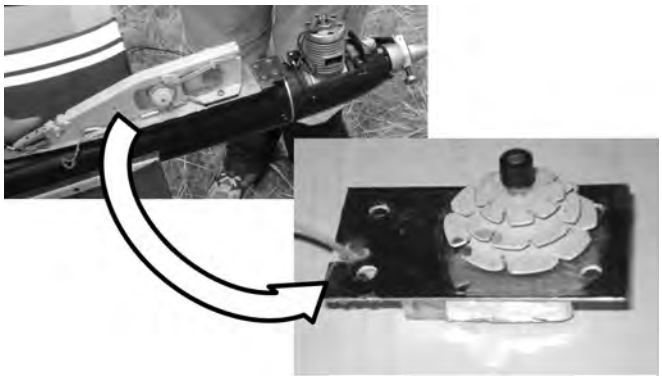


Figure 7 – Plastic Timers as "slaves"



Figure 8 – "SkyZilla!"



Figure 9 – Even folded "SkyZilla" is huge!

Q: You and Ken Phair were both in Denver and both working on flappers, yet the mechanisms and models are somewhat different. (In the Hartil book he thanked you for helping him avoid many mistakes and shortening his development time.) How important was it to have someone local to bounce ideas off of?

Ken and I spent a lot of time working on props. I hadn't forgotten that third thing that stuck in my mind, the single bladed prop. We developed a great single bladed prop for him when he went to the World Champs. See Figure 11.

Engines were the big factor in FAI Power at the time and conventional models using aluminum foil sheeted wings were another big thing.

I had plenty of conversations with a lot of modelers at that time and traded many letters. I think since I tried so many, well too may, ideas that I figured out pretty quick which ones should be tossed. I crashed a lot of models.

A bit of interruption in the interview: Bill had a fascination with single blade props. Note the progressions in Figure 10 of his many attempts at finding the perfect prop. Bill built a fixture that had a rotating arm with the engine/prop mounted on it. The resulting speeds developed were by timing laps.

Ken Phair's History of the F1C Single Blade Propeller Used from 1985 through 1998:

April 24, 2019

Following my move to Denver in 1974, I got to share FAI Power model development concepts and efforts with Bill Gieskieng. Watching his Silver Ship (the Siren-Dipity) climb and glide



Figure 10 - Some of the Single Blade props tested

inspired me to build some flappers of my own. My flappers were nowhere near as successful as Bill's Silver Ship. I concluded that it would be better to seek success through well-trimmed and well-flown traditional models.

Bill was not offended by my moving away from flappers. I worked on my traditional models to increase consistency and performance of the models and the sportsman. Shortly after returning home from the 1984 Team Selection Finals, Bill called with an offer to design and mold not one, not two, but three unique propellers for me to try and pick from for use at the 1985 World Champs. Having already flown one of Bill's two bladed props that out-performed the props I had been using, I eagerly accepted his offer.

The winter proceeded with updates from Bill on the research, design, and fabrication of the three propellers. By early spring Bill called to say that all three of the props were ready to test. After running the three props on the engine test stand, one stood out as the best candidate. It was a fixed single blade design. The prop was the best of the three, but it was not contest ready. Engine rpm was not where it needed to be, but the prop design offered a number of paths to operation at higher rpm.

With the prop selected, Bill gave me the technical backup for the design along with the prop mold and complete instructions on how to mold the propeller. The propeller design included an airfoil that had been developed in England for full scale turboprop aircraft. This airfoil had been shown to provide significant improvement in take-off and climb performance. The airfoil also provided good performance at trans-sonic velocities. The airfoil allowed a low solidity blade planform (low blade area) that for our purposes in free flight would minimize losses in the glide. Another feature of the prop was a "Gurney Flap" on the trailing edge of the blade. Being in-tune with the road racing world, I knew of the origins and benefits that the Gurney flap had provided to open wheel racing cars. However, I had not made the connection that Bill did to apply the concept to our free flight models.

I then got into molding and developing the prop for use on my models. The primary variables for the propeller development process included effective diameter, station-by-station blade thickness, and station-by-station depth of the Gurney flap. Initial development on the test stand was followed by flight testing and further development. By the time I departed for the World Champs, I was confident the single blade prop was performing very well.

Events at the World Champs in Livno confirmed that others recognized that the prop was special. Following a practice flight I heard Reinhard Truppe of Austria call out to me saying "I want your prop!!" Later the entire Chinese power team came to check out my prop. Their eyes and comments became animated when they felt the Gurney flap. At the close of Power day, I spent time showing the prop to Power flyers from a number of countries.

I continued to use and further develop the prop. I found that different engines – be they Rossi, Cossi, or Nelson each wanted a different mix of the prop variables. The basic prop served me well in local, national, and international competition for many years. See Figure 11.

The time came when it was imperative to go to a folding propeller. Using Bill's original mold

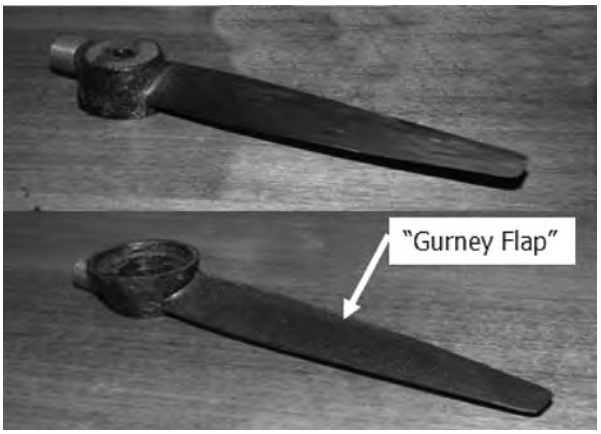


Figure 11 - Ken Phair's Single Blade Prop

that had already produced many dozens of fixed blade props, I molded a prop that was then finished and cut up to become the mold master for the folding single blade prop. Then, using the techniques and materials Bill had fully shared with me, I made a new mold for the folding blade. I used the folding single blade prop on F1C models through the late 1990s.

The story isn't quite over. The folding blade mold included the ability to adjust the basic pitch of the blade. This year, Bill's prop design has re-emerged as a 9 inch diameter two-blade folding prop for use on AMA Class B and C free flight power models. The 2 blade folding prop is currently going through development similar to the original fixed single blade prop. Ken Phair

Returning to the Interview with Bill:

Q: Have you found most modelers willing to share information, rather than run their own "skunk works" in secret?

I don't remember anyone who didn't trade ideas with me. If they were there I probably didn't hear from them or didn't notice since I was pretty open about what I was doing on my own.

Q: Evidently many of the Eastern Bloc team managers strongly discouraged innovation, instead placing emphasis on reliability and consistency, rather than maximum performance. Any comments?

When I asked Bill this, his answer was kind of interesting... "If you want to win you stick with the conventional model with refinements." He acknowledged that using too many gadgets without proven reliability isn't what the flying to win is about, but having the best of the current state of the art is. The state of the art flowed from planform to auto surfaces to engine performance to faster climb and better glides. In his world, he had the ideas to manage the state of the art development but didn't have the time nor resources to put them all together ahead of the technology curve, but he did "father" a lot of this stuff. His ideas "at the time" were dealing with the current state of the art.

Q: Has the elimination of the builder of the model rule stifled individual experimentation?

Another interesting answer: He said "It's the flyer, not the model." He compared it to the time consuming effort to invent or come up with ideas and then trying to actually implement them into a model. His goal was thinking ahead to the ultimate model. He admitted that even though he won contests, he did it with conventional type models and noted that at a major contest (world champs maybe?) Verbitsky's assistant came up to him and asked if he [Bill] was the ""Father of the folder/flapper and Verbitsky told the guy "Yes."

Q: Why were model names so much better back then?

Let's see... Sour Cream, Oblivion Express, Dream Weaver, Gastove, Uncle Remus, Miss Muffett, So Long For Now, etc... now all we have is letters & number (EV-34). (My own favorite name was "Creamed Pea" a P-30 I designed in the early 1970s when I was jonesing to build a Koster-like F1C. It had triple fins, double-tapered wings, etc. A sign of the times I guess. Early on guys used to name bombers after their sweethearts. ["Cream" was named by Koster after the rock group?] Phair's "Oblivion Express" you might ask Ken but I think he always thought it was heading to a crash. "Sky-Zilla" was named by the MMM club when it first flew and they watched it unfold.

The MMM Club Tribute

Sunday March 27, 2011 was Bill G's big 80th birthday. To celebrate this event and to honor our most famous Mountain Man we [the MMM Club of Colorado] gathered in Colorado Springs

Thank you for the note of Bill's passing. I didn't realize he was quite that old. I always enjoyed the time spent with him on my visits when in Denver. RIP Bill Vanderbeek

Thermals, Bill Vanderbeek

to treat him to dinner and celebrate his many accomplishments. Why Colorado Springs you ask? Well, the club was invited to take part in an open house of the Colorado Springs City Auditorium, our indoor site. This brought the club leadership together at the foot of Pikes Peak.

The MMM Club is well known around the world wide free flight community largely due to the work of Bill. His innovative designs as well as having been the publisher of the NFFS Digest with the able help if the late Annie went a long way to establish the MMM Club as a leader in the free flight community.

Bill was presented with a special award. There was an etched photo of Annie and Bill taken at the memorable Finals event in Winfield Kansas, which was electro-etched on to the metal. It was the perfect salute, not only to him but to the memory of Annie.

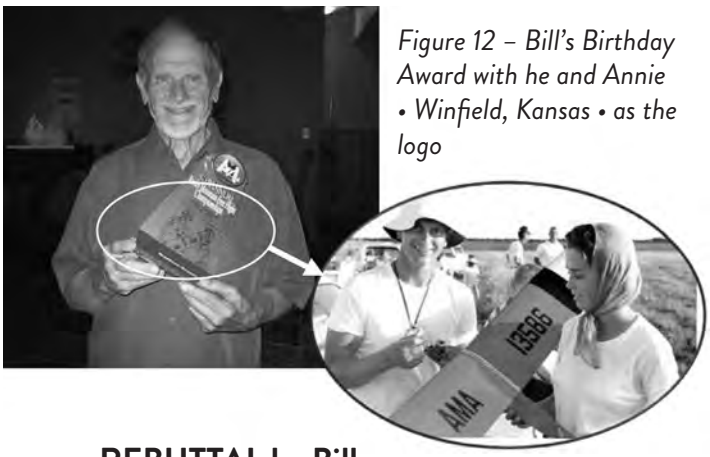


Figure 12 – Bill's Birthday Award with he and Annie • Winfield, Kansas • as the logo

REBUTTAL by Bill...

Summing it up in his own words to all of us:

Comments from the guy who at one time was asked ...."Hey, mister! Didn't you used to be Bill Gieskieng?

"Now I always need to point out that the glue that held all this together...from the Digest to the subscriptions/memberships/help desk was not me but rather Annie. Virtually everything that was NFFS at that time landed on her shoulders. In a much deserved recognition of her exceptional efforts Annie was inducted into the 1986 NFFS Hall of Fame.

Looking around my mind went back to the 60's. That was the time that, supposedly, according to the Model Magazines, Free Flight was dead.

I'm reminded of what Ed Collins said at one occasion...Ed held up a letter that he had received from a far-away modeler-- a hands across the sea sorta thing –

Ed said (holding it up high) – ***"this is what it's all about!"***

I didn't pick up on it. At that time I thought it was the competition that was the motivator... Now I understand where he was coming from.

Free Flighters are the friendliest group ever in our highly competitive world...To that, may I say that it seems to me that we have morphed into less a society arranging contest between individuals but instead have become more and more a band of brothers -- who together, as a whole body -- have set out to discover and collect all the hidden tricks and secrets of our special brand of flight...free flight, that is... and to freely enlighten all concerning the many mystery's making up a MAX!

However I can't help but think fondly of the Good Old Days when I could whip out a wing in a couple of days or so... and it makes me grimace to remember that at the time I considered such a breeze some great and monumental effort on my part.

...the best, etc.

Bill "Skykieng" Gieskieng, "Billious" the Invincible!"

Thanks to the following persons who contributed to this article:

Ken Phair

Bill Lovins

Gil Morris

Bill Vanderbeek

Dave Wineland

P-18 – A "NEW" BEGINNERS EVENT

AUTHORS
JOHN MCGRATH
& JERRY MURPHY

If you've been paying attention, you've noticed there's a lot of P-18's flying around. From local contests to the AMA NATS, this class is growing, and for good reason. Unlike some of the lighter classes, a down-to-weight P-18 is genuinely attainable by new builders. They fly surprisingly well, and everyone from 10 year olds to those many decades older are having a blast flying planes made to this simple rule. Science Olympiad and Technology Student Association students entering AMA-style flying find themselves in familiar territory with P-18, and fresh converts from other disciplines in model aviation find P-18 to be a comfortable entry point. Whether you fly P-18 or not, there's no question the class has struck a nerve.

Who better to tell the P-18 story than its originator? In this interview by Symposium staff, Jerry Murphy, member of the AMA Hall of Fame, takes us through the class's beginnings and development.

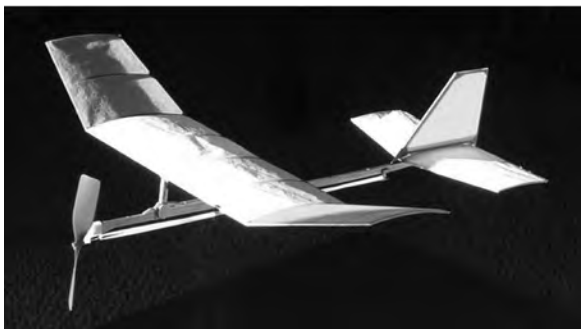


Figure 1 - The P-18 Model

Hence, an Interview by Symposium staff with Jerry Murphy, member of the AMA Hall of Fame and originator of the P-18 rule

Q: Murph–Could you describe how the P-18 event came about?

Sure. In 2015 when Rob Romash and I were preparing for the Nats here in Colorado Springs, we were looking for a STEM event for kids. You know–show them indoor free flight, how we do it. We wanted to build on-site, with the help of local modelers, not all of whom were free flighters. We wanted the plane to climb, circle, safely fly for about a minute, which pretty much eliminated the Delta Dart. For one thing, the DD isn't as easy to build as it seems, and for another, we didn't think it was up to that level of flight performance.

At one or two previous Nats (Johnson City, notably) there had been a Pro-Am event in which the "pros" built an LPP, brought it with them, and were paired up with a beginner to learn how to operate it and fly it. That was a good idea, but it created a burden on the "pro" to build and transport a Pennyplane during the runup to the Nats, and a few other things. We wanted to build on site.

Q: You used the P-18 Hawk, right?

Right. I'd been aware of Don Mace's P-24 design but thought that would be too big. We were looking for something around 18"

so it could easily go home in a copy paper box. I contacted Don Mace, learned about the "P-18 Hawk" and also learned that he'd stopped making kits for it because of the difficulty in sourcing good wood. I contacted John McGrath, who was actually a new member of the MMM club at the time, and who I knew had a business making laser-cut kits for Science Olympiad for some time. I asked whether he would consider making a Hawk kit for us, which he did. This solved a few other issues for us too, because John's kits don't need building boards, pins, knives, etc., in order to assemble them, and on our Build Day, we were able to build something like 20 Hawks in maybe an hour and a half with one modeler working with two or three kids.

One side note–John's per-kit cost was going to be around $15, and with our anticipated number of participants, that was going to be a healthy hit to the budget, especially when you factor in winders, so Pete McQuade and I visited with folks at the Museum of WWII Aviation here in ~~the~~ Colorado Springs, and they were kind enough to give us $500 in sponsorship to support the Nats and this event in particular.

The Hawk event was a huge hit. The kids (and we were targeting middle school, but had younger and older as well) were amazed at how well those things flew. You should have seen the looks on their faces! And if their plane made it up to the ceiling and hit it? Even better. The mass launch was incredible.

Q: Okay–take us from the Nats to the P-18 Rule

At the time of the 2015 Nats, there really wasn't a P-18 rule. Those of us adults who flew the event there and at later contests pretty much just made Hawks from plans or from the kit, but weight made all the difference. There was something like a 3 gram difference between the lightest ones and the heaviest ones (averaging around 7 or 8). We saw that this event–something around 18 x 18", plane buildable with hobby shop wood, easily able to do 1-2 minutes, able to be built by a beginner–had the potential to be a game changer–as long as it could be kept from becoming a no-holds barred National Champ type event. The thing is, this type of plane is great not only for kids, but also for RC converts, outside free flighters trying indoor for the first time, or indoor fliers who just aren't into half-gram, film-covered high-skill events. It would lose that appeal if a rule were created that allowed too much advantage to go to high-level builders and fliers.

So, keeping in mind these ideas–a minimum weight that's doable but not a pushover, a plastic prop to save folks from the "tyranny of the front end," covering options that went as far as plastic like you find in supermarket bags–not film–and a size that's easily transportable (and sort of similar to LPP), we put together the rule and proposed it. Some of the controversies along the way had to do with prop size–which ended up growing to 6" from the original 5.5" to afford more options, and length, which remained as originally proposed, giving an 18 x 18 box rule. Most of the discussion during the comment period had to do with improving the performance of the model (lighter, longer, bigger prop) and while that sounds good on the face of it, we were satisfied that planes of this design and performance level would be great for the target audience (mostly those new to the hobby or this branch of the hobby) and would remain so as long as we made sure we had "intentional stagnation of development." The rule now calls for 18" x 18" span/length, max chord 4.5". Stab 9 x 3.5", and 7.5 gram minimum weight, 6" max plastic prop, 10" to 10" hook-to-hook distance maximum, and no film covering. Common times in the gym are maybe 1:45 to 2:15, something like that.

Q: What about the Provisional Event status? Why's the P-18 a Provisional Event?

There have been other so-called beginners events before, that have morphed into high-level models. The Easy-B comes to mind. That

was originally supposed to be a plane with kind of the same idea as the P-18. Good for beginners, converts, etc. Over the years, under pressure of national record setting, plus adjustments to the rule and maybe the rule's language that high level modelers could exploit, the Easy-B has become anything *but* a beginners event! So again, anything that helps to intentionally stagnate or constrain development is good for this event. Provisional Events have no records kept, which is just fine.

Q: You mentioned something about outdoor modelers trying indoor free flight. I've also heard you mention before that indoors is the best way to get new free flighters. How does that connect with P-18?

That's right. I believe that indoor flying is the key to the health of free flight overall. If you tell someone they're going to have to drive an hour or more out into the desert or the prairie to try out this hobby, that's a pretty tough sell, but if you tell them, "come over to the high school on Sunday and check out some free flight," they're much more likely to stick around for more. Sure, when the warm weather comes around, get them out to the field, but in the meantime they can enjoy the hobby far easier and cheaper indoors. Oh, and here's a type of plane you can build and fly right alongside us experienced modelers.

It's the same with converts to indoor flying. We have several examples right here in our own club of national-level outdoor flyers who are starting to fly indoors simply because the P-18 event is so doable. We make a point to suggest P-18 as the first event to try with newcomers of any type–Sci Oly students, R/C converts, outdoor FF'ers, family members. It's just a great plane for learning how to simply operate an indoor model. Learn how to wind, trim, launch, time a flight–all that stuff. I've even heard of a club that keeps a box of P-18's already built and trimmed, ready to put into the hands of visitors, so they can get in on the action. That's great!

Some of us did an event a couple of years ago–a STEM fair for young students at the local university–and found something interesting. You know how lots of people (of all ages) are a little klutzy at launching a plane the first time, even with coaching? We found that by sticking a pair of wheels on a P-18, we could give the wound plane someone, say "set it down right here and let it go," and kid (or adult, for that matter) would have a great–and memorable–first flight.

Q: After a few years of working with the P-18 rule, what would you change?

(Long silence :))

Too tell you the truth? Not much. We probably should have gone with "single piece, molded" on the prop, kind of like P-30, but that hasn't been a problem. Builder of the Model rule has been suspended for P-18, and that's okay too. I still think there's nothing like the look on a kid's face when he sees something he built climb and turn its way up to the ceiling, but getting help's a good thing, and if we can set the hook and get that kid (or adult) coming back for more, it's all good!



Figure 2 - A happy Logan AIves, 2019 AMA Indoor NATs Junior Winner, with his P18 and Jerry Murphy

Q: Do you fly P-18?

Oh absolutely. I'm working on a new Hawk right now from plans, with increased stab span. Had to add weight to get it to 7.5g!


...AND FOR MY TALENT I WILL MAKE THIS AIRPLANE FLY!
ALL SCHOOL TALENT SHOW
600222

FINALS: THERMALS, PERFORMANCE AND GRACE

AUTHOR
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There must be a better way to select A, B and C teams" is a topic debated after every Finals by those who did not make the cut. The Finals is a single contest in which the three teams are selected over three flying days plus a reserve day. For each event, a Finals can be a single contest over two days (the older version) or a pair of daily contests (the current version). In a pair of contests, team spots can be granted to the daily winners (both days), to the second daily winner or none at all. The other team spots (1, 2 or all 3) can be assigned to the flyers with the lowest sum of ranks in both flying days or be confined to the group of flyers who placed in the top three on each daily contest.

An alternative to a Finals is holding a series of multiple regional contests.

Considering the future – (1) Should we only consider the top-3 daily flyers (Alternative 3)? (2) Should we allow flyers with small time drops (so called "non-clean flyers") to participate in the first daily flyoff? (3) Should we forego the 8-minute max in the second daily flyoff?

Criteria

Finals are a *stress test* and should have the following features:

- **Thermal flying.** To test flying in thermal conditions.
- **Performance.** To test a flyer's ability to reach the second flyoff, provided they have are in the first fly flyoff. A good team placement in a World Championship requires having at least two flyers in the second flyoff.
- **Grace** means granting a flyer a second chance if they drop on one flying day or when they have a small time-drop.

Mechanics

Due to the lack of a readily available pool of skilled timers at a Finals, events are crossed timed. Each event flies two days and times one day, so a Finals has three flying days plus a reserve day. As two events are flown in parallel each day, regular rounds are staggered. One event flies "early", the other "late". In a two day contests rounds are typically 25 minute long followed by a 35 minute break. (For example, 9:00-9:25 am is

the early round and 9:30-9:55 am is the late round.) Each flyer is assigned a timer (the event timing that day, a volunteer or a paid helper). With this setup, the whole line could launch simultaneously. Staggered flyoffs are held in the evening for the "early" and "late" events that day.

Contest Formats

There are three contest formats

1. A Single Contest

A 14-round format flown over two flying days for each event was used between the late 80's until 2011. Flyers in each event fly two days and times one. The first three days of the Finals had 7 early and late thermal rounds as noted above. To test performance, the first round had a 5-minute max, so one could be eliminated in the first flight.

However, the attrition rate over 14 consecutive flights was high enough to leave a few clean flyers after 14 rounds. Frequently the team was the last three people standing. And if more maxed out, a single early morning flyoff was sufficient to determine the team.

2. Double Contests

The lack of systemic performance testing and the absence of a "Grace factor" (one could pack up following any significant drop) together with a proposal by Jim Parker that was submitted a number of times to the team selection committee (TSC), resulted in switching to a new Finals' format in 2013. Each event flew two daily contests, called Day-1 and Day-2. However, the mechanism of each event flying two days and timing one was retained.

The winners of Day 1 and Day 2 won team positions. Until 2018 the third member, called the combination flyer, was the flyer with the lowest daily sum of ranks. (Winning gets a rank of 1, second a rank of 2 etc.) The lowest possible sum of ranks was to be second on both days. Two way ranking ties were possible: For example a pair of flyers who were (2nd and 4th), (4th and 2nd). Even a 3 way ties was possible with a third flyer placing (3rd and 3rd). Ideally, ranking ties should have been resolved by a flyoff, since factoring a flyer's absolute time is arbitrary. (In other words, flipping a coin would have been fairest.)

3. Multiple Contests

A free flight team can also be selected by a series of regional contests. These could be

a subset of the American Cups, to test flyers under diverse flying conditions. Our contests are mutually-timed which means that a pair of flyers time each other and retrieve their models each round. Those who are timed by a non-flying friend double their flying opportunities while unpaired flyers need a favor from a bystander to be able to fly later in a round. Another issue is finding experienced CDs who would agree to forego participating in the contest themselves. Field processing or spot checking are unlikely.

Scoring multiple contests should account for the relative placement and the number of participants accounting for a flyer's the best score per site over say three different sites. Using ranks, say 1 for first, 2 for second etc. quickly runs into multiple ties due to transitivity [2]. Scoring systems based on the number of flyers beaten magnify/penalize large/small contests. Instead, a scoring system similar to the America Cup – 25 points for the first place, 20 points for second etc. plus say a bonus point for every flyer above 5 is possible. So the winner of a contest with 7 flyers would get 27 points, the fifth place would get 7 points and the 7th place gets a point. (By default, all American flyers are counted, even though some may not enter the program.)

Finally, multiple contests should be limited to 4-6, with a person's best three results per site counting. But which sites would qualify?

In multiple site proposals I've seen, typically list three western sites: Lost Hills, Eloy and Las Vegas; Denver CO in the center and Muncie IN in the East. Well, a cross country flight and car rental plus a hotel costs around $1.5K. Doing it twice or three times over a cycle is out of the question.

Alternatives to the 2018 Format

The post-2018 Final's survey had two main criticisms.

1st - selecting the team member in a single contest, the Day 1 walk-on winner.

2nd - using ranks to select the combined flyer.

To clarify, ranking and finding the Day-2 winner could be correlated. For example, suppose there are 2 clean flyers on Day 2, one with a *low* Day 1 ranking (Flyer #1) the other with a *high* Day 1 ranking (Flyer #2). Let Flyer #3 be the flyer with the smallest drop, who happened to have an *intermediate* Day 1 rank. So Flyer #1 would be on the team even if he lost the fly-off (placing second) as the combined flyer. To avoid the perception that Flyer #1 could select his team mate (Flyer #2 or Flyer #3), the contest should be terminated, placing Flyers #1 and #2 on the team.

The good news is that the next program will replace the combined flyer by a direct a flyoff between the top three daily flyers net of the daily winners. The concept of the top-3 daily flyers was suggested at the January TSC meeting.

Following the TSC meeting participants could choose between two alternatives.

Alternative 1.

Only the Winner of Day 2 makes the team [3]. The top three flyers from Day 1 and the 2nd and 3rd flyers on Day 2 fly off for the other two team positions.

Elimination of the Day 1 winner addresses the criticism of leveled at making the team on a single day walk on [4].

If 6 different flyers place in the top three each day, 5 of them fly off for two team positions. If the same three flyers place again in the top 3 on Day 2, one is team member by winning Day 2 and the others are also on the team. If one of the top flyers of Day-1 wins Day 2, 4 fliers fly off for two team positions and 4 flyer fly for two positions if he places 2nd or 3rd on Day 1 etc.

Alternative 2

The team consists of the two daily winners. The third flyer is determined by a flyoff between those who are the two daily 2nd or 3rd positions held on the reserve day.

If 6 different flyers place in the top three each day, two make the team by being daily winners and the other 4 fly off for the third team positions. If those in the 2nd and 3rd position on Day 1 repeat on Day-2 they fly off for the 3rd team position. If only one 2nd or 3rd flyer from Day 1 is again a 2nd or 3rd flyer on Day-2, the three flyoff for the third team position. In other words, placing twice in the 2nd or 3rd position each day only reduces the number of flyers flying off for the third position.

Alternative 2 won with a landslide as you might have expected and is the 2020 Final's format.

Future possibilities

Evidently, alternatives 1 and 2 are a *mixture* of the top 3-flyers net of the daily winners. Repeats by the top 3 Day 1 flyers only reduce the number of flyers in the reserve day. As an intellectual exercise, let's award a top 3 repeat a team positions and those who are in the top 3 fly off against each other on the reserve day. Consequently, the daily winners disappear.

Alternative 3

Contests are flown until the 3 top flyers that day are identified. The flyers that are in the top-3 daily flyers twice make the team. Fliers who are in the top 3 once, fly off among themselves on the reserve day [5].

Note that finding the top 3 daily flyers can be faster than finding a daily winner (requiring less flyoffs).

With no repeats (6 different flyers place in the top 3 positions on Day 1and Day 2) there are 6 flyers in the reserve day in a flyoff for 3 positions. For one/two repeats there are 4/2 flyers competing for 2/1 positions on the reserve day. Finally, with three repeats no reserve day flyoffs are required and the alternate can be the flyer not on the team with the highest absolute score.

To make the team one has to be twice in the daily top 3, or be once in the top 3 and fly off against the other 6, 4 or 2 in that position. Grace applies since a drop in either day does not wipe you out.

The Daily Contest

Luck or randomness can skew a Final's daily contest. A standard daily contest format that conditions participation in the flyoffs on being clean after the thermal rounds can lead to *excess attrition* in the thermal rounds. The second weakness is that flights exceeding 6 minutes allow the thermal queen to play a larger role.

Roughly about half the flyers in a World Championship are clean after the thermal rounds and fly in the first flyoff. We have had Finals where 80% of the participants in the first flyoff and others, such as B's Day 1 in 2018, only 4 out of 17 flyers made the first flyoff.

1st Flyoff Quota

The possibility of excess attrition over the thermal rounds can be addressed by using a participation quota for the flyoffs. Suppose the participation quota for the first flyoff is say 50% of the flyers whom have flown ALL the thermal rounds [6]. If 50% or more of the flyers are already in the first flyoff then just continue. Otherwise, allow the non-clean flyers with increasing time-deficits to fly in the first flyoff. (For example, add the flyer with the smallest drop, say 2 seconds, followed by the flyer with the next smallest drop, say 15 seconds etc. until the participation quota is reached.) Let the time-deficit of the last flyer added to the first flyoff be **D0** seconds. These non-clean flyers can continue to fly as long as they max (Remember, in alternative 3 we are only trying to find the top-3, not the daily winner.)

First-Flyoff

The next question is who should advance to the second flyoff? Of course anyone who maxes the first flyoff should advance to the second flyoff. Let **D1** be the largest timedeficit (in seconds) among those non-clean flyers who *maxed* the first flyoff. (D1 is equal or less than D0). So if there is at least one non-clean flyer who *maxed* (D1 > 0) then we should allow any clean flyer who has *dropped* up to D1 seconds in the first flyoff to also advance to the second flyoff. (Basically, dropping X seconds in the regular rounds is equivalent to dropping X seconds in the first flyoff.) These flyers with up to a D1 timedrop (non-clean and clean flyers in the regular rounds) are called the D1 grace flyers. They continue flying as long as they max.

To illustrate, see Table 1. Suppose there are 3 flyers (Flyers #1, #2, #3) are clean in a (240, 3x180, 240) daily contest as shown in the

A morning and evening PFs

	Clean flyers			Non-clean flyers		
	Flyer 1	Flyer 2	Flyer 3	Flyer 4	Flyer 5	Flyer 6
1st Perf Flight	360	340	180	360	360	300
Thermal rounds	1020	1020	1020	1010	1000	990
Sum	1380	1360	1200	1370	1360	1290
2nd Perf Flight	360	360	stopped	300	360	stopped
Sum	1740	1720		1670	1720	
	Team	Team			Team	

Table 1 – Flyoff Illustration

table. The 50% quota adds three nonclean flyers (Flyers #4, #5, #6) with Flyer #6 having the largest time-deficit of **D0 = 30** seconds (row 1).

Next, suppose Flyers #1, #4 and #5 max the first flyoff. The non-clean flyer #5 who maxed has time deficit D1 = 20 seconds (row 1) also maxed (row 2). Consequently, the clean Flyer #2 who dropped 15 seconds in the first flyoff (row 2) can also to advance to the second flyoff. (In other words D1 = 20 seconds and the D1 flyers are Flyer #2 and #5.) Since Flyer #3 and Flyer #6 have dropped more than 20 seconds they quit flying (rows 2 and 4.)

Second-flyoff

A second flyoff is requited when there are at least four "live" flyers – any combination between clean flyers who maxed the first flyoff and the D1 grace-flyers. However, the second flyoff results are strictly based on flyer's absolute scores.

In the example illustrated in Table 1, Flyers #1 and #4 maxed the second flyoff with a 6 minute max (row 5). Although Flyer #2 dropped, his score exceeds that of Flyer #5 (row 5), making him the third top 3 flyer.

Flyoffs and the top-3 daily flyers

Suppose there are 6 flyers in the second flyoff – 3 clean flyers who maxed the first flyoff and 3 D1-grace flyers (who dropped up to D1 in the regular rounds or in the first flyoff). If they all max the second flyoff, the 3 clean flyers are the top 3 daily flyers (because we are now looking at absolute scores.)

If one of the clean flyers drops then the third top 3 flyer will be the D1 grace flyer with the smallest drop etc. And if one adds a clean flyer and all the seven max out, then the four clean flyers proceed to an early morning flyoff on the reserve day.

2nd Flyoff Max

What should the second flyoff max be? As noted, increasing the max above 6-minutes introduced an element of luck. Unlike a regular contest, the goal is to determine the top three daily flyers. It's claimed that an 8-minute second flyoff is not essential to determine the top 3 daily flyers.

But a 6-minute max might be insufficient to whittle down the number of clean flyers to the daily top 3. One could argue that if the second flyoff is large, that raising the max to8-minutes is justified, given the need to conclude the daily contest.

Conclusion

The Finals are a pressure cooker, awarding good preparation, logistics and discipline a better chance of making the team. Systematic testing should allow some non-clean flyers to participate in the first flyoff if there are too few flyers clean flyers and a 6-minute max in the second flyoff to reduce the impact of a random hot air bubble.

Conceptually, there are two internally consistent approaches to select a team over two daily contests. Alternative 3 only factors in the top three daily flyers. Its advantage is that daily winners are not required but it most likely requires an additional flyoff on the reserve day.

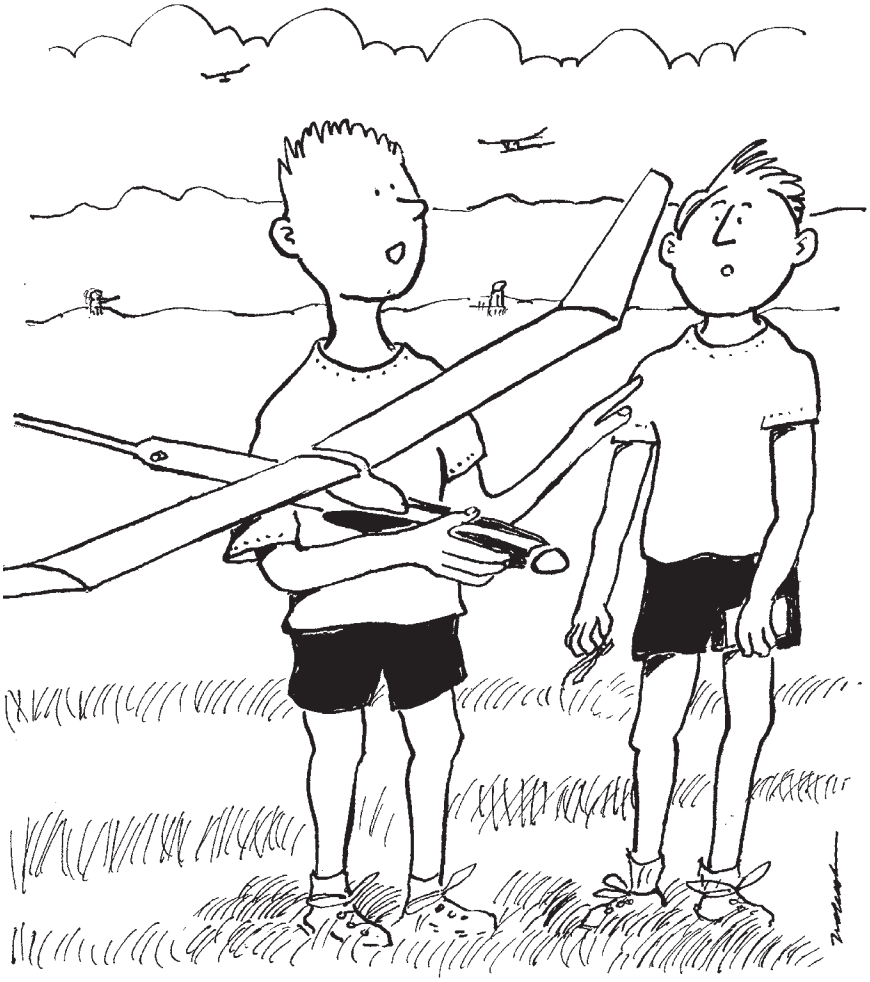
The second (a hypothetical Alternative 4) is to select all team members by the sum of ranks (avoiding the complication of awarding a daily winner a team spot). It's clean and straight forward without an additional flyoff, but it requires finding the daily winners to rank all flyers. Here, a flyer that places poorly on the first day, say with a 0 round, is unlikely to make the team even if they win the second day. In fact, Alternative 4 resembles the old 14-rounder with four flyoff flights thrown in.

Awarding the daily winner a team spot is a nice spectacle ("celebrating the daily winner") but it shortcuts the systematic testing required in a Finals.

1. Disclosure – I'm the representative of District 2 on the team selection committee

(TSC). Obviously, these are all my personal opinions. I would like to thank Blake Jenson and Bill Booth for help on some factual issues. This is also to thank the editor and his readers for going through many drafts.

2. Suppose we consider a flyer's 3 best regional contests out of three. Let Flyer #1 places 1st, 2nd and 3rd in three specific contests; Flyer #2 places 2nd, 3rd and 1st and Flyer #3 places 3rd, 1st and 2nd in the same three contests respectfully. So, they are tied with same sum of ranks (i.e. 6). Increase the number of flyers and the number of eligible contests guarantees a myriad of ties.
3. My proposal of Alternative 1 was to only award Day-2 winner a team position and grant the other two positions by the lowest sum of ranks. But this avoids addressing the correlation between ranking and selecting the Day-2 winner.
4. Hypothetically, Day-2's winner could have spent Day-1 trimming or hanging out at Denny's, but this is rather unlikely.
5. This alternative was dreamed up after the TSC meeting in Dallas at the end of January.
6. The 50% participation rate is practical, given the need for two flyoff timers per flyer. But raising the participation quota increases the chance of a flyer with a large D0-time deficit placing in the top daily 3 could be perceived as unfair.



"Let's design a card that gives us a score for luck!"

F1E HISTORY AND EVOLUTION IN NUMBERS

AUTHOR
DANIEL PETCU, PHD
IN THE MEMORY OF JON DAVIS

The present paper makes a statistical analysis of FAI official F1E events and presents it strictly mathematical in the form of matrices. However, a pure matrix does not describe the true event, only the results of that event. Nor can one tell from a summary at a higher level of matrix the details of that event. There is always a deeper back story.

In algebra, a matrix is defined as a rectangular tabular of real numbers, symbols or expressions arranged in rows and columns.

Matrix applications are found in most scientific areas. In every branch of physics, such as classical mechanics, optics, electromagnetism, quantum mechanics, and quantum electrodynamics, they are used to study physical phenomena. In computer graphics, they are used to project 3D models on two-dimensional screens. In probability theory and statistics, stochastic matrices are used to describe probability distributions in economics to describe systems of economic relations, and in history to describe events.

The statistics below are based on actual events and resulted from the research of Ian Kaynes GBR archives.

An individual element in a matrix represents an event that has or has taken place under the conditions described by the line and column order numbers at the intersection of which the event occurs, provided that this element is different from zero.

Senior World and European F1E Events

The number of events contained in a matrix is equal to the product of the number of lines and that of the columns. The matrix in Figure 1 has 10 lines and 10 columns, so 100 elements, 37 of which are different from zero and located in time and space, year and country, describes the 37 World and European Championships for Seniors that took place between 1974 and 2018.

Each element of the matrix can describe one or more separate stories. Relative to the 2003 event to give an example, Bob Sifleet USA could write how he won the 2003 World Championship that took

		Organiser									
Country	Total	Year									
Romania	10	1991	1996	2000	2003	2006	2007	2010	2012	2016	2017
Germany	6	1974	1979	1982	1986	2008	2009				
Slovakia	6	1999	2002	2005	2013	2014	2018				
Poland	4	1989	1993	1998	2001						
Czechoslovakia	3	1988	1992	1995							
Austria	2	1981	1984								
Czech Republic	2	1997	2004								
Serbia	2	2011	2015								
Italy	1	1994									
Switzerland	1	1980									
Total	37										

Fig. 1 World and European Championships

place in Romania, Edith Mang AUT could tell us the reasons why he took the last place and not last but not least, Jean-Luc Drapeau FRA would meet the curiosity of knowing why he missed the podium for only 29 seconds in the second fly-off. That particular event in the matrix, 2003 in Romania, does not fully describe the event.

The events in such a matrix are not independent as, for example, Bob Sifleet do not tell me that the outcome of 2003 or previous events (2002, 1996, ...etc) was not the basis for his subsequent results (2005, 2007 ... etc). It follows that from such a matrix we can write an infinite number of real histories that would represent an enormous work.

A well-done statistic, it says more than a million words and causes the researcher to remember what happened if he participated in the event or to imagine what might have happened if he did not.

The matrix in Figure 2 contains 703 elements of which, 349 are symbols and are different from zero. The symbols represent the different countries' participation in the World and European championships of seniors and also the order in which they entered the circuit.

Strictly mathematical, at least 349 stories can be made, though in reality they again would be infinite.

Being pure mathematics, the elaborate statistics do not take into account emotions, feelings,

Seniors' Events						Participating Countries																		
Year	Event	Place	Organiser	No. competitors	No countries	AUT	GER	ITA	SUI	CS	CZE	SVK	GBR	POL	ROU	HUN	USA	RUS	FRA	MLD	SRB	RUS	NED	UKR
1974	ECh	Himmilberg	GER	12	4																			
1979	ECh	Hesselberg	GER	15	5																			
1980	ECh	Melchsee	SUI	16	5																			
1981	ECh	Salzburg	AUT	17	6																			
1982	ECh	Wasserkuppe	GER	18	6																			
1984	ECh	Wolkerhogel	AUT	18	6																			
1986	ECh	Wasserkuppe	GER	21	7																			
1988	ECh	Brezno	CS	19	6																			
1989	ECh	Nowy Targ	POL	21	7																			
1991	WCh	Cluj Napoca	ROU	22	7	A																		
1992	ECh	Rana	CS	28	9																			
1993	WCh	Krynica	POL	31	10																			
1994	ECh	Vicenza	ITA	28	9										B									
1995	WCh	Brezno	SVK	28	9																			
1996	ECh	Turda	ROU	28	9																			
1997	WCh	Rana nr Louny	CZE	31	10																			
1998	ECh	Muszyna	POL	30	10																			
1999	WCh	Liptovsky Mikulas	SVK	28	9																			
2000	ECh	Turda	ROU	25	9																			
2001	WCh	Nowy Targ	POL	28	10												C							
2002	ECh	Liptovsky Mikulas	SVK	29	10																			
2003	WCh	Turda	ROU	36	12																			
2004	ECh	Rana nr Louny	CZE	28	9																			
2005	WCh	Liptovsky Mikulas	SVK	34	11																			
2006	ECh	Turda	ROU	34	11																			
2007	WCh	Turda	ROU	36	12																			
2008	ECh	Rhon	GER	34	12																			
2009	WCh	Rhon	GER	40	13																			
2010	ECh	Turda	ROU	29	10																			
2011	WCh	Zlatibor	SRB	33	12																			
2012	ECh	Turda	ROU	38	13														D					
2013	WCh	Martin	SVK	36	12																			
2014	ECh	Martin	SVK	40	13																			
2015	WCh	Zlatibor	SRB	36	12																			
2016	ECh	Turda	ROU	32	11																			
2017	WCh	Turda	ROU	38	12																			
2018	ECh	Martin	SVK	34	11																			

Fig. 2 Number of competitors and countries participating in the World and European Championships for Seniors

accidents, nothing about wind, rain, lightning, snow, nothing about sleeping in the car parks, driving thousands of kilometers, etc. It leaves it to the reader to imagine all this. It should be compulsorily imagined the physical and material efforts of time and money that sportsmen, wives and their children, assistants, referees, organizers have been able to make since 1974 when the class has become official to date. For example, I will refer to 4 events A, B, C and D contained in the matrix in Figure 2.

Event A could be Fritz Mang AUT's story about how he became double World Champion in 1991, Cluj Napoca (Romania) both in the individual and team classification with the Austrian team.

Event B. F1E ECh, Mount Sisemol in the Alps Mountains. I descended the mountain to recover my model and I was attacked by a violent hailstorm. I stripped off my pants and waterproof jacket, packed the airplane in them to protect it and climbed the mountain to the starting line. Arrived there, for more than half an hour I could not articulate a word because of the severe hypothermia I suffered.

Event C.

C1. If he were still alive, Jon Davis USA could tell us how he got in touch with Daniel Petcu in 2000 to participate in F1E in secret, as Maggie, his wife did not leave him to fly alone from New Mexico to Europe two weeks after terrorist attacks in September 2001. Jon could tell us we met in Poland, as we competed side by side and how he won the 4th place, dropping the podium for only 7 seconds in favor of Fritz Mang AUT who won the bronze.

C2. Fritz Mang could tell us how the panties were shaking on him counting Jon's flight seconds.

C3. Maggie Davis could have entertained her stories about how she froze and filled with mud when she fell into a water trench by recovering Jon's models on that autumn day when it was cold and it rained all day. She could also tell us how she thought I was taking narcotics when I was putting salt in my milk from a black Kodak photo box at breakfast. Or to report on how, even though she had three boys of her own, fell in love with an 18-year-old Romanian kid, the girl she never had, and named her. She has invited the girl many times to visit the USA, and the same number of times the US Embassy in Bucharest refused to give the visa to the kid.

C4. Most of the participants and the organization staff of the 2001 World

Championships were housed in a hotel in the mountains. I think we were over 200 people out there. One evening after dinner, a business was set up between a competitor and a woman in the organizing committee. The things were so hot that it turned on the fire alarm throughout the hotel. The firefighters canceled the alarm but in the early morning I was awakened by that competitor to help him raise the woman out of bed to retrieve his national flag under her. He desperately needed the flag on the contest field.

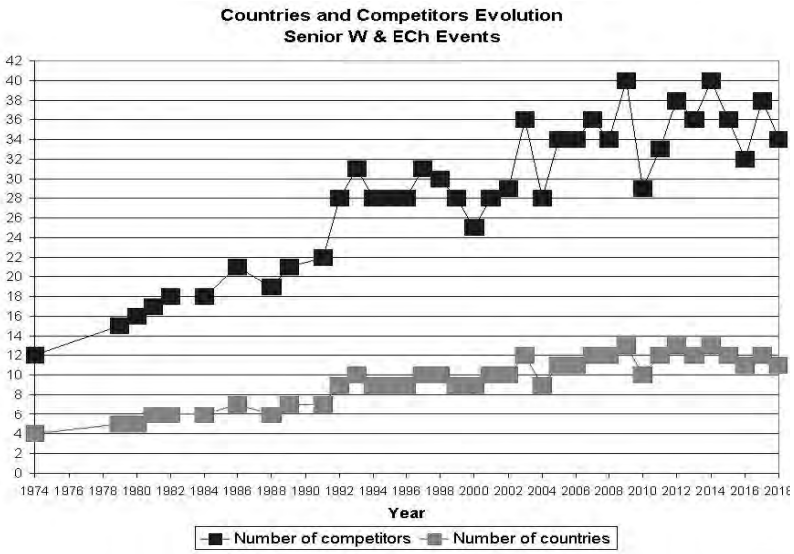


Fig. 3 The number of competitors and participating countries at the World and European Championships for Seniors

All time Senior Team Classification - World and Euro Ch

Year		Country/Place																	
		AUT	GER	ITA	SUI	CS	CZE	SVK	GBR	POL	ROU	HUN	USA	RUS	FRA	MLD	SRB	NED	UKR
1	1974	1	2						3										
2	1979	3			2	1													
3	1980	3	2		1														
4	1981	3	2			1													
5	1982	3	1			2													
6	1984	3	2			1													
7	1986		3	2		1													
8	1988			3	2	1													
9	1989	3	1			2													
10	1991	1	2			3													
11	1992	2	1								3								
12	1993		2	3			1												
13	1994		3	1	2														
14	1995				1			2			3								
15	1996			3	2						1								
16	1997				1		2	3											
17	1998		3				1				2								
18	1999	3	2					1											
19	2000						3			2	1								
20	2001		1					2			3								
21	2002	2	3				1												
22	2003						2			3	1								
23	2004			3			1								2				
24	2005							3					2		1				
25	2006			2			1			3									
26	2007				3						1				2				
27	2008	3									2				1				
28	2009	1								3	2								
29	2010						2			1					3				
30	2011						3			1	2								
31	2012	3	2												1				
32	2013										3		2		1				
33	2014						2	3		1									
34	2015		3	1											2				
35	2016						3	2		1									
36	2017							2		1	3								
37	2018			2			3				1								
Events		37	37	35	37	10	26	26	24	31	28	18	9	2	17	1	7	1	3
Gold		3	4	2	3	5	5	1		5	5				4				0
Silver		2	8	3	4	2	4	4		1	4		2		3				0
Bronze		9	5	4	1	1	4	3	1	3	5				1				0
																			37
																			37
																			37

Note: CS is the former Czechoslovakia

All time Senior Team Classification

Rank	Team	Events	Number of medals			Total
			Gold	Silver	Bronze	
1	ROU	28	5	4	5	14
2	CZE	26	5	4	4	13
3	CS	10	5	2	1	8
4	POL	31	5	1	3	9
5	GER	37	4	8	5	17
6	FRA	17	4	3	1	8
7	SUI	37	3	4	1	8
8	AUT	37	3	2	9	14
9	ITA	35	2	3	4	9
10	SVK	26	1	4	3	8
11	USA	9		2		2
12	GBR	24			1	1
Total			37	37	37	111

Fig. 4 All time senior team classification

Event D. Alain Roux, Pierre Chaussebourg and Jean-Luc Drapeau FRA could write a novel in three volumes about how Alain won a major individual title for the second time and how his team won the first major title for France.

In all time senior team classification ROU takes the lead with 5 gold medals, 4 silver medals and 5 bronze medals, followed by CZE with 5/4/4 and the former Czechoslovakia with 5/2/1.

In all time senior individual classification, Ivan Treger SVK takes the lead with 4 gold medals and 1 silver followed by Alain Roux FRA with 3 gold and 1 silver and Ivan Crha CZE with 2 gold, 4 silver and 1 bronze.

Classification of all seniors who have at least one place on the podium over time

Rank	1st name	2nd name	Country	No. of Top 10	Year/ Individual Place											
1	Ivan	Treger	SVK	11	2008/1	2009/1	2011/1	2017/1	1992/2	2005/4	1998/6	1994/7	2012/7	1997/8	2014/9	
2	Alain	Roux	FRA	7	2007/1	2012/1	2013/1	2008/2	2014/5	2015/6	2016/7					
3	Ivan	Crha	CZE	12	1997/1	2000/1	1988/2	1991/2	1994/2	1996/2	1989/3	1993/4	1999/4	2002/5	1992/7	2004/8
4	Herbert	Schmidt	GER	10	1992/1	1995/1	2001/2	1993/3	2008/3	2010/4	1989/5	2005/7	1999/8	1982/10		
5	Rudolf	Musil	CZE	9	1981/1	1993/1	1989/2	1995/3	1988/4	1984/4	1998/7	1980/8	1992/8			
6	Fritz	Mang	AUT	11	1991/1	2002/1	1994/3	2001/3	2009/3	2006/4	1992/5	2010/5	1999/7	1993/8	2012/10	
7	Andreas	Tschanz	SUI	5	1994/1	2001/1	2003/3	1996/5	2009/8							
8	Klaus	Salzer	AUT	2	1988/1	1989/1										
9	Stanislav	Kubit	POL	9	2005/1	2006/2	2007/2	2011/2	2017/3	2014/6	2016/6	2003/8	2012/9			
10	Jaromir	Orel	CZE	7	2015/1	2003/2	2009/2	2010/3	2016/3	2006/6	2011/10					
11	Marian	Popescu	ROU	10	2006/1	2000/2	2015/2	2014/4	2011/5	2009/7	2007/8	2013/9	2016/9	2017/10		
12	Karl	Lintner	AUT	6	1984/1	1981/2	1982/2	1974/4	1980/5	1979/9						
13	Robert	Sifleet	USA	3	2003/1	2013/2	2011/9									
14	Pavel	Stloukal	CS	2	1986/1	1984/2										
15	Rene	Pfister	SUI	9	1979/1	1996/3	2007/4	2008/4	1982/5	1980/6	1994/9	2002/9	2004/10			
16	Franciszek	Kanczok	POL	8	2016/1	2000/3	1995/4	2011/4	2009/5	2003/6	2017/7	2002/8				
17	Vojtech	Zima	CZE	4	1998/1	2002/3	2004/4	2000/10								
18	Daniel	Petcu	ROU	7	2004/1	1997/5	1998/5	2000/5	1996/6	2001/6	2005/6					
19	Miroslav	Drmla	SVK	3	2010/1	2016/4	2017/6									
20	Giuseppe	Berto	ITA	3	2018/1	2015/8	2009/10									
21	Robert	Haller	SUI	2	1980/1	1984/6										
22	Peter	Schroder	GER	2	1982/1	1984/7										
23	Maurizio	Tomazzoni	ITA	2	2014/1	2000/8										
24	Kiss Balazs	Sarusi	HUN	2	1996/1	2002/10										
	Juraj	Uhrin	SVK	2	1999/1	1998/10										
26	Paul	Fynn	GBR	1	1974/1											
27	Cringu	Popa	ROU	3	1995/2	1997/2	1999/3									
28	Daniel	Bildea	ROU	3	2017/2	2018/2	2016/8									
29	Maurice	Bodmer	SUI	3	1979/2	1974/3	1989/10									
30	Florian	Draghici	ROU	9	2002/2	2003/5	1996/7	2008/8	1998/9	2009/9	2010/9	2006/10	2007/10			
31	Werner	Hauenstein	SUI	7	1980/2	1981/4	1988/8	1995/9	1984/10	1993/10	1991/10					
32	Heinz	Bleuer	SUI	3	2016/2	2018/5	2010/10									
33	Kurt	Bleuer	SUI	3	2004/2	1997/4	2003/9									
34	Frantisek	Doupovec	CZE	3	1999/2	1998/4	2004/9									
35	Milan	Mravec	SVK	2	2005/2	1991/4										
36	Jacek	Zurowski	POL	2	2014/2	2017/5										
37	Heinz-Karl	Schellauf	SUI	2	1986/2	1997/7										
38	Reinhard	Wolf	AUT	2	2012/2	2016/10										
39	H	Arbogast	SUI	1	1993/2											
	Peter	Schobel	AUT	1	1974/2											
	Peter	Teller	HUN	1	1998/2											
	Piotr	Tendera	POL	1	2010/2											
43	Pierre	Chaussebourg	FRA	10	2004/3	2006/3	2013/3	2005/5	2008/5	2002/6	2018/6	2010/7	2012/8	2015/10		
44	Karl-Heinz	Ritterbusch	GER	10	1998/3	1992/4	1991/5	2004/5	1979/6	1989/6	2010/6	2001/7	2007/7	1994/8		
45	Helmut	Schuberth	GER	10	1984/3	1979/4	2002/4	1999/5	1974/5	1986/7	1991/8	1996/8	2008/10	1994/10		
46	Eligio	Bau	ITA	4	2018/3	1980/4	2013/4	2015/7								
47	Bohumir	Berger	CZE	4	1988/3	1984/5	2001/5	1986/6								
48	Werner	Ackermann	GER	3	2007/3	2015/5	1997/6									
49	Jaroslav	Mach	CZE	3	1986/3	1988/5	1995/10									
50	Konrad	Zurowski	POL	2	2015/3	2016/5										
51	Frantisek	Bartak	CS	2	1981/3	1982/7										
52 - 61	Vincent	Croghan	USA	1	2005/3											
	Wieslaw	Dziuba	POL	1	2011/3											
	Karl	Aust	AUT	1	1991/3											
	A	Harmath	HUN	1	1992/3											
	H	Martinez	GER	1	1980/3											
	Jacek	Pawlik	POL	1	1997/3											
	A	Riedlinger	GER	1	1982/3											
	Clemens	Schobel	AUT	1	1979/3											
	Dominik	Andrist	SUI	1	2012/3											
	Marta	Vysoka	CZE	1	2014/3											

	Gold
	Silver
	Bronze

Rank	Country	Number of Individual Medals			Total
		Gold	Silver	Bronze	
1	CZE	6	8	8	22
2	SVK	6	2	0	8
3	AUT	5	4	5	14
4	SUI	4	6	4	14
5	GER	3	1	7	11
6	FRA	3	1	3	7
7	ROU	2	7	1	10
8	POL	2	5	5	12
9	ITA	2	0	1	3
10	CS	1	1	1	3
11	HUN	1	1	1	3
12	USA	1	1	1	3
13	GBR	1	0	0	1
Total		37	37	37	111

Fig. 5 Classification of all seniors and countries who have at least one place on the podium over time in individual classification and reach the top ten

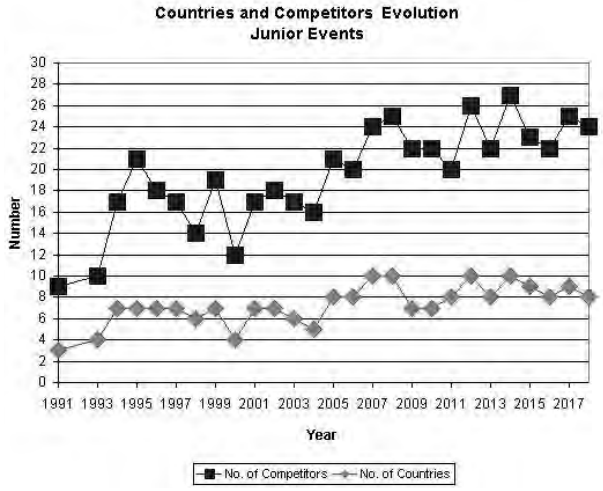


Fig. 6 Number of junior competitors and countries versus time

Juniors' Events																							
						Countries																	
Year	Event	Place	Organiser	Competitors	Countries	AUT	GER	ITA	SUI	CZE	SVK	POL	ROU	HUN	USA	FRA	MLD	SRB	NED	UKR
1991	WCh	Cluj Napoca	ROU	9	3															
1993	WCh	Krynica	POL	10	4															
1994	ECh	Vicenza	ITA	17	7															
1995	WCh	Brezno	SVK	21	7															
1996	ECh	Turda	ROU	18	7															
1997	WCh	Rana nr Louny	CZE	17	7															
1998	ECh	Muszyna	POL	14	6															
1999	WCh	Liptovsky Mikulas	SVK	19	7															
2000	ECh	Turda	ROU	12	4															
2001	WCh	Nowy Targ	POL	17	7															
2002	ECh	Liptovsky Mikulas	SVK	18	7															
2003	WCh	Turda	ROU	17	6															
2004	ECh	Rana nr Louny	CZE	16	5															
2005	WCh	Liptovsky Mikulas	SVK	21	8															
2006	ECh	Turda	ROU	20	8															
2007	WCh	Turda	ROU	24	10															
2008	ECh	Rhon	GER	25	10															
2009	WCh	Rhon	GER	22	7															
2010	ECh	Turda	ROU	22	7															
2011	WCh	Zlatibor	SRB	20	8															
2012	ECh	Turda	ROU	26	10															
2013	WCh	Martin	SVK	22	8															
2014	ECh	Martin	SVK	27	10															
2015	WCh	Zlatibor	SRB	23	9															
2016	ECh	Turda	ROU	22	8															
2017	WCh	Turda	ROU	25	9															
2018	ECh	Martin	SVK	24	8															

Fig. 7 Number of competitors and countries participating

All time Junior Team Classification																	
	Year	Country/Place															
		AUT	GER	ITA	SUI	CZE	SVK	POL	ROU	HUN	USA	FRA	MLD	SRB	NED	UKR	
1	1991		2					1	3								
2	1993		1					3		2							
3	1994		1				2		3								
4	1995			2		3	1										
5	1996		3			1	2										
6	1997		1				2		3								
7	1998						1	3	2								
8	1999					3	2		1								
9	2000					2		3	1								
10	2001		3					2	1								
11	2002		3				2		1								
12	2003		1				3		2								
13	2004		3					1	2								
14	2005					1	2		3								
15	2006						1	2	3								
16	2007							2	1			3					
17	2008			1		3			2								
18	2009			3		2			1								
19	2010						1	2	3								
20	2011							2	3			1					
21	2012		2					3	1								
22	2013					3			1			2					
23	2014		1			2			3								
24	2015			1			2	3									
25	2016			2			1	3									
26	2017			3			2					1					
27	2018		2						1			3					
	Events	2	26	19	10	24	24	27	27	14	3	12	1	4	1	3	
	Gold		5	2		2	5	2	9			2				0	27
	Silver		3	2		3	8	5	4	1		1				0	27
	Bronze		4	2		4	1	6	8			2				0	27

All time Junior Team Classification						
Rank	Team	Events	Number of medals			Total
			Gold	Silver	Bronze	
1	ROU	27	9	4	8	21
2	SVK	24	5	8	1	14
3	GER	26	5	3	4	12
4	POL	27	2	5	6	13
5	CZE	24	2	3	4	9
6	ITA	19	2	2	2	6
7	FRA	12	2	1	2	5
8	HUN	14	0	1	0	1
9	SUI	10	0	0	0	0
10	USA	3	0	0	0	0
11	AUT	2	0	0	0	0
Total			27	27	27	81

Fig. 8 All time junior team classification

Concerning the countries, CZE takes the lead with 6/8/8 followed by SVK with 6/2/0 and AUT with 5/4/5.

Junior World and European F1E Events

Junior major events starts in 1991 to present days. The competitors and countries evolution is shown above.

In all time junior team classification ROU is in the lead with 9 gold medals, 4 silver medals and 8 bronze medals, followed by SVK with 5/8/1 and GER with 5/3/4.

As can be seen in Figure 9, in all time junior individual classification Martin Horn CZE is in the lead with gold medals and 1 silver, followed by Alexandru Popa ROU with 2 gold and 1 silver and Adrian Draghici ROU with 1 gold and 1 silver.

Concerning the participating countries, ROU is in the lead with 5/10/5 followed by SVK with 5/2/8 and CZE with 5/1/2.

Classification of all juniors who have at least one place on the podium over time									
Rank	1st name	2nd name	Country	No. of Top 5	Year/ Individual Place				
1	Martin	Horn	CZE	4	2004/1	2009/1	2003/2	2001/4	
2	Alexandru	Popa	ROU	3	1997/1	1999/1	1996/2		
3	Adrian	Draghici	ROU	5	2002/1	1999/2	2000/4	2003/4	2001/5
4	P	Hegedus	HUN	2	1993/1	1994/2			
	B	Puettner	GER	2	1994/1	1993/2			
6	Pavel	Nosko	SVK	3	1995/1	1999/3	1994/4		
7	Peter	Nosko	SVK	2	1996/1	1998/3			
	Miroslav	Polonec	SVK	2	1998/1	1997/3			
	Mikolaj	Stryja	POL	2	2015/1	2012/3			
10	Florian	Winker	GER	2	2014/1	2017/4			
11	Laura	Kozuchova	SVK	2	2016/1	2017/5			
	Andrea	Marchiori	ITA	2	2008/1	2010/5			
	Konrad	Zurowski	POL	2	2013/1	2011/5			
14	Hariton	Dorobantu	ROU	1	2018/1				
	Jakub	Drmla	SVK	1	2010/1				
	Andy	Eyrich	GER	1	1991/1				
	Bjoern	Hoefs	GER	1	2003/1				
	Petr	Hofman	CZE	1	2000/1				
	Krzysztof	Jezewski	POL	1	2006/1				
	Theo	Laura	FRA	1	2017/1				
	Kukasz	Morgala	POL	1	2001/1				
	Magdalena	Orlova	CZE	1	2012/1				
	Adrian	Secan	ROU	1	2007/1				
	Dejan	Stancevic	SRB	1	2011/1				
	Jakub	Janata	CZE	1	2005/1				
26	Daniel	Bildea	ROU	3	2004/2	2005/2	2002/5		
27	Mateusz	Kanczok	POL	2	2007/2	2010/2			
	Andrei	Anca	ROU	2	2009/2	2011/2			
29	Mihnea	Niculescu	ROU	4	2012/2	2009/3	2013/3	2008/4	
30	Michaela	Noskova	SVK	3	2001/2	2002/3	2005/4		
31	Dominika	Drmlova	SVK	3	2006/2	2010/3	2005/5		
32	Nick	Finke	GER	2	2014/2	2011/3			
33	Catalin	Dragusin	ROU	1	1998/2				
	Nils	Finke	GER	1	2016/2				
	Piotr	Jarkiewicz	POL	1	1991/2				
	Philipp	Kuttler	GER	1	1997/2				
	Christian	Neumann	GER	1	2018/2				
	Stefano	Parziani	ITA	1	2008/2				
	Victor	Salistean	ROU	1	2002/2				
	S	Sartori	ITA	1	1995/2				
	Angelo	Sartori	ITA	1	2017/2				
	Krzysztof	Szulik	POL	1	2000/2				
	Aurelie	Trachez	FRA	1	2013/2				
	Laurentiu	Anca	ROU	1	2015/2				
45	Nathan	Laura	FRA	3	2014/3	2018/3	2015/5		
46	M	Wuest	GER	2	1993/3	1994/3			
47	Martin	Doupovec	CZE	3	1996/3	1997/4	1998/4		
48	Patricia	Valastiakova	SVK	3	2006/3	2002/4	2003/5		
49	Peter	Barna	HUN	2	2005/3	2007/4			
50 - 60	Christian	Andrist	SUI	1	2008/3				
	Viktoria	Drmlova	SVK	1	2015/3				
	Cristian	Faur	ROU	1	2004/3				
	Jozef	Filip	CZE	1	2003/3				
	Sebastian	Ionita	ROU	1	2001/3				
	Piotr	Klaput	POL	1	1991/3				
	Dejan	Kostic	GER	1	2000/3				
	Armin	Mang	AUT	1	2007/3				
	Horia	Selegean	ROU	1	1995/3				
	Clarisse	Trachez	FRA	1	2017/3				
	Jakub	Wisniewski	POL	1	2016/3				

Rank	Country	Number of Individual Medals			Total
		Gold	Silver	Bronze	
1	ROU	5	10	5	20
2	SVK	5	2	8	15
3	CZE	5	1	2	8
4	GER	4	5	4	13
5	POL	4	4	3	11
6	ITA	1	3		4
7	FRA	1	1	3	5
8	HUN	1	1		2
9	SRB	1			1
10	AUT			1	1
11	SUI			1	1
Total		27	27	27	81

	Gold
	Silver
	Bronze

Fig. 9 Classification of all juniors and countries who have at least one place on the podium over time in individual classification and reach top five

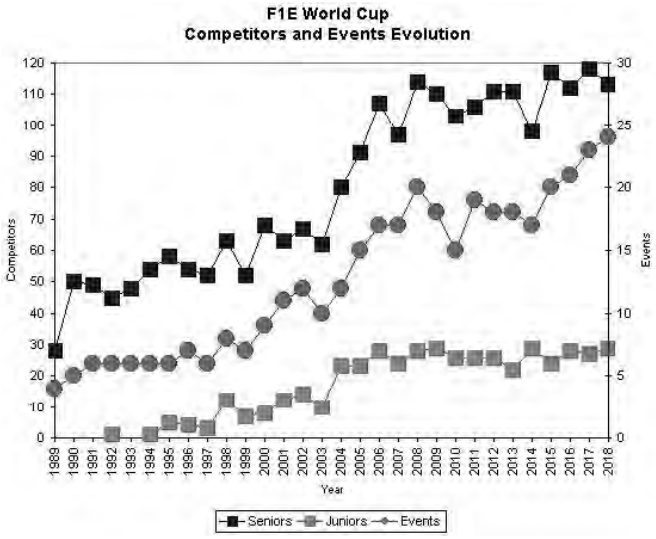


Fig. 10 F1E World Cup competitors and events evolution

World Cup F1E Events

The World Cup competitions have been held uninterrupted from 1989 to date, cumulating 383 competitions on two continents: 348 in Europe and 35 in North America. There has been a general individual ranking and since 2003, a separate ranking for juniors. The evolution of the number of competitions and competitors is shown in Figure 10.

The entry of the organizing countries into the circuit as well as the number of organized competitions is shown in Figure 11. The AUT World Cup competitions died with the death of Felix Schobel (Sr) in 2002..

In general classification Marian Popescu ROU is in the lead with 6 gold medals, 2

F1E World Cup

Year	Flyers		Events	Organizer																		
	Seniors	Juniors		SUI	GER	AUT	POL	ITA	CS	ROU	SVK	CZE	HUN	FRA	SRB	BUL	UKR	USA	NZL	NED	DEN
1989	28		4	1	1	1	1														
1990	50		5	1	1	1		1	1												
1991	49		6	1	1	1	1		1	1											
1992	45	1	6		1	1	1	1	1	1											
1993	48		6		1	1	1			1	1	1									
1994	54	1	6		1	1		1		1	1	1									
1995	58	5	6		1	2				1	1	1									
1996	54	4	7		1	2				1	2	1									
1997	52	8	6		1	2				1	1	1									
1998	63	12	8		1	2	1			2	1	1									
1999	52	7	7		1	2				2	1	1									
2000	68	8	9		1	2				2	2	2									
2001	63	12	11		1	2	2			2	1	2	1								
2002	67	14	12		2	2	2			2	1	2	1								
2003	62	10	10		1		2	1		2	1	2	1								
2004	80	23	12		2		2	1		2	2	1	2								
2005	91	23	15		2		2	1		2	2	2	2	2							
2006	107	28	17		2		2	2		2	2	2	2	2				1			
2007	97	24	17		2		2	2		2	2	2	2	2				1			
2008	114	28	20	2	2		2	2		2	2	2	2	2	1			1			
2009	110	29	18	2	2		1	2		2	2	2		2	2			1			
2010	103	26	15		2		2	2		2	2	2		2				1			
2011	106	26	19		2		2	2		2	2	2		2	2			1		1	1
2012	111	26	18		2		2	2		2	2	2		2			1	3			
2013	111	22	18		2		2	2		2	2	2		2			1	2	1		
2014	98	29	17				2	2		2	2	2		2			1	2	2		
2015	117	24	20		2		2	2		2	2	2		2	1		1	2	2		
2016	112	28	21	1	2		2	2		2	2	2		2		2	1	2	1		
2017	118	27	23	1	2		2	2		2	2	2		2		2	1	3	2		
2018	113	29	24	2	2		2	2		2	2	2		2		2	1	3	2		
Total/Country				11	44	22	40	32	3	49	43	44	13	28	6	6	7	23	10	1	1
Total Events				383																	

Rank	Organizer	Number of World Cups
1	ROU	49
2	CZE	44
	GER	44
4	POL	40
5	USA	35
6	FRA	28
7	AUT	22

348	Europe
35	USA

Fig. 11 World Cup organizers evolution

silver and 2 bronze, followed by Stanislav Kubit POL 4/0/3 and Daniel Petcu ROU 3/3/0. As can be seen, during the time some juniors reach the podium in general classification e.g. Andrei Anca ROU gold in 2011, Christian Winker GER silver in 2014, Sebastian Ionita ROU bronze in 2001 and Zorin Valeanu ROU bronze in 2012.

Taking into account all 30 editions of the F1E World Cup, ROU has 10/6/7=23 medals, POL 6/2/3=11 medals, CZE 5/6/6=17 medals and so on.

The junior classification is in the figure 13.

F1E World Cup 1989 - 2018
30 Editions Results
top five competitors who reach at least one podium in general classification

Rank	Surname	Name	Country	Gold	Silver	Bronze	Total	Year/Place
1	Marian	Popescu	ROU	6	2	2	10	03/1 04/1 05/1 07/1 13/1 16/1 02/2 10/2 00/3 18/3 09/4 12/4 15/4
2	Stanislav	Kubit	POL	4		3	7	09/1 10/1 12/1 15/1 05/3 06/3 13/3 02/4 07/4 11/4
3	Daniel	Petcu	ROU	3	3		6	99/1 01/1 02/1 00/2 03/2 04/2 98/4 97/5
4	Ivan	Crha	CZE	2	2	2	6	91/1 00/1 90/2 97/2 92/3 99/3 94/4
5	Ivan	Treger	SVK	1	4		5	92/1 98/2 06/2 07/2 08/2 10/4 05/5
6	Fritz	Mang	AUT	1	1	5	7	06/1 92/2 94/3 98/3 04/3 07/3 17/3 00/4 01/5
7	Jaromir	Orel	CZE	1	1	1	3	08/1 17/2 14/3
8	Helmut	Schubert	GER	1	1		2	93/1 94/2 91/4 97/4
9	Frantiszek	Kanczok	POL	1	1		2	14/1 13/2 10/5
	Reinhard	Wolf	AUT	1	1		2	97/1 99/2 98/5
	Jacek	Zurowski	POL	1	1		2	17/1 12/2 15/5
12	Alexander	Winker	GER	1	1		2	18/1 16/2
13	Juraj	Uhrin	SVK	1		1	2	98/1 96/3 92/4
	Felix	Schobel Jr.	AUT	1		1	2	94/1 93/3 95/4
15	Jaroslav	Mach	CZE	1		1	2	90/1 91/3 92/5
16	Rudolf	Musil	CZE	1			1	96/1 94/5
	Milan	Valastiak	SVK	1			1	95/1 91/5
18	Andrei	Anca (J)	ROU	1			1	11/1
	Karl	Salzer	AUT	1			1	89/1
20	Vojtech	Zima	CZE		2		2	01/2 05/2 99/4 06/5 07/5 14/5
21	Alain	Roux	FRA		1	1	2	11/2 09/3 05/4 18/4
22	Peter	Brocks	USA		1	1	2	15/2 11/3 14/4 13/5 18/5
23	Karl-Heinz	Ritterbusch	GER		1		1	91/2 93/4
	Christian	Winker (J)	GER		1		1	14/2 13/4
25	Peter	Nosko (Sen)	SVK		1		1	93/2 00/5 03/5
26	Cringu	Popa	ROU		1		1	96/2 95/5
27	Bohumir	Berger	CZE		1		1	95/2
	Jean-Luc	Drapeau	FRA		1		1	18/2
	W	Kuttler	GER		1		1	89/2
	Maurizio	Tomazzoni	ITA		1		1	09/2
31	Florin	Draghici	ROU			3	3	03/3 08/3 10/3 04/5
32	Jiri	Blazek	CZE			2	2	97/3 15/3 96/5 99/5
33	Ernst	Reiterer	AUT			2	2	89/3 90/3
34	Sebastian	Ionita (J)	ROU			1	1	01/3 03/4
35	Ian	Kaynes	GBR			1	1	16/3 12/5
36 - 40	T	Groh	GER			1	1	89/3
	Edith	Mang	AUT			1	1	02/3
	P	Maurer	SUI			1	1	89/3
	Peter	Nosko (Jun)	SVK			1	1	95/3
	Zorin	Valeanu (Jun)	ROU			1	1	12/3
Total of Medals				30	30	32	92	Note: They are 32 bronze medals because in 1989 they was 3 competitors on the 3rd place

F1E World Cup 1989 - 2018
30 Editions Results

Rank	Country	Gold	Silver	Bronze	Total
1	ROU	10	6	7	23
2	POL	6	2	3	11
3	CZE	5	6	6	17
4	AUT	4	2	9	15
5	SVK	3	5	2	10
6	GER	2	5	1	8
7	FRA		2	1	3
8	USA		1	1	2
9	ITA		1		1
10	GBR			1	1
11	SUI			1	1
Total		30	30	32	92

30 Gold
30 Silver
32 Bronze

Fig. 12 World Cup competitors and country evolution in general classification

Junior F1E World Cup 2003 - 2018
16 Editions Results
top five competitors who reach at least one podium in junior classification

Rank	Surname	Name	Country	Gold	Silver	Bronze	Total	Year/Place				
1	Daniel	Bildea	ROU	2			2	04/1	05/1	03/4		
2	Andrei	Anca	ROU	2			2	10/1	11/1	09/5		
3	Christian	Winker	GER	2			2	13/1	14/1			
4	Jakub	Drmla	SVK	1	1	1	3	09/1	08/2	07/3		
5	Zorin	Valeanu	ROU	1	1		2	12/1	13/2			
6	Dominika	Drmlova	SVK	1		1	2	07/1	09/3	08/4	10/4	
7	Armin	Mang	AUT	1			1	08/1	06/4	07/4		
8	Jakub	Matisek	SVK	1			1	06/1	05/4	08/5		
	Clarisse	Trachez	FRA	1			1	18/1	15/4	16/5		
10	Julia Maria	Petcu	ROU	1			1	03/1				
	Theo	Laura	FRA	1			1	17/1				
	Ema	Kozuchova	SVK	1			1	16/1				
	Jan	Kabacinski	POL	1			1	15/1				
14	Konrad	Zurowski	POL		2	2	4	12/2	14/2	10/3	13/3	11/4
15	Mihnea	Niculescu	ROU		2	1	3	09/2	11/2	12/3	10/5	
16	Adrian	Draghici	ROU		2		2	03/2	04/2	05/5		
17	Katarzyna	Szymanska	POL		1	2	3	10/2	08/3	11/3		
18	Florian	Winker	GER		1	1	2	16/2	17/3	13/5		
19	Laurentiu	Anca	ROU		1		1	15/2	16/4			
20	Patricia	Valastiakova	SVK		1		1	06/2	04/5			
21	Andrei	Moisescu	ROU		1		1	05/2				
	Monika	Sowa	POL		1		1	07/2				
	Dan-Adrian	Vasilescu	ROU		1		1	18/2				
	Jakub	Wisniewski	POL		1		1	17/2				
25	Cristian	Faur	ROU			2	2	04/3	05/3			
26	Boby Florian	Buliga	ROU			1	1	18/3	17/4			
27 - 31	Zbigniew	Benisz	POL			1	1	06/3				
	Sofija	Chorna	UKR			1	1	14/3				
	Viktoria	Drmla	SVK			1	1	15/3				
	Dorobantu	Hariton	ROU			1	1	16/3				
	Mihai	Sandu	ROU			1	1	03/3				
Total of Medals				16	16	16	48					

Junior F1E World Cup
2003 - 2018
16 Editions Results

Rank	Country	Gold	Silver	Bronze	Total
1	ROU	6	8	6	20
2	SVK	4	2	3	9
3	GER	2	1	1	4
4	FRA	2			2
5	POL	1	5	5	11
6	AUT	1			1
7	UKR			1	1
Total		16	16	16	48

	16 Gold
	16 Silver
	16 Bronze

Fig. 13 World Cup competitors and country evolution in junior classification

The F1E class glider was invented in 1957 and the information about what happened between 1957 and 1980 disappeared with the pioneers, the great missing world model airplane competitors. Those who are still in activity are young people aged between 60 and 80 years old as can be seen on the next page.

The longest-running competitors at international events

Rank	Competitor		Country	International Activity		Years
1	Paul	Fynn	GBR	1974	2017	43
2	Rene	Pfister	SUI	1979	2018	39
3	Peter	Kuttler	GER	1981	2018	37
4	Amedeo	Berto	ITA	1980	2016	36
5	Karl Heinz	Ritterbusch	GER	1979	2014	35
	Romeo	Sartori	ITA	1982	2017	35
7	Eligio	Bau	ITA	1980	2014	34
8	Siegfried	Puttner	GER	1986	2018	32
9	Herbert	Schmidt	GER	1982	2013	31
10	Fritz	Mang	AUT	1989	2018	29
	Ivan	Crha	CZE	1988	2017	29
	Antoni	Frieser	GER	1989	2018	29
	Stanislaw	Bocheński	POL	1986	2015	29
	Alfred	Andrist	SUI	1989	2018	29
15	Friedhelm	Mehr	GER	1989	2017	28
	Franco	Brumat	ITA	1989	2017	28
	Ivan	Treger	SVK	1990	2018	28
18	Klaus	Salzer	AUT	1984	2011	27
	Jiri	Blazek	CZE	1991	2018	27
	Giuseppe	Berto	ITA	1991	2018	27
	Franciszek	Kanczok	POL	1991	2018	27
	George	Arghir	ROU	1991	2018	27
	Eugen	Pop	ROU	1991	2018	27
	Daniel	Petcu	ROU	1991	2018	27
25	Norbert	Heiss	AUT	1992	2018	26
	Edi	Mauri	ITA	1984	2010	26
	Andreas	Tschanz	SUI	1990	2016	26
28	Reinhard	Mang	AUT	1993	2018	25
29	Frantisek	Doupovec	CZE	1994	2018	24
	Alexander	Winker	GER	1994	2018	24
	Florian	Draghici	ROU	1994	2018	24
	Milan	Valastiak	SVK	1991	2015	24
33	Milan	Mravec	SVK	1989	2012	23
34	Vojtech	Zima	CZE	1996	2018	22
	Werner	Ackermann	GER	1996	2018	22
	Sandor	Litomiczky	HUN	1992	2014	22
	Claudio	Bognolo	ITA	1989	2011	22
	Marian	Popescu	ROU	1996	2018	22
39	Reinhard	Wolf	AUT	1996	2017	21
	Helmut	Schuberth	GER	1989	2010	21
	Gerhard	Viktor	GER	1984	2005	21
	Ian	Smerengal	SVK	1994	2015	21
43	Rudolf	Musil	CZE	1980	2000	20
	Pierre	Chaussebourg	FRA	1998	2018	20
	Igor	Miertus	SVK	1992	2012	20
46	Jaroslav	Orel	CZE	1999	2018	19
	Tino	Cosma	ITA	1990	2009	19
	Wieslaw	Dziuba	POL	1999	2018	19
	Kurt	Bleuer	SUI	1989	2008	19
50	Edith	Mang	AUT	2000	2018	18
	Bohumir	Berger	CZE	1984	2002	18
	Antonio	Ghiotto	ITA	1990	2008	18
	Maurizio	Tomazzoni	ITA	2000	2018	18
	Daniel	Bildea (J-S)	ROU	2000	2018	18
	Adrian	Draghici (J-S)	ROU	2000	2018	18
	Cristian	Faur (J-S)	ROU	2000	2018	18
57	Karl	Lintner	AUT	1974	1991	17
	Massimiliano	Gobbo	ITA	1993	2010	17
	Jan	Wojtak	POL	2001	2018	17
	Stanislaw	Kubit	POL	2001	2018	17
	Maurice	Bodmer	SUI	1974	1991	17
62	Antonio	Borchia	ITA	2002	2018	16
	Cristian	Suciu	ROU	1995	2011	16
	Heinz	Bleuer	SUI	2002	2018	16
	Peter	Nosko	SVK	1990	2006	16
	Juraj	Uhrin	SVK	1990	2006	16
67	Jean-Luc	Drapeau	FRA	2003	2018	15
	Peter	Dolby	GBR	1982	1997	15
	Bernhard	Schuessler	GER	1989	2004	15
	Rolando	Amato	ITA	1979	1994	15
	Czeslaw	Ziober	POL	2003	2018	15
	Stefan	Razman	ROU	1994	2009	15
	Simeon	Vintileanu	ROU	2003	2018	15
	Peter	Brocks	USA	2003	2018	15
	Robert	Sifleet	USA	2003	2018	15

The longest-running competitors at international events

Rank	Competitor		Country	International Activity		Years
76	Felix	Schobel	AUT	1986	2000	14
	Frantisek	Kratena	CZE	2004	2018	14
	Jean-Marie	Chabot	FRA	2004	2018	14
	Horst	Falch	GER	1999	2013	14
	Horst	Nitsche	GER	1989	2003	14
	Mario	Amato	ITA	1980	1994	14
	Gianfranco	Maggi	ITA	1992	2006	14
	Jozef	Wojtek	POL	1991	2005	14
	Vlad	Cristea (J-S)	ROU	2004	2018	14
85	Alain	Roux	FRA	2005	2018	13
	Alexandre	Trachez (J-S)	FRA	2005	2018	13
	Michele Del	Fabro	ITA	2005	2018	13
	Marek	Lysakowski	POL	2005	2018	13
	Victor	Paireli	ROU	2002	2015	13
90	Alfred	Dotzl	AUT	1990	2002	12
	Aurelie	Trachez	FRA	2006	2018	12
	Remigio	Lucchini	ITA	2006	2018	12
	Cyprian	Blaszczyk (J-S)	POL	2006	2018	12
	Robert	Haller	SUI	1980	1992	12
95	Karl	Aust	AUT	1989	2000	11
	Ernst	Reirrerer	AUT	1989	2000	11
	Jaroslav	Mach	CZE	1986	1997	11
	Yvon	Jallet	FRA	2007	2018	11
	Andre	Trachez (J-S)	FRA	2007	2018	11
	Sabine	Trachez	FRA	2007	2018	11
	Ian	Kaynes	GBR	2007	2018	11
	Jeffrey	Palmer	GBR	1981	1992	11
	Paul	Seren	GER	2007	2018	11
	Piotr	Szymanski	POL	2005	2016	11
	Iuliana	Paltane	ROU	1997	2008	11
	Wener	Hauenstein	SUI	1980	1991	11
	Pavol	Polonec	SVK	2006	2017	11
108	Armin	Mang (J-S)	AUT	2006	2016	10
	Jozef	Hacar	CZE	1995	2005	10
	Frantisek	Martan	CZE	1991	2001	10
	Robert	Champion	FRA	2007	2017	10
	Friedrich	Wankerl	GER	2008	2018	10
	Christian	Winker	GER	2008	2018	10
	Florian	Winker	GER	2008	2018	10
	Kis Sarusi	Balazs	HUN	1998	2008	10
116	Mickael	Rigault	FRA	2009	2018	9
	Daniela	Seren	GER	2007	2016	9
	Jeno	Asboth	HUN	1996	2005	9
	Konrad	Zurowski (J-S)	POL	2009	2018	9
	Cringu	Popa	ROU	1991	2000	9
	Mara	Straffelini	ITA	2010	2018	8
	Sebastian	Ionita (J-S)	ROU	2001	2009	8
	Julia Maria	Petcu	ROU	2003	2011	8
124 - 127	Hans	Althoff	GER	1992	1999	7
	Nick	Fincke (J-S)	GER	2011	2018	7
	Mikolaj	Stryja	POL	2010	2017	7
	Tom	Ioeger	USA	2008	2015	7

2019 MODELS OF THE YEAR AWARD

MOY COMMITTEE: Ross Jahnke, Chair Vance Gilbert Charlie Jones Yuan Kang Lee Richard Mathis

This was an interesting year for the MoY. Nominations were fewer, and getting plans, photos, and text on each recipient was more challenging. With that said, the models we selected are the best of the best! Their competition records, dominance in their events, level of innovation and quality of craftsmanship set all of them apart from the other nominees this year.

Artem Babenko's "Raptor" F1C is the dominant model in that event. The Raptor moved the folding wing F1C concept from the radical fringe to the mainstream by making it reliable. With a stellar climb and a thin, high aspect ratio wing, it is in my opinion, the ideal set up for the 4-second engine run. My Snider Swamp colleagues might disagree with that point, though one of them earned the alternate spot on the US team using a Raptor. Every member of the team will have one at the World Champs in October, and the model will likely be in the hands of many others from around the world. Expect one on the podium.

Stepan Stephanchuk's Orca F1B is equally impressive as the Raptor with its innovative design and construction. Like Artem, Stepan has used the carbon/foam molding process to build a clean, efficient, reliable model. F1B's require a light weigh tail and wings order to achieve the 200 gram minimum weight, and be responsive in thermals. Stepan has designed a solid structure that is equal in weight to comparable built up parts, with airfoils unmarred by sagging covering between the ribs.

The committee went outside the norm by awarding two scale models this year. Both models are extremely impressive but for different reasons. Vance's Martin MB-1 is 54" of flying scale madness, with two motors, two wings, two fins, four wheels (all in a row), and a mile of bracing wire and control cables. Enrique Maltz's Waco YKS peanut scale is more modest in complexity but the finish work is equally impressive, especially considering its size. Plus it won the FAC Nats in terribly windy conditions, managing to fly when others floundered in the turbulence. What is most touching about Enrique's model is the thoughtful correspondence between Enrique and Dave Stott, who drew the plans for Enrique in 2006.

Nicholas Ray has achieved the best performance record among this years models. He set ten National F1R records in four years, and currently holds the national record in all four ceiling categories. When we began gathering information during the nomination process, Nick had only eight national records, sufficient to deserve the award. By publication time he had two more. Like all of the models, Nick's F1R is well thought out and beautifully crafted. The simplicity of its appearance masks a very thoughtful evolution in design. I agree when he says that a 40-minute F1R is within reach, and my guess is that Nick Ray will be the one to do it.

MODEL OF THE YEAR RECIPIENTS

FLYING SCALE MARTIN MB-1 MAIL PLANE	***– Vance Gilbert***
RAPTOR F1C	***– Artem Babenko***
ORCA F1B	***– Stepan Stephanchuk***
#2 F1Q MODEL	***– Omri Sirkis***
F1R, CATEGORY I, II, III, & IV NATIONAL RECORD HOLDER	***– Nicholas Ray***
FLYING SCALE WACO YKS-6 PEANUT SCALE	***– Enrique Maltz***

FLYING SCALE MARTIN MB-1 MAIL PLANE

by Vance Gilbert



Vance Gilbert embodies intensity and soul as he launches the Martin.

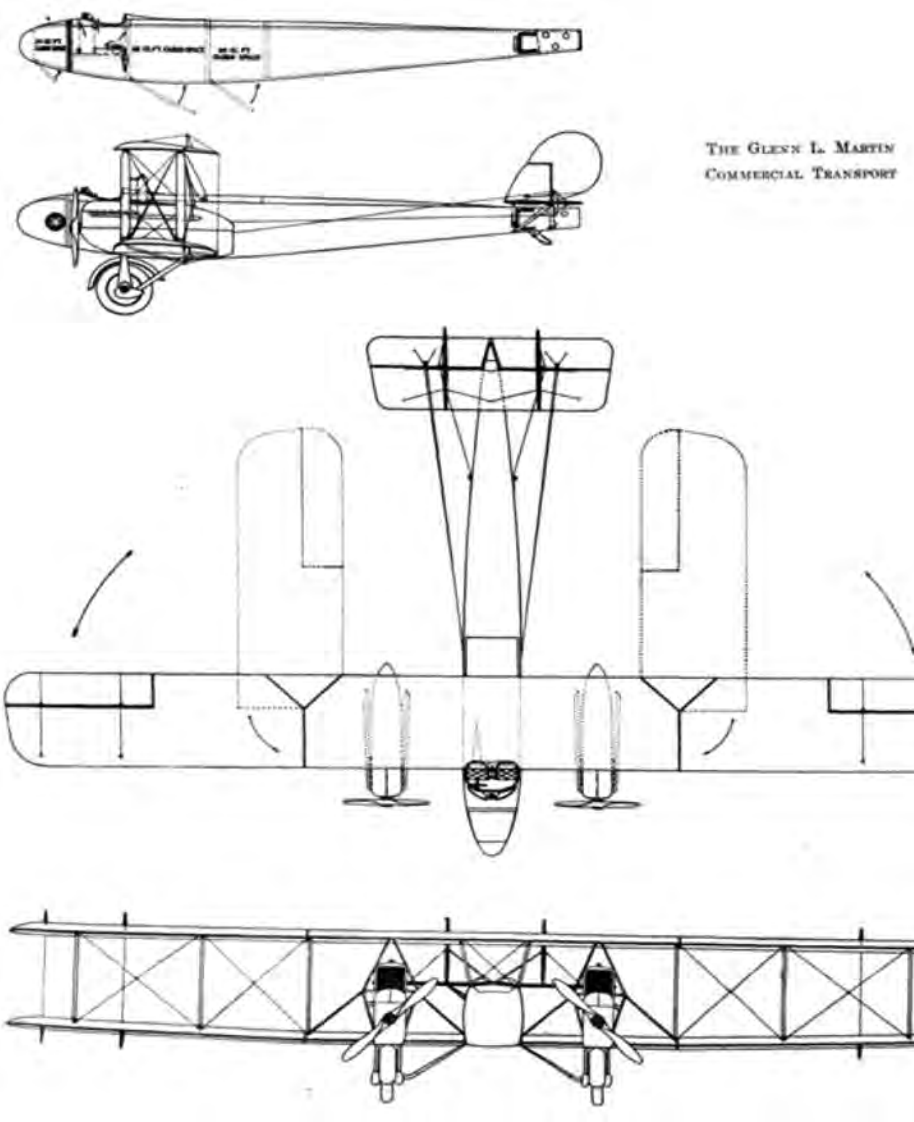
Truly, this ship was built on a dare. Amongst the many great events at the 2018 Flying Aces Club Nationals, were two special events commemorating the 100th anniversary of the first regularly scheduled airmail service in the United States (May 15, 1918). Announced midsummer 2017, there was to be a three-flight event and a mass launch event for all U.S. mail planes flown from May 15, 1918 through December 31, 1932. As the lists of appropriate ships were growing, someone joked about twin-engine mail planes, and I joked back about the Martin MB-1. Then the egging on began. Compound this with the fact that I was on tour in Australia (I'm a musician). I only had a week during Christmas to cobble together a plan.
I found a print shop within walking distance of my hotel, and after about 4 solid days of drawing and using whiteout, I had pulled together a pretty reasonable drawing. It was the first aircraft ever I've drawn with nothing but my phone and iPad as documentation gateways - the only actual paper was the plans. The lettering that took forever, as it tapers in each direction on both sides of the fuselage.
The model has a 54" wingspan, and weighs 240 grams without rubber. Power is three loops of 3/16" and one loop 1/8" per side. Props are counter-rotating, 10" diameter cottage-cheese-container-on-a-stick affairs. The motor sticks are carbon fiber tubing, 3/16" in diameter, and 13" hook-to-hook. Like the rest of the model they are painted olive drab. Amongst all the itinerant draggy stuff all over that airplane, the motor sticks protruding out of the engine nacelles don't seem to be a visual issue.
I added dihedral to the top wing otherwise the Martin would probably fly like a kitchen plate. I also added more dihedral to the bottom wing to compensate visually. Because of vanity and my effort to keep it historically AOK, it still it may not have enough dihedral over all. I haven't gotten her high enough to make a clear assessment.
The rear landing gear struts are shaped from dime store flexi-foam, unattached where they would connect to the wing or fuselage bottom. The front struts, allow the landing gear to flex and carry landing load.
Lettering was cut from white painted tissue and attached to the covering with glue stick. The Martin logo was printed on white typing paper to achieve better color saturation and opacity, then the back of the paper was gently sanded post-printing to reduce thickness. I used a photo of the Martin MB 2 in the U.S. Air Force Museum in Dayton Ohio as the source for the cockpit details. I did the best I could to duplicate that in relief. It was much fun!
Irony is that I never got an official flight at the FAC Nationals, as the wind was daunting. The evenings were much calmer, so I flew post-supper. For the flights in the video, I used old rubber at about 65% winds. That last 33 second test flight would be a minute plus with calm air, more aggressive winding, and fresher rubber. See the Martin MB-1 in flight:
https://www.youtube.com/watch?v=-vZonYHiXSY



The carbon motor sticks are camouflaged by the bracing wires and control cables that are everywhere on this airplane.



It is even more amazing in the air than on the ground.



Raptor F1C by Artem Babenko

When creating my models, I always wanted them to not only fly well but also have a beautiful design. Creating the Raptor, I wanted the model to have its own style. When I took the model in hand, I realized that it combined elegance within itself: the smooth lines of the wings and the stabilizer, and at the same time it is aggressive, with the black color of the carbon, the turbulator, and the new cowl. Raptor – a model of the embodiment of power and stability.

Artem Babenko



Artem Babenko holding a Raptor surrounded by his trophies.

At the 2016 Fab Feb in Lost Hills, my first contest with the four-second engine run, I was flying Achterberg Hummers that had served me well at the World Champs in Mongolia at five seconds. Although the models still flew well enough to make the fly offs, with the lower launch height I was beaten by the Babenko models by two or three minutes given their floating glide. It became obvious to me that to be anywhere near competitive, I would need a model with much greater emphasis on the glide phase of flight, therefore a higher cambered foil. I immediately ordered two of Artem's B2 powered three panel folding models with hopes of being able to make the 2017 team.

Once I had generally learned the nuances of the Babenko models, they have become a joy to fly. Straight up launch is critical, but once achieved the transition to glide is magnificent and then they just float. My first flight at the 2019 team selection contest was a four minute 360 degree beauty. One circle in four minutes was so cool. In my observation, Babenko models around the world dominate most contests results these days. I think Artem told me he has sold models to flyers from over twenty-five countries. All three F1C flyers representing the United States in the up coming World Championships have Babenko models. I believe that once again that Artem Babenko's models will rule the podium.

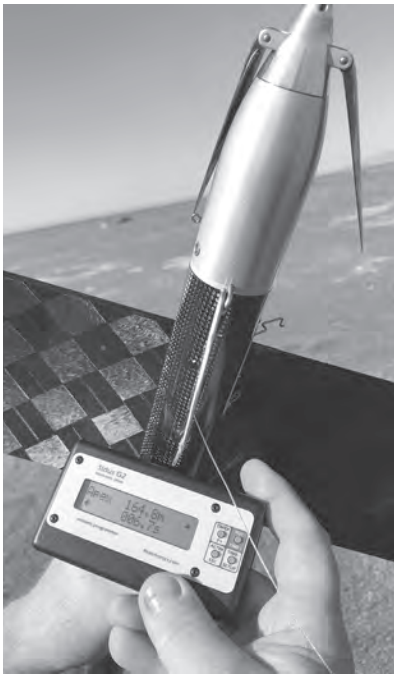
Mike Roberts



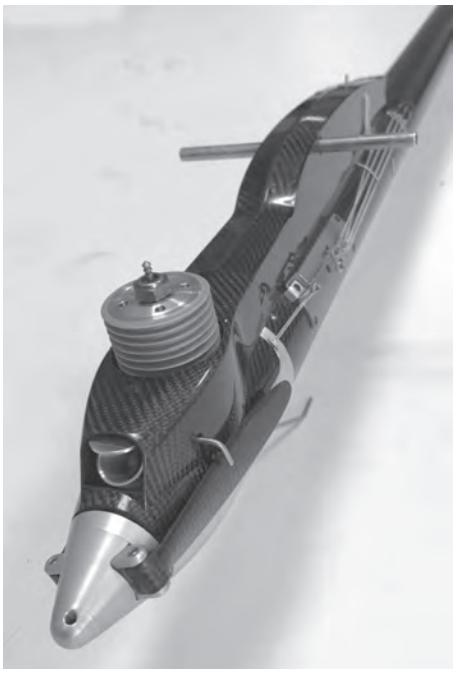
Sasha Babenko with a Raptor.



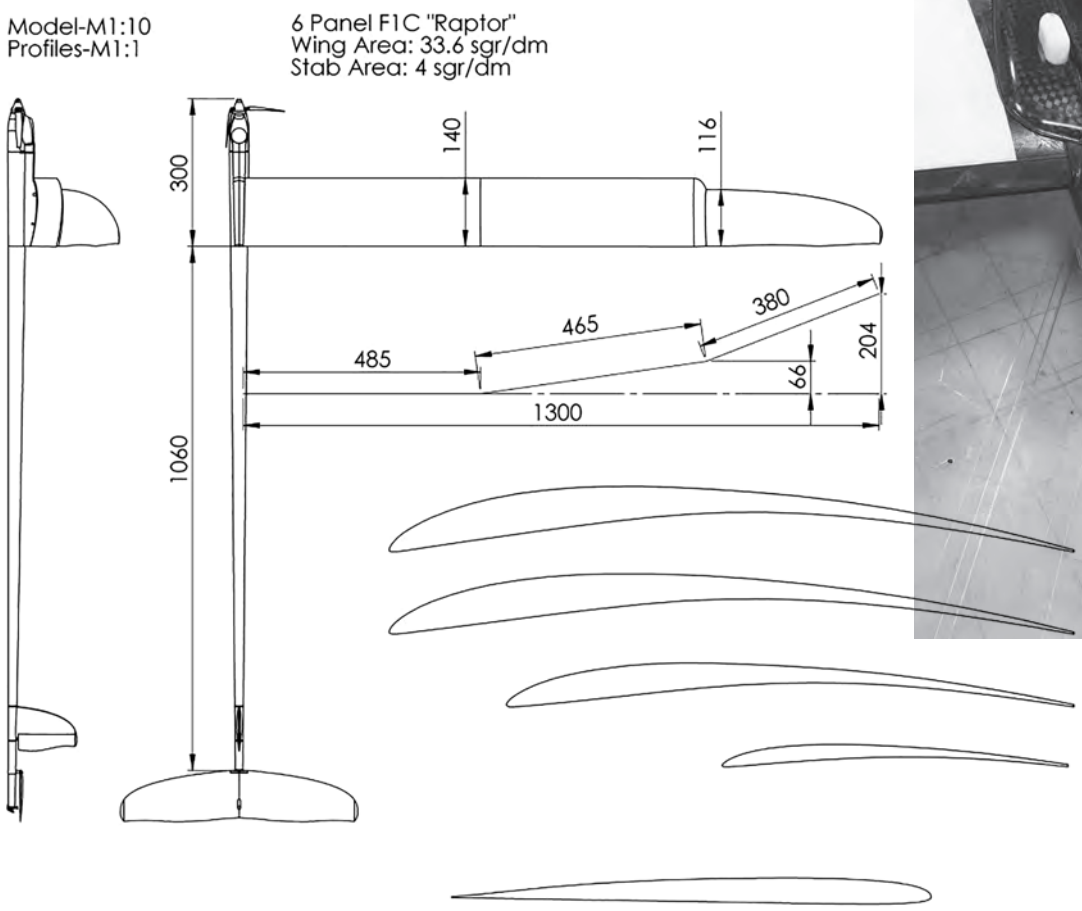
The beautiful carbon wings for which the Raptor has become so recognizable at the flying field.



The built in Sidus altimeter shows just how high a Raptor can get at the top of the climb.



An earlier version of the Raptor fuselage.





The current version of the Raptor fuselage with the characteristic bulges in the wing mounting area and the redesigned cowling.

STEPAN STEPHANCHUK - ORCA F1B

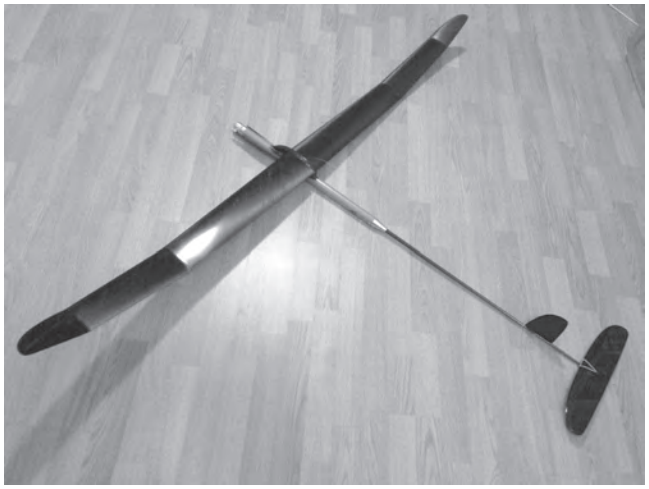
Orca is a new version of my CTC-70 design. It received the name – "Orca" because of the similarity in geometry of the wing tips with the fin of the orca whale. CTC-70 is a very successful model with a wing designed Tony Matthews and airfoils designed by Brian Eggleston.

Technology moves quickly: the computerization of design and fabrication, electronics, the new materials available, and machine tools provide considerable opportunities for the free flight community. All flying surfaces are constructed with a molding method in forms machined from aluminum. The core of each part is made on a CNC machine tool from Rohacell 31 with 58-psi compressive strength and 2 lbs./ft2 density. Each half of the six-panel wing is molded in one piece. This eliminates the subsequent glue joints at the dihedral breaks, saving time and weight in the construction of the model. The finished wing weighs 55-58 grams, the one-piece fin weighs 1.4 grams, and the stabilizer weighs 4.4-4.8 gram. The motor tube is made from Kevlar. The pylon is molded from carbon fiber cloth. The propeller blades are made in a mold and covered in C80 carbon.

Orca has auto-surfaces similar to other contemporary F1B models, with a three-position



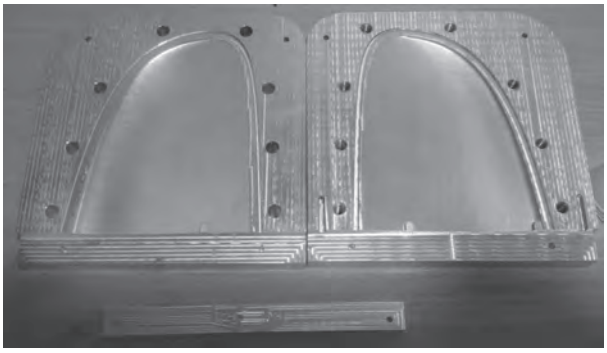
Orca looks deceptively simple because of the advanced technology behind its manufacture. Not the smooth transitions at the dihedral breaks.



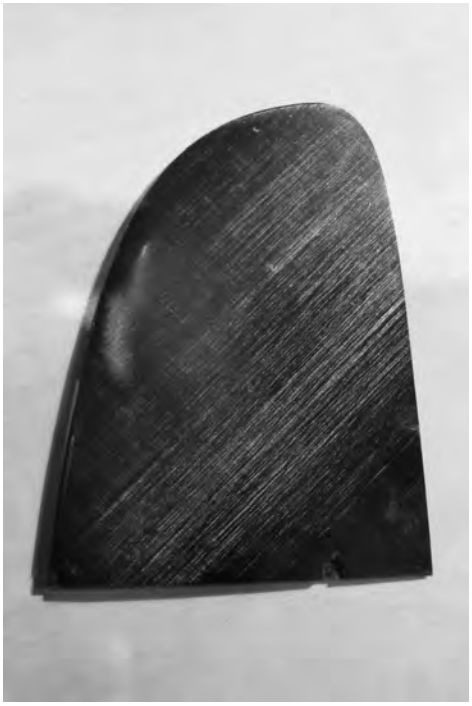
Stepan's design is especially clean, with its one-piece molded flying surfaces of Rohacell 31 and carbon.

rudder, two-position stabilizer, and wiggler on the left wing. Following launch and DPR, the timer releases the stabilizer at 4.6 seconds, the fin to cruise position at 25 seconds, and the left wing/fin move to glide at 36 seconds, very close to the end of the motor run. The model uses the Sidus G2 electronic timer. It is a very reliable timer with many functions. The model also has RDT and uses the Pyxis GPS model tracker system.

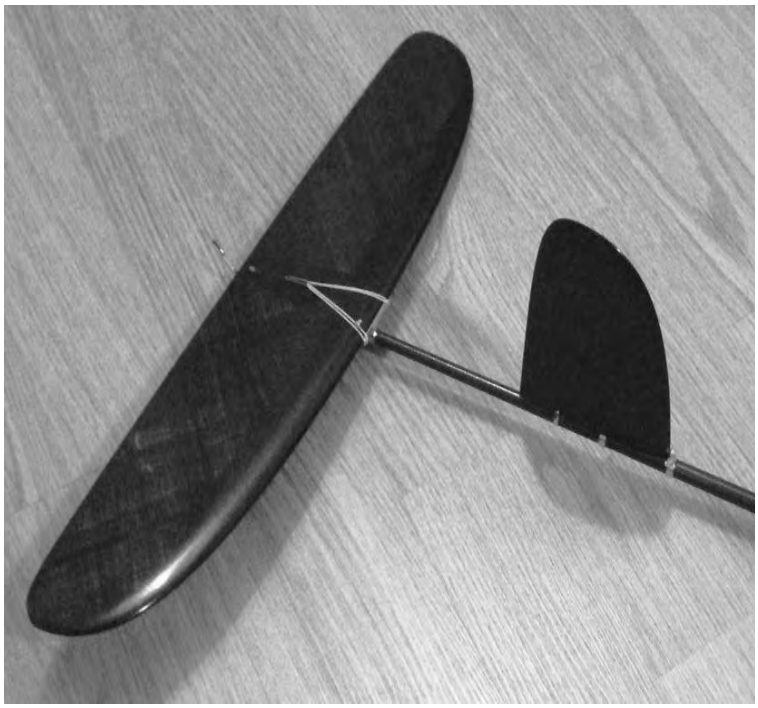
Orca uses the 30 mm variable pitch DPR front end from Alexander Andruikov (AA-005). The angle of the blades is set to 26 degrees at a radius of 200 mm. The model is powered by FAI Super Sport rubber 330-340 mm in length, wound to about 410-430 turns. The model has a motor run of 36-40 seconds. Altimeter data indicates that the best flights climb to 115 meters.



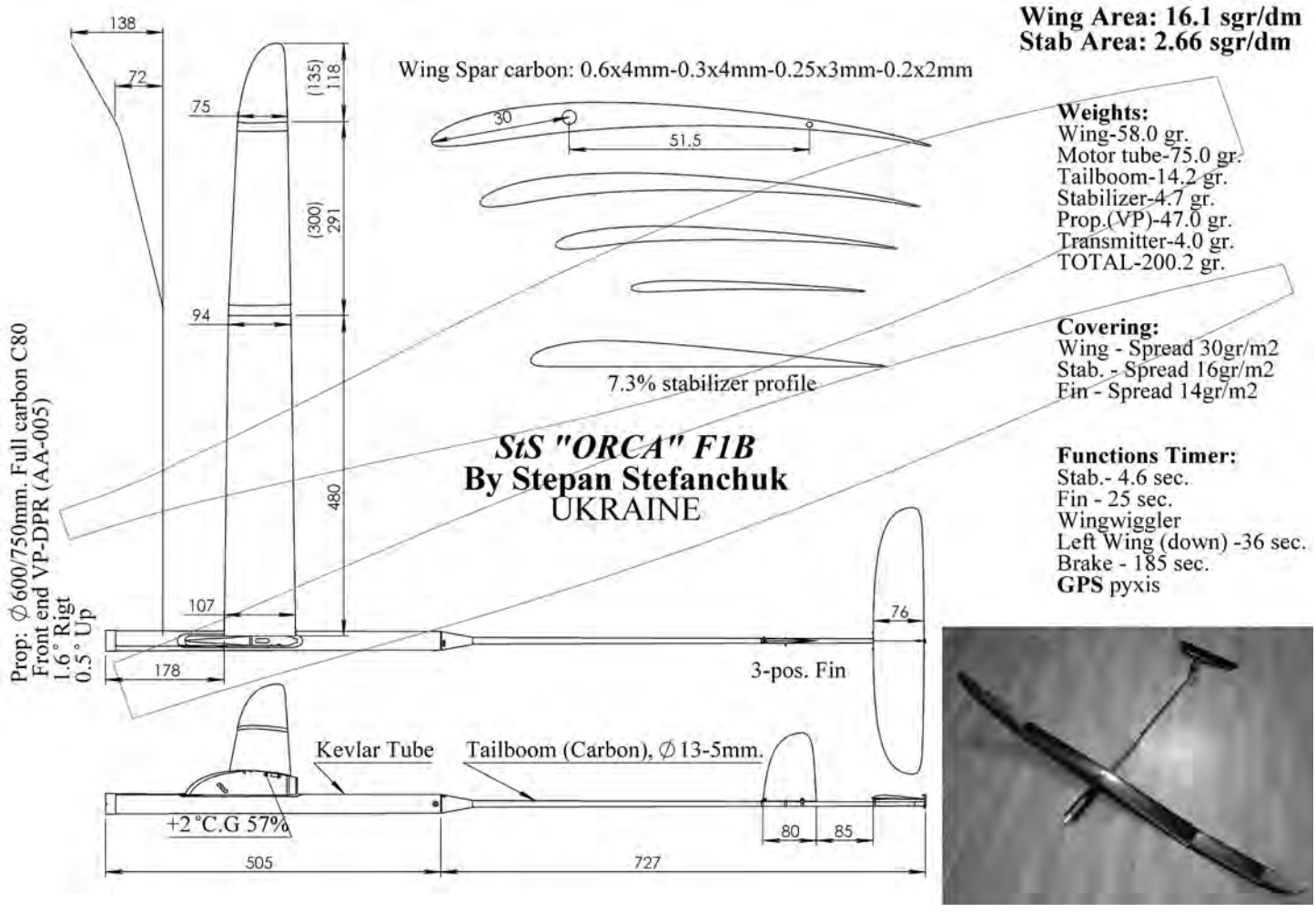
The three-piece mold for the rudder.



A finished rudder weighs only 1.4 grams.

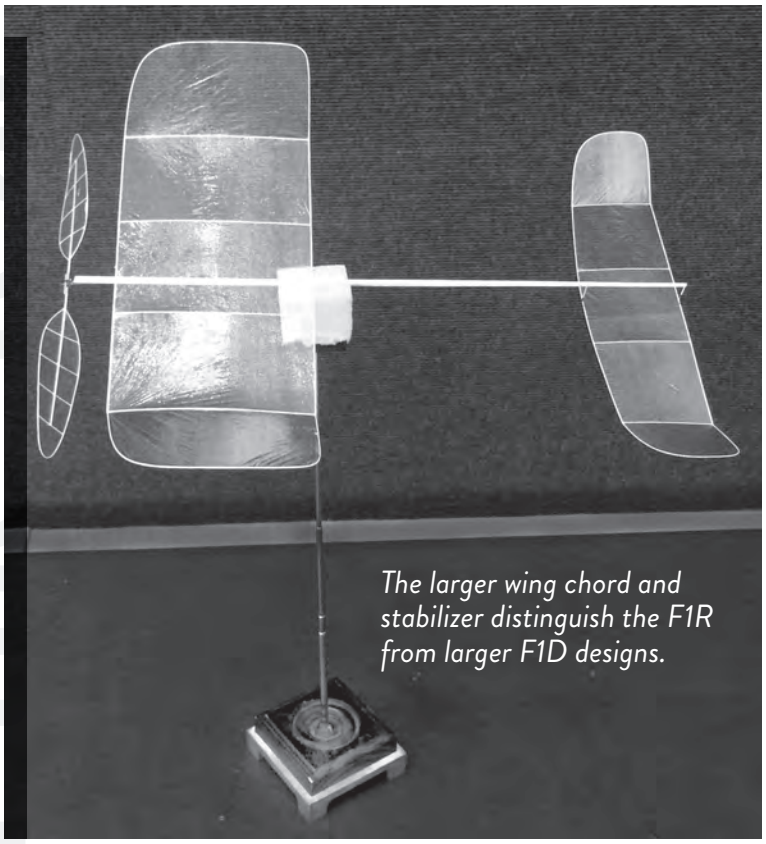


Thin carbon cloth over Rohacell one piece stabilizer wieghs between 4.4 and 4.8 grams, as light as a built up structure.



F1R, Category I, II, III, & IV National Record Holder

Nicholas Ray



The larger wing chord and stabilizer distinguish the F1R from larger F1D designs.

I started flying F1R, at the time called 35cm, when I was in college. Bill Gowen agreed to build one as well for our monthly club contests so we could compete against one another in the off season to stay sharp. The first models were a scaled down version of the F1D design I was flying at the time, and they were satisfying to fly even with a fixed pitch prop. I was ecstatic to make 12 minutes in a Cat I site back in those days and I recall a 27-minute flight on a particularly good day at Lakehurst. Over the years I have come to love the event. Its compact size for travel and high-performance potential makes it particularly attractive to me compared to F1D or HLS.

In the quest for more time, the design began to evolve. I input the existing design into a modified version of Bernie Hunt's design program. The program favored a larger horizontal stabilizer span and an increased wing chord. These changes increased the theoretical duration capability of the model, and I used the wood sizes from published plans of Bob Bailey and Tony Hebb to reduce overall model weight, but without a reliable VP mechanism the design could not show its true potential.

At the 2012 World Championships I met Ivan Treger and acquired one of his F1D hubs with the intention of copying it. He asked me to take one of his F1R hubs to another US based flier. I could not help but study it before passing it on. Treger's F1R hubs are miraculous for their 38mg weight and they feature precise three screw adjustment. I ended up building 14 copies of Ivan's F1D hubs, but only on that scale does it approach being cost effective. When the US started tracking F1R records in 2015 I decided to follow Tony Hebb's lead and purchase hubs directly from Ivan Treger instead of retooling to build them myself. I cannot recommend Treger's hubs highly enough.

Since the inception of US record keeping the model has set a total of 10 National Records and, at the time of this article, holds all four National Record categories simultaneously.

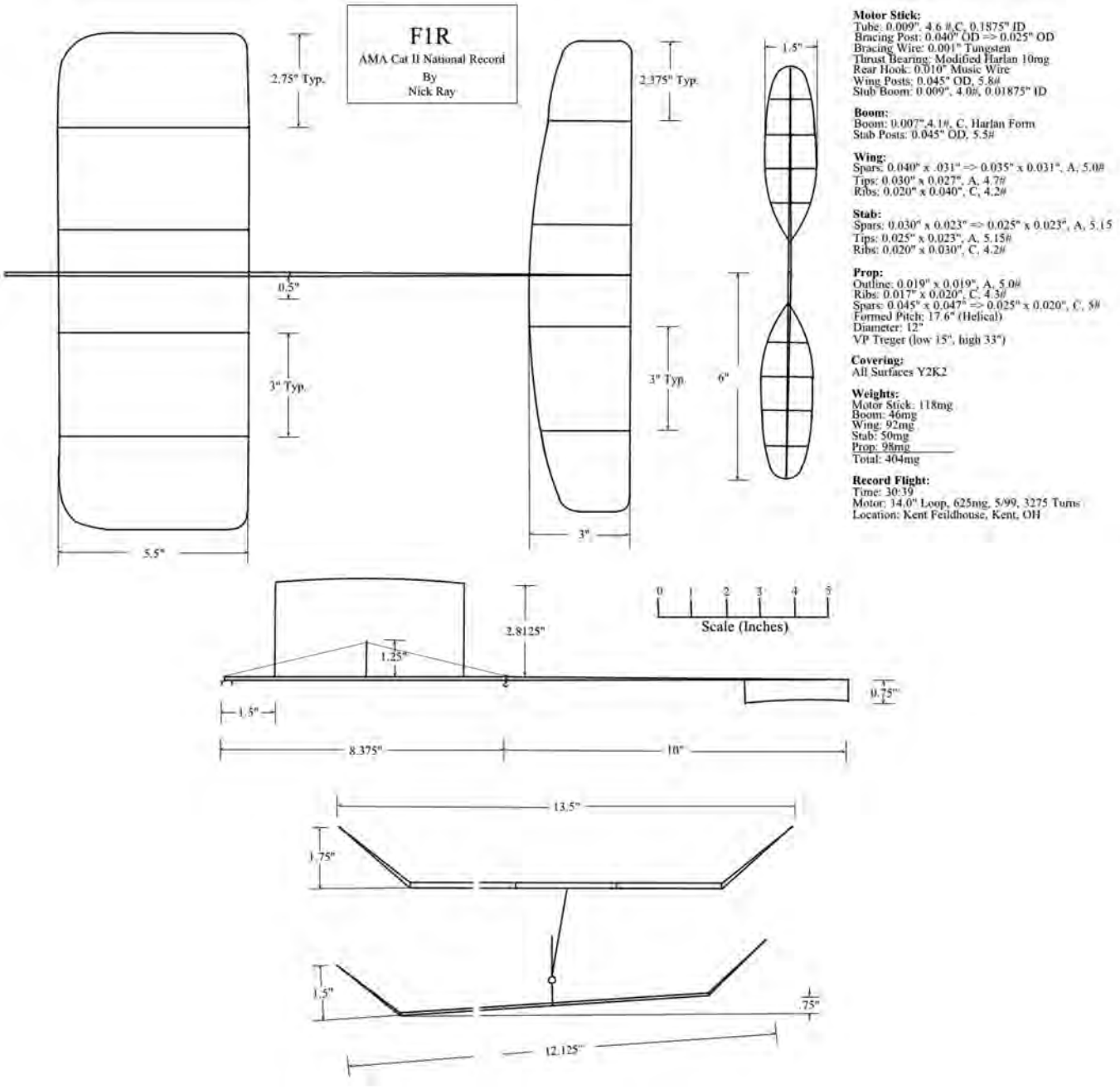
Nick's F1R national records since 2015:

Cat II 30:39 – Kent 4/20/19
Cat I 29:02, – St. Luke's 4/3/19
Cat IV 33:42 – Lakehurst 6/17/18
Cat II 27:22 – Rantoul 10/8/17
Cat I 26:35 – St. Lukes 8/19/17
Cat III 28:39 – West Baden 3/25/17
Cat IV 29:38 – Kibbie Dome 6/26/16
Cat I 24:21 – St. Lukes 3/12/16
Cat IV 27:17 – Kibbie Dome 6/26/15
Cat III 21:11 – West Baden 3/29/15

During that time, parts have been replaced due to damage, and a total of three models have been built with the same specifications. There are slight variations in the published bills of materials, however, they are substantively the same. Variations reflect the wood I had on hand at the time rather than intentional design changes. The general trend of flying increasingly higher rubber to model weight ratios is the most salient change that has occurred over the years.

Looking forward, I am experimenting with carbon spar-less props and further reducing the overall model weight. I think there is more time to be coaxed from the existing design, nevertheless, I am also eternally searching for the next innovation. I trust that Joshua Finn and Tom Sova will keep me on my toes.

I hope that featuring this model so prominently will encourage others to give the class a try. It is not as dependent on good rubber as F1D. Moreover, it is easy to travel with, and yet it offers the potential for fights in excess of 30 minutes. Perhaps one day, someone will join the 40 Minute Club while flying an F1R.



Flying Scale Waco YKS-6 Peanut Scale

by Enrique Maltz

The Waco YKS-6 flew very well despite the gale winds at Geneseo. The wind took the models very far away from the launch area, and I thought that I had lost it twice. Fortunately so many people were looking for lost models as well, that others found it for me. I guess I had some luck behind my FAC peanut scale win.

I constructed the model in 2006, and it weighs a heavy 8.5 grams. I recall starting the build while on tour in Korea and taking a photo of the tail surfaces on top of a black table in my hotel room. I initially flew it here in Israel, then took it to the US to be stored at Tom Hallman's house for future use. International travel is difficult with large numbers of models. I am a professional cellist and on my numerous visits to the US with the Israel Philharmonic Orchestra, I leave models behind in order to have them ready when I have an opportunity to return.

Dave Stott designed the YKS for me, a true fatherly figure in several accounts, surely in model building. I was so honored that he thought I had some talent building models! After designing the model Dave sent a letter describing his process. The following excerpt best explains the design of the model:

Here is the Waco plan. I am not altogether pleased with it, but it is good enough for a talented fellow like you to make an excellent model from. As I mentioned before, the published scale drawing left a lot to be desired. Things shown on one view did not line up with another view, this lead to a lot of re-drawing. The other thing that bothered me was that we could not communicate with each other. I had many questions as to your preference on certain things. This led me to design it in a way that was not mine, and not yours either. So rather than include details on the model drawing, I have left it to you to pick up from the scale drawing. Things such as the window frame outlines, stringer number and location, tail wheel, wood size, etc. In this way you can "Maltzize" it to your liking.

What I DID do was to enlarge the scale drawing to 13" wingspan. I enlarged the stabilizer a bit and used incidence and dihedral angles that I think will work. Leave enough room in the back to change the stabilizer incidence if needed. If I were building it myself, I probably would not bother with a wire landing gear.. I do not bother with that on all of Airdevils [models] except for the low wing models. You can never trust them to land gently. I also used rib spacing to suit my style. You may pick up the scale spacing from the scale drawing if you choose.

Airdevil Dave

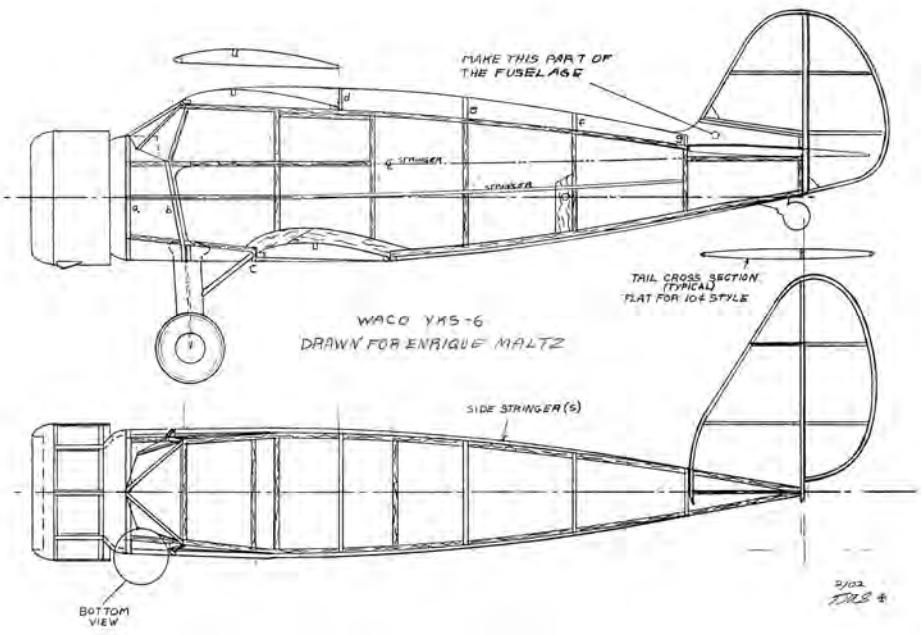
On my trips to the US I always visited Mr. Stott whom I first met about thirty years ago. Dave loved classical music and Mozart's music for violin was his favorite. He and his wife Terry came twice to Tangelwood to hear our concerts. Dave gave me his violin from childhood; I fixed it and donated it in his name to a conservatory here in Israel.



Unfortunately you can't see the vivid orange and silver color scheme, but you can see the crisp black stripes and panel lines on the fuselage.



Thank you to Tom Hallman, stateside caretaker of Enrique's Waco YKS-6, for providing these gorgeous photographs.

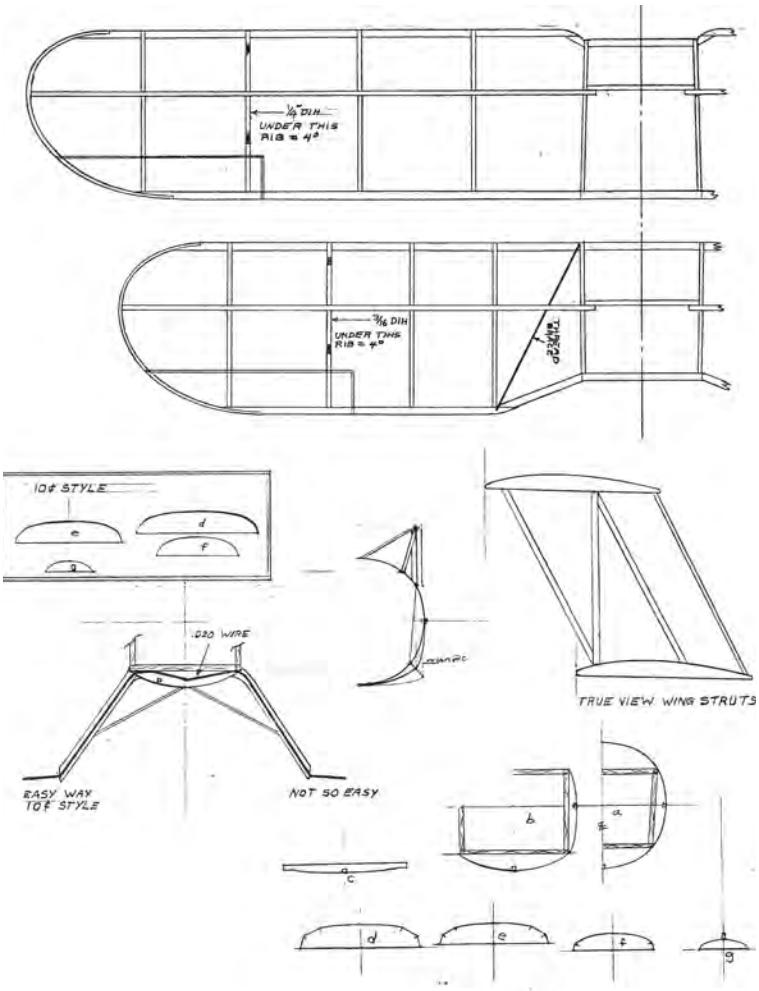


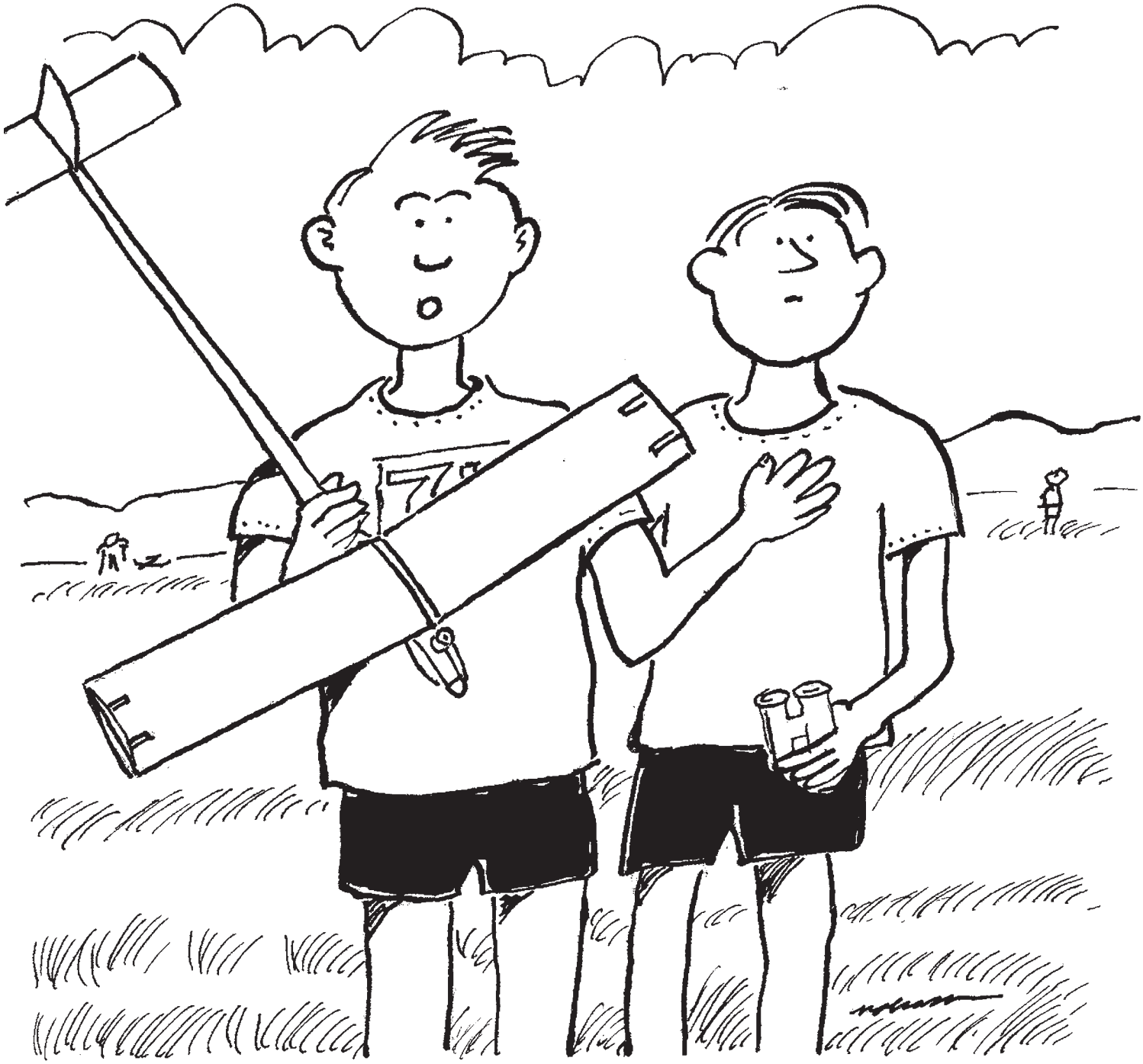


The Waco YKS-6 may be the most beautifully proportioned biplane of the golden age.



Note the intricately detailed radial engine and how the propeller is scalloped to clear the cowling.





"If I could pick thermals better, I wouldn't have to do all this high tech stuff....."

HALL OF FAME

MIKE McKEEVER, HOF Chair

NFFS Hall of Fame Inductees for 2019

The committee and I thank those that proposed or sent in nominations for the NFFS Hall of Fame. There were a number of excellent candidates and I would encourage anyone who's nominee did not get in this year to renominate their candidate next year.

This year there were two obvious nominees.

In his last year as our President, John Loribecki, deserves the honor for the excellent work he has done on behalf of this organization. His administration of the Nationals, organized approach to improving NFFS and innovative solutions to various issues that come up will be missed.

Paul Lagan, from New Zealand who passed last year deserves recognition as a great flyer, designer, administrator and for his tireless efforts to support Free Flight all around the World. We will all miss Paul.

Finally, a Hall of Fame award goes to an entire family from Oregon. Without the Grell Family from Tangent there would likely be no free flight activities in an area where there is currently a thriving community.

Congratulations to our inductees for 2019. On a personal note, this is my second year as chairman for the Hall of Fame selection committee. It's time to give another individual a chance to chair the selection process. Anyone interested feel free to contact John or our new President in 2020. I can tell you it's a great experience.

Mike McKeever

HALL OF FAME INDUCTEES

John Lorbiecki **Grell Family** **Paul Lagan**

JOHN LORBIECKI

John was an obvious choice for National Free Flight Society's Hall of Fame but getting his "story" for the submission was not so easy. When asked for a brief history of his free flight career John sent a Steve Martin (the comic) clip which began," I was born a poor black child…" John is a modest fellow, never seen without the dirtiest black (might have been gray at one time) Summit Racing hat in the world. That stems from his love of the sport of drag racing which he and his son, John Jr, enjoy.

John has been President of NFFS for the last seven years and says this will be his last before stepping down in 2020. His stewardship with the NFFS has been outstanding.

As President, John has either been Contest Director or unofficial Contest Director for the NATS for the last ten years at our AMA field in Muncie Indiana. In a week where John could fly events every day, he rarely flies more than a couple of event during NATS. He takes total accountability for making the NATS successful from organizing necessary paper work for scoring to the NFFS Banquet which he has chaired to the weenie roast and raffle to occasionally acting as NATS law enforcement when the situation requires. He handles all these diverse duties with tact and professionalism. In short John has made the NATS the premiere all inclusive event on our annual contest schedule.

As NFFS President, he has accomplished many improvements to our organization. He was responsible for introducing a full color Digest and added a web-based version available online. He has reduced costs substantially by having regular teleconferences with his staff, changed the plan service to an AMA based operation that significantly reduced mailing time to customers as well as costs to both the consumer and NFFS. As previously mention, he plans and executes the NATS program by finding CDs to run the event as well as works closely with AMA staff to ensure a fine event. John's close work with AMA staff deserves praise and is a wonderful example of creating a close relationship for the benefit of both organizations. In addition to the above, John has been chiefly responsible for acquiring Symposium Editors and staffing key organization positions, at times in emergency situations. He and his wife Patti, are also responsible for the NFFS store which they manage from their home in Wisconsin.

John's exemplary work running the day to day activities of NFFS is enough to grant him admission into the NFFS Hall of Fame, but wait, there's more.

While John's contest results have been limited due to his work as President of NFFS, over his career he has compiled hundreds of contest wins and placing in a broad range of events. Primarily a competitor in power events, likely due to his "hobby" drag racing, he has flown U-control speed events, placed at many contests in F1A with his Woody design, published his own hand launch glider which he successfully campaigned, and generally participated in a wide range of free flight events. One of his recent wins occurred during the 2018 NATS where be managed to win the highly contested F1J power class flown in rounds between frequent golf cart trips to whichever venue required his attention. In addition to his flying, he has continued to work as a contest director and was F1D Finals contest



Patti and John Lorbiecki

Director in 1988 as well the Free Flight Finals Director in 2018, three decades of service to the free flight community later.

One interesting if not predictable accomplishment is he has used his professional career as a mechanical engineer to build from scratch a total of six model airplane engines in sizes from .15 to .36 which are quite impressive in both appearance and performance.

He has modified many engines including OS, Super Tiger, and Rossi for his use as well as for other competitors. John has been the Power editor for the Digest for years and has published many articles including a series on engine assembly. He was also editor for the 2011 NFFS Symposium. Clearly John has fully distinguished himself in our free flight community.

Appreciation of Family has always important to John. Both he and his son are commercial pilots (well his son might take the award here as a F16 pilot for Wisconsin's Air National Guard). John tells some interesting stories about their shared cockpit experiences. John Jr. was also mentored to a Junior World Champs victory in Moncontour, France in 2004 (he was runner-up in 2002) by his proud father who fully supported his free flight activities. John's daughter, Kaitlyn, while never catching the free flight bug, did attend and support John Jr in his Junior World Championship win.

Anyone who has been to the NATS knows how hard Patti Lorbiecki works getting everything ready for the event and working the scorers booth. It is fitting that this award to John Lorbiecki ends with mention of his family. The Free Flight community has been made so much better through the dedicated efforts of the Lorbiecki Clan.

The GRELL FAMILY



Al and Dee Grell

Like the Lorbiecki's there is another family that has brought years of great service to the Free Flight community. There are a series of very fine contests in the Willamette Valley in Oregon every fall that are very well attended. They are flown in an area that grows grass seed in large empty fields. Were it not for the efforts of a family farming in this valley these contests would not occur. The Grell Family, living in Tangent Oregon, are our next inductees into the NFFS Hall of Fame.

The Grell family has been active in the Oregon Free Flight scene since the 1950's. Al and Dee Grell owned a grass seed farm in Tangent and were very active free flighters. Owning a large open area farm, Al was just a few steps away from a great free flight field.

When the Willamette Modelers Club was formed in 1960, Al was elected treasurer, a position he held for 20 years. Their farm served as a center for club activities and equipment storage. Al was the AMA District Contest Coordinator from 1962 until well into the 70's. Dee was secretary of the club as well as handled the club's administrative duties. She worked on the club's excellent newsletter, WMC Patter, as well as organizing the areas free flight community address book.

Probably their finest gift to the area Free Flighters was their close relationship to other area farmers. The Willamette Modelers have had several excellent Free Flight fields made available to them due to the close relationship among the area seed farmers. If you have not made the trip to Tangent, Oregon for the late summer contests you are missing a treat. It is one of the most pleasant and enjoyable areas for a free flight contest. While the events don't always take place on the same fields, the fields chosen are always perfect for the free wide variety of flight events held there.



Glenn and Linda Grell



A smiling Bruce Grell

Al and Dee had three sons, Paul, Bruce and Glenn. All three enjoyed flying model airplanes with their parents as they grew up and were original members of the Willamette Modelers. The entire family continued to support the local modelers. When the Willamette Modelers became exclusively a free flight club in the early 1970s the Grell family began to host a "hamburger feed" for those attending the contests. That tradition continues to this day for the three fall contests in August September and October. A wonderful Spaghetti dinner has replaced the hamburgers and the event continues to be a very well attended event bringing upwards of 100 Free Flighters and their supporters together as a community. One of the notable activities by the Grell family was in the mid-1960s was the silk screen printing of the first "Bird" logo shirts for the newly founded National Free Flight Society.

Dee passed away in 1998 and Al passed away in 2009. The Grell family free flight tradition has continued through their sons. The farm was split between Bruce and Glenn, with Bruce retaining the buildings and some acreage while Glenn received a good share of the land. Paul moved on with his life and dropped out of free flight.

Glenn married Linda who has essentially assumed the duties of Dee.

Bruce and Glenn have been contest directors for over 20 years. They continue to host the fall events to this day. Glenn took over his dad's duties on the AMA Contest Board and has been in that position for over 15 years. As with their parents, Bruce and Glenn have flown in many contests over the years.

The majority of Glenn's interest lies in multiple rubber events along with Linda. Glenn will occasionally pick up a hand launch or catapult glider and most recently has found an interest in the popular electric events. Bruce likes to fly power like his father. He has a keen competitive interest in the popular Golden Age 1/2 A event. Both fly contests on the West Coast from Seattle, Washington to Lost Hills, California with frequent stops in Sacramento. Unfortunately there is a harvest season in July and August that make a Summer Muncie trip to the NATS impossible, although at some point in the future they would all like to make the trip.



Glenn and a Twin Fin P-30

As you can see, it would be difficult to pick one member of the family out for nomination which makes it appropriate that the entire family go into the Hall of Fame. As long time Willamette Modelers Club member and nominator of the Grell family, Bob Stalick, stated, "free flight in Oregon would not exist if the Grell family were not involved". There were no shortages of flyers that came forward to second Bob's nomination.

Welcome the NFFS Hall of Fame Grell Family.

PAUL LAGAN

1941-2018

The World lost a fine modeler in Paul Lagan last year. Paul was a dedicated modeler from New Zealand with a well-rounded resume of Free Flight which included service to the sport, exceptional contest performance record as well as well thought out and published model designs he flew.

Born is Christchurch, New Zealand in 1941, he immediately discovered aeromodeling. Early on he flew a number of different disciplines including control line and free flight. He joined the Christchurch Model Airplane Club and by 17 was the Secretary of that club. He held New Zealand records in Hand Launch Glider, A-1 Glider, Open Rubber, One Hour Aggregate, Class 1 Control line speed and Class A Control Line Team Race.

A year later he joined the Royal New Zealand Air Force and chose a career in Air Force Avionics Engineering and began working as a Radar Fitter. His career in the Air Force was as distinguished as his success in model airplanes. As with some notable Americans, he was able to continue to fly model airplanes while in the service. He won many New Zealand events and was National Champion of Champions an outstanding 18 times. Paul also worked in Australia during his stint in the Air Force and in in fact he was elected to the Australian Model Aeronautical Association Hall of Fame in 2000. Paul had an excellent International Contest record. He began his experience by proxy flying a model at the 1963 World Championships in Wiener Neustadt, Austria.

From 1971 Paul travelled to World Championships in Sweden, Spain, the United States, Australia, Switzerland and Israel. Results included a forth at Taft California in F1B in 1979, a third in F1A in 1981 in Burgos, Spain, and a second in F1A in 1983 in Goulburn, Australia in a close fly off with US flyer, Matt Gewain. He won the individual Trans-Tasman title in all three international events currently referred to as F1A, F1B and F1C. He was also a keen competitor in R/C soaring and pattern events and represented New Zealand 35 times in those R/C venues.

As impressive as Paul's contest record was his service to the sport in many administrative roles he undertook. He helped establish two new New Zealand model airplane clubs as well as The Free Flighters of New Zealand Association. He served on the South Island Model Aeronautical Association, twice as President. He organized several New Zealand Nationals as well as Trans-Tasman Championships. During these volunteer activities he produced several publications for these associations, including a technical journal called the South Island News or SIN. In recognition of his record of service to model aviation he received the FAI prestigious Aphonse Penaud Diploma in 1993. Certainly Paul will be remembered for his exemplary service to our sport.

Paul designed and built models in all three FAI disciplines. His F1A designs began with a model he called Kiwi with the 2C version his most refined. The model was flown from 1980 through the 1983 including the World Champs at Taft, California and Goulburn, Australia. He built Andres Lepp's AL-29 and later revised this design to his own called Big Apple. His combination of the Kiwi 2C, Al-29 and Big Apple netted him his best World Champs finish, a second in Australia.

Paul also designed several F1Bs which he flew at several World Champs. His first designs in 1967



were fairly conventional in their appearance for the time they were built. A derivative of these designs was the attractive Rasputin with an flying stab that featured long power modes and were capable of excellent dead air times. The model was flown to 4th place in the World Champs at Taft. All his designs were published in various newsletters and symposiums.

Paul also flew F1C. His first model design was the 18 Ton in 1962, which was a rather boxy square tipped design that Paul admitted was not very attractive. His Teuton 1 and 2 designed around 1970 were better examples of the state of the art in F1C. They featured fully sheeted wings (as well as an open structure version) with the Cox .15 used in the 18 Ton replaced by Rossi .15s. These models were used extensively and allowed Paul to compete in all three FAI events during this period adding to his reputation of being an extremely well-rounded competitor.

There were many other published designs in other events including a hand launch glider in 1969 that included a built in dethermalizer, anhedral stab and built-up wing construction, features now common to modern hand launch glider design.

Clearly Paul Lagan cultivated a Free Flight reputation of the highest levels in competition, design and in general support of free flight. His contribution to our sport was outstanding and he clearly deserves recognition in our NFFS Hall of Fame. He will be sorely missed in the community.

NFFS HALL OF FAME INDUCTEES

Lt. H. Alden (D), 1979
Merrick Andrews (D), 1985
Alexander Andriukov, 2008
Randy Archer, 1998
Ray Arden (D), 1982
Bill Atwood (D), 1979
Phil Ball, 2018
Cezar Banks, 2000
Andrew Barron, 2001
Maxwell Bassett (D), 1981
George Batiuk, Jr., 2007
Tim Batiuk, 2012
Ken Bauer, 2015
Jim Bennett, 2017
Bob Bienenstein, 1985
Joe Bilgri (D), 1979
Richard Black (D), 1979
Woody Blanchard (D), 1990
Jim Bradley, 2015
Charles Broadhurst (D), 1979
John Brodbeck (D), 1978
Hardy Brodersen (D), 1993
Willis C. Brown (D), 1979
Steve Brown, 1999
W.L. Brown, 1978
Stan Buddenbohm, 2009
James Cahill (D), 1980
Larry Cailliau, 2013
Lee Campbell, 2009
Al Casano (D), 1992
Stan Chilton, 2014
John Clapp, 2016
James C. Clem (D), 1993
Johnny Clemens (D), 1989
Henry Cole, 1980
Larry Conover (D), 1982
Larry Coslick, 2011
Paul Crowley, 2010
Hal Cover, 2013
Frank Cummings, 1988
Vic Cunningham Sr. (D), 1987
Larry Davidson, 2011
Don DeLoach, 2014
Reginald Denny (D), 1983
Ed Dolby (D), 1998
Robert Dunham II, 2018
Bill Effinger Jr. (D), 1981
Brian Eggleston, 2017
Frank Ehling (D), 1978
Joseph Ehrhardt (D), 1991
Joe Elgin (D), 1982
Art Ellis, 2009
Walter Erbach (D), 1988
Mike Fedor, 2010
Emmanuel Fillon (D), 1990
Per Findahl, 2017
Joe Foster (D), 1986
Duke Fox (D), 1981
Carl Fries (D), 1979
Norm Furutani, 2018
Louis Garami (D), 1980
John Gard (D), 1983
Doug Galbreath, 1995
Matt Gewain, 2016
Walter J. Ghio, 2006
Annie Gieskieng (D), 1986
Bill Gieskieng, 1991
Lew Giltlow, 2015
Carl Goldberg (D), 1978
C.H. Grant (D), 1979
Grell Family 2019
Paul Guillow (D), 1985
Bob Gutai, 2013
Merrill Hamberg (D), 1978
Bob Hanford, 2012
Bill Hannan, 1986
Ray Harlan, 2014
Bill Hartill (D), 1997
Bob Hatschek (D), 1986
Bill Henn, 2013
Lee R. Hines, 2006
Rex Hinson, 2008
Milt Huguelet (D), 1991
Bob Hunter (D), 2011
Bill Hunter (D), 2011
Tom Hutchinson (D), 1988
Bob Isaacson (D), 1999
Tony Italiano, (D), 1993
Jay Jackson, 2010
Robert Johannes (D), 2013
Louis Joyner, 2012
Ian Kaynes, 2000
Ed Keck (D), 2004
Phil Klintworth, 2009
Herb Kothe, 2008
Dick Korda (D), 1978
Thomas Koster, 2000
Larry Kruse, 2005
Paul Lagan (D), 2019
Chet Lanzo (D), 1978
John Lenderman (D), 2005
Al Lidberg, 2017
Ed Lidgard (D), 1984
Gordon Light (D), 1982
Dave Linstrum (D), 2011
John Lorbiecki, 2019
Joseph Lucas (D), 1981
Lew Mahieu (D), 1992
Chuck Markos, 2014
Dr. John Martin (D), 1987
Clarence Mather (D), 1992
Richard D. Mathis, 2005
Don McGovern (D), 1983
Mike McKeever, 2016
Tom McLaughlan (D), 2002
Paul B. MacCready, Jr. (D), 2009
Robert Meuser (D), 1990
Walt Mooney (D), 1987
Roger Morrell, 2015
John Morrill (D), 2017
Gil Morris, 2007
Harry Murphy (D), 1993
Jerry Murphy, 2012
William Nakashima, MD, 2007
Ed Naudzuis (D), 1989
Hank Nystrom, 2004
Irwin Ohlsson (D), 1978
John Oldenkamp (D), 1999
Richard Obarski (D), 1991
John O'Donnell, 2011
Jim O'Reilly, 2007
Joe Ott (D), 1981
Faust Parker, 2010
Jim Parker, 2015
Frank Parmenter, 1998
James Patterson (D), 1987
Fred Pierce, 2009
Bob Peck (D), 1989
Sandy Peck, 1989
George Perryman (D), 1985
Hewitt Phillips (D), 1979
Paul Plecan (D), 1984
Irv Polk (D), 1978
Nat Polk (D), 1978
Bert Pond (D), 1978
John Pond (D), 1983
Ralph and Walt Prey (D), 2017
Ocie Randall (D), 1978
Bob Randolph (D), 2004
Ralph Ray (D), 2014
Carl Redlin, 2012
Dave Rees (D), 2012
George Reich, (D) 1983
Lin Reichel, (D), 2007
James Richmond, 1985
Gerald Ritz (D), 1982
Bud Romak, 1990
Walter Rozelle (D), 2008
Andre Schandel, 2002
Walt Schroeder (D), 1978
Ben Shereshaw (D), 1980
Leon Shulman (D), 1982
Bob Sifleet, 1995
Wally Simmers (D), 1980
Reid Simpson, (D) 2008
Roger Simpson, 2008
Lawrence Smithline (D), 1983
Charlie Sotich, (D) 2001
Pete Sotich (D), 1978
Henry Spence (D), 2014
Hank Sperzel, 2017
Earl Stahl (D), 1985
Bob Stalick, 2004
Victor Stamov, (D) 2015
Ron St. Jean, 1997
Henry Struck (D), 1978
Don Srull, 2012
Phil Sullivan, 2012
Frank Swaney (D), 1989
Andrew Tagliafico, 2010
Sal Taibi, 1978 (D)
John Tatone (D), 1997
Ralph Tenny (D), 1979
Mark Troutman, 2012
Bill Vanderbeek, 2011
Abram Van Dover, 2003
Eugene Verbitsky, 2007
Jim Walston, 2004
Bill Warner, 2001
Elbert Weathers (D), 1988
Charles Wehrle (D), 1987
Carl Wheeley (D), 1991
Bob White (D), 1988
Ken Willard (D), 1984
Bill Winter (D), 1978
C.O. Wright (D), 1978
John Worth (D), 1990
George Xenakis (D), 1995
Frank Zaic (D), 1978
Don Zipoy (D), 1987



2019 PRESIDENT'S REPORT

By John Lorbiecki, NFFS President

Welcome to the 2019 version of our world famous Symposium. This is probably the longest continuing technical model publication in the world. Since 1967, editors have been producing volumes of technical, practical, and hypothetical articles to advance the sport of free flight modeling. This year's addition is no different. Through the hard work of John McGrath and Rick Pangell (returning for another year) you have the latest version in your hands. I want to thank all the authors and editors for their contributions. As a past editor, I know the work involved as well as the pleasure of seeing all your work being published. And, once again, we Steve Galbreath (The Printer) to thank for the wonderful work in turning all our ideas into print.

Least I forget, I need to acknowledge Bill Vanderbeek for his work in regards to the patron letters. Without this work, the price of this book would be substantially higher. And finally, thanks to all the patrons for their kind and generous donations. We could do this without you!

The NFFS is in fine shape. We have Don Deloach doing his normal fantastic work as editor of the Digest. He has worked hard to cover all aspects of the sport in each issue and has been very successful. David Lindley has taken over as membership chairman (replacing Marty Richardson who I have to say a big thank you!) and has been looking at methods to streamline the system. We lose members constantly because they plain old forget to re-up and David as well as our webmaster extraordinaire Allen Petersen have been working towards more automation in this regards. JP (Julie Parker) has taken over from the late Frannie Masterman and made the transition very painless. She has the right attitude and has kept our financials up to snuff. Plus, she keeps the board in line, just as Frannie did. Thanks so much.

I also need to thank David Gerspacher for his work in maintaining the plans service. He has worked with AMA and typically plans are delivered within a week. And if that isn't fast enough, the modeler can download the plan and get it copied themselves.

Model of the year is once again run by my long time friend, Ross Jahnke. It is getting harder and harder to find those revolutionary models but somehow he has been able to do it. Hall of Fame has been run by another good friend, Mike (World Champ) McKeever. As always, he has done his job and done it well. Thanks guys!

NFFS has multiple committees that handle everything from indoor to nostalgia and each one has done their work with basically no input from me. There are too many names to mention, but thanks to all. After I don't know how many years, Bob Mattes has stepped down and has earned his time off. Good work and I wish you the best.

Finally, I need to do a big shout out to my wife, Patti Lorbiecki. She took over as NFFS Publications chair and has done a remarkable job. Most shipments go out within a day or two and she is constantly looking at ways to reduce postage charges. We have been able to actually give members a refund when excessive postage has been found. Love ya and thanks for all you have done. Plus the members love her cookies!

I cannot forget the board. Gene Ulm, Rick Pangell, Glen Scheider, and Bob Sowder have all worked towards keeping NFFS running. Without these guys I would be, well, without a board! Thanks guys.

Financially, NFFS is very solvent. From various donations as well as watching our pennies, we have been able to survive on our checking account. We have not needed to touch our savings and we have never had to even think about our stock market investments. This is all due to you, the members, with gracious donations as well as having very good treasurers who keep an eye on things.

This is my last year as president and it has been my pleasure to work with all of you. I have met many wonderful people and made many friends. I feel I am leaving NFFS in a better place and hopefully have set the groundwork for the next president to build on. Please be kind to my replacement and make him feel as welcome as you all have to me. It has been a great 8 years and now maybe I can actually do some flying at the Nats. Plus, I will be able to save my voice at the raffle.

So, I hope you enjoy this addition of the Sympo and look forward to many more. Thanks again and as always, see ya downwind!

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Roy White
Spence Wise
Richard Zbinden



Grandfather Eduardo Guerrero-Gajardo from Chile with Grandson Cristobal Guerrero-Robinson from Tucson at the 2019 Indoor NATs Photo by Bruce Grawberg

AUTHORS AND CONTRIBUTORS



Alexander Andriukov

Alex Andriukov's model aviation career started early. "I first joined the model airplane club [in Riga, Latvia] in 1962 at the age of six and built some simple models," says Alex. "I started free flight with FIH in 1968 and built my first Wakefield in the winter of 1969-1970 and first flew it in 1970. I flew control line at the same time until 1980, with my best placing being sixth in Team Racing at the Russian Republic Nationals. But I always considered Wakefield my primary category."

His interest in modeling lead to a degree in Mechanical Engineering for Aircraft Structures at Kazan Aviation Institute (now Kazan State Technical University). At university, Alex met several students who also flew FIB, including Andrey Burdov and Andrey Khrebtov. The dozen or so members of this group are now considered to be some of the best FIB fliers in the world. Alex claims that this is when he became serious about the event.

As a competition flyer, Alex is truly the best in the world. He was a member of the USSR FIB team nine times, the Ukrainian team six times, and the United States team once. He has won many World Championship, European Championships,and World Cups.

The development of the model that Alex flies today, and sells worldwide, was started in 1972. Obviously, there have been many, many iterations, some of which have spawned ideas and design concepts that are now considered the benchmark in FIB.

Alex immigrated with his family to Simi Valley, California United States from Ukraine in 1997.



Dr. George Arghir

Born: Brosteni, County Vrancea, Romania; June 9, 1937.

Parents: Barbu Arghir (professional soldier Royal Army) and Ana Emilia Arghir (née Caloianu).

Married: with Maria (née Popazov, landlord family), April 16, 1962.

Education: Technical High school of Cluj (1955); Polytechnic Institute of Cluj: Machine Building Technology (1961); University of Cluj: Solid State Physics (1971); University of Bucharest: Radioactive Isotope Utilization (1985); University of Notre Dame: Materials and Metallurgy (PhD, 1977).

Professional activity: Mechanical Works of Cugir, Technofrig Works of Cluj, Technical University of Cluj Napoca Cluj.

Registered in the Stiinta (Science) Sport Club in 1951, club of aeromodelling. Build starting gliders, rubber and engine models, including F1D. Entered in the contests. Champion of district starting 1954. I loved gliders. I build and flew them. I was influenced by Hans Gremmer of Germany and introduced F1E class in Romania. I was National Champion first time in 1969. There were 120 senior competitors.

Included details for awarding “The Paul Tissandier Diploma”. 2008

The Paul Tissandier Diploma

Details: Dr. George Arghir is (air model) pilot since 1951 and member of: Sport University Club “Polytechnic” of Cluj-Napoca for 58 years, and is emeritus maestro of sport in aeromodelling. He has been organizing National and International Contest “Napoca Cup” at Free Flight classes in the last 50 years, being at the Jubilee Edition of 2009. He introduced in Romania, F1E class of air models in 1970 and organized first national Contests. He obtained 5 medals at FAI European and World Championships in F1E Class. He had the position of trainer of national team of Romania of Free Flight classes F1ABC and latter F1E and that of President of National Air model Commission. He had been a member of the FAI CIAM Free Flight Subcommittee for many years, and is number one timekeeper of Romania. He was for 5 times Member in the FAI International Jury of World and European Championships in Romania and other countries. He was 7 times Contest Director of FAI World and European Championships in Romania for classes: F1A, F1B, F1C, F1D, and F1E.”

The last position: Member of the FAI Jury at the EUROPEAN CHAMPIONSHIP OF F1D CLAAS, 3-8 June 2019, Tachov, Svetce, Czech Republic.

I am member of 10 International and National Scientific Societies and Member of Honor of the Romanian Academy of Technical Sciences.

I wrote and published 19 studies about air models in national and international well known magazines.

I was interested in technics, technology, materials, captivated by the flight and gliders.



David Aronstein

I am a 3rd-generation modeler. My grandparents started the Brooklyn Hobby House. My Dad taught me modeling. His stories of stick models with motor tubes rolled out of 1/64” sheet, flying at walking speed, props turning so slowly that you could count the revolutions, ignited a lasting interest in Indoor.

I fly Rubber Scale, from Pistachio to Coconut; No-Cal (especially with no weight minimum because that enables a wider variety of designs to be competitive); non-scale Cabin events; and some Stick events. I also build many models which do not fit existing classes, such as Rubber Ducted Fan and Walkalong Gliders, and sometimes make up my own classes, like Washingtonian Cabin (7g model / 1g rubber). I believe that for the health of our hobby, we need a mix of events including BOTH the limited classes with well-defined parameters to help beginners quickly get into the right 'ball park'; AND classes with freedom to experiment and trade-off all design parameters against each other.

I studied aeronautical engineering at Princeton University, Stanford University and the University of Washington. In my career, I have been a company subject matter expert in Stability & Control, Multi-Disciplinary Analysis & Optimization (MDA&O, it is a thing), and Systems Engineering. I am currently an engineering manager in Vehicle Integration.

I am married, with four wonderful children. My family gives me joy and purpose.

My hope is that my article in this Sympo will contribute to advancement in various classes of Indoor models; including even the absolute Indoor duration record; and to the increased enjoyment in flying by many, whether or not at the forefront of competition.



Paul Bradley

I have been involved in the model airplane hobby since the early 1950's. My interests have included Free Flight, Control Line, and Radio Control. My principal interest has been and continues to be Free Flight.

I graduated from Northrop Institute of Technology in 1964 and Texas A&M in 1968. While trained in Aeronautical Engineering, my professional career was in computers following a stint in the Apollo program.

I like to design, build, and fly. My competition flying is not as frequent as it was during my younger years, but I do build on a regular basis and fly those models as often as I can.

My competition flying these days is limited to the smaller electric powered classes like E-36 and E-20, along with some of the Flying Aces Club events.

I am a fan of emerging technology as applied to the model airplane hobby. I am also a big fan of the NFFS and its work in promoting and growing the Free Flight aspect of the model aviation hobby.



James DeLaurier

Was active with free-flight models during the 1950's, and a member of the Chicago Aeronuts. Designed and built a variety of sport models (gas, rubber, and Jetex), but specialized in competition Indoor Tissue Stick, and outdoor Unlimited Rubber. Subsequently attended University and received a Ph.D. in Aerospace Engineering from Stanford.

Career experience included work at NASA Ames (Apollo Project), Sheldahl Inc. (scientific balloon design), and Battelle Memorial Institute (various industrial research projects). Moved to Canada in 1974 to accept a position as a professor at the University of Toronto Institute for Aerospace Studies, where research topics included Lighter-Than-Air technology, sustained flight by beamed microwave power, and flapping-wing flight.

Upon retirement in 2006, has performed consulting and is writing books on aircraft design and aeroelasticity. Also has designed and built a wind tunnel in the basement (every home should have one), which has been used for consulting projects and research. Most recently this has been used to measure the performance of F1C propellers designed by Brian Eggleston.

Chris Edge



Chris Edge (aka CHE and EoB in various FF organs) has been flying free flight models for over 40 years and occasionally looses them. Starting with a 3rd hand 'Caprice', Chris has almost exclusively competed with towline models, to World Championships level, after breaking his arm throwing an HLG back in 1978, but this didn't stop him setting a world record for paper plane duration as part of a professional team in 1996.

Chris has always been an early adopter for 'tackle' and GPS is no different, with plots of flights being shared after a weekend's endeavor; please make him stop !

Chris is a career mechanical engineer with a specialism in complex structural simulations (NL-FEA) and has worked on issues as diverse as bird impact, elastomer fatigue, composite turbine durability, and offshore installation prediction.

He lives with Sue in rural isolation with a number of animals that varies week-by-week but at the time of writing was in the mid-40s. When not flying models, he's creating piles of swarf in his workshop, some of which recently and miraculously transformed in to a working clock.



Brian Eggleston

Active in flying open power and F1C models starting in 1952. Eventually quit modeling in the 1980's due to job pressures. Designed the Creep F/F power model published in the Aeromodeller in 1955, now popular again as a vintage model. Flew F1C for Canada at W/Cs in 1965, 1969, 1973 and 1975. Entered the aircraft industry in 1955 with A.V. Roe (UK) and emigrated to Canada in 1963 to join De Havilland Canada. Worked in aircraft technical design until retirement in 1998, and thereafter as a consultant.

Born 1936 in the UK. Graduated from the College of Aeronautics, Cranfield, UK, in 1961 in aircraft design.

While in industry was directly involved in aerodynamics R&D and new aircraft studies until booted up to senior management in the late 1980's. Now retired, gets recreation from software development and studying new ideas for aircraft using aerodesign tools freely available over the internet.

Harry Grogan



My aeromodeling hobby started with Comet and Guillows kits in the late '50s. I enjoyed building those stick & tissue models but never got one to fly. A friend of mine built a control line Ringmaster with a Fox .35, and I was hooked. There was a park near my house and control line flying was quite popular on the weekends. We then discovered that flying in contests was even more fun. I flew combat, rat race and speed in many contests in the Southeast during high school. During my freshman year at college I built a hand launched glider, and after trimming it out it promptly flew out of sight. That day was the beginning of my free flight hobby. Since the mid '60s I have flown AMA gas, unlimited rubber, hand launched glider and towline glider. I was the KOI grand champion in 1970 flying nine events which included several C/L speed events. During the '70s and '80s my main interest was F1A glider and tried out for the U.S. Team many times. Came close to making the team a few times, but close only counts in horseshoes.

My interest in aviation motivated me to obtain degrees in Aerospace and Mechanical Engineering, and retired from Lockheed-Martin in 2006. I have life memberships in AMA and NFFS. I was the editor of the 2006 NFFS Symposium and co-editor of the 2017 Symposium. For the past five years my main

Tom Ioerger



I started free flight at the age of fourteen with a 1/2 A GAS KIWI , my first successful free flight model.

I joined the Phoenix Model Airplane Club at that time and continued with 1/2 A GAS models,hand launch gliders and Payload models. I am still a member of the PMAC.

With a technical education, my interest in free flight became more experimental and computational. I ran a computer aerodynamic analysis of free flight airfoils as part of my Physics degree requirements back in 1973.

In 1975, I started flying F1B competitively and trying to improve my performance with research and experiments. Of course, my career in International Project Management slowed this process greatly and our friends from the Ukraine and Russia passed us all up and have stayed ahead to this day.

Lately, F1E steering has been an area of interest to me along with the development of F1Qs, but now I take even more pleasure in flying and competing with my free flight friends of many years.



Ross Jahnke

I am a Professor of Art at Nicholls State University where I teache printmaking and color theory. I received my BFA from the University of Wisconsin – Milwaukee and his MFA from Louisiana State University. He primarily flies F1B, F1G, and P-30 and has recently become involved with electric models. I was Editor of the 2001 and 2014 Symposium Reports and was responsible for establishing the branding and templates used for all Symposium Reports since 2001.

John Lorbiecki



I have been into modeling since 1959. I began with Control line and got involved in competition free flight in 1967 thanks to the Astro-Wings club and later the Bong Eagles (still a member). My primary interest has always been FAI (power and glider).

I have been a past Sympo editor as well as multi-time NATS contest director. My presidency for the NFFS started in 2014. Along with that I have been involved in multiple world champs, as both a competitor

(through my son John) and organizer. Along the way I have contributed many Digest articles.

My profession has been as a mechanical engineer, primarily in the medical industry. I did a lot of work in the MR and ultrasound modalities. Along the way I gained machining and prototyping knowledge and now have a fairly complete machine shop with a CNC mill, lathe, welding capabilities, 3D printing, and a Full Spectrum laser. I recently started a one man engineering and prototyping business, JPL Designs LLC.

I am a commercial pilot as well as a certified flight instructor and presently own a Cherokee 180. I also am known for my drag racing, having competed with everything from an 11 second Volkswagen to nitro fueled funny cars and dragsters. I own a front engine dragster and a 1932 Bantam altered.

I am married to Patti (NFFS Publications Manager) and have two children. John is a former FF junior world champion and is presently flying an F-16 for the ANG. Kaity, my daughter, is a massage therapist and went back to school for physical therapy.



John Mcgrath

I got into free flight after observing some indoor flying at the Colorado Springs, CO, City Auditorium about twenty years ago and hosted sessions there for more than ten years, simply flying for fun. Coming in out of the cold, I joined Colorado's MMM club around 2013 and became involved with competition indoors and out. Indoors I focus primarily on LPP, P-18 and now A6, while outdoors I mostly fly P-30, with occasional attempts at Coupe and HLG. I've been involved with Science Olympiad for seventeen or eighteen years as a coach and event supervisor at Regional and State levels. Professionally, I teach AP Physics, AP Statistics and LOTS of Algebra to high school students. They may not learn much math, but they know not to flinch when a Pennyplane hits them. I've enjoyed earlier careers as a Navy Surface Warfare Officer and business consultant. My education includes a B.S. in Mechanical & Aerospace Engineering (Cornell '82) and a Masters in Curriculum (University of Colorado at Colorado Springs '05). Just to make sure there's no free time in my life, I'm current MMM Club President and owner/operator of Laser-Cut Planes LLC.



Mike McKeever

Mike McKeever has been in the sport of free flight since he was 10 years old. He has held several AMA records including the current F1A record. In the last 20 years he has primarily flown F1A, made several US Teams, and was World Champion in F1A in Argentina in 2005. He has been a past Vice President of NFFS representing the West. Mike has been a Contest Director for the last 20 years and currently is responsible for the Sierra Cup World Cup event in October. He is Vice President of the Southern California Aero Team (SCAT) although he currently lives in Gardnerville, Nevada.

Jerry Murphy



Currently serving as the chairman of the AMA Free Flight Contest Board gives me a unique insight into the rules making process. I entered my first free flight contest in Beaumont Texas in 1958 and have been hooked on the beauty and thrill of free flying models ever since. Growing up in the Dallas/Ft. Worth area it was easy to become a modeler as the US Navy hosted the NATS in our backyard. My flying buddies in those days were fellow Cliff Cloud Climbers such as "young" Don Chancey, Mike Fedor, and Dick Mathis. We had a lot of fun and gained the skills to make our models fly better. In 1972 my job at Hewlett Packard resulted in moving to Colorado Springs. I joined the Magnificent Mountain Men club and have been fortunate to serve as club president several times over the years. Here my new flying buddies are Darold Jones, Rick Pangell, Chuck Etherington. It has been wonderful to see this great club grow and prosper with members such as Don DeLoach.

I firmly believe that free flight needs strong clubs as well as a strong national voice. I joined NFFS as Charter member #150 and have been a loyal supporter ever since.

I enjoy all aspects of free flight, both indoor and outdoor. I have participated in the FAI program flying F1A as well as SAM rubber and AMA events. Currently I have been building indoor models with a couple of new electric projects.

The highlight of my free flight experience was being elected to the NFFS Hall of fame in 2012.

I worked for Hewlett Packard and Agilent Technologies for 36 years retiring in 2005.

My first day of retirement was spent on the field at Muncie for the 2005 NATS. What a way to start retirement. I served as contest director of the 2007 NATS and am looking forward to flying in the 2019 edition.



Will Nakashima

Will Nakashima grew up in San Leandro, California. At the age of eight, his uncle Shuji Maruko, taught him how to make a Thermic glider. Uncle Shuji also helped Will build a profile control line trainer powered by a Bantam .19 engine. By age 14, Will was a member of the San Leandro Line Twisters and was flying control line stunt in the Western Associated Modelers circuit in northern California.

Will graduated from Stanford, then Tulane Medical School. He started drawing cartoons in college and was published 8 in the university humor magazine called The Chaparral. He became a member of something called the Hammer and Coffin Society, which is for people who contributed to the Chaparral.

Free flight began during his medical internship in San Jose at the Santa Clara County Hospital in 1966 through 1967. Will met and received encouragement from John Lenderman. Then Will went into the Air Force and was stationed at the March AFB hospital in Riverside, California. This lasted two years, and he and his wife, Suzanne, began to go to contests at Taft.

Will is an internist and is still working full time. Every day brings a new experience. Medicine is science, but it is also art and human experience. One can tell when one is having a real life experience. Artists and poets try to record them. This is what Will tried to do with his cartoons.

Rick Pangell



I have been flying free flight models since the early 50's. I started out with Comet Kits, Spee-Dee-Bilts and control line flying like everyone else, but my interest focused when I discovered the free flight activity. I have been active ever since. Free flight modeling gave me my life long career.

I graduated from the University of Minnesota in 1968, Aeronautical Engineering and subsequently overeducated. 40 years of Design and Engineering management in aircraft and spacecraft...I loved it. I retired in 2006 so I could have more free time...yeah, right.

I am an active flyer, Current NFFS Central VP, NFFS Life Member #28, SAM Life Member #3309, , AMA CD for over 35 years AMA CD, AMA Leader, Administrative and Technical, MMM Club Leader Member and newsletter editor of the "Max-Out" for the Magnificent Mountain Men FF Club in Colorado since 1982 (37 years!). I edited a previous Symposium in 2008.

I like fly just about every event you can invent whether indoor or outdoor. I'm somewhat opinionated and editorial, but the goal has always been to the betterment of free flight and the nurturing of its advocates.

I am I a firm believer in Free Flight Models and the NFFS.

Daniel Petcu, PhD



Born: Câmpina, Prahova County, Romania, December 15, 1955

Parents: Grig (electrician and famous radio amateur YO9HO), Alexandrina (dressmaker)

Married with Iuliana, Mars 6, 1993

Education: Technical Oil and Gas High school of Campina (1975), Institute of Oil and Gas, Faculty of Well Drilling and Oil and Gas Reservoir Exploitation (1981), Numerical Simulation of Fluid Flow in Porous Media (PhD, 2004).

Professional activity: Videle Oil Field (1981-1983), Oil and Gas University of Ploieşti (from1983 to the present) - Department of Petroleum Resources Geology and Reservoir Engineering.

I build airplane models from 1964, initially at the Pioneers' House in Câmpina and from 1971-1989 at a sports performance club sponsored by the Oil and Gas Research Institute in Campina. In 1990, I set up an aeromodelling section at the university where I work, within the University Sports Club where I am currently active.

I have made a passion for everything that means free flight, but over the years I have also chucked with the control line, gliders or motogliders controlled by radio.

I was influenced to build and fly F1E gliders by Dr. George Arghir when he was a lecturer at the airplane coach school that I graduated in 1974. It was the first time I saw flying an F1E glider and I was fascinated.

The highest performances I have achieved in the F1E class, where I have been active since 1990 until now. Throughout the years, I have led a lot of juniors and seniors to the great heights of performance.

I introduced F1E to the USA through Jon Davis, building for him some models and competing side by side at the World Championship in Poland in 2001, as well as publishing in the NFFS Sympo numerous specialized articles about F1E gliders. I also introduced the F1E class in Bulgaria in 2016 with the help of Bulgarians Lubomir Bakalov and Valentin Savov.

I was awarded by FAI with Antonov Diploma in 2007 for technical innovations in F1E and for the published papers in NFFS Sympo. Also I was awarded by Romanian Modelling Federation with "emeritus maestro of sport in aeromodelling" title.

Regarding the organizational part, I was the contest director of 2014 European Free Flight Championships (F1ABC) held at Salonta (Romania).

As far as propaganda is concerned, I uploaded on my YouTube channel (petcudan55) over 160 videos about flying model airplanes and restoring old motorcycles (a second big passion of mine) now part of my little collection.



Paul L. Rossiter

Paul Rossiter and his father Laurie started control-line and free flight aeromodelling back in the 1950's (including a Jetex-powered "Fizzlequick" which went OOS on its first flight, his first such FF experience!). They then moved into early R/C, building much of their own equipment and actually managed semi-controlled flight of a single channel model with a valve transmitter and early transistorised receiver. Paul also built some multi-channel reed sets but they were only used in boats.

With the seemingly inevitable interruption due to cars, girls and study (PhD in physics), Paul drifted out of the hobby until the 1970's when he and his father again returned to R/C. Having gained some proficiency in basic aerobatics, he became drawn to the challenge of electric flight and experimented with battery/motor systems. He helped establish an electric flight interest group in Melbourne, Australia and went on to win a number of events at National Electric Flight meetings. A final distraction was model helicopters, including electric powered versions.

However, the lure of free flight was again felt in the 1990's and he became involved in all rubber classes as well as Slow Open Power. Part of the fascination was to use his professional background in physics and engineering to gain a better understanding of how to optimise performance. He has won a number of State, National and World Cup free flight titles and represented Australia in F1B at three World Championships, his best result being 9th.

He has written for a number of magazines and newsletters, including a regular series in Electric Flight International (now defunct) and had two plans and associated construction articles published. More recently he has served on two editorial panels for the NFFS Symposium and is also on the editorial team of Free Flight Quarterly.

Aram Schlosberg



Aram was born in South Africa and grew up in Israel. He was on the '63 Israeli team to the World Championship in Austria, flying F1A (placed 14th) and F1C. He came to the US in the early 70's to do graduate work. By the early 80s he started flying F1A again and jointed the Brooklyn Skyscrapers. In 2005 he switched to flying F1B and was instrumental in establishing the new F1Q electric event.

Yury Shvedenkov



In 1985 I fell in love with building and flying model aircraft. A couple of years later I focused on FAI F1C power models. After moving to Canada in 2005 joined Toronto Free Flight Group and in 2009 for the first time I made Canadian team for the World Championship. Since then I flew for Canada at all World Champs. I became F1C World Champion in 2017. I teamed up with Brian Eggleston and James DeLaurier with the idea to improve aerodynamical characteristics of contemporary free flight power models.

Born 1975 in the USSR. Graduated from Novosibirsk State University in 1996 and received Ph.D. in physics in 2001. Currently expanding my efforts as the head of R&D department of CardioMed Supplies Inc. (Lindsay, Ontario).



Robert Sifleet

The first model airplanes I built were Comet kits of WW2 fighter planes in 1945. I flew my first contest in 1952, and my first Nationals was in 1954. As a Jr. and Sr. I flew all classes of outdoor FF, U control aerobatics and speed. Eventually I became proficient enough to win The nationals Open and Grand championship in 1960, 1962, 1966 and 1976.

I attended Northwestern University 1961 thru 1963 and earned a degree in electrical engineering. After 5 years in the defense industry I worked for AT&T for 30 years. After an early retirement, I had my own greenhouse nursery business primarily growing orchid plants.

Over the years my wife, Betty, fully supported my modeling and encouraged the many projects that helped me to occasionally excel.

Some of my best efforts were the development of the Maximus AMA gas model, and the Centaur F1C model that was flown with the first tuned pipe used in the USA. It took nearly 2 years to make the proper tuned pipes and engine modifications

The FAI classes have been my main interest. I have participated in all team selection programs starting in 1956. I was a team member in F1A in 1959 ,1977 and 2011, in F1C 1969 (bronze medal). and 1987.

I was introduced to F1E in2002 and have been on every team since then. I won gold in 2003, and silver in 2013. Two team silver medals were won in 2005 and 2013.

Robert Sifleet continued...

I initiated the USA Jr. Team Selection Program and was team manager for 3 of the first 4 teams.

I have been a member of the FF team selection committee since it was formed in 1970.

After totally retiring in 2016, I moved to Muncie IN to be able to do more model development.

I decided to try the electric FF classes. During the second season of flying F1Q, I won 10 of 12 contests and was awarded the FAI world cup for 2018.



Bob Stalick

I have been a free flight modeler since i was in grade school. My first gas powered kit was a Berkeley Baby Bootstraps powered by a Baby Spitfire 045. I received it as a gift on my 14th birthday.

It wasn't until I finished college at the University of Oregon, and got my first job teaching English and drama in Albany, Oregon that I become involved in free flight competition. I joined the Willamette Modelers Club of Oregon just as it was being formed in 1960. I became the WMC newsletter editor and have held that post for 58 years. In the intervening years, I helped co-found the NFFS, and I served four terms as VP of the AMA from District XI. I flew in two FAI Finals, and I have flown in ocal, regional and national free flight competitions.

I also become involved with contest management, obtaining my CD license. I was a magazine columnist for American Modeler and wrote the freeflight column for Model Builder for over 20 years. I have served as a member of the NFFS Board of Directors and have been President of the NFFS on two occasions--both for 8 years. I have served on numerous committees for the NFFS and am currently the Competition Committee Chair. I was inducted into the AMA and NFFS Halls of Fame in 2002.

I enjoy flying indoor sport models, and just about any form of outdoor model. Currently, my interest leans toward Vintage FAI and Nostalgia gas.

I am proud that my late wife, Barbara, and I had three children and that all of them were active in building and flying free flights. Two of them are still active fliers, and they have passed their interest to their kids, my grandkids, who have been involved in free flight as well. Daniel, Nathan and Connor Vucovich were perennial Nats contestants as Juniors and Seniors., Alex Stalick flew on two World Championship teams. Both Daniel and Alex won college scholarships from NFFS. Eleanor and Roman Stalick were Nats contestants and Roman was on the 2018 World Champs F1A team. I am proud of their accomplishments and the support their parents gave to help them in our sport.

I am fortunate to live in an area of Oregon which has easy access to some large free flight fields, and I enjoy doing some fun flying with my club mates in addition to competing at our contests and other west coast meets..

I retired from being a school superintendent nearly 20 years ago, but I remain active in my community by being a member of several community organizations and serving as an officer of a local school foundation board.

Being involved with freeflight has given me an opportunity to meet people around the country and the world. I have many friends as a result of my involvement, and I believe this sport and hobby are part of the reason I live a productive and happy life. I believe involvement in free flight is one of the keys to happiness.

Adelaide Machado Ulm



Adelaide was seven years old when Dave Lacey entered her in her first contest after watching her rocketing catapult gliders into the sky. The Eastern Free Flight Championship no longer exists, but it ignited Adelaide's passion for Free Flight.

Now at sixteen years old, she is currently a sophomore in high school at Georgetown Visitation in Washington D.C., and dances, plays the flute and piccolo, and is an editor for the school's newspaper. Her dad Gene Ulm is her greatest supporter of flying, and he suspected her love of flying since she wished she could fly.

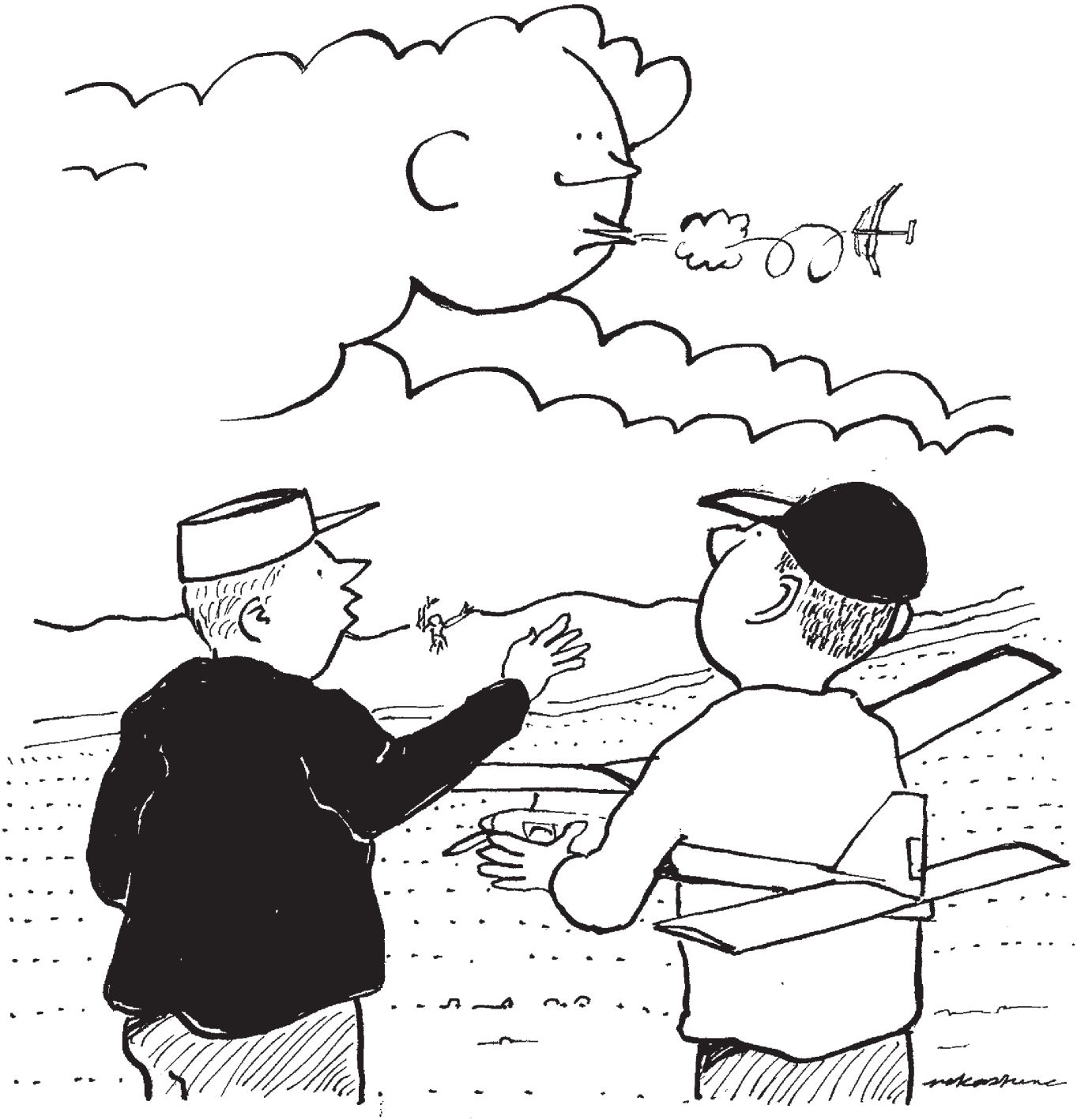
Adelaide has competed at international, national, and regional contests and enjoys seeing other Juniors fly as well; Free Flight has been one of her defining summer activities.



Sergei Vorvihvost

I was born 1967 in Poltava, Ukraine, USSR. In school I started aeromodelling. In 1985 I entered Moscow Aviation Institute and graduated in 1991, My specialty was aircraft engines.

I mostly built and flew F1C models during that time. Afterward, I returned to Ukraine and was select to the National Free Flight Aeromodelling Team. In which was third in the 1996 Euro Champs. At the end of the 1990's I started to build "small" powered F1J and F1P models and then in 2007, F1Q models. I still built and fly those models.



"Out here, one learns how to appreciate the outrageous...."



John McGrath Launching Unlimited Rubber in Denver