R/C
Radio controlled
Soaring Digest
THE JOURNAL FOR R/C SOARING ENTHUSIASTS

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About RCSD

R/C Soaring Digest (RCSD) is a reader-written monthly publication for the R/C sailplane enthusiast and has been published since January, 1984. It is dedicated to sharing technical and educational information. All material contributed must be exclusive and original and not infringe upon the copyrights of others. It is the policy of *RCSD* to provide accurate information. Please let us know of any error that significantly affects the meaning of a story. Because we encourage new ideas, the content of all articles are the opinion of the author and may not necessarily reflect those of *RCSD*. We encourage anyone who wishes to obtain additional information to contact the author.

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"Tech Topics"

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Tom Nagel: Travel Saga Correspondent
"Have Sailplane Will Travel!"

Mark Nankivil: Columnist
"Electric Connection"

Greg Smith: Columnist
"The Sloper's Resource"

Dave Garwood: Photographer, Writer

The Soaring Site

RCSD on the Web

This month, for their contributions to the electronic version of *RCSD*, special thanks go to:

Jimmy Andrews, TX via Singapore
Paul Debry, FL
Mike Glass, TX
Keith Love, CA
Richard Weil, Australia

It's also thanks to Richard Weil, an original subscriber to *RCSD*, for taking the time, not only to express his appreciation for all the years of *RCSD*, but to request e-mail notification as issues become available for downloading. B^2 researched the possibility of e-mail notification and the end result is a Yahoo! Group called RCSoaringDigest:

http://groups.yahoo.com/group/RCSoaringDigest

There is also a link off the *RCSD* home web page that takes you directly to the Yahoo! Group. (This is not a discussion group, rather it's designed for notification purposes only.)

Thanks go to B^2 for establishing the Group!

Another person deserves the limelight this month. Craig Burton asked a simple question regarding a series of old articles and, in the course of our e-mail correspondence, Craig asked if he could help create PDF documents of old issues. We discussed the process, ran some tests and, as of this writing, Craig has completed his first two PDFs, January and October 1988. (Thanks for volunteering Craig! PDF conversion is extremely time consuming; if you get bored, please let us know!)

B^2 are also working on PDF documents having completed the first twelve issues of *RCSD*: January - December 1984. And, our own Dave Register has also volunteered to help! (Thanks, Dave!) And me? I've completed 2001 and now working on year 2000.

While we plan on making those issues available soon, we're also looking out into the future, attempting to analyze the magnitude of our undertaking. How much server space will ultimately be required is a number one priority. For those of you downloading *RCSD* PDF files, you've likely noted that most of the past issue PDFs are actually being downloaded from <http://soaring.ryanflowers.com/rcsd-pdf/>. Ryan Flowers, Reno Nevada, has devoted substantial space on his server to the *RCSD* endeavor. We really appreciate Ryan's help in this area. Thank you, Ryan!

Having only one site in the future would be great but, at this stage of the conversion process, it is certainly not necessary. If any of you have spare server space you can share, we'd like to hear from you!

Judy Slates
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http://www.b2streamlines.com/RCSD.html

SAGE COMPULSION

Dynamic soaring in Frankfort, Kentucky, Gordy Stahl flies a Sage Compulsion. Speed was approximately 100 mph.

Photography by Bruce Davidson (past DHLG Nats Champion) from Louisville, Kentucky.

on the Wing B²

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Diva, Part 3

This has been an exciting series of weeks for us because Diva construction has progressed rapidly. As this column is being written, the entire framework is complete and all radio gear has been temporarily installed. The airframe, minus covering and painting, weighs 1300g, a bit under 46 ounces, which is right on target.

Photo 1: Aileron bellcrank mount.

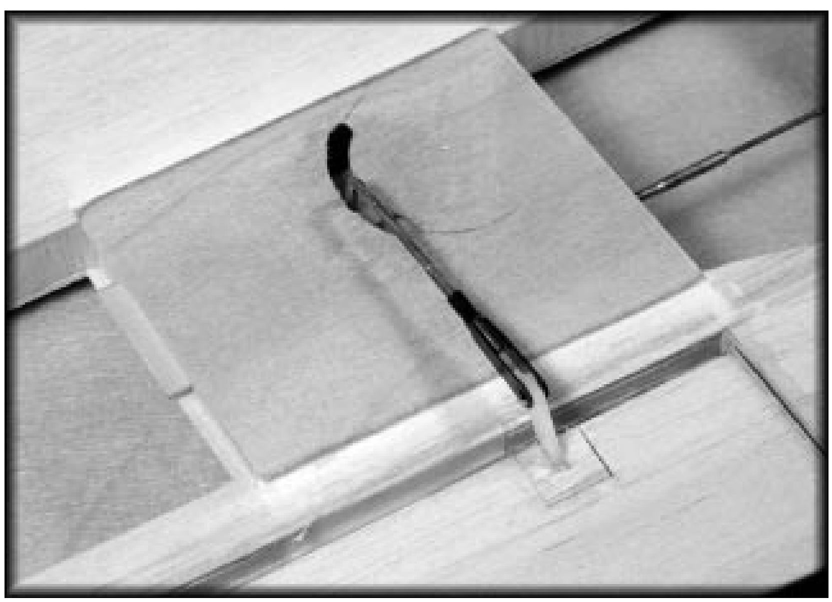

Photo 2: Aileron pushrod.

Finishing the wing

The most critical part of wing construction is the D-tube formation. Once the upper and lower sheeting is bonded to the spars, ribs, and leading edge, it's nearly impossible to take out or put in any wing twist. Because the Diva wing uses a triple reverse taper, we set up three separate sets of jigging fixtures. As we had made templates for all of the wing ribs, getting heights and angles for the various fixture pieces was a simple, but time consuming, matter.

After getting all of the ribs glued into place on the spar and adding all of the trailing edge pieces, the wing was jigged into position right side up and the upper surface leading edge sheeting was glued onto the structure, along with all of the upper surface rib cap strips. This procedure was performed on both wings.

The wings were then inverted and aligned again. Using the rib templates, we made sure there was no twist built in. Because the rear upper surface of the wing is very slightly concave, it's possible to set up the wing so that it is self aligning. Once assured everything lined up properly, the lower surface leading edge sheeting was attached to the spar and ribs. The leading edge stock was then glued on with the wing still in place in the jig, followed by the lower surface rib cap strips.

The aileron bellcrank is mounted on a piece of 1/16th plywood which is attached to two adjacent ribs. See Photo 1. The pushrod from the bellcrank to the aileron comes out of the bottom of the wing. Since this is in an open bay, the covering must have some sort of attached substrate. We used a large piece of specially cut 1/64th plywood for this purpose. The pushrods come straight out of the cutout from the bellcrank, and then bend back to the control surface through a 90 degree angle. Photo 2, taken before covering was applied, shows the aileron linkage and wing cutout to good effect.

Photo 3: Aileron bellcrank mount.

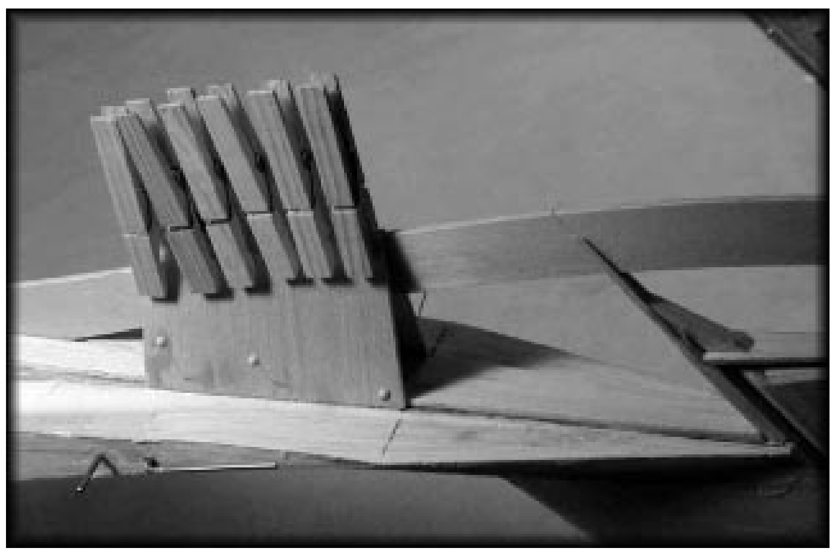

Photo 4: Aileron pushrod.

Vertical fin and rudder

Choice of an airfoil for the vertical fin and rudder was dependent upon the aft fuselage taper and the need for an airfoil which could also be used for the sub-fin. To make the transition from the fin and rudder to the ventral fin easier to configure, we looked for an airfoil with flat sides for most of the aft portion. We selected the BTP8 section from our archives. This section was originally designed for use in model rockets, but in the past has also been used with success for tail surfaces on conventional tailed RC models. We've included a coordinate table for this section along with a low res plot. The maximum thickness point of the BTP8 is just ahead of 20% chord and the surfaces are straight lines from about 30% chord to the trailing edge. The trailing edge lends itself well to sheet balsa construction, as it is very thin and blunt.

Some mathematical skills were required to get the templates for the diagonal ribs printed out, as the percent thickness of these ribs changes slightly along the rib length. We started cutting balsa once we were sure each of the ribs matched the width of the fin trailing edge. Fin construction consisted of blocking the leading and trailing edge off the table and adding ribs at 90 degrees to the spruce fin trailing edge. The base rib was then oriented to match the top of the fuselage and glued into place, as was the end rib. The rough cut tip block was then glued in place.

Rudder construction was fairly straightforward as the entire structure has a triangular cross-section. The forward edge is a square C-shape structure, the trailing edge is simply two sheets of 1/16th balsa laminated to a central core of 1/64th plywood. The triangular rudder ribs were easy to make as all that was needed was the leading edge width and total length.

The tip block was shaped in outline and cross-section, and all exterior surfaces were sanded to accept plastic shrink covering material. You can see the completed fin and rudder, along with the ventral fin discussed next, in Photo 3.

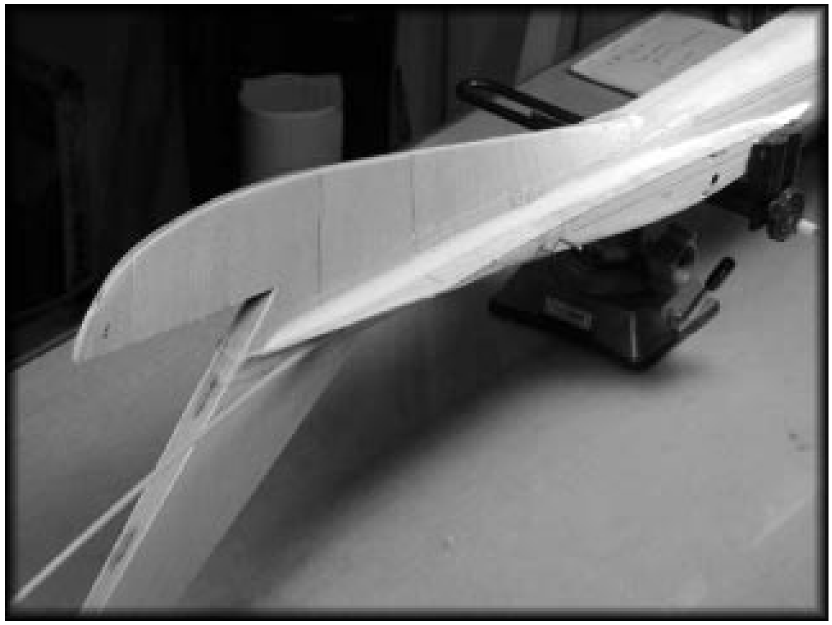
Photo 5: Completed fin and sub fin.

Ventral fin

Because the vertical tail tends to get blanketed when the wing is at higher angles of attack, we've always made sure there is substantial ventral fin area. The ventral fin was designed to drive the wing to below its zero lift angle upon touchdown, preventing ballooning following a bounce. This surface, while of extremely low aspect ratio, must also be able to absorb potentially large side loads which may be imposed during touchdown.

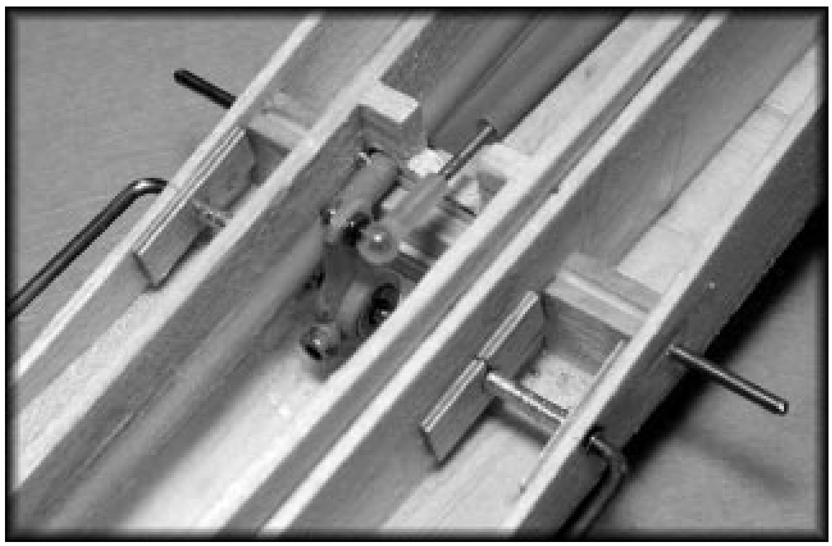
Photo 6: Elevator control system.

The ventral fin core consists of a 1/8th plywood rim mounted on a balsa base rib which maintains the vertical tail airfoil. 1/16th hard balsa sheeting is then edged to match both the base rib and fuselage surface on one edge and create a large gluing surface against the plywood rim. The initial pieces of sheeting must be carefully positioned in order to keep this fin precisely aligned with the fuselage. We used the method shown in Photo 4.

The completed ventral fin, as shown in Photo 5, will eventually receive a layer of one and a half ounce fiberglass along the edge which comes in contact with the ground. Additional 'glass cloth will then be applied to tie the lower portion of the fuselage into the structure and strengthen the balsa sides against those side loads.

Elevator control system

The elevator control system described in Part 2 was installed in the fuselage before the top sheeting was glued on. Photo 6 shows the installed internal system and pushrod. This is a no slop system which is both rigid and free moving.

The elevator halves were cut free of the main wing panels and set aside until the control mechanism was installed in the fuselage. Once we knew where the control arms exited the fuselage, placement of the brass tubes in the elevator was undertaken. This involved taping the elevators to the wing in the neutral position and sliding the wing into position. We marked the elevators using a 48 inch straightedge, then drilled out the ribs by hand to accept the brass tubing receptacles. Some plywood pieces were glued to the balsa ribs and within the trailing edge to spread stresses across larger surfaces.

At the field, the wing slides along the main wing rod a short distance and the elevator drive rods are then inserted into the brass tubing receptacles in the elevators. The servo wiring is plugged in while the gap is relatively large. As the wing is set against the wing-fuselage fillet, the incidence pin plugs into a brass tube in the wing near the elevator hinge line.

The future

Next month's column will focus on the fuselage and the wing-fuselage filleting. A consistent line of questioning at the flying field starts with something like, "How do you shape such a sleek rounded fuselage from a bunch of balsa and plywood?" For this reason, particular attention will be paid to transforming the fuselage from its original primitive square cross-section into a much more aerodynamic shape. Additionally, we'll share some photos of the completed airframe.

Since we're so close to finishing Diva, we're already trying to choose our next construction project. Potential builds include an R-2 enlarged to XC size, a Raven S of either 100 inch span or enlarged to XC, and a Raven FF adapted to RC, but we're open to other suggestions. Go to the RCSoaringDigest Yahoo! group page <http://groups.yahoo.com/group/RCSoaringDigest/> and click on "Polls." Let us know what you think we should tackle next!

Don't forget, we're always available at P.O. Box 975, Olalla WA 98359-0975 or through <bsquared@appleisp.net>.

BTP8

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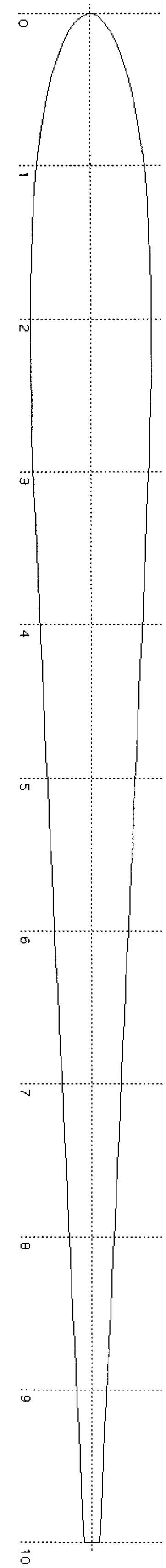

HAVE SAILPLANE, WILL TRAVEL!

The Southern Kite

By Tom H. Nagel
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Troy Lawicki's first place RES Duck.

Trekking to Toledo HSWT Visits the Weak Signals Expo

On March 15th the buzzards return to Hinkley, Ohio. A month later, tax returns are due. In between those dates each year RC fans from all over feel the urge to migrate to the Seagate Convention Centre in Toledo, Ohio for the massive WEAK Signals RC Expo.

The Avenger

This year was the Expo's 50th Anniversary. For RC Sailplaners, the show can be summed up as follows:

50 years
270 commercial vendors
5000 plus attendees
and about 6 sailplanes.

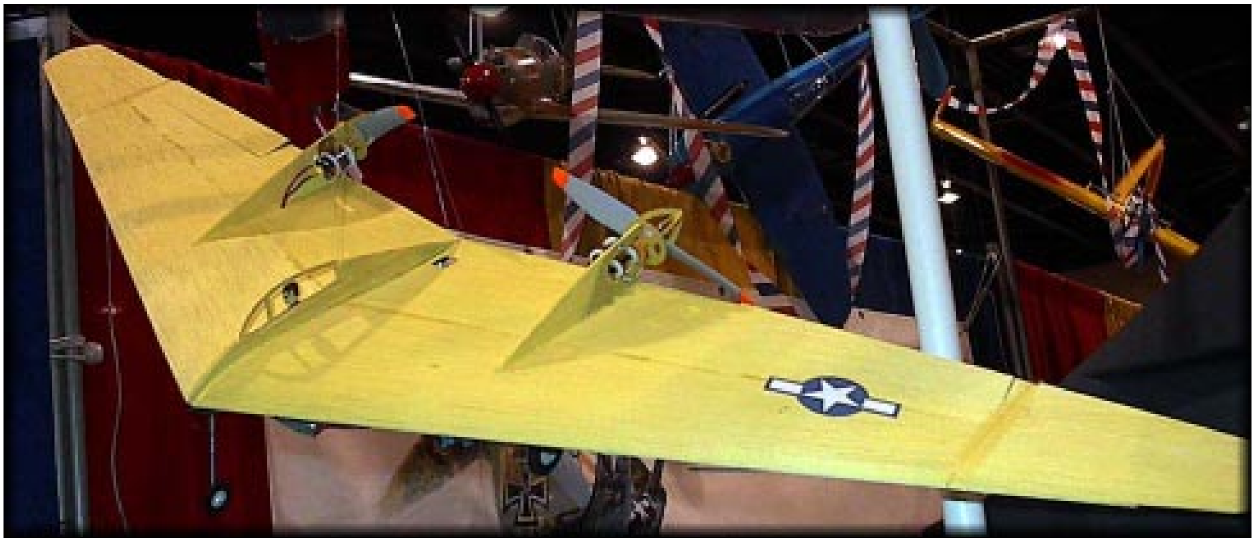
I have been going to Toledo for about ten years. This year I drove up with Don Harris who has been attending since the early 70's. It seemed to both of us that there were fewer sailplanes to be seen than in prior years. On the other hand, The Expo is a gigantic event, and half a Toledo is better than none.

We were both psyched. To me it felt like a combination of Christmas morning and the first day of deer season. Don told me he'd been awake since 3 a.m. "Boy, are we a couple of terminal sailplane geeks or what?" I thought as we headed north from Columbus at 6:30 a.m.

The show opens a 9 a.m.; I have the drive timed so closely that we pulled into the parking garage at 8:58 a.m. We entered through the maze-like swap shop area on the second floor mezzanine. I cruised fairly quickly though the swap shop, but it was still 10:30 a.m. before I even made it to the box office to buy my ticket. (Yes indeed, the swap shop is a free event. You could spend a whole day, even a whole weekend, or a whole IRS refund check in the swap shop and never buy a ticket to the show.

In past years I have ogled many a used sailplane in the swap shop. My acquisitions there have included an

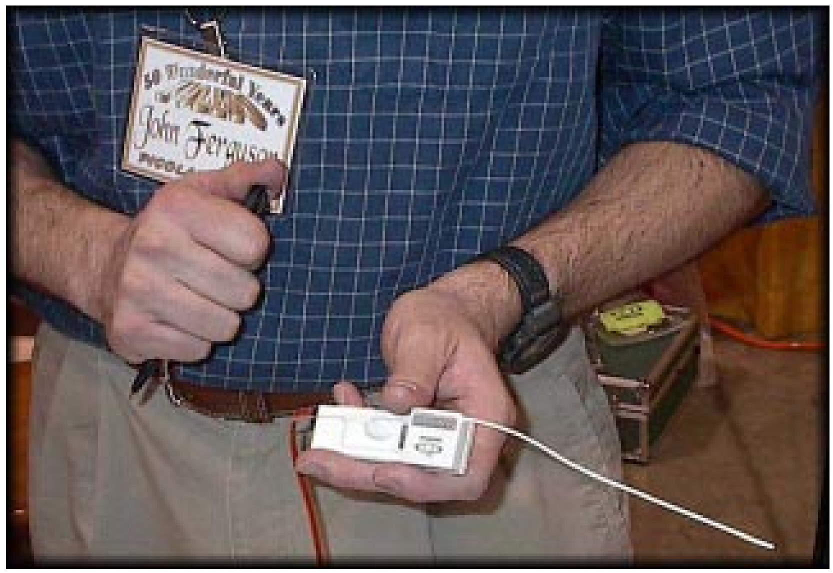
Northrop N9M



DJ Aerotech "Roadkill" scale N9M

original Ken Bates flying wing and a beautifully built 2M Chrysalis by Dave Leach. This year I didn't see a single sailplane in the swap shop.

The guys who make an insanely large line of coroplast and Canadian downspout-pipe power planes did have a short video of a coroplast pterodactyl sloper. (Say that three times real fast!) Check out <www.plasticconceptplanes.com>. They might just have a SPAD sloper. But not at the show.



John Ferguson holding the Picalario module.

I spent a few minutes at the crowded Sky and Technology booth talking to owner Terry Rollins about the new universal synthesized receiver he is marketing. The $75 eight channel unit is claimed to mate with a transmitter of any make and any frequency, and will reject signals from any other transmitter, even on the same frequency. The Sky and Technology receiver has been the subject of a lot of discussion on *RCSE* recently. By 10 a.m. on Saturday, Terry had already run out of all of his literature and even his business cards. He was limiting receiver buyers to "forty per person."

LSF Officers

Also worth a look is Rollins' smaller (8 grams) 7 channel receiver that he sells for $40. It will accept any single conversion crystal and like its big brother lock onto your transmitter to the exclusion of all others until death do it part. This unit is model No. CRX-M7. Check out Sky and

John Gill's 1916 Burgess-Dunne flying wing seaplane

Technology's website at <www.4mht.com>.

When I finally worked my way down to the jam packed main floor, my first destination was the League of Silent Flight booth. The new LSF officers were there to greet folks and pass out vouchers and distribute *RCSD's* "Getting Started in RC Soaring" pamphlet. Pictured are Tom Kallevang, President; Larry Storie, VP; Jim Deck, Secretary; and Steve Siebenaler, Treasurer. Outgoing Pres. Jack Strother and Princess Monokote were also at the show Saturday, but had the freedom to roam the convention center for a change.

In the booth next door John Ferguson was demonstrating the Picolario vario. For those of you who have not seen a picture of that tiny device, here it is. Ferguson and Picolario are working on upgrade modules, which will eventually enable the Picolario to read out speed, current draw, voltage, temperature and other variables.

The Evolution on display at the Picolario booth and the plane in the LSF booth were two of the very few sailplanes on display. Tower Hobbies had a Bird of Time ARF in their area but no kits to sell. Northeast Sailplane had a 12-servo scale monster on a rotating display, and it looked to

Tom Skully's K-8 (Mark Gellart
and Seve Sibenaler inspecting it).

be a DLG with a built-up wing. I think Sal should have gotten a special award for either "sailplane requiring the most servos" or "commercial booth with Sailplane in its name but almost no sailplanes."

Mr. Sobox was there with a beautiful electric sailplane on display, but apparently no kits to sell. Other than a few Zagis at Jerry Tiesan's booth, that was it for sailplanes in the commercial area.

Missing this year were Skybench Aero, Gordy and Volz, Denny Maize and Polecat Aero, M & M Modeltech, Dymond and many others. I have a theory:

The Weak Signals Expo features a large static display contest. The contest categories are sort of arcane:

military scale boat

designer scale plane
working vessel unarmed
non-military sport scale
best unarmed forklift
best small sport steam powered
ornithopter
and so forth.

For all the categories you can check the Expo's website <www.toledoshow.com>. Sailplanes are waaaaaaay at the bottom. I think one of the problems is that the WEAK Signals folks lump all the sailplanes together in one category. We need to lobby for more categories, like the power folks have done:

Best Thermal Duration
Best Thermal Scale Sailplane
Best Power Scale Sloper
Best Woodcrafter Sailplane
Prettiest Foamy
Prettiest Mantis
Tom Skully Model of the Year

NSP's 12 servo monster.

Let's get to work on the Weak Signals folks and see if we can't get them to give us more niches to fill!

The sailplane entries this year were:

Troy Lawicki's 118" RES Duck, which won the sailplane category. The Duck was beautifully finished with molded in spoiler hinges and a nice orange sauce.

Tom Skully's 148" Scale K-8 from a Flair kit. Tom won second place. He has carried away first place at Toledo for several years with a series of beautiful models. The K-8 had pull-pull controls on both rudder and elevator. Late in the day I saw an elderly gentleman with a big grin on his face and a Flair K-8 kit on his shoulder, heading for the parking garage. I wonder where he got the idea.

Ed Wilson entered the Southern Kite, which is both NOS and RES legal. This was another unusual entry, which got a lot of attention from glider pilots. It won third in the sailplane category.

John Wolf entered a nubblie nosed Avenger.

John Diniz entered a Tragi Limited.

And Dale Corven showed a Sharon RES.

Due to the dearth of sailplanes at Toledo, I decided to send along some flying wing photos for Bill and Bunny Kuhlman. The giant semi-scale Northrop N9M spans twelve feet and nine inches and is powered by two OS .46 engines with 17" propeller shafts. One of the engines is custom made to counter rotate. The plane weighs 16 pounds. The airfoil is an Eppler 334. Aircraft design was done using Compufoil and Designer CAP. Leading edge sweep is 22 degrees and twist is 4 degrees. Two little electric GWS ducted fan units are tucked into the air intakes to keep the gas engines cooled while the plane is ground maneuvered.

DJ Aerotech, formerly sailplane manufacturers and currently providers of fine Roadkill electric models, were showing their own profile scale N9M. Don Stackhouse showed me how the prototype N9M features nose wheel steering and flies on rudder and elevator controls, with no mixing required. The production version will likely sport split wingtip drag rudders just like the full sized Northrop wing.

A beautiful scale model of an early biplane flying wing was also entered in the competition. My photos do not do justice to the beautifully detailed woodworking and engine detailing.

Don and I headed home late in the afternoon, foot weary, lugging bags of batteries, magazines and assorted goodies. We'd seen lots of friends and met lots of new folks and we'd gotten our RC fix for the week. And there is hope for sailplanes at the Weak Signals Expo. This week gas prices hit a record level of $1.80 per gallon. Who knows? By next year, we may be the only ones who can afford to fly!

• • •

GORDY'S TRAVELS

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All Mixed up!
V tails Aren't Always
- Flaps can be Ailerons

V-tail, Flaperon, Spoileron, Rudder/Aileron Mix, Elevator to Flap, Flap to Elevator, Elevator Compensation, Multi-Point Elevator Compensation Mix, and Differential are terms we see in the menus of our transmitter and hear about all the time, but may seldom understand.

In this article I intend to debunk the mystique behind these terms! It's important for Thermal Duration competition pilots to have a clear understanding of every single component of their sailplanes. Currently it's not unusual for the average thermal competition RC sailplane pilot to have closer to $2,000 in his model rather than $1,000. It just doesn't make sense to possess that amazing capability without optimizing its set ups.

So begins this trip!

While on a recent trip to Houston, Texas, I was presented with the challenge of using a Stylus TX for a V-tail RES Kummerow Searcher.

The owner couldn't understand why he was having trouble getting the TX to work his plane. He had engaged the 'V-tail' mix, and got elevator working properly on both halves of the V tail, but couldn't get his right stick (aileron) to work the rudder function.

It was interesting that he knew the names of the functions but couldn't seem to separate them in his mind from which transmitter stick should be operating them.

If you have a sailplane with a V shaped tail group and no ailerons, V tail function is NOT the function you want to engage. You say, "Come on Gordy, you're way off on this one!" But in fact I am not.

The rear of the plane has two components: V shaped or cross tailed. Those functions are Rudder and Elevator. Seems pretty simple right? So then why the confusion?

Let me state their names again: Rudder and Elevator. The combined name for this set up is Rudder-vator, a combination of Rudder and Elevator, and it's that function (Rudder-vator) that is engaged when using the "V-Tail" mix on all transmitters, since the beginning of time.

The confusion comes into play when we forget that a V Tail is Rudder and Elevator, which is controlled by ALL transmitters, using the Left stick (side to side) to operate Rudder and the Right stick to operate Elevator. No one I've met uses two sticks to operate sailplanes with only those functions.

They use the Right stick (up and down) to operate elevator, and also use the Right stick to operate the 'rudder'.

However, the right stick is the Aileron Function. So a two channel sailplane outfitted with a V-shaped tail group is actually a combination of Aileron and Elevator functions. This is commonly referred to as Aile-vators, and they provide the exact same functions as Elevons, Elevator and Ailerons, mixed for use on tail-less sailplanes such as the Zagi type wings.

Right stick & Right TRIMS.

I was telling this story to a local club mate who has been at this hobby a lot longer than I have been and, not so surprisingly, he told me that one of our members was using the V-tail Mix function on his Stylus and it was working fine! I tried to clarify that, while he had the V-tail Mix turned on, he was actually only 'sort of' making it work.

By using the Rudder to Aileron Mix function in combination with the V-tail Mix, he was allowed to use the Right stick to operate his Rudder-vators as if they were Aile-vators. However, while he could certainly 'fly' his V-tailed RES ship that way, using only the Right stick, in fact his Rudder Trim was the only way to trim his V-tail.

That was because he was actually using the Rudder channel, not the Aileron channel.

So here are the V-tail definitions again:

V-tail – A V-shaped tail group.

Rudder –Vator – a mix combination of Rudder function and Elevator function which, on the Transmitter, means the left stick and right stick are mixed, the functions mixed when engaging the "V-Tail" mix in your transmitter.

Aile-Vator – a mix combination of Aileron and Elevator, both functions located on the Right stick.

So if you have a RES sailplane with a V-tail, you will want to have both functions on the Right stick. To do this, you need to engage the Elevon Mix function, sometimes called Delta Wing Mix, so that your Aile-vators work properly and your trims are both on their correct locations.

But, IF you have a full house ship with a V shaped tail group, that is ailerons, elevator, rudder and flaps, then "V-tail' Mix Function (Rudder-Vators) is the correct function, putting the V-tail's operation on the Rudder stick and on the elevator stick, with ailerons working on the Right stick.

Ailerons used to act as Flaps, or to act as Spoilers is another commonly mis-represented or mis-understood function.

Spoilers work differently than Flaps. Flaps provide lift through cambering the wing; Spoilers reduce lift by flattening the airfoil on top. When ailerons are used to assist the lift capability of the wing, this function is called "Flaperons." That's when both ailerons are used (full span, no separate flaps) to create lift or drag by setting them down to add undercamber to the wing.

Flaperons deployed characteristically cause the model to balloon its nose upwards because of the added lift they create.

Spoilerons on the other hand, uncamber the wing, reducing lift and characteristically when deployed usually cause the model's nose to drop as the wing has less ability to 'lift' its own weight much less the entire airframe.

So Flaperons (mixing flaps for added wing camber with the aileron function) cause the model to balloon upwards and Spoilerons cause the model to drop. The idea of mixing ailerons with flap or spoiler is to avoid using two more servos, and having two separate flaps or spoilers.

Full house ships DO use a modified version of Spoilerons and Flaperons when flaps and ailerons are mixed to move together. In that case the ailerons are put to work helping create lift (Flaperons) and the flaps are put to work as added aileron length. When the ailerons are used as 'Spoilerons' along with the flaps, the function is mostly considered Reflex, the idea not so much used for landing assist, but rather to clean up the drag of the airfoil for improved penetration when returning from downwind.

Our sailplane functions are simple and sometimes that makes them confusing. But just remember that Rudder is on the left stick and aileron is on the right stick. V-tail function is a mixing of Rudder Stick and Elevator stick, not a mixing of the aileron stick and the elevator stick.

So while your sailplane's tail may be V-shaped, it is likely not being used as a conventional "V-tail," Rudder/elevator, but rather it may be set up as an Aile-vator.

IF you don't take time to clearly understand your sailplane's actual functions and how they are controlled from the TX, you'll never be good at hitting a spot landing or likely not making your task time.

SO if your TX doesn't have Elevon, Delta, or Aile-Vator function, what to do? Well, you can use the V-tail function and then use the Rudder to Aileron Mix function. Or you can get an electronic two channel mixer which would allow you plug in and have the mixing done electronically.

Rudder Aileron Mix - why?

First, use it because you paid for it when you bought your transmitter! Next, because when you want to 'turn' your sailplane using only aileron, various things cause your sailplane to roll, but not axially. Instead it's likely that the fuselage will angle upwards, so that the nose is diagonal to the ground - nose attempting to go upwards.

That means that the energy your sailplane has will be dissipated in its attempt to drive upwards on that diagonal, when in fact you want all the energy going around thru the *turn*. (Hope that makes some sense.)

You always hear about making 'coordinated turns' which, if perfect, would be like a train riding on rails thru a turn, versus you hopping on one leg through a turn. One is very efficient and one isn't.

By initiating some rudder command it gets the nose of the plane moving 'around' instead of around and up. So, how much mix should you use? Most say set the mix at about 50%, but with a little in flight experimenting you can actually dial in the 'right' amount. Remember if, without rudder used in the turn (non-coordinated), your model angles up and around, and a perfect turn (coordinated) would be one that has the fuse coming around parallel to the ground, too much Rudder Mix would make the turn 'un-coordinated' or the fuse nose would angle down and around. Again your goal is to roll the sailplane into a bank without a change in pitch (nose up or down).

Elevator to Flap

First read that phrase out loud to yourself and identify which of the two is the 'boss'. In this case Elevator is being tied to the OPERATION of the Flap. So Flap is the boss. When the flap is moved down, the Elevator can be mixed in to keep the model from either ballooning or diving. Since the first phases of down flap cause increased wing camber (lift strength), that causes the front of the plane to pitch upwards. But mostly it causes the wing to have more DRAG. Think in terms of a passenger jet landing; the flaps go way down, drag is dramatically increased so the pilot pours on the throttle to keep the plane moving ahead versus stalling. He also puts in some down elevator. This keeps the plane in the flight attitude he wants and moving forward.

Since our sailplanes don't have throttles to add more thrust we have to rely on gravity to increase or maintain our 'power' - that's down elevator. So it makes sense to use in flight camber to make the sailplane a little floatier in light lift. Or, for strong lift, dial in a little down elevator.

So how much is enough? Again this is a pretty simple common sense evaluation. While flying, our goal should be to maintain a uniform airspeed while flying thermals. No diving and climbing through the circle, which creates airspeed increases and masks the ability to read air conditions.

Fly the sailplane level with just enough up trim to maintain a flat (flat does not mean a diagonal glide to the ground!) hands off glide. Move the flap to camber to the desired amount and see what effect it has on the model's attitude and speed. If you notice the model pitches up, or slows noticeably, dial in some down Elevator to Flap mixing.

Flap to Elevator

Who's the boss here? Same as before, one being tied to the other. In this case it's the Flap that is being slaved to the Elevator. Why? This function allows the pilot to 'help' the sailplane make its movements (turns) in a more efficient format and allows the pilot to 'cheat' some by cambering the wing slightly to assist the nose and model in general in its climb during a thermal turn without babysitting the elevator during the turn. This function became popular during slope racing, as it shortens the radius of the turn without burning off as much airspeed as horsing the elevator did. Often referred to as 'pump' or 'snap flap.' Flap to Elevator combines lift with pitch.

How much is enough? This one is a lot trickier, but keep this single thought in mind. The more you camber the wing, the more drag you create; the more drag you create the slower your model flies; the slower your model flies, the more it sinks. So 1/8" to 3/16" full deflection is about the limit. This is one worth 'playing' with.

Elevator Compensation Mix

This function is usually used as a device during landing. It gives the pilot the ability to hold the model on a level plain with either the deployment of lift killing devices such as Spoilers/Spoilerons or reflex, which cause the sailplane to drop its nose by automatically feeding in up elevator in degrees as those devices are deployed. Or to keep the sailplane from pitching up by feeding in down elevator in degrees with the deployment of Flaps, Flaperons or camber. This one is a big deal and is important to get right. Again, the goal is to have the sailplane maintain its glide path angle without pitching up or down as either is deployed, regardless of airspeed changes. So if you have too much or too little elevator compensation dialed in, as your Spoilers or flaps are deployed, simply remove or add some elevator compensation in until the model stays on path regardless of how much of either you have in at any point in deployment.

Multi-Point Elevator Compensation Mix

Think about it. For this explanation I will talk about Flaps, but the same logic applies to the use of Spoilers.

In the initial stages of deploying landing Flap to slow the sailplane's decent down, the wing's ability to create lift is greatly increased; since this happens usually with fairly high airspeed, it's likely that the sailplane's nose will want to pitch up. But as the Flap continues downward, changing from camber to just drag, and since added lift dissipates (both because of less camber and because declining airspeed), less down elevator is needed at full landing flap deployment.

So with most sailplanes, if you have enough down elevator to counteract the pitching caused by the camber, then you'll likely have too much for when the sailplane slows with full flap, causing the sailplane to be diving with full landing flap deployment. Multi-Point Elevator Compensation Mix allows the pilot to have an automatic adjustment or relationship to the flap stick position, providing lots of down elevator on the first part of the stick and less at the end, all toward the goal of keeping the sailplane on a consistent glide path.

Differential

I hope you've been following my articles in recent past editions because I have gone into the importance of understanding the use of aileron Differential. This is another one of those settings often dismissed with, "Set it at about 50% less down than up aileron." When in fact it really is a very important contributor to the efficiency and value of the whole sailplane's performance that you paid all that money for! When one aileron is deflected down, it creates both lift and drag; the lift part is good, but the drag part is bad. It causes the oh-so-dreaded 'adverse yaw.' Simply put, if you wanted to 'turn' right, that adverse yaw would drag the sailplane's left wing back, causing it to yaw (turn) left when you were hoping to yaw (turn) right. It's an energy killer for sure.

How much is enough? While flying the sailplane in calm conditions, trimmed for easy hands off flat and level flight (rudder/aileron mix OFF!), simply rock the aileron stick extremely quick back and forth; take care not to mix elevator stick movements into this experiment. IF you have too much or too little differential, the model will WIGGLE its tail while you move the stick, versus staying straight on path. Then if you have the Aileron Differential set just right, the sailplane's roll should be axial, not barrel looking.

We pay big bucks for a Transmitter that gives us capabilities; it's up to us to get our money's worth from them. Sailplanes are all about energy, making the best possible use of the energy outside our models (versus from a motor).

Take some time to travel the Mixing 'road', one leg at a time. Think about each item and then go out and experiment in the sky with the TX settings. However, if you have that little bit of extra nose weight (for extra stability), don't expect any of the above to be easy. Figuring mixing, starting with a crooked sailplane, is a challenge.

So go back to my article on balance "Gordy's Balancing System." Get the sailplane balanced, and not by measuring some spot as the sailplane teeters on some pegs on the bench! Balancing a sailplane can only be done where it 'works' - in the air! Then have fun with Mixing!

Hope you enjoyed this trip!

AMA Safety Committee Announcement
April 23rd, 2004

EMERGENCY SAFETY ALERT
Lithium Battery Hazard
From AMA Safety Committee

Lithium Battery Fires

Lithium batteries are becoming very popular for powering the control and power systems in our models. This is true because of their very high energy density (amp-hrs/wt. ratio) compared to NiCads or other batteries. With high energy comes increased risk in their use. The, principal, risk is FIRE which can result from improper charging, crash damage, or shorting the batteries. All vendors of these batteries warn their customers of this danger and recommend extreme caution in their use. In spite of this many fires have occurred as a result of the use of Lithium Polymer batteries, resulting in loss of models, automobiles, and other property. Homes and garages and workshops have also burned. A lithium battery fire is very hot (several thousand degrees) and is an excellent initiator for ancillary (resulting) fires. Fire occurs due to contact between Lithium and oxygen in the air. It does not need any other source of ignition, or fuel to start, and burns almost explosively.

These batteries must be used in a manner that precludes ancillary fire. The following is recommended:

1. Store, and charge, in a fireproof container; never in your model.

2. Charge in a protected area devoid of combustibles. Always stand watch over the charging process. Never leave the charging process unattended.

3. In the event of damage from crashes, etc., carefully remove to a safe place for at least a half hour to observe. Physically damaged cells could erupt into flame, and, after sufficient time to ensure safety, should be discarded in accordance with the instructions which came with the batteries. Never attempt to charge a cell with physical damage, regardless of how slight.

4. Always use chargers designed for the specific purpose, preferably having a fixed setting for your particular pack. Many fires occur in using selectable/adjustable chargers improperly set. Never attempt to charge Lithium cells with a charger which is not, specifically, designed for charging Lithium cells. Never use chargers designed for Nickel Cadmium batteries.

5. Use charging systems that monitor and control the charge state of each cell in the pack. Unbalanced cells can lead to disaster if it permits overcharge of a single cell in the pack. If the batteries show any sign of swelling, discontinue charging, and remove them to a safe place outside as they could erupt into flames.

6. Most important: NEVER PLUG IN A BATTERY AND LEAVE IT TO CHARGE UNATTENDED OVERNIGHT. Serious fires have resulted from this practice.

7. Do not attempt to make your own battery packs from individual cells.

These batteries CANNOT be handled and charged casually such as has been the practice for years with other types of batteries. The consequence of this practice can be very serious resulting in major property damage and/or personal harm.

The Natural Side of Thermal Soaring *by Lee Murray*

Now that RCSD is in color, some of the information I have previously communicated can be shown and described more effectively than before. The particular example is from the first day of club soaring at the Anderson Sod Farm in Appleton, WI where the silent flight group of the Valley Aero Modelers calls home. We also have a wet-power field where fliers seem to like the short cut grass that helps them get airborne more easily.

This first day is usually a day to shake out the "kinks" from the equipment and skills that have been dormant over the ice fishing season. This year's opener was certainly exciting, although not as many people showed up as expected. The threat of strong thunderstorms across the Midwest was probably a factor. If you have been reading this column, have been educated in "weatherman" language, or know about the physics of thermal soaring, you probably associated the warning of strong thunderstorms with an unstable atmosphere and a high lapse rate. I'll admit that I didn't do the thermal analysis on this before going flying. I knew that this was the day to test the repaired 2M RES Prodigy that I damaged last summer. The conditions were excellent and I'm taking this as another lesson in using lapse rate data.

After a successful hand toss, it was off to the winch, to check out the transmitter mixer settings between the spoilers and the elevator. The second flight was 10 minutes and the third flight 20 minutes, before the Vision transmitter let me know that the transmitter battery was dying by giving the beep, beep, beep sound. This was scary because I had just skied it out for the third time that flight. I did get it down in time – thank heavens. Bob Johnson was having similar success with his Majestic and Tom Rodgers also with his electric Eclipse. The Internet chatter on RCSE carried stories of the Chicago club having what they called a "big air day". So what did the government lapse rate tell us about that day?

I used the following link to get my atmospheric data from the Internet http://raob.fsl.noaa.gov. There I filled in the blanks as follows:

I. Input Dates: (UTC units)

From: yr 2004 mo 4 dy 18 hr 12

Thru: yr 2004 mo 4 dy 18 hr 17

II. Sounding Specific Information

Hours of access: All Times ***Data levels:*** All Levels

Wind Units: Knots

III. Select Stations / Data

Select Radiosonde Sites by: State

From this screen select proceed and select the state where you live or soar from.

IV. Access by State

Note: Use your left mouse button to select states

AK = ALASKA
AL = ALABAMA
AR = ARKANSAS
AZ = ARIZONA
CA = CALIFORNIA

`I selected WI = WISCONSIN here`

View / select stations from the states you have selected? NO Select YES

V. Select Output Options

Sort Order: Station Series Sort

Note: We now offer a new FSL output format, and a skewt display format.

Format: FSL format (ASCII text)

Again click on "Continue Data Access"

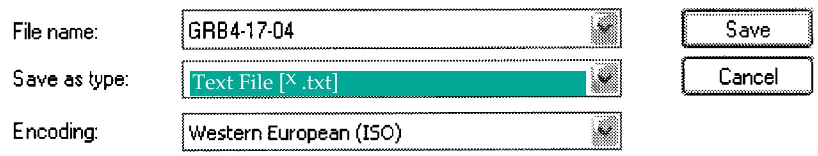
The data will appear in text file format in the browser window as shown below. The file is not being shown in its full length. (the 99999 code means missing data)

```
254      12      18      APR    2004
      1  14898   72645   44.48N 88.13W   210   99999
      2    300    1730    1850     76  99999       3
      3            GRB                      51      kt
      9   9890     210     106     93     80      10
      4  10000     124   99999  99999  99999   99999
      6   9778     304   99999  99999     75      14
      5   9510     534      94  99999  99999   99999
      6   9424     609   99999  99999     65      26
      5   9290     728     114    106  99999   99999
      4   9250     774     116    108     70      18
      5   9140     873     116    109  99999   99999
      6   9095     914   99999  99999     75      15
      5   9000    1001     120     60  99999   99999
....
```

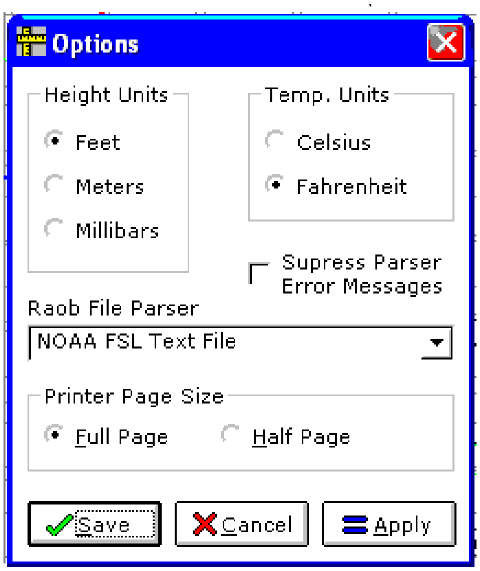
Save the data by going to your pull-down menu bar: **File / Save As...**

Enter a file name that you will recognize such as the Site Location and Date, e.g. GRB4-17-04

Enter the file type as TEXT and encoding as Western European (ISO)



I am using Soarcast that I downloaded from the thermal soaring part of the Harvard University - SSA web page (http://acro.harvard.edu/SOARING/ssa_programs.html). When you have the file set up, you need to make some settings in Soarcast. Go to the Tool menu and select options. Select the options as follows:



Soarcast shows the lapse rate data and the wet and dry adiabatic lines allowing you to predict how high you can climb your model and how fast it is possible to climb. The plot is shown below.

There is lots of information on this chart, including wind direction and velocity by altitude. An explanation will be saved for another article. However the Blue, Red and Green lines are what we most want to know about. The X-axis is in deg F. and the Y-axis is the altitude in Feet. The chart notes a trigger temperature of 66°F. This is the temperature at which thermals are possible for full size gliders.

The green line predicts the temperature of air parcels that rises to various altitudes starting from the ground at the 70°F maximum ground air temperature for the day. As long as the green line is to the right of the red line, the air parcel will continue to rise. The slope of the green line and other diagonal lines is the dry adiabatic lapse rate, -10° C/ 1,000 m (-5.5° F/1,000) feet of altitude[1].

The dry adiabatic lapse rate describes how a parcel of air, if completely isolated from its surrounding air, will change temperature as it rises from ground through the atmosphere. So air at 70 degrees will be lighter than air above and can rise as a thermal. The air will rise at some

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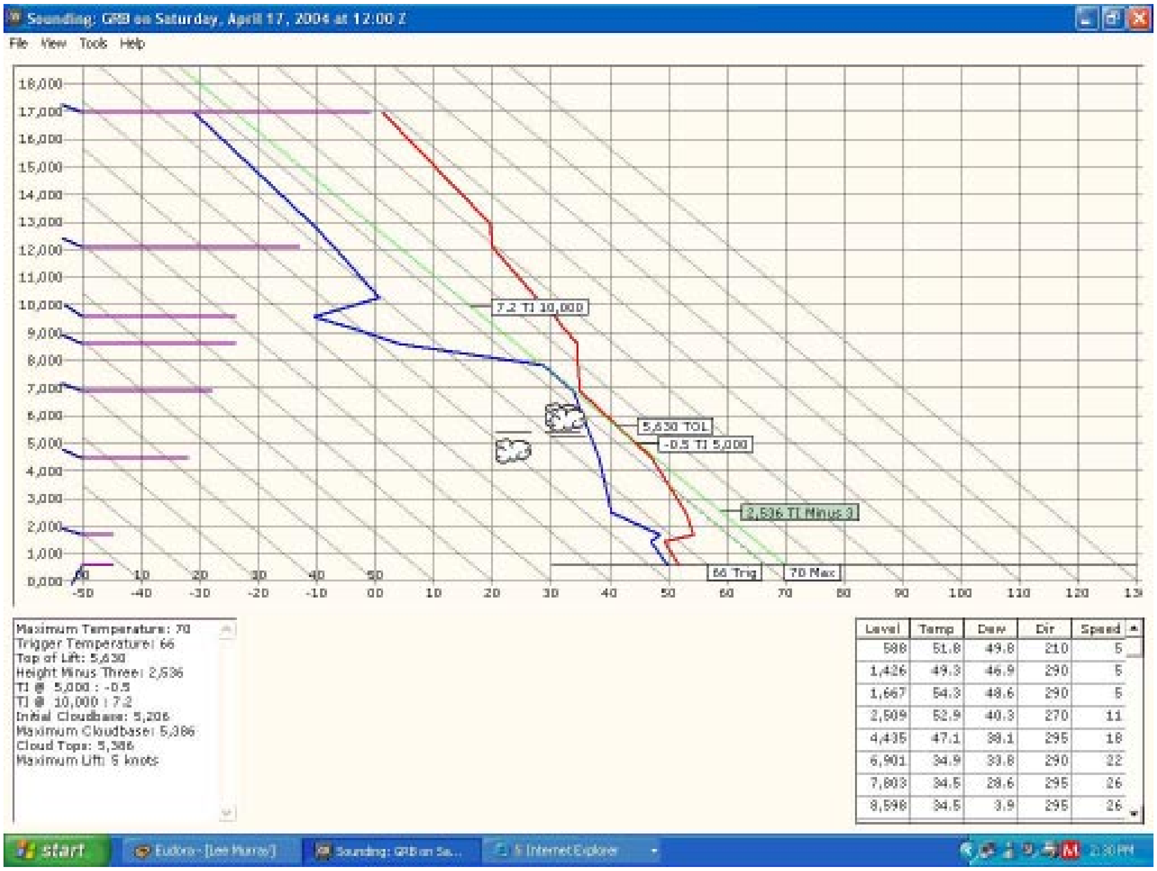
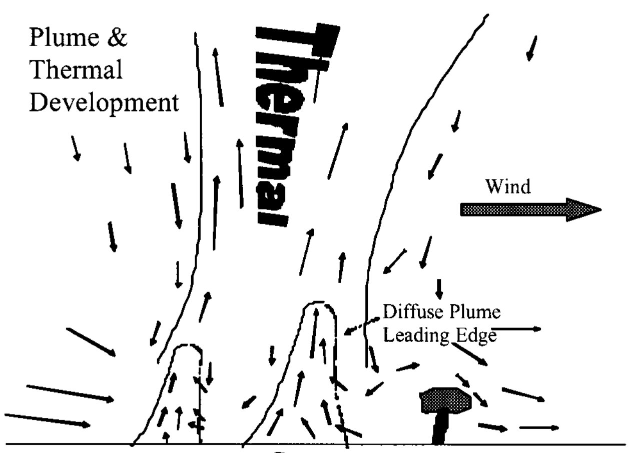
[1] Pagen, Dennis, Understanding the Sky - a sports pilot's guide to flying conditions 1st. Edition, 1992 by Dennis Pagen, page 14



point on the ground such as a tree line, building, ridge or just a hot surface. It will first rise as a plume and then potentially organize with other plumes rising at the same time into a thermal. The thermals don't rise forever, but meet a layer of air that is as warm. This is often the cloud base (also the dew point of the air packet). In cases where the air with condensed moisture is still warmer than the surrounding air, a cumulonimbus cloud is formed.



I apologize if I have covered too much ground here in one article. The lapse rate model for instability and thermals is not easily understood on first reading. Feel free to e-mail me for more explanations[2].

Lee Murray
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[2] Lee Murray, *RC Soaring Digest*, Vol 18, No. 12, Dec 2001, The Natural Side of Soaring, page 16

THE WINCH SCENE

New Winches
– A Club Project

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The Rocky Mountain Soaring Association has been a chartered AMA club since 1976. Though it seemed like the winches were that old as well, the reality is that the club built the current 5 winches that we use starting back in the late 80s. You can see some of the various versions in Photo 1. Last year a long-time club member, Mark Howard, donated a trailer he had to the club for the transport of the winches to and from our contests. In the past the club winches were allocated to willing (or unwilling) volunteers who took then home and were responsible for getting them to the contests. This was always a headache for the CD who had to call all the winch masters and ensure that they were going to attend the contest or arrange for the transport to the contest if they were not. The trailer simplified this process, one member stores the trailer and either brings it to the contest or arranges some other member to bring it. All of the stuff necessary for running our contests is in the trailer – frequency pins, landing tapes, scoring equipment, tables, chairs, etc. The only thing missing is the computer.

We have a process where, once the winch master brings the trailer, we randomly select 6 pilots at the contest to be "Winch Master for a Day." These pilots are responsible for setting up and tearing down the winches, and reloading them into the trailer. This was always painful, since the existing winches were difficult to set up, the wheels needed to be removed before use, each winch was different and subsequently we often had equipment problems because the winch masters were unfamiliar

Photo 1. Old Winches Before Disassembly

Photo 2. Handle Attachment Cut-out (The hole on top is the stake-down hole, and the ring on the side is to attach the handle pin when not in use.)

Photo 3. Bare Frame After Powder Coating

with each winch setup. We record who did the duties, and at the next contest we select only from those pilots that have not yet been a winch master. When everyone has had the "opportunity" – we start the list over.

Based on the need to reduce weight and the desire to have smaller, easier, and consistent to set up winches, we decided to build all new winches over the winter. I took the lead in preparing the design for the winches and researched a number of existing designs. None of the commercial designs really fit our need to have a wheeled frame to drag into the sod farm that prohibits motorized vehicles, so I decided to create a new design. The new design goals were:

1. Be light and compact.
2. Easy to set up – just stake it in.
3. Integrated storage for the handle so we don't have them bouncing around separately.
4. Wheels big enough to pull easily thru the sod.
5. Robust brake arms. (We break a lot of these on the current winches.)
6. Enough extra parts and tools to field repair any mechanical failures.

Making measurements, I designed the smallest frame that would hold all the components, then went to Home Depot and bought enough steel to fabricate one prototype frame. Most of the prototype components were easy to get with a few exceptions. The .25" thick steel vertical motor mount needed to be cut a specific size with a 2.125 round cutout for the motor, so I went to a welding shop with a plasma cutter and gave them the dimensions and 3 days later had a nice mounting plate. The other pieces that were difficult were the brake arm components. For this I contacted the local aluminum supplier and had him cut some rectangular aluminum stock 1.5" x .5" x 7" for the basic arm, and some 1" diameter aluminum cylinder for the belt hold down. With some help from the neighbor and his MIG welder we welded all the pieces together and had a basic frame complete. It's a good thing it was a prototype! Assembling the components showed that I was too aggressive on cutting the size down. It was a real challenge to get everything mounted. I got some wheels from the farm store, and we were ready to rock.

Photo 4. Completed Winch – Note the handle slides into the receiver for compact storage.

Photo 5. Front View – You can see the rubber band used for belt tension to the bolt on the brake arm.

After about 1 month of near daily use, I looked for what changes would be necessary for the production winches. First the shape of the vertical motor mounting plate was changed to allow more space for the components. The handle attachment point was also redone. The prototype showed some side to side bending from the way the handle attached. This was cured by making the cutout smaller, thus stronger, and by using a fitted hitch pin to transfer the side loads better. See the handle cutout picture in Photo 2. The frame itself was also widened about 1 inch to allow more room for the tools box to be attached. With these changed the design met our requirements. I built one more prototype and documented the build and assembly process, then it was time for the production build.

Photo 6. Winch with Handle Extended

We decided to do the build in two stages. Day 1 we would cut and weld all the parts together, clean up the frames and then send them out to be powder coated. We decided that we would build 8 complete frames with 2 being kept for expansion and the 6 completely built out for our contests. After the frames returned from powder coating we would disassemble the old winches and assemble the new ones.

I made a parts list and ordered all the steel to be cut. Instead of Home Depot, I found the parts to be much cheaper at the local industrial steel shop. They also cut the 8.25” steel mounting plates. Member Charlie Miller donated the use of his auto repair shop one day while it was closed to do the work. This was great, since we had plenty of room, workbenches, vices and any tools that we forgot to bring. We got everyone that showed up working, cutting metal, sanding, polishing, drilling, etc. Dr. Dan Williams, and Mark Howard volunteered to do the welding and they did a great job. Their first job was to weld up a jig that we used to hold the components together while they welded the corners. This worked great and all the frames came out level and true. As they finished welding, the cutters gave them new components while other folks took the frames and cleaned up the welds. After about 6 hours we had 8 new frames and handles ready to go to powder coating. It was amazing how well everyone worked together to get them to this point. I took all 8 frames to the powder coater the next day and in one week they were done and BEAUTIFUL. The finished unassembled frames are shown in Photo 3.

Now it was time to schedule final assembly, again at Charlie’s Garage. A mostly new crew showed up for this operation. One incentive was that we would give the old frames to any member that came to help, first come, first serve. So we began by disassembling the old winches; we basically salvaged the motors, drums, power switches, and everything else was new. I brought all the nuts, bolts, solenoids, switch wiring and a written set of assembly instructions to get things going. Charlie had pre-assembled all the wiring using #2 welding wire, and soldering on nice connectors on the ends. Don Ingram predrilled all of the brake components, so they were also ready to assemble.

I took everyone that came, divided them up into teams of 2, each assigned the task of disassembling – then assembling one winch. Although the instructions were pretty good, there were definitely some things I overlooked and some components were assembled a couple of times. The good thing is that the prototype was there as a model for everyone to look at. There were really only two significant issues encountered during the assembly. First, although I used on of the switches as a model for the prototype, it was discovered that the mounting plates were slightly different on each of the other winches which

Photo 7. The Loaded Winch Trailer

made for some fiddly work getting the switches mounted. Second, the drum brakes seemed to have some loose screws holding them on, but when we tightened the screws we could not get the drums on the motor shaft. After much consternation we finally used an air grinder to ream out the inside of the brake shaft to get the clearance we needed with the bolts tight. After about 6 hours we had a great looking set of club winches. Winch details are shown in Photos 4-6. We lost a total of 150 pounds of weight that greatly helped the trailer. The 6 winches loaded in the trailer are shown in Photo 7.

This was a great club effort, where the rewards were first reaped in March at our first contest. The new winches set up and tear down quickly, and operated near flawlessly. The 'near flawlessly' is tempered by a couple of backlashes due to the new brake belts which, until they get broken in, tend not to be as effective as normal. To solve this problem we simply put a rubber band on the brake arm to give it more tension. By the end of the contest the bands were not needed any more.

The total cost for building 6 complete winches and 2 backup frames was about $1200 (including 5 new Linemaster pedals). Note that this did not include motor, drum, or power switches which were reused, but did include the costs for the prototypes. The club is very happy with this investment of approximately $200 per winch and 2 spare frames for expansion.

Thanks go out to all the club members that supported this effort; they are too numerous to mention, but all the club members appreciate their involvement.

• • •

Last year, we received a simple e-mail request:

"I'm trying to find a place to buy a sailplane winch without much luck, could you please help?"

That request which was answered behind the scenes and Mike Garton's recent column in the May 2004 issue of *Model Aviation*, triggered a series of e-mail messages among the authors and columnists of *RCSD*.

The outcome was the creation of a new column called "The Winch Scene." It will pick up where Mike's column left off, providing more detail where it's available.

We encourage anyone who has a hint, tip, photo or suggestion on the subject of winches to send it to <RCSDigest@aol.com>.

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Airfoils, Planforms, and Twist

Mark Drela

Chris Adams writes:
I am trying to understand the reasons for changing camber as one progresses from the root to the tip on small wings. Can anyone tell me more about the lower camber at the tip and whether this induces effective washout on the wing?

Answer:

There are numerous airfoil/planform/twist conflicts between the following requirements:

1) Good penetration L/D or good handlaunch height. This wants all spanwise locations to go to zero Cl at the same time as the aircraft's AoA is reduced, and also for each location to remain within its airfoil's drag bucket.

2) Tip stall resistance in tight circling maneuvers. This wants smaller Cl towards the tip, preferably with more stall-resistant tip airfoils. This is complicated by the lower tip Reynolds numbers due to taper.

3) Minimum induced drag. Assuming the span is fixed, this ideally wants the c*Cl distribution to be elliptical at slow thermal speeds. Two extreme possibilities are :

i) a constant chord c, with elliptical Cl via washout --- great for 2), awful for 1)

ii) an elliptical planform c, constant Cl via flat wing and constant airfoil --- OK for 1), bad for 2)

The simplest safe baseline compromise solution is:

a) A constant airfoil, zero twist, and a planform with a considerably wider tip than elliptical. This is nearly ideal for 1), OK for 2), and least favorable for 3).

The following fine-tuning mods can be done:

b) The tip airfoils are thinned, while maintaining their camber and keeping the zero twist. This benefits 2) the most, since it compensates for the lower tip Re and usually gives a larger local Clmax. But this thinning narrows the tip airfoil's bucket somewhat, which may penalize 1). The c*Cl stays the same, and so 3) is unaffected by this modification. Note: The smaller thickness makes the tip airfoils appear more undercambered, even though their camber has not really been changed.

c) The tip chords are narrowed slightly from the "simple" wider-tip solution, and some washout is added. This mod can make the loading nearly elliptical, and benefits 3) the most. On the other hand, 2) is more or less unaffected, but 1) will suffer if the washout is done to excess.

d) The tip chords are narrowed slightly as in c), but the tip chords are decambered the correct amount in lieu of washout. This benefits 1) at some cost to 2). The benefit to 3) is same as with c).

My HLGs use a blend of mods b) and d). My current 2-meter RES project uses a blend of b),c),d) in suitable proportions.

I don't know what's best for F3B.

The best combination of mods b), c), d) depends on which performance consideration is most important. If 1) is most important, like in a windy-day HLG, the simple flat wing solution a) may be best. If you want a calm-day floater for small and weak thermals, then making mods b) and c) is most appropriate. Mod d) is useful in lieu of c) to keep the wing flat for easier construction perhaps.

- Mark Drela

GOLDEN STATE X.C. RACE
California Valley, California
Contest Results

by Mike Gervais

We had six teams from as far north as Oregon and as far south as L.A., CA. The first day's task was a distance task running the course in the direction you entered it, i.e. clockwise or counter clockwise, and using the turnpoints on the outside of the course, 50k circuit. The only way you could reverse direction was to come back to the launch site and relaunch. The second day's task was the speed task which is to fly as far as you can as fast as you can. This task allows you to use the various turnpoints on course. There was a minimum flight time of 2 hours and max of 3 hours. The first day's distance task total for six teams was 195 miles for an avg. of 33 miles per team. The longest flight of the day was 63.2 miles or 101.1 K for pilot Rich Spicer for # 5 100k pin. The second day's speed task avg. speed was @ 12 mph with the fastest being 23.95 mph for pilot John Elias.

Saturday Distance

Team	Miles	Points	Place
Atomic Fireball	63.2	1000	1st
Tuna	57.7	913	2nd
Necron	32.7	518	3rd
Elias	22.5	356	
G-force	11.2	177	
Broken-Arrow	10.4	165	

Sunday Speed

Team	MPH	Points	Place	Overall
Elias	23.9	1000	1st	2nd
Atomic Fireball	20.0	836	2nd	1st
Necron	18.4	768	3rd	3rd
G-force	14.4	597		
Tuna	8.6	361		
Broken-Arrow	6.3	263		

Atomic Fireball
Rich Spicer & Fred Olsen

Elias
John & Marketa Elias

Tuna
Mike Gervais, Scott Meader, Dean Gradwell

G-force
Paul Gradwell, Bob Claar, Ron Mc Cellion

Broken-Arrow
Jim Rolle & Bruce Moore

Necron
Greg Norsworthy & Noel Siegel