Radio Controlled
Soaring Digest
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Front cover: Trevor Shultz captured the ground reflection on the wing lower surface of a landing sailplane during the 2011 Milang F3J International event. Photos from this event by Trevor and John Blanchard, accompanied by Chris Adams' text coverage, start on page 51 and end on the back cover.
Sony DSLR-A200, ISO 100, 1/500 sec., f5.6, 75mm

Back Cover: Red and white against a deep blue sky. Photo taken at the 2011 Milang F3J International event by Trevor Shultz.
Sony DSLR-A200, ISO 100, 1/640 sec., f5.6, 300mm

R/C Soaring Digest

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In the Air

Recent correspondence from Bruce Abell:

"Well, my mate Dennis came over the other day and downloaded Acrobat Reader into my computer, so I was able to have a look at my dissertation in the February issue. Unfortunately, there's a typo in it.

"*RCSD* got an early copy where I said that, when initiating a turn, the forward moving wing increases in projected area and the retreating wing reduces in projected area. Unfortunately, the reverse is true, so perhaps a mention in a future issue might be appropriate..

"Thinking about the effect of the forward moving panel of a forward swept wing, perhaps it needs more clarification.

"As the model is yawed and one panel moves forward, the projected area does not actually reduce but, instead, because of the continued sideways motion, the effective lifting area is reduced. Thus this panel is effectively one with a very short span and a very large chord and, consequently, there is a deduction in lift. The retreating panel is far less adversely affected and thus the model tends to want to drop the forward moving wing and bank against the direction of yaw. However, the high aspect ratio fin and rudder, coupled with the tip dihedral, overcome the adverse effect.

"This is very difficult for me to put into clear, concise, understandable wording but perhaps the above is clear enough and explains the reasoning for the polyhedral and very large rudder.

"The model actually is only marginally stable in a turn but this means that it will, once in a turn in a thermal, lock into the turn and core the thermal with only a bit of up and rudder trim."

Time to build another sailplane!

B²

Killing Gremlins

Sherman Knight, duworm@aol.com

The conclusion to "You have one chance to get it right"

Last month we reviewed Critical 1 Single Failure Points and found that most of them occurred at connections. If you are gonna fly RC, you will have to deal with electrons and how they get from A to B. The mess of wires and connections in a typical sailplane install are a breeding ground for gremlins. Gremlins are born for a single purpose, to interrupt of the smooth flow of electrons. The gremlin version of the "home run" is a random interrupt of the electron flow in a way or location so you cannot find it. Then, when you are close to finding the interruption, the gremlin recedes and allows the fault to close up and disappear as if it never existed.

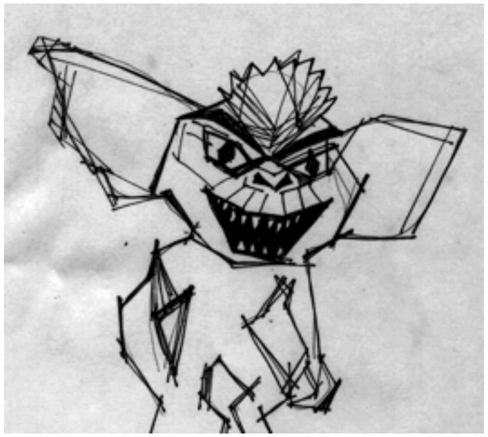
Gremlins hunt in packs. The alpha male of the gremlin pack lives for one purpose, to drive you nuts. All the other gremlins live for one purpose, to do a better job than the alpha male at driving you nuts.

Gremlins were first discovered sabotaging Royal Air Force (RAF) aircraft in the 1920's stationed in Malta.

Aviator Pauline Gower discusses gremlins in her book entitled "The ATA: Women with Wings" (1938). She discusses portions of Scotland described as "gremlin country," a mystical and rugged country where scissor wielding gremlins cut biplane wires when unsuspecting pilots were about.

The existence of gremlins was confirmed during the Second World War among airmen of the UK's RAF units, in particular the men of the high-altitude Photographic Reconnaissance Units. The creatures were responsible for otherwise inexplicable accidents that sometimes occurred during flight.

At the time, gremlins were thought to have enemy sympathies, but investigations revealed that enemy aircraft had similar and equally inexplicable problems. As



Police artist sketch of a suspect gremlin

such, gremlins were equal opportunity tricksters, taking no sides in the conflict, and acting out their mischief from their own self-interests.

Gremlins never do their dirty work in plain sight. No one has ever seen one or caught one in the act of sabotaging an aircraft, radio transmitter, receiver, battery or wiring harness. The instant any human looks for a gremlin, it vanishes, although evidence of its damage may remain.

The result of a 12 Volt gremlin attack. The black charring is indicative of an arc.

The technical term is an intermittent fault or failure. When you move the switch to the "on" position, you are completing the circuit and allowing the electrons to flow. This is a "closed" circuit. An "open" circuit stops the electron flow. As long as you control whether the circuit is open or closed, everything is fine. The real gremlin knows how to "open" your circuit when you really want it closed, and then sneak off allowing the circuit to close on its own.

Let's take a look at where the gremlins live and what we can do to make them go away.

Heat Kills. It is a pretty simple concept. When dealing with electrons, if you piss them off they get hot. When things get hot, nothing but bad happens.

As electrons move from A to B, they like a smooth, uninterrupted boring trip. Electrons don't like to be squeezed into tight crowded places. They don't like tight curvy single lane roads. They don't like potholes. They don't like speed limits. They prefer a wide-open freeway without any other traffic on new smooth asphalt.

When a wire runs into a plug, it connects to a pin. The pin is an electrically different material than the wire. If it has a higher resistance and a smaller cross section (and they almost always do) the electrons are forced to squeeze together or speed up to pass the bottleneck. The electrons are not happy so they start to get hot. The tighter the squeeze, the higher the heat.

To the electron, the squeeze may be merely irritating and result in a little warmth. Squeeze enough and the insulation will melt off the wire and plug housings will deform.

Sometimes the faults causing the "open" circuit may only be a few electrons across, forcing electrons to jump a gap. Arcing can create a tremendous amount of heat depending on current and the distance the electrons have to "arc."

Arc welding (forcing a lot of electrons to jump at the same time) creates enough heat to fuse metal to metal, requires special clothing and restricts watching

It's just a bunch of electrons jumping from one location to another.

Vibration cut through the insulation resulting in an arc. For a period of time, this presented itself as an intermittent fault that came and went without apparent reason. The intermittent arc ate away at the metal until the intermittent fault became a catastrophic fault.

This connection was very tight, but a buildup of oxidation and dirt created enough resistance to heat the steel threaded bolt to a temperature that melted the lead post. Notice the hardened lead puddle in the foreground.

through special filtered lens so you don't permanently injure your eyes. This example may seem a little excessive, but the same concept happens at RC voltages. At the current levels we typically work with, arcing can occur; it is just not as bright as the sun. Nonetheless, arcing can still melt metal or burn through plastic. You typically only see the result of the arc or smell something melting from the heat.

Gremlins have a natural instinct to seek out all places where electrons get hot, out of control or forced to arc. Gremlins hide in these locations and wait. Wait for a chance to make it worse.

The Dead Short

In the world of electrons, the dead short is the result of a suicidal gremlin. The dead short occurs when the positive and negative wires encounter each other and create a circuit with zero resistance. This becomes the electron's version of yelling "fire" in a crowded theater. Every panic-stricken electron wants out of the battery at the same time. The result is a catastrophic failure.

Some of you are thinking, "You're kidding, it's just a little battery." Check out the images of "gremlins going postal" on the next page. It didn't take long for the wire to glow so hot that the insulation melted off! The plug melted into an unrecognizable blob of plastic. As soon as the wire started glowing I flipped the switch to off, but the wire just kept glowing. Flipping the switch didn't matter because the two wires, without any insulation, were touching - the switch was no longer in the circuit. The plastic on the end of the battery caught fire in less than 6 seconds!

Keep in mind just how close together some of those wires are through the power system.

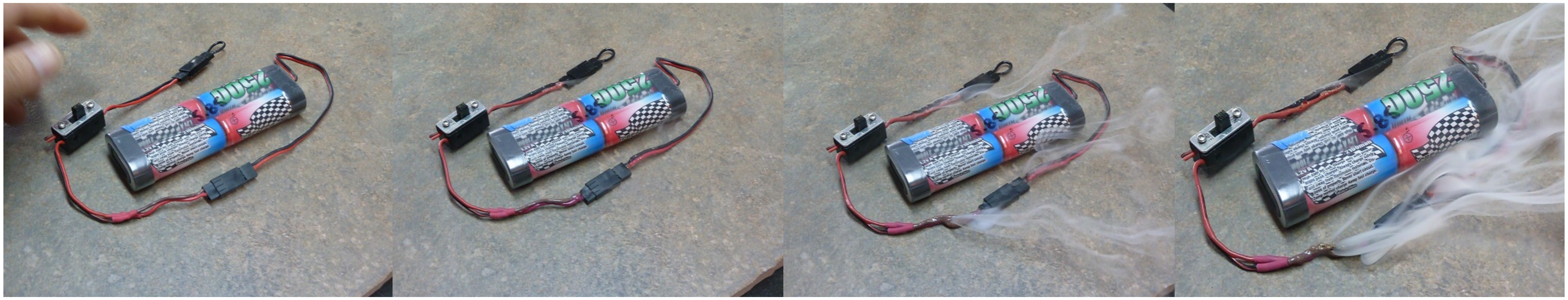
The Cold Joint – Birth Place of Gremlins

A successful solder connection requires heat, lots of heat, somewhere between 650 and 750 degrees F. Higher if you are soldering large wire or batteries. With all that heat, how can you have a "cold" joint? You need to know because a cold joint is nothing more than a hangout for every gremlin and the ghosts of gremlins ever to haunt electronics.

A "cold solder joint" can occur when one of the components to be soldered is not hot enough to melt the solder or if the components are moved prior the solder solidifying. Dirty surfaces (grease from you finger), a dirty or oxidized iron tip (too hot) or a lack of flux can all contribute to a cold joint. Because most of us are amateur electricians and never practice our soldering, we make many more cold joints than we realize.

Most of us do not wait for the components to get hot enough, so we touch the solder to the tip of the solder iron to help it along. The solder seems to melt onto the joint and we assume it is good enough.

Gremlins Going Postal – The Dead Short



It took only 1.5 seconds to melt the wiring and plugs to the point they can never be used again. At three seconds, you can't see the wire. It smelled terrible.

At 4.5 seconds, you can hardly see the battery. The smoke obscured the wire, but when it cleared at 5.5 seconds, the 22ga. wire was red hot.
The test was aborted at 5.5 seconds by flipping the switch to off. But the two wires were touching somewhere so the glowing continued.

In the first two images, that is not a red wire. The insulation is gone and the wire is glowing red hot! Fire starts at 6 seconds.
The last image is all that is left of a standard battery/servo plug. Gremlins can never hide there again.

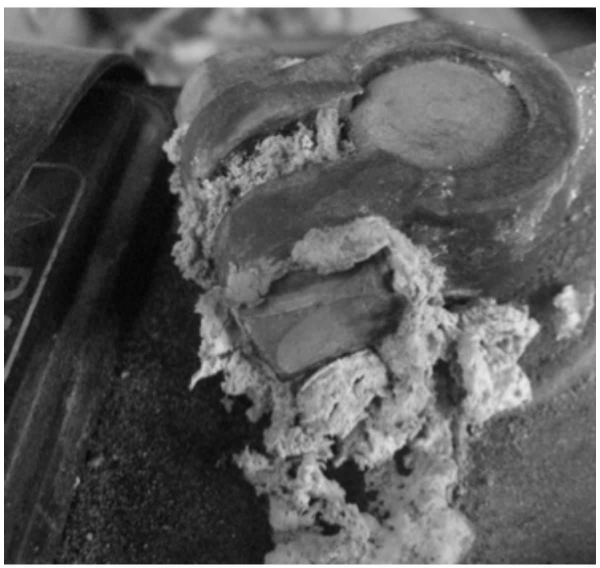
Unfortunately, the iron melted the solder rather than the metal components melting the solder. Because the metal is not hot enough to melt solder, the solder melts around it rather than into it. There is a high likelihood you just created a cold joint.

Another common cause is one of the components moving before the solder has completely cooled and solidified.

A cold joint is brittle and prone to physical failure. Generally, a very high resistance connection can affect the operation of the circuit or cause it to fail completely.

Cold joints are often recognized by a characteristic grainy, dull gray color, but this is not always the case. A cold joint can often appear as a ball of solder sitting on the pad and surrounding the component. Additionally, you may notice cracks in the solder and the joint may even move.

Often, the cold joint may feel tight and you may not be able to see it. A good mechanical connection may not be a good electrical connection. This is a gremlin's dream come true.



Other Forms of Intermittent Faults - The Dirty Connection

Did you know that oxygen can create a barrier to electrons? Oxygen is an extremely corrosive gas. Without it, metal would not rust. Oxygen causes a sliced apple to turn brown. Without oxygen, there is no fire. In the world of rockets, you hear the word "oxidizer" used when discussing rocket fuel. Without oxygen, many of our electrical problems would go away. When you add an electrical current, oxidation can build up so fast that a connection that was good yesterday may intermittently fail today and catastrophically fail tomorrow.

In addition to oxidation, dirty connections are caused by many things. Dirt, debris, grease, rust, the residue left from electrolysis from two dissimilar metals in proximity to an electrical current, and so on. The list of gremlins is quite long.

Most of us respond to a poor connection by making the connection tighter. A tighter connection does not remove oxidation that is already there.

I wish it was that easy.

You need to take the connection apart and remove the oxidation and anything else in the way. Sometimes the oxidation is so bad it must be physically removed with a wire brush or scraper. Oxidation happens all too often to the battery posts on winch batteries.

The Gremlin Killer – Better Electrical Connections

There are three things that can be done: (1) clean the connections, (2) improve your soldering skills, and (3) learn to crimp.

Contrary to popular belief, soldering and crimping are not a form of black magic. There is no "art" to a solder joint or a crimped connection. Both are an easily learned skill with a little practice and the correct tools. Both types of connection have strong detractors, but not for the reasons you think. Dissatisfaction with a particular method is usually a combination of two factors: crappy tools and lack of practice.

SOLDERED CONNECTIONS

Most of us do not solder very often, so we are not interested in purchasing soldering equipment unless we find a $7 iron in the half-off sale bin at the local hardware store. Did I just mention crappy tools? *Half-off does not make a crappy tool half as crappy.* Remember, you have one chance to get it right.

Contrary to popular belief, duct tape cannot fix everything.

The Soldering Iron

My dad had a simple saying, “gotta use the right tool for the job.” I am just now beginning to understand why there was never any duct tape in the house.

If you only have a “pistol” style soldering “gun,” throw it away. It creates heat by induction which might damage the electronics in your equipment. In addition, they provide heat well in excess (250 to 300 degrees in excess) of what you want. In other words, it is the wrong tool for the job.

The right soldering iron depends on the size of the wire connection or the size of the items you are soldering. The larger the wire or surface, the more Wattage is necessary.

There are two types of heaters used in soldering tools. Wire-wound heating element technology works like your kitchen toaster, it uses electrical resistance to heat up the iron. Like your toaster, it takes a long time to heat up and get the job done. It heats up the entire heating element, which in turn heats up the soldering iron tip. Wire-wound heating elements are less expensive to manufacture, thus the soldering iron’s performance is equal to its price. Prices range from dirt cheap, $1.49 on-line, to $35 or so.

Ceramic heating element technology heats only where the heat is needed most, at the tip. This type of heating element is very efficient, produces more heat, maintains its heat longer, and its thermal recovery - the tip’s ability to come back up to soldering temperature when soldering heavy loads - is FASTER than a wire-wound heating element; 12 seconds versus four minutes at startup. Ceramic heating elements cost more to manufacture, thus the soldering iron’s performance is equal to its price. Prices range from inexpensive to very expensive, $28 to $1500.

Nearly all of us own a $7 “fire starter” soldering iron. These toaster type irons are typically rated at 15 to 25 Watts and get so hot in your hand you can’t hold it for very long. Amazingly, if the tip is properly tinned and maintained, it will actually do a pretty good job.

A fire starter may take three to seven minutes or so to get hot enough to melt solder. Tinning the tip may cool the iron 30 degrees or more. Touch it to a wire and lose another 20 degrees. Touch it to a Deans connector or to a small battery and it may cool off so fast that solder solidifies and the tip becomes stuck in the solder. Without a heat reserve, it takes a long time to heat back up.

Unregulated temperature is typical of a fire starter iron. Generally, as Wattage goes up so does temperature. Unfortunately, you have no idea what the temperature of

Madell QK202D 90 Watt Soldering Station with digital temperature and tip control. Complete with sleep and auo-off mode.

Are you kidding me?

NICE!

the iron may be. The difference between a 15 Watt and a 35 Watt iron may be as much as 275 degrees.

Temperature regulated irons and stations can be set to a predetermined temperature no matter what the Wattage is.

Because temperature can be set, Wattage is what you pay for. Higher Wattage provides a greater heat reserve and the ability to maintain the temperature of the tip of the iron. Touching the tip to solder, a wire or a battery will suck the heat out of a toaster iron. Heavy Deans connectors or heavy gauge wire will suck it out even faster. Higher Wattage ceramic heaters allow the heater in the tip to keep up with heat loss. It does not sound like much, but the difference is huge.

Regulated or unregulated temperature, here are the Wattages you will need based upon the task. Based upon what we use them for, I would not buy an iron over 35 Watts unless I could control the temperature.

15 Watts – 22 ga wire and smaller.
25 to 45 Watts – 16 ga wire and smaller.
50 to 70 Watts – 10 ga wire and smaller.
70 to 90 Watts – Batteries and motor connectors.

Even if you purchase a smaller Wattage iron, spend the money and purchase one with a ceramic heater. You will be glad you did. A 15 Watt HAKKO ceramic iron regulated to 700 degrees is only $28.

The 90w digital station shown in the photo at left goes from cold to 700 degrees in 12 seconds. More expensive ones in even less time. Its heat reserve is huge. It does not matter what you are trying to solder, it just works. If only I had made this purchase earlier.

If you leave a tip at 700 degrees for too long without cleaning it or tinning it, you can easily ruin it. As you step into the $130 range, solder stations will turn the temperature down when not in use or turn it off altogether if you forget. Because of its ceramic heater, it is back to 700 degrees in five to seven seconds. Pretty cool.

<u>Tinning the Tip</u>

Within hours of using that new fire starter, the tip no longer seems to work. Touch solder to the tip in some places and it does not melt. Other places melt just fine. This is because the alloy plating covering the copper tip of most fire starters is dirt-cheap. If left on too long, temperature is too hot, failure to tin between use, failure to clean the tip and a bunch of other stuff, the tip will oxidize. Once the tip oxidizes, it is shot and needs replacement. Sand it, grind it, clean it all you want, it will never work the same again. If your soldering iron gets hot but has a hard time melting solder, buy a new tip and then properly tin it before you turn on for the first time. You will be surprised.

On cheap irons, the plating is very thin. So thin that pinholes are left in the plating allowing the copper underneath to oxidize. That spot on the tip will never work right.

Before you turn it on for the first time, do the following. Clean the tip with a wet sponge. Then dip the tip in rosin or coat in rosin paste. Wrap some solder around the tip and turn it on. The rosin boils off taking any contamination with it and the solder seals the tip before it can start to oxidize.

Danger! Danger! Gremlin food can be found at your hardware store. It's guaranteed to accelerate the growth of your baby gremlin by 400%.

Now you have to maintain that tip. Before each solder, clean and tin the tip. After each solder, clean and tin the tip before putting the iron back in the stand. Tin it again right before you turn it off. I know it is more steps than you use now, but if you take care of your iron, it will take care of you.

If you buy a solder station or an iron holder with a sponge, the sponge may have a cutout in it. Drag the tip across the edge of the cutout to remove larger gobs of solder. This leaves the rest of the sponge clean for wiping the tip.

The Temperature

Buy a digital controlled, ceramic heated solder station that you can set between 675 and 725 degrees for most situations. Add another 50 to 75 degrees higher for large gauge wire or batteries.

Cleaning the Items to be Soldered

The second you strip a copper wire it starts to oxidize. If you twist it with your fingers, you coat it with oil residue from your skin. Dirty connection are hard to solder. Some of you think just add a little more heat and everything will be fine. EXTRA HEAT DOES NOT FIX THIS PROBLEM.

Surface prep is the first, perhaps most critical, step in ensuring: adequate heat transfer, good solder wetting, and ultimate joint strength. The surfaces need to be free of wax, oil and surface oxidation. If you can't get the surface clean, give up. It ain't gonna work.

Flux can do the cleaning for you. Embrace the use of flux and all your soldering will improve immediately.

If you purchased a container of flux at a hardware store, throw it away. If you purchased water-based flux, throw it away. Both of these types contain acid as its cleaning component. The residue left after soldering continues to remain active, slowly eating away at your connections, and attached wires. (Just another gremlin hideout.)

Only use rosin flux. It really is a gremlin killer. It comes in three varieties, but you are only interested in RA or RMA. RA contains the stronger activators and is easier to solder.

It also comes in three forms, liquid, paste and within the core of the solder. In most situations we deal with, the rosin

Liquid gremlin killer

Paste gremlin killer

core solder is just not enough. Liquid rosin is easy to work with, but you need a plastic bottle with a metal tip so you only apply what you need. If you only want to purchase one variety, get the paste.

Applying the paste is easy; just dip the end of the wire in it. Other locations, just dab it on. It does not take much. (If you are building battery packs and 10 ga wire connections, use liquid rosin on the wire before tinning the wire. Paste may not work its way into the inner wires.)

Here is another situation where a good iron is important. The rosin needs to boil off. If it does not, the rosin may actually act as an insulator of sorts and may be the cause of a cold joint. Irons without a heat reserve may cool off before it can boil off the rosin. You see this when someone tries to solder to a battery with an undersized iron.

Solder

DO NOT USE LEAD FREE SOLDER. It is very difficult to solder, requires special technique, and neither NASA nor the military will use it. I swear that lead free solder was invented by gremlins to further their cause.

DO NOT USE ACID CORE SOLDER. It's acid. Another gremlin invention.

Most of us use 60/40 solder. Composed of 60% tin and 40% lead, this solder melts at 374F, but doesn't become completely solid until it cools to 361F. This means it has a "pasty range" or "working range" of 13 degrees. It is the pasty range where gremlins are born. Usually something moves and instead of a bright shiny joint, it immediately clouds over and turns dull. This dull look is the sign of a cold joint.

Instead, use 63/37 solder. This solder is 63% tin and 37% lead. It becomes liquid at 361F, and solid at 361F, with a pasty or working range of 0 degrees. This solder is a eutectic alloy, which means at 361F, you can go instantly from solid to liquid to solid just by applying or removing the heat source.

The advantage should be obvious. If it solidifies immediately, there is less chance of a cold joint. In addition, it forms a better mechanical bond and tends to crack less. The avionics industry, NASA and the high-end audio industry use this stuff exclusively. In addition, it is easy to find. Radio Shack sells it but the gauge is pretty thick for our applications. Any electronics store will carry this magic solder. Just look for this information on the label : 63/37 - .031 or 23 ga – RA or RMA core flux (about 2.2% flux). It should take care of your needs.

Soldering Technique

The gremlin soldering manual reads, "Apply heat, melt solder, remove heat." I wish it were that easy; the gremlins are hoping you think it is that easy.

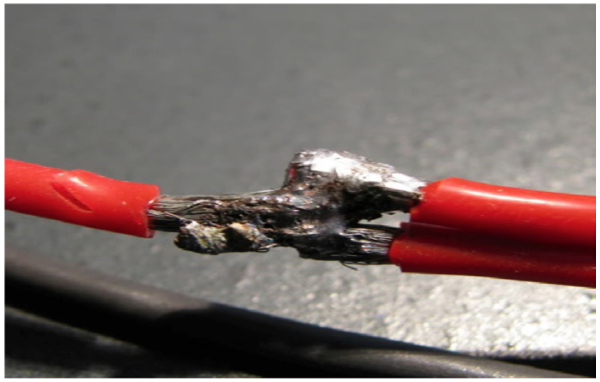
The gremlin method goes something like this:

Touch the un-tinned tip to the wire and then touch the solder and nothing happens. The solder refuses to melt into the wire.

So you pull off and try to melt some solder onto the tip of the iron. Finally, a drip of solder hangs from the tip. As you move to the wire, it falls of the iron.

So you do it again and this time you successfully touch the solder to the wire. The solder sorta attaches itself to the wire. So you touch it some more until the solder seems a little more smooth. Still kinda messy so you touch it again with the iron hoping a little more heat will do the trick.

You keep applying more heat in an attempt to "force the solder to take." Finally, you think it must be good enough and it looks like this:



Iron on one side and solder on the other, let the wire melt the solder.

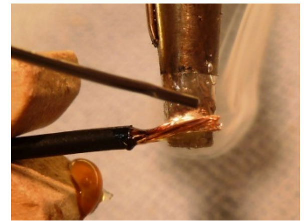
Welcome to Gremlin City, the home of the cold joint. This is exactly what the gremlin wants you to do. Eradicating the gremlins is rather simple, there are just a few more steps. Remember keep it clean and heat the metal first.

The gremlin killer method goes like this:
1. Turn on the iron – make sure you have the Wattage for the job and the right temperature. (675 to 700 degrees).
2. Once hot, clean off the tip with a damp sponge.
3. Tin the iron tip by applying solder to the tip.
4. Apply flux to the wire.
5. Use 63/37 solder.
6. Touch the iron to one side of the wire and the solder to the opposite side of the wire. Do not touch the solder to the tip. Once the wire is hot enough to accept the solder, it will melt into the wire. This is called tinning the wire. Repeat for other wire.
7. Hold the wires together and touch with the iron. Solder from both wires melt and contribute to a solder joint forming between them.
8. Clean of the tip with a damp sponge.
9. Tin the tip and place the iron in the stand. That's right, clean and tin the tip after each joint.
10. At the end of the day, clean the tip and tin it. Then turn it off. This will coat the tip in solder keeping oxides from building up on the tip while in storage.

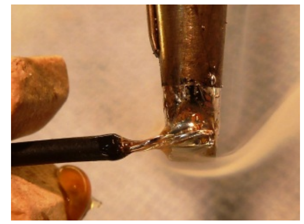
On this page and the next page are examples of soldering the connections we use most: the overlap joint, the battery connection, and multiple wires to a DB-9 connector.

It really is not difficult. The right tools, a little patience and some practice and you will be soldering like a pro.

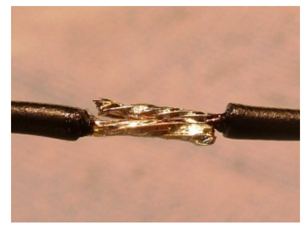
Add Flux to the wire, either a drop of liquid or dip in paste.



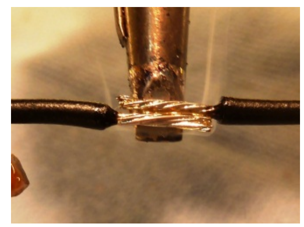
Tin the wire. Hold the iron on one side of the wire and the solder on the other. Wait until the solder "wets" itself into the wire.



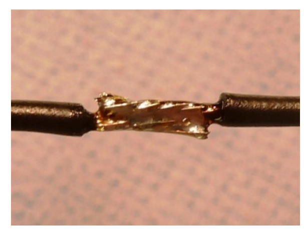
Flux and tin the other wire.



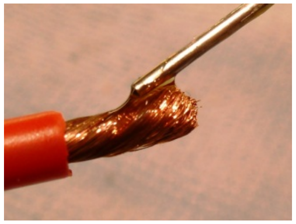
Hold the two previously tinned wires together.



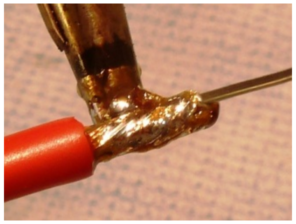
Apply heat to the two wires and the solder in the wires will "wet" together. You might need to add a little solder.



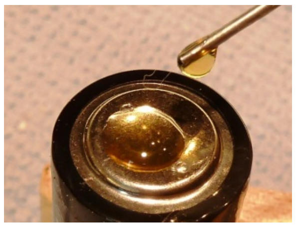
Notice how shiny the joint is. No Gremlins were born here today. If you try to pull this apart, the wire will break before the solder does.



Add Flux to the wire. Because of the wire size, use liquid paste to make sure it works its way into the core.

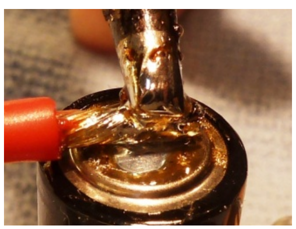


Tin the wire. Hold the iron on one side of the wire and the solder on the other. Heat the wire until it is hot enough to melt the solder.



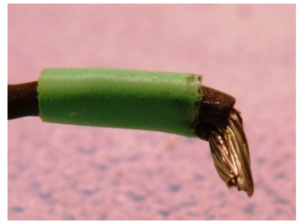
If tinning the wire seems to take forever, you need more heat “reserve.” Flux. Then apply heat and solder to form a puddle on the battery.

After it solidifies, the solder should be bright and shiny.



Hold the previously tinned wire to the battery and apply the iron to the wire. Let the heat go through the wire to melt the solder on the tinned battery.

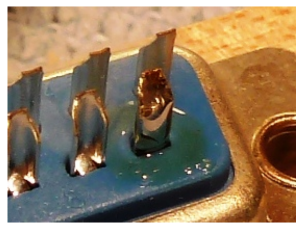
Wow!



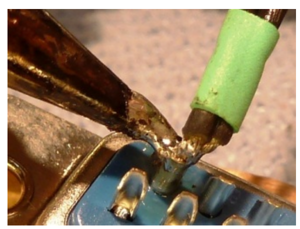
Bundle and bind wires with a little heat shrink. Better than a third hand. Add flux and tin.

Flux the pin. Paste flux on a toothpick works well.

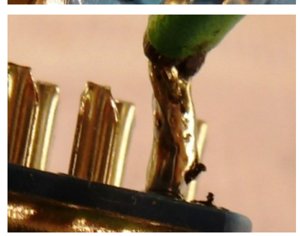
A little heat and solder.



The solder “wets” into to the concave side of the pin. .



Pull the wire bundle into the pin with the iron tip. Heat the wire and let the heat from the wire melt the solder on the pin.



Nice!

CRIMPED CONNECTIONS

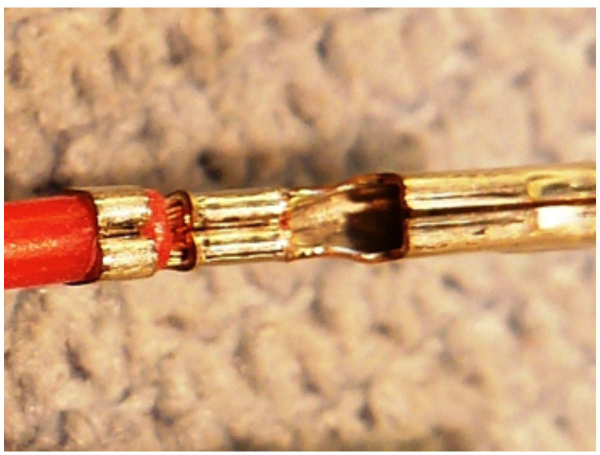
In the typical RC wiring harness there is a combination of soldered connections and crimped connections. ***Most of them are crimped.*** So why does everyone own a fire starter but almost no one owns a crimping tool?

In the RC world, most crimp terminals are designed to be crimped, not soldered. If the crimp is done poorly, solder won’t save it. Moreover, a proper crimp does not need any solder. In fact, soldering a crimped terminal may weaken the mechanical connection, may reduce electrical conductivity, and may damage the terminal. As a general rule, you should not solder a crimp terminal.

In the case of insulated wires, a proper crimp actually consists of two crimps: one crimp to cold weld the wire strands to the connector barrel; and a second crimp to secure the insulation to the connector. The first crimp establishes electrical continuity; the second crimp provides stress relief to prevent physical separation.

Some like to tin the wires with solder before crimping them or

Is this really the right tool?



The crimp adds strain relief. The first crimp grabs the insulation and the second crimop grabs the wire. This crimp was done in my shop with the HT 225D crimping tool.

solder them after crimping. The belief is that this will make the crimped connection more solid. Unfortunately, the solder wicks up the strands making them brittle or turns the stranded wire into a solid wire causing the wire to fracture and break sooner in the duty cycler than a simple crimped pin.

A properly done crimp, done with the right tool - a ratchet crimping tool for less than $30 - is 100% as strong as a soldered connection and provides some stress relief at the same time.

A proper solder connection does not rely on the solder for a mechanical connection. However, in RC, solder is often used as the only mechanical connection, as when joining battery cells or wiring Deans connectors.

Solder adds resistance to a connection. The lead/tin alloy has a much higher resistance than copper. Solder joints carrying a lot of current have unsoldered themselves due to the heat generated in the joint. A proper gas-tight crimp provides a lower resistance connection than a soldered one.

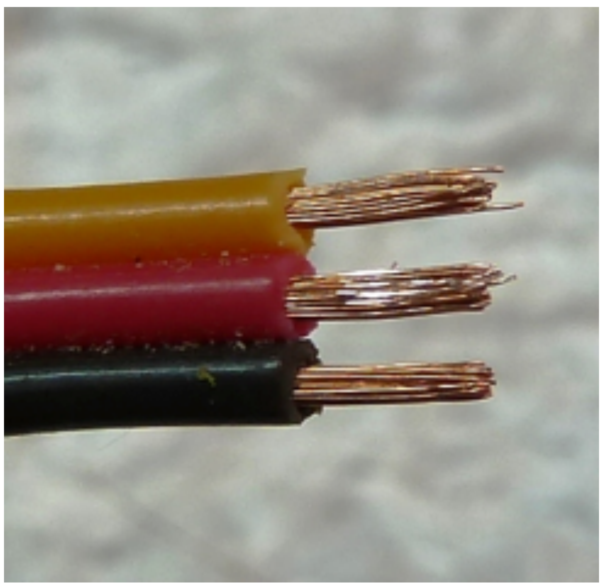
More importantly, it takes less skill to do a good crimp connection than a good solder joint. When you compare quality crimping equipment to quality soldering equipment, crimping is less expensive, too.

The ultimate wire stripper.
All three wires at one time!

A properly crimped connection has benefits.

• It is electrically superior,
• when done properly, the wire will break before the wire can pull out of the pin,
• it provides some stress relief,
• it is fast,
• easily learned,
• and the tools don't cost much.

The depth of the jaw is adjustable so the same amount of insulation is stripped each time.



The results of one pull on the stripper. This type of wire stripper may be overkill, but once you use one you will wonder how you managed to get along without it.

At the same time, a good soldered connection is better than an improperly crimped connection.

Good crimping starts with a good wire stripper. The "peel it back with an X-acto knife" technique works, but it is time consuming and if you mess up one of the wires, you have to start all over.

At a minimum, a wire stripper that looks like a pair of pliers is a must. Make sure you purchase one that will strip 28-30 ga wire.

If you build your own wiring harness, you might want to invest in a self-adjusting wire stripper. You can set the jaws to strip the same amount of insulation every time.

If you are going to try crimping, don't start with a cheap "beginner" tool and work your way up to a better tool. Just start out with a good ratcheting tool. You can find one on-line for under $30 bucks.

Some of you have tried crimping, but with mixed results. If you used a pair of pliers, I am going to assume that you're the guy buying all the duct tape from the 50% off bin. You can NEVER accomplish a crimp with a pair of pliers.

If you used one of those cheap non-ratcheting crimping tools, well I'm not surprised. A cheap crimper has its own problems. The pin falls out if you have to put the tool down, the pin falls out if you bump it with the wire and usually just mashes the contact onto the wire in a few spots.

HT 225D Full Ratcheting Crimping Tool

As you close the handles on a "ratchet" tool, it begins to click. A few clicks of compression holds the pin place and the handles will not open. Insert the wire and continue to squeeze the handles. The clicking will continue. When the clicking stops you have reached the correct amount of pressure on the pin, the ratchet opens and the handles will separate. You're done.

A good tool compresses the contact so that the entire contact surface of the contact is in intimate contact with the wire forming a gas-tight contact. This type of contact will resist corrosion by excluding oxygen from the contact surfaces. Buy a "ratchet" crimping tool and you will never look back.

A ratchet tool is typically adjustable with a "star" shaped adjuster. This allows the user to adjust the tool to adapt to different wire gages. Unfortunately, adjustment is a trial and error ordeal. If you can pull the crimped pin off the wire, adjust for a tighter crimp. If the crimp flattens the pin, then adjust for a looser crimp.

Whether you solder or crimp, don't go over to the dark side and combine the worst features of both methods. Never attempt to reinforce a poor crimp by adding solder.

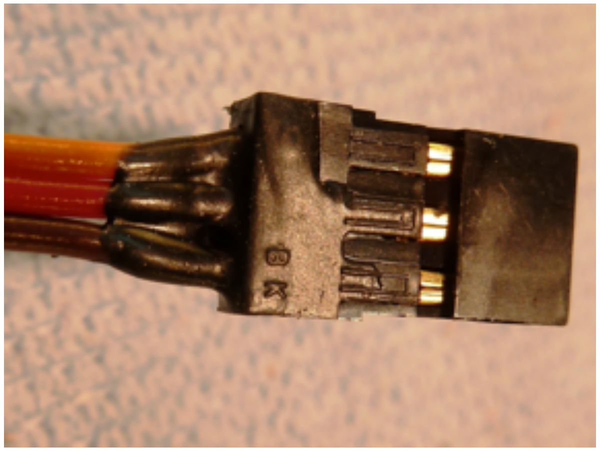
Crimping is easy. You need a ratcheting crimper of the right size, a wire stripper (trust me, it is worth its weight in gold), and a pin. That's it. For a one minute video on crimping all three pins on a servo connector in less than a minute go here.

If that is all it takes, why don't you own a crimping tool?

Strain Relief

Sometimes the methods of connection are dependent on the nature of the connection. There is little concern over stress relief or wire fatigue with the wire joining cells in a battery or connecting to a large Deans connector.

That is not true where servos are plugged into the receiver and the receiver is jammed into the fuselage, those that like to use a plug instead of a switch or with wing or outboard wing panels where electrical connections are made by hand. The need for stress relief may determine the method of connection



Additional strain relief from liquid insulator. A good way to insulate wires on a db9 connector.

IN CONCLUSION

In reality, gremlins are a form of "passing the buck" or deflecting blame. Sometimes gremlins are born from a form of impatience when there is not enough time to do a proper investigation or build it right. Sometimes gremlins are a denial of your own mistake.

In all cases, failure to find and eradicate the gremlin can result in a dead aircraft.

As pointed out in the beginning of this article, no one has ever seen or captured a gremlin. Does the gremlin really exist?

In the section that follows, move the cursor over the blue text, hold down the Ctrl button and left click the mouse. The link should automatically open in your browser.

Soldering

Watch this video comparing three unregulated soldering irons of different Wattages to see what they can and cannot do. Wattage Comparison If you are confused about Wattage, this will help.

Solder iron 15 to 25 Watts:
15 Watts for $1.49
15 Watt Radio Shack for $9
Real 15 Watt ceramic heater for $30 – 700 degrees by Hakko

Solder iron 30 to 50 Watts:
30 Watt ceramic heater for less than $8
30 Watt ceramic heater for less than $15
25, 30 and 35 W fixed temp 750 degree for $40
48 Watts for $60 Station Nice!

Solder station 50 to 70 Watts:
Check this out! 60 Watts for $60 Best deal here!
I own the Madell AT201D 70 Watt soldering station that can be found on line for $65 or less. (Radio Shack sells the same unit with different packaging for $79)

Solder Station 70 to 90 Watts:
I own the Madell QK202D which has been re-bundled as the SMT QK202D 90 Watt soldering station. It can be found on line for $130 or less. I found mine on ebay and received it in 3 days. Associated, the RC car guys, sell the same unit with different packaging for $279 It is an extremely small package for what it can do. A better set of instructions can be found here.

Solder iron tips:
You may want to buy additional tips. The replaceable tips for the QK202D are more expensive ($13) than others ($6 to $12) because the thermocouple and heater are built into the tip. For what we do, I would recommend a chisel tip around 1.5 mm for wiring and 3.5 mm for batteries and heavy deans connectors.

63/37 solder:
Google "63/37 solder" It is all over the place. You can purchase it in all kinds or thicknesses; 0.032"/22 gage is about the right size for what we do. Flux RA. Get it here, or get a smaller amount in a tube here, or at Vetco either in a roll or in a tube.

Flux paste:
You can find it at Radio Shack. The stuff from Caig Industries (DeoxIT) is really good.

Liquid flux:
Liquid flux can be found all over the place. Here is an example of liquid flux found on line. I use this brand and it works great. Get it at Vetco.

Flux bottles:
Google "flux bottle" and you will find something with a metal tip or go to Vetco.

Wire sponge:
The Wire sponge replaces the wet sponge and works great!

Wire stripper:
One of the nicest wire strippers is made by Platinum Tools. It strips a wider range of wire size (16 to 32ga) and the information on the stripper is laser etched rather than silk-screened. It is also available from Vetco for $16 bucks. The Klein Curve wire stripper for 22 to 32 ga wire available from Home Depot for $15. The self adjusting jaws wire stripper is only $19 at Vetco.

For you Seattle guys, solder, flux, flux bottles, wire strippers, wire sponges and liquid strain relief can all be found at Vetco in Bellevue.

Crimping

Crimpers:
I have two different crimpers. The cheap one that I am giving away and a Ratcheting Crimp Tool that I just purchased for $35 bucks which included shipping. Here it is again for even less. If you can't find one, Google HT-225D. Make sure you purchase the one for 18 to 30 gauge. Here is an online guide to Crimping RC Servo Leads and crimping in general

Watch this video to see a one minute demonstration crimping a servo connector. Crimping Tool in Action

Strain relief:
Vetco also has this great Liquid Insulator for use as a strain relief. Just use a toothpick to apply it. Home depot has "Liquid Insulator," but it is thick and cracks easily.

Building the

Thermal Queen

Pete Carr WW3O, wb3bqo@yahoo.com

The Thermal Queen ready for initial flight testing. The combination of thin airfoil and quarter inch diameter wing rods makes for interesting wing bow on the launch. Care should be taken in gusty conditions not to over stress the wings.

Carl Lorber of Virginia is the designer of this sailplane which was published in the November 1970 issue of Flying Models magazine. Carl is very active in modeling and regularly attends the Cumberland Slope-For-Fun event held each fall near Cumberland, MD. As you can imagine, it's unusual to be able to fly with a model designer and pick his brains about a design. This is the second of Carl's designs that I've built and the second time we've had the chance to discuss his stuff in the light of 30+ years experience.

About five years ago I built the Gaggler sailplane that was also published in *Flying Models*. This ship has elliptical wing tips and stab outline, is two-channel control and very elegant to look at. I had e-mailed for Carl on the RC Soaring Exchange web site and he e-mailed right back. That began a friendship that remains today. A lot of great people and excellent information passed through the Exchange over the many years of its existence under the auspices of *Model Airplane News* and I miss it a lot.

The Gaggler fuselage was supposed to be fabricated from pine! I decided to use balsa with fiberglass skin and that worked out great. The ship had an under cambered wing with polyhedral and two inch rib spacing. That's a lot of ribs to cut and I remembered the hours of labor involved. When I found out that Skybench Aerotech, owned by Ray Hayes, had a rib kit available I bought that and saved a lot of work.

The sailplanes of the time used radios that were very large and heavy by today's standards. The radio room of the 'ship will hold a large battery because the receiver and servos of today don't take up very much room. The Gaggler and the Thermal Queen both hang in the clouds all day, so it's a good thing to have a big battery.

I modified the Gaggler to include spoilers. They were a tough install because of the thin airfoil but I pressed ahead with it due to some landing concerns at the local flying field.

When Carl and I met at Cumberland and he saw and flew the Gaggler he remarked that I had probably done a lot of unnecessary work on the spoilers. He felt that the Gaggler didn't need them and I disagreed.

The ship is controlled by a restored Proline radio on 53.2 MHz and I asked Carl to fly the 'ship and the radio and give me his opinion. The Gaggler quickly gained height to nearly speck-out range and Carl had to dump spoilers to get it back down safely. That made a believer out of him.

The Thermal Queen is simpler. The span is larger, the airfoil is thicker and still under cambered. I resolved to install a set of spoilers to it in the knowledge that, when it got really small overhead I could get it down in one piece.

For those of us who enjoy balsa dust in our hair, glue, not CA, on our fingers and the fun of solving building problems, this is a wonderful winter project. On many a cold and snowy morning I've come into the basement from shoveling, stopped to change shoes and then set another piece of balsa in place to dry. Somehow, that was a reward for the never ending chore of snow removal here in Northwest Pennsylvania.

The actual build began by ordering the plans from the magazine. A copy of the article is available for download at the Skybench Aerotech web site so the detailed discussion of the various parts is all there. The rib kit which also contains ply parts for the fuselage was also detailed there. When the plans arrived I spread them out on the living room floor where the scope of the project was apparent. My wife Lolly is quite used to seeing these massive sheets of paper each fall and the gleam her husband's eye!

Once the plans and the rib kit were in hand I placed an order for wood from National Balsa and from Sig Manufacturing Company. National has been my preferred balsa supplier over the last 10+ years because the wood I get is the same grade of wood I ordered. They don't presently sell spruce although I asked them about that at their booth at the 2011 Toledo Show. They indicated that they would be offering spruce in lengths up to 6 feet.

I did buy the spars from Sig who continue to provide the best wood in the business, along with 30 minute epoxy and fiberglass cloth.

Many years ago I attended the Chicopee Massachusetts AMA Nationals when they still measured the wingspan of Standard Class sailplane entries. We used to have to stand in line in a hotel ballroom with these big birds, clanking wingstips and chatting away about the fun to come.
A friend of mine, who shall remain

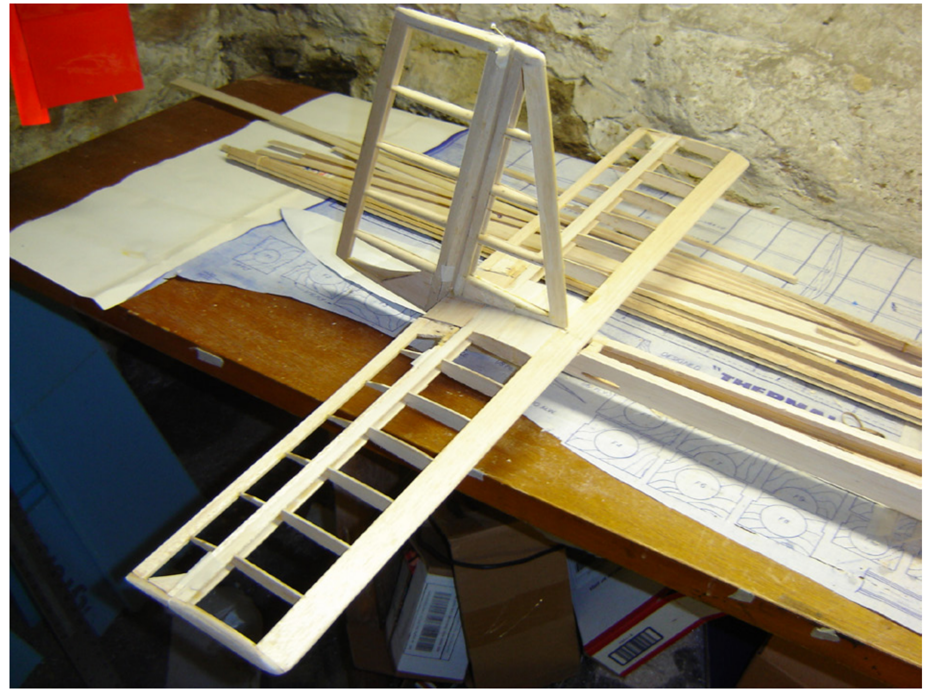
nameless, was forced to endure the indignity of cutting off a half inch from each wingtip to fit the measuring template. Those beautifully sculpted bits of balsa wound up on the ballroom floor and his excuse was that the plans were photocopies and had “grown” in the copier. I remember that he was nearly laughed out of the room for that comment. I now owe him a formal apology because the same thing happened to me.

The plans from *Flying Models* were a copy of a copy and not very sharp. There was a difference between the plans and the stab ribs as supplied by Ray Hayes. For some reason the wing ribs matched the plans perfectly but the stab ribs were too short. This required a bit of “Marine” modification to the ribs where I had to improvise, adapt and overcome the problem.

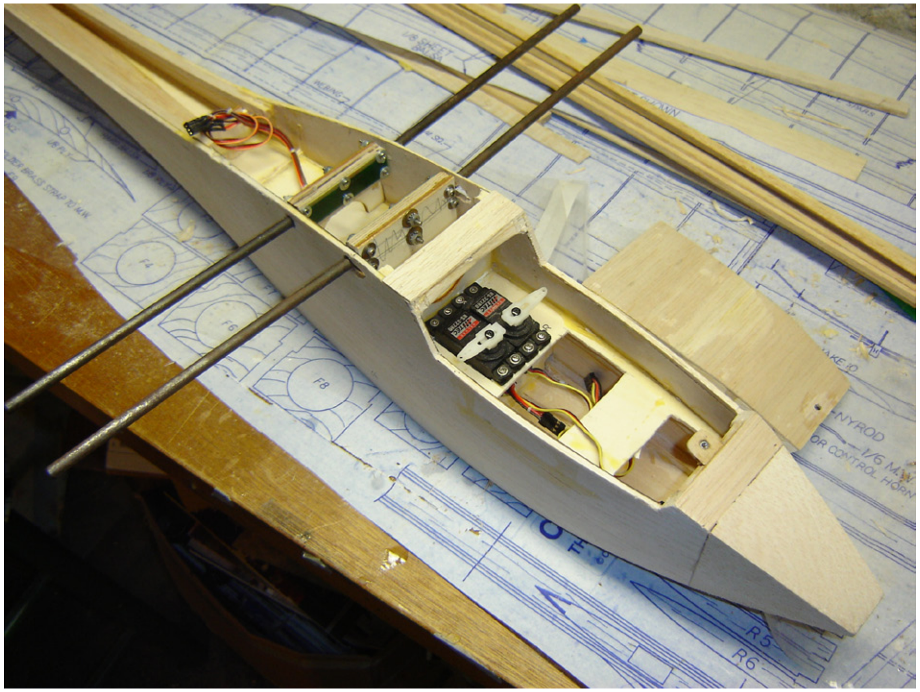
The end result was fine but added some unnecessary labor to the job.

The Thermal Queen uses a fixed stab instead of the flying stab used on the Gaggler. That means that the incidence between the wing and stab is not adjustable after completion. I decided to attache the stab to the fuselage using two long 4-40 bolts and blind nuts. This was fortunate since the initial stab angle was over three degrees. I reshaped the stab saddle to zero out the stab and the ship flew right off the building board. It makes transportation easier, too.

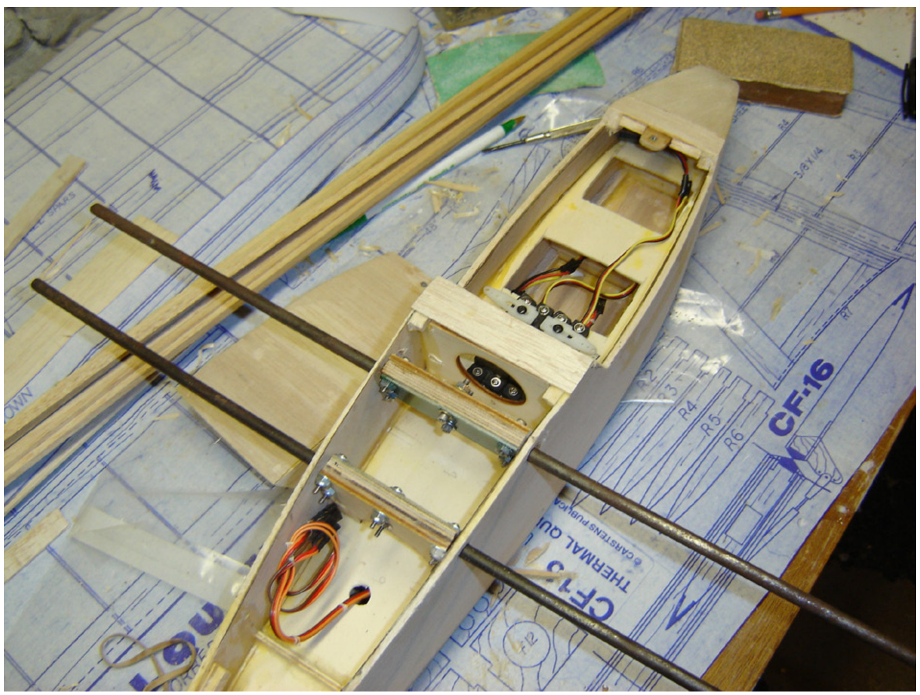
The wing rods were a problem. Since the airfoil is thin there isn’t room to establish any dihedral angle in the wing tubes. They have to be installed in the wing straight. That means that the rods themselves must be bent and then installed in the fuselage and braced in place. I bent the rods in a very large vice and matched their angles. Then I built a sandwich of 3/33 inch fiberglass sheet and plywood that would hold the rod angle. This sandwich was secured with 4-40 bolts and epoxied to the fuselage sides. This has handled the launch loads very well. The wing flexes like a Sailaire but returns to normal when the line is dropped.



The tail section of the Thermal Queen is attached through the fuselage bottom with two 2.5 inch long 4-40 screws and blind nuts. The nuts are attached to the stab bottom and covered with a layer of fiberglass cloth. This is essential for adjustments to stab angle during flight tests.



The wing rods are secured in a sandwich of fiberglass and plywood to prevent rotation on landings. The dihedral angle is also supported which helps the stiffness of the wing structure.

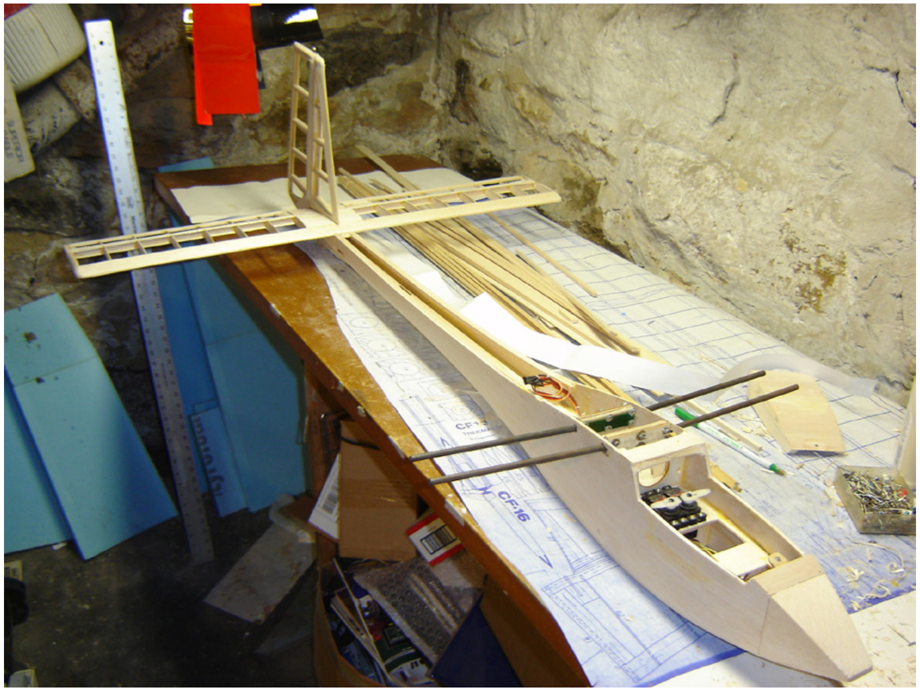


The rear mounts of the servos are visible through the large hole in the bulkhead behind. This spacing makes the angle of the push rods at the servo arms difficult to adjust without binding. The construction of the wing rod support system is also evident.

When I built and flew the Gaggler it lacked rudder authority in gusty conditions. After two seasons of fighting with that full-flying rudder I built a larger one and the Gaggler steers just fine now. In light of that experience I chose to enlarge the rudder of the Thermal Queen about 30 percent. I increased the height of the rudder and also added some area behind the hinge line. The ship handles very well even with the large area of the untapered wing tips.

The typical fuselages of the day had short noses and long tails. The Thermal Queen is the poster child for this type of design. That means that extra care needs to be paid to tail weight. The stab and vertical fin are good at that but the fuselage crutch supplied with the rib kit is rather heavy. I used the front part and replaced the back part with much lighter wood and am glad I did. The final carving and sanding also reduced the need for nose weight considerably.

That fuselage crutch is sized to hold the old, large size radio gear. I reworked the cut outs in the radio room to fit the receiver, two standard size servos and the battery. A little pre-planning here will save some work later. The Sullivan pushrods were left to last and the top of the fuselage was left open until the major pieces were done. At that time I could mount the control arms to the rudder and elevator and then align the push rods to line up straight with them.



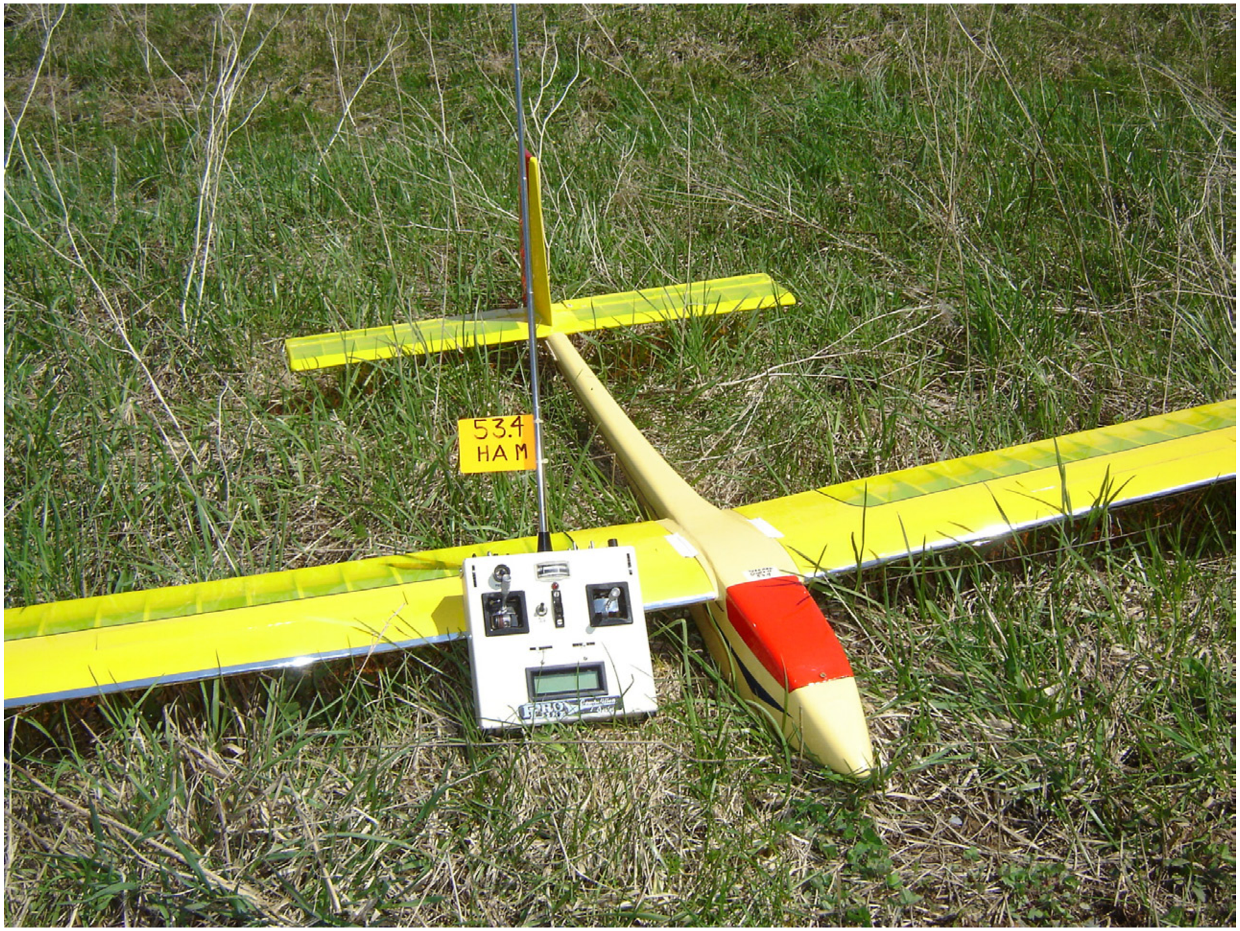
The top of the fuselage is not installed so the push rods can be added. I used 48" Sullivan rods which show little change in length with heat. Once the tail is positioned and the rods are installed it is easy to position the rudder and elevator control arms for smooth operation. Then the top of the fuselage can be added.

The two wing halves are finished and sanded. The plywood end ribs have not been added yet. Spoiler wiring and spoiler blade installation are finished. The under cambered airfoil section is evident.

The space from the rear of the servos to the bulkhead just behind them is fairly tight so you might want to prevent a bind in the linkage at the servo arms in that area. Ask me how I know! The pictures of the fuselage build show this area and the servos so you can see where that is located.

There was no way I was going to build a wing with all those ribs and then cover them up with plain Monocote. I chose transparent yellow since that really glows in the sun and shows off the interior work. The sheeted areas were covered in plain Monokote because of some pen markings and dumb mistakes that were fixed but ugly. The fuselage was painted using the cheapest spray can paint I could find. The higher priced stuff tended to run and didn't cover well. I asked my son Jeff, AE1O, and he made that suggestion which worked perfectly.

We have all suffered with the rainy, cold weather of the Spring 2011 season. The Thermal Queen sat in the basement for over a month before it was possible to do the first hand-toss tests. Carl is a careful designer and likes to have his models survive these initial flights. He sets the center of gravity quite far forward and then trusts the builder to pull out the lead as trimming progresses. I believed Carl and stuffed a lot of lead into the nose. I've removed about five ounces of weight and am still not sure that it's in final trim. Proceed carefully with this procedure.



The Thermal Queen is controlled by a Proline transmitter with a MicroStar encoder and 53.4 MHz RF deck. This offers mixing of spoilers with elevator for pitch compensation on landings. The transmitter case is over 30 years old while the electronics are the latest version of the encoder. The combination of transmitter and vintage aircraft design work well together.

After flying the ship down the field several times I rechecked the wing tips for wash out. They had some twisted in after covering, but that was nearly gone. I went home and retwisted them and the ship became much better behaved. The value “retwist” is a quantity that is a fudge factor like a “K” factor or Boltzmann's Constant that isn’t easily defined but you know when you need it. The slight trimming of the wing tip trailing edges shown on the plans is supposed to do this for you but more is needed. That also influences the weight removal and flying trim so should be done first and then rechecked periodically.

The Thermal Queen isn’t a fast sailplane so isn’t comfortable in winds much over 10-12 kilometers per hour. The wings do flex and suffer in gusty conditions. Still, they don’t show any tendency to flutter and there has been no wrinkles in the Monokote to indicate any undo stress points. After ten or so flights I’m still removing small chunks of nose weight and adding down elevator trim. Undercambered wings show a pronounced “step” that makes the ship come alive in the air. The Gaggler has it and the Thermal Queen is very close. More work is needed, but the promise is there.

I will look forward to bringing the ’ship to the Cumberland event this fall and having Carl fly it. There was a look on his face when he flew the Gaggler that was priceless. You could see 30+ years of time just melt away as he guided that model in the wonderful lift. That was the extra reward for me in building that 'ship and will hopefully be again when we meet up this fall.

Until then, I'll pull up the lawn chair, get a cool drink and the iPod and chase the clouds and the birds.

Resources:

Skybench Aerotech
Source for model kits and plans.
http://www.skybench.com

National Balsa
Vendors of balsa sticks and sheets and plywood.
http://www.nationalbalsa.com

Sig Manufacturing Company
Source for spruce and building materials.
http://www.sigmfg.com

Flying Models magazine
http://www.flying-models.com
For Thermal Queen full size plans go to the *Flying Models* main page and select Flying Models Plans Directory, then Radio Control Plans, then R/C Soaring, then Thermal Queen. The item number for the plans is CF0016 and the plan was published in the November 1970 issue.

The thin, narrow-chord wing is remarkably stiff and shows no sign of flutter, even in aggressive descents. The vertical stabilizer assembly was enlarged 30% for better handling in gusty conditions, especially in the landing approach.

THE CROSS COUNTRY SAILPLANE

NOTES BY MARTIN SIMONS FOR THE MARCS SYMPOSIUM, OCTOBER 1992

This material was submitted to RC Soaring Digest *by Martin Simons during Winter 1993-1994. It was published in printed form by the Madison Area Radio Control Society in the* Proceedings of the 1992 M.A.R.C.S. National Sailplane Symposium, *now out of print.*

The experience of full scale cross country soaring

I begin with this heading because it seems to me that model cross country soaring is about to enter an era where the knowledge acquired by full scale soaring pilots, will be of most direct use to model fliers. There always has been a close association between models and full scale aviation. Most pilots of the larger aircraft have been, or still are, active modelers too. I suspect that most pilots of model sailplanes have tried, or would like to try, full sized soaring too. It becomes expensive in time, energy and money if one becomes seriously involved. I should say nevertheless that modelers generally would benefit from some full scale soaring experience. (For one thing, they might discover some truths about turning downwind, circling in thermals, stability and centers of gravity, and safe flying generally.)

The link between the two forms of soaring will become closer in future when we begin to fly model sailplanes across country as a matter of regular routine.

Hill soaring across country

Hill soaring cross country flying by models is already well established.

In a few well chosen places, with plenty of alternative slopes for different winds, cross country contests are held regularly. A course of some difficulty, with turning points in awkward places and some testing manoeuvres as well, is laid out and the pilots struggle to complete the task. They are normally expected to land on top near the starting place, or cross a finish line in flight. Merely completing the course is a challenge, let alone doing it in a fast time. The limits are, often, the pilot's inability to run through rough country and climb over fences and other barriers, while retaining control of the model. There are the usual problems of radio frequency clashes and since the models may be airborne for long periods, it is common for pilots to have spare sets of crystals to enable all to fly.

The models in these contests are taken to the summit, or nearly to it, to be hand launched directly into the slope current. There are a great many excellent slope sites where really long cross country flights would be possible but where there is no access to the top, no place to launch, no place to land, or no way of getting from one summit to another. We should adopt a different attitude for such regions.

It is often possible to launch a model by winch or hi start from fields at the foot of a slope, fly back to find the lift and then run along the hill. A four wheel drive vehicle then makes it possible to do a cross country flight. Evidently this kind of flying requires a team of people for each model and, rather like the full-sized equivalent, a pilot will need a dedicated and reliable crew.

There is much fun still to be had with hill soaring but most of what I shall say here relates to cross country thermal soaring. This, too, is not new, but so far as I know, nothing has been said in print about the theories involved or the kind of instrumentation that will be needed. Fortunately, a great deal has been written about cross country soaring for full sized sailplanes and I have, in my time, done quite a lot of this kind of flying. The theories do work providing, as always, that they are used with common sense.

The variometer

What instruments shall we need?

Full scale thermal soaring in the early days was delayed for lack of one vital instrument. Above level ground, small vertical motions of the air, or, more importantly, of the sailplane in the air, are practically undetectable from the cockpit without a reliable method of judging rates of rise and fall. The pilot lacks any visual reference. So called “flying by the seat of the pants” is not of much help. A bump from below, a sudden sensation of rising, might mean a thermal but might not. Turbulent air might mean lift or sink or neither, there was rarely any way to tell the difference. The altimeter is quite incapable of indicating small variations of height associated with thermal lift or sink. About 1927 it was realized that an instrument, already invented by balloonists in the nineteenth century, would be useful for soaring. This was the sensitive rate of climb indicator or, as it is now universally known, the variometer. When rising air, however feeble, was entered, the variometer would give the pilot an almost immediate indication. The technique of circling in thermals was very soon developed once variometers came into general use.

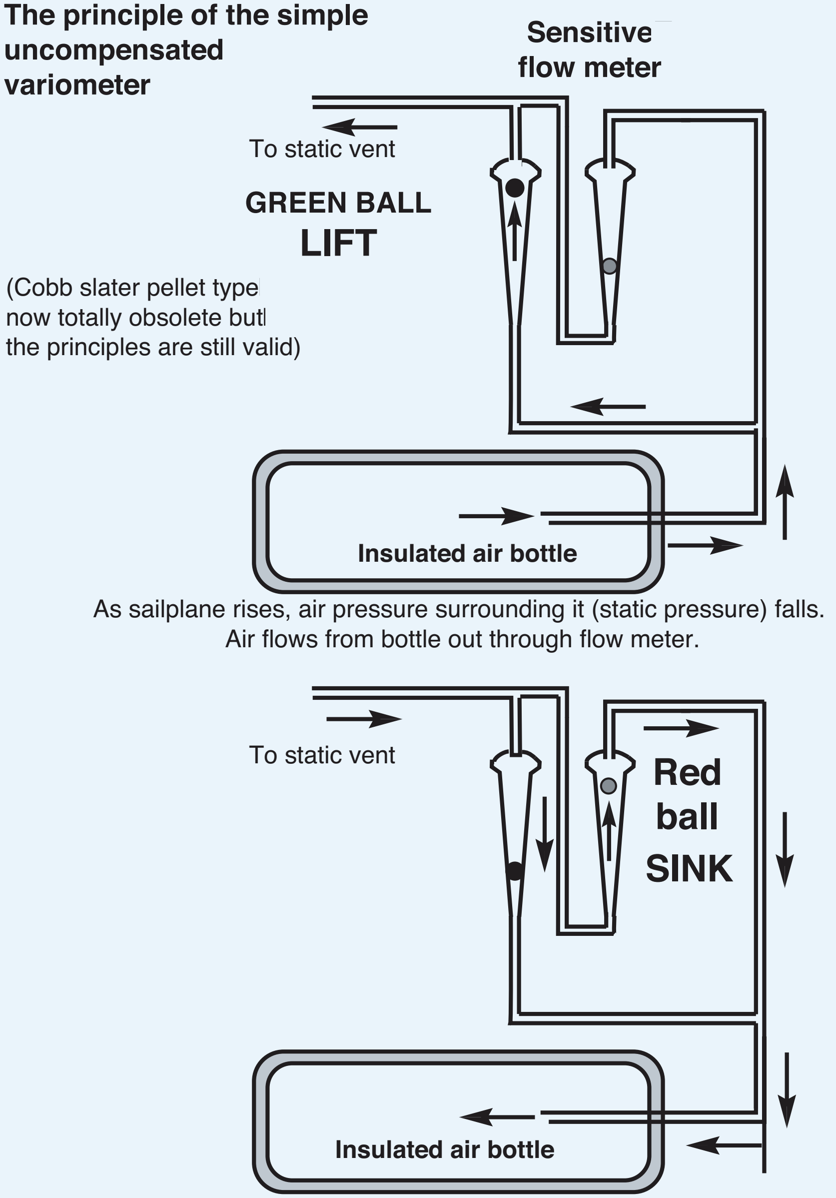
For cross country flying with models, we must expect to be operating often at considerable distances and heights, so for us, too, it will be difficult to tell whether the sailplane is in lift or sink. We are going to have to fit variometers which will not only indicate rises and falls, but will signal immediately to the pilot on the ground.

Figure 1 illustrates how one of the early mechanical variometers worked. There were other types, produced by firms in Germany and Poland, but this one, the Cobb Slater, or COSIM (Cobb Slater Instruments, Matlock) invented about 1935 in England by Bert Cobb and Louis Slater, was very simple and easy to understand. As distinct from the altimeter, the variometer is essentially a very sensitive flow meter.

A flask, often a vacuum flask which might otherwise have contained coffee, provided a temperature insulated reservoir. On ascending, the reduction of “static” pressure outside would allow air to move from the flask to the atmosphere, on its way out blowing through the conical tube containing the green ball. The green ball would pop up. Hence, ever since, British soaring pilots have spoken of “green air” for lift. In descent, the red ball came up. The simple COSIM was sensitive enough to record, almost instantaneously, if one lifted it gently from the floor to put it on the table. I did my first soaring and my first cross country flights, using this type of instrument.

The COSIM was not very accurate in measuring varying rates of climb or descent, especially since in a tightly banked turn the green ball was forced some way down the tube by centrifugal force, to pop up again when the bank came off. (A highly misleading signal if one was not prepared for it.) Similarly, in a “negative g” manoeuvre, both balls would pop up together. A more serious defect was discovered in dry climates, since static electricity generated by the

Figure 1
The principle of the simple uncompensated variometer



As sailplane sinks, air pressure surrounding it (static pressure) rises.
Air flows into bottle through flow meter.

little pith balls inside their glass tubes, caused them to stick.

All mechanical variometers rely on the same basic aerodynamic principles although in most types a balanced vane is used for the flow meter, reading to a circular dial with a needle, rather than the Cobb Slater upright tubes. The dial instruments are not subject to positive and negative "g" errors. Sailplanes today still sometimes carry mechanical variometers in case the more sophisticated electronic ones break down.

The first move toward electronic variometers was to replace the green and red balls, or the delicate vanes of the dial instruments, with a simple Wheatstone bridge electrical circuit which measured the differential cooling, and hence resistance, caused by the air flowing out of the flask, or into it, passing over the heated coils or, eventually, thermistors. These relatively crude devices worked well so long as the batteries were charged, but were almost too sensitive, being upset by small scale turbulence. Flow restrictors in the plumbing and electrical dampers had to be used to smooth the needle motions.

Nowadays, with pressure transducers and other electronic devices, compensated for temperature variations and coupled to small computers and even navigation systems, the variometer for the full sized sailplane has become far more accurate and is at least as sensitive as the old mechanical types.

One very important improvement, which came with the first electrical variometers, was the invention of the audio variometer. Now, the pilot does not have to look at the face of the instrument, but hears it. This enables a better look out to be maintained, reducing the risk of collisions.

Usually there is a beeping when the sailplane is in lift, with the tone rising to inaudible pitches in very strong thermals. There is a depressing groan in sink.

With models too, an audible output will be necessary, since the pilot needs to keep eyes on the model all the time. It will not be advisable to keep glancing at an instrument panel. The pilot will have an ear piece through which this vital news will come to him.

There is another important principle to be considered.

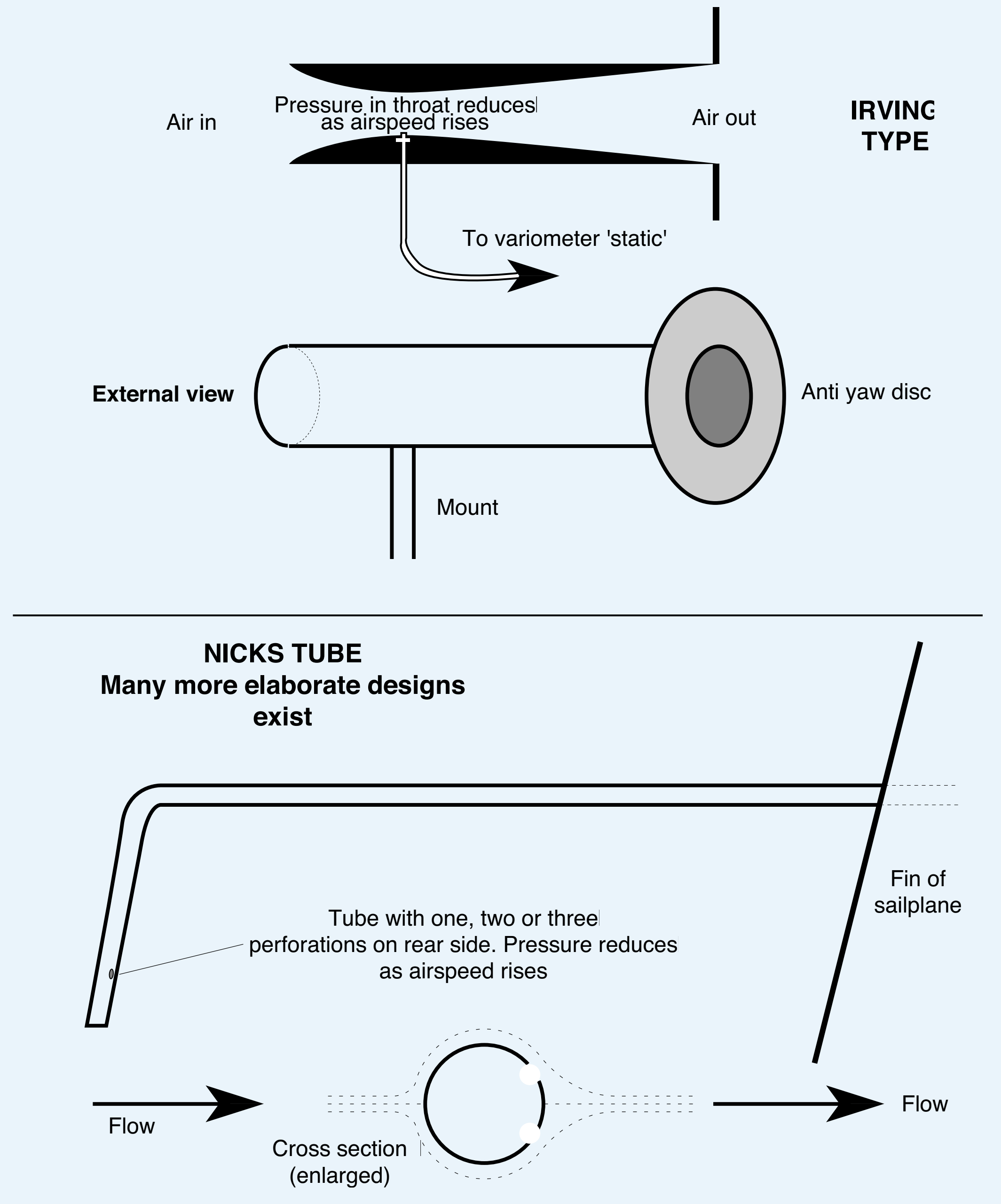
Total energy compensation

Model sailplane fliers know that if, when the sailplane is flying, the stick is pulled back, the model pitches up, rises rapidly for a little time and loses airspeed. We have to learn the difference between such a brief gain, a "stick thermal', and the sailplane's behavior as it enters a genuine up current. Similarly, on moving the stick forward, the model pitches nose down, gains airspeed and loses height. In a full scale sailplane, unless compensated in the manner I shall describe, stick thermals cause wildly misleading indications on the variometer.

To compensate for "stick lift" and sink the simplest devices are the total energy venturi and the "Nicks tube" or some variation of it (Figure 2). Even now, with all the electronic equipment available, every full sized sailplane carries a probe of this, or some similar, type.

When a fluid flows through a constriction such as a venturi, as Bernoulli showed some centuries ago, the increase of flow speed in the constricted passageway causes a

Figure 2. The total energy variometer



reduction of fluid pressure in the throat. Mathematically, the pressure is in inverse ratio to the flow speed. Flow speed up, pressure down. (The same effect allows wings to provide lift.)

If a venturi is mounted correctly on the aircraft, the pressure in the throat will rise as the airspeed falls and fall as the airspeed rises. A change of kinetic energy in the flow is necessarily balanced by a compensating change in potential energy. By careful design and placement of the venturi, the pressure in the throat can be made to compensate quite exactly for the airspeed variations.

Instead of connecting the variometer to the ordinary "static" pressure vents on the sailplane (usually two or four small holes on the rear fuselage, or sometimes on the old fashioned "pitot" head), it is now connected to the throat of the venturi. Stick thermals virtually disappear. The term "total energy" relates to the total of potential and kinetic energy of the sailplane. In other words, an indication of a rise on the variometer indicates a genuine gain of energy, not a stick thermal, and a down reading on the instrument indicates a loss of energy, i.e., sinking air.

The Nicks tube is even simpler than the Irving venturi but works in an equivalent manner. The pressure at the small vents in the tube follows the total energy equation quite closely. Apparent simplicity conceals a lot of careful research by Oran Nicks, the inventor. Usually the Nicks tube, or a refinement of it, is mounted on the fin, well clear of any aerodynamic turbulence or interference. The drag is slightly less than for the venturi.

Nothing in soaring is ever simple. For various reasons, no variometer is ever quite without lags and errors and no compensator is ever capable of giving perfect total energy information. The sensing head, for example, is often affected by yaw, by aerodynamic turbulence and local pressure variations caused by the airflow over the sailplane. It takes an appreciable time for flows in the long lengths of plumbing which connect all the parts together inside the sailplane, to reach the sensing instrument. Condensation and dust, after a while, find their ways into the system. A microscopic leak in the tubing can cause complete confusion. There are also some inertial and lag effects on the sailplane itself, so that changes of speed and height are not instantly apparent. In practice, the pilot learns to allow for these errors and delays. The seat of the pants remains useful.

Cross country soaring models also are going to need compensated variometers, which must signal gains and losses of total energy, rather than stick thermals. Without this we shall be confused rather than helped by the messages sent to us from the sailplane.

Other instruments

No other instrument is so important as the total energy variometer, but an accurate altimeter with temperature compensation will be needed for the model and equally, an airspeed indicator. I shall not describe how these work, except to point out that both need to be connected to atmospheric probes which must be carefully placed to avoid, as far as possible, position errors. For example, the altimeter requires a "static" pressure connection, not to the interior of the fuselage, but to the outside air. This static vent has to be placed where the pressure input is not upset as the aircraft changes speed, yaws or stalls. This placement is very far from easy. The airspeed indicator also requires a static vent and a pressure input. Both may be provided by a pitot head which has to be clear of turbulence.

Altimeter and ASI will be required not merely because it is nice to know height and speed, but because they will be be combined with the variometer readings to maximize cross country performance. This leads to the next diagram.

Classical cross country soaring

The first cross country thermal soaring flights by full sized sailplane were achieved without much theoretical analysis. It seemed obvious to pilots that when they found a thermal, they should squeeze every possible foot of height from it. Even if it was feeble, it should not be wasted. Long periods were spent circling, up to the base of any clouds that might form and, if gyro instruments were carried, into the clouds.

Having reached the top of the thermal, the pilot would set course and trim the sailplane for its best glide ratio, always faster than the trim for minimum rate of sink. The ensuing glide might bring the inexperienced down to a premature landing. Pilots soon learned to divert a little from their course towards likely sources of lift, even stopping to do a little slope soaring if nothing else offered. When another thermal was found it would be used to the full, and then another long glide would carry the flight forward (Figure 3).

The first important change in this classical method came when it was realized that to fly at the best lift/drag ratio or L/D of the sailplane, giving the best distance for height in still air, was never the best way to reach the next thermal. It is safe to say that, except on extremely rare occasions of dead flat calm, no intelligent

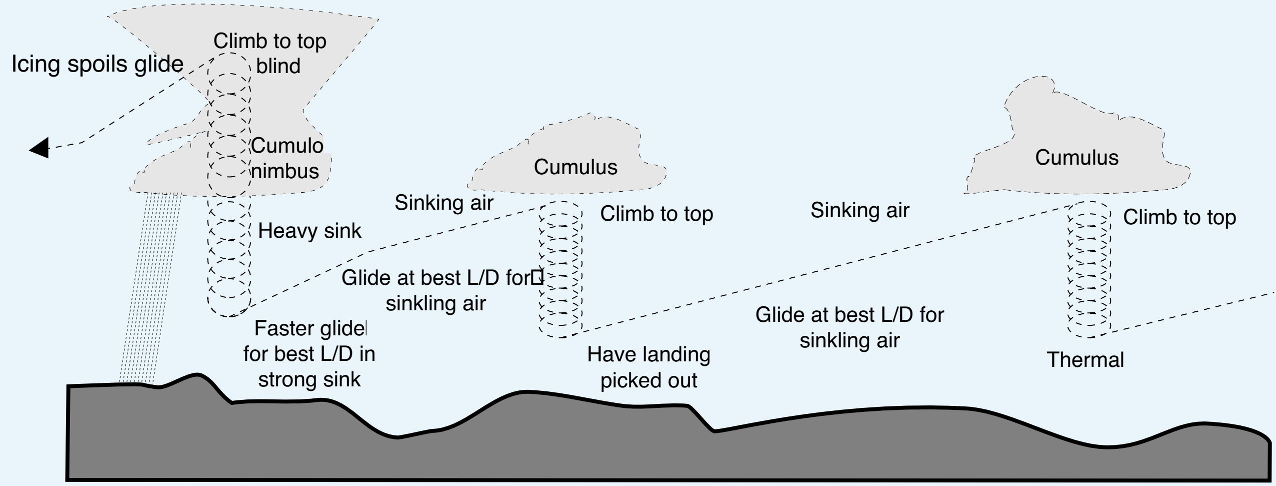


Figure 3. The classical style of cross country flying.

Information needed: Climbing or sinking.
Altitude now.
Prospects of lift ahead.
Speed to fly through sink.
Suitable landing areas.
Wind speed and direction.
Hours of daylight remaining.

Instruments needed: Total energy variometer (compensates for airseed variations).
Altimeter.
Airspeed indicator.
Oxygen breathing if likely to go above 10000 ft.
Maps.
Clock.

Figure 4. The performance polar of a sailplane

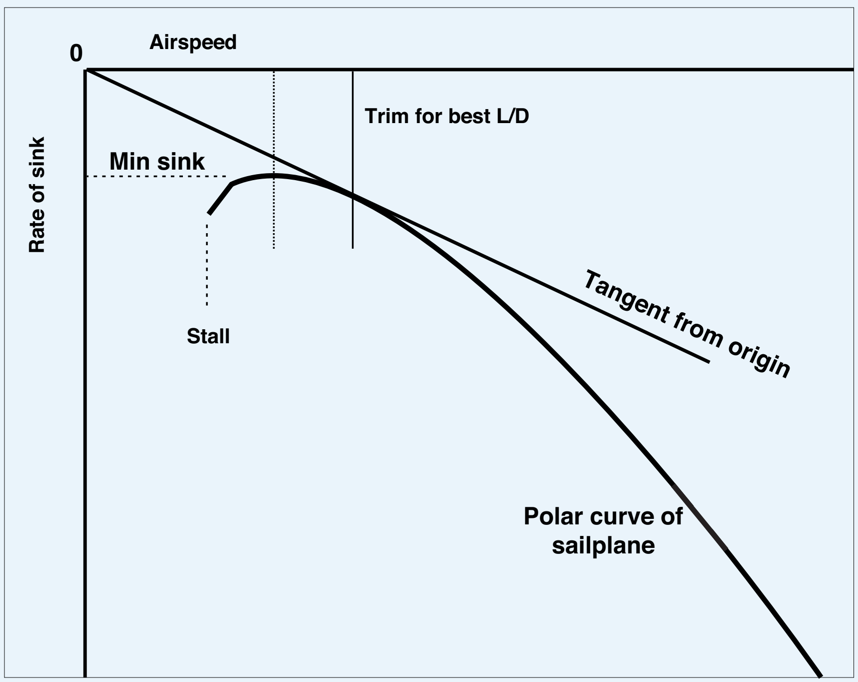
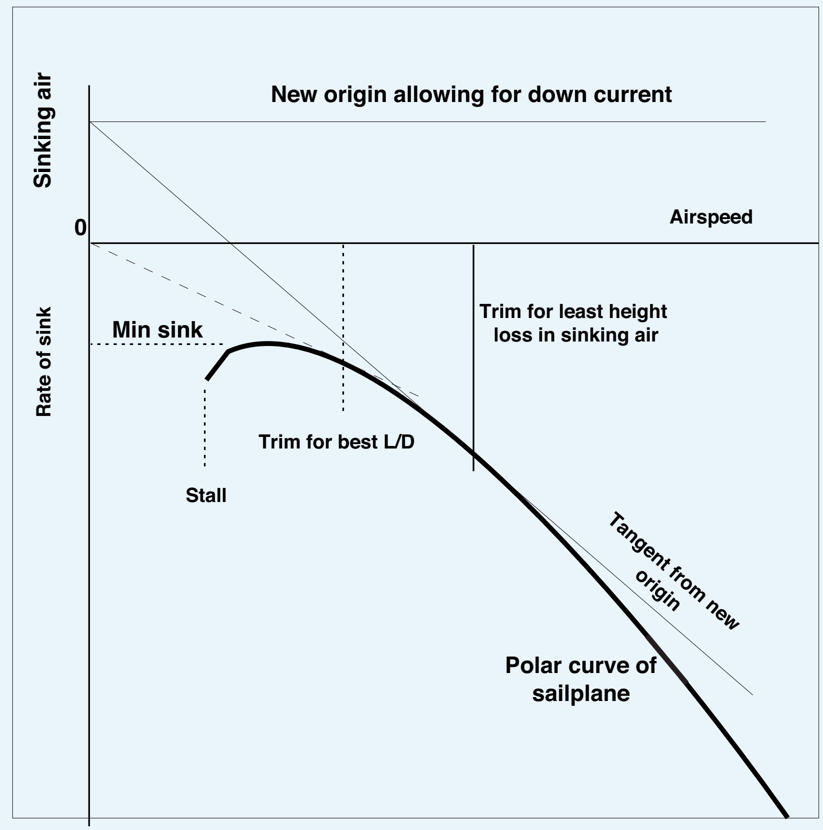


Figure 5. The performance polar of a sailplane in sinking air



sailplane pilot ever flies at the nominal best L/D trim.

Figures 4 and 5 show why. The heavy line in Figure 4 represents the straight flight performance curve or polar, of a sailplane. The exact shape of the curve does not matter much, nor do the particular figures for sink, best L/D, etc. All sailplanes of whatever type have a polar like this.

The vertical axis on the chart indicates the rate of sink of the sailplane through the air. The horizontal axis is the airspeed. It is easy to see that the minimum rate of sink occurs where the curve reaches its highest point on the chart. The trim required for this is the airspeed vertically above the summit of the polar.

The maximum L/D or best glide ratio is found by drawing a line from the origin or zero-zero point where the two axes cross, to touch the polar curve tangentially. If the air was always totally still, this would be the best speed to fly in order to achieve the greatest distance across country, after a climb. But if a sailplane can climb in thermals, some air is going up. If there is air going up there must be air coming down, and it will come down between the thermals. The glider trying to cross the gap from one area of lift to another, is almost always trying to pass through, or penetrate, areas of sink.

On the chart, we can easily represent sinking air by extending the vertical axis upwards, as shown in Figure 5. If the sailplane is in a down current, the speed of the sinking air has to be added to the sinking speed of the sailplane. If it was sinking at 2 ft per second, and enters air which is going down at 1 fps, it will descend at 3 fps and so on. The sink can be represented by shifting the origin as shown.

To find the best trim for penetrating sink with least waste of height, the tangent has to be drawn from the new origin. It is immediately obvious that to conserve altitude between thermals, as soon as there is sinking air to penetrate, the airspeed must be increased. To early sailplane pilots this seemed quite against their basic instincts. Desperately anxious not to sacrifice altitude, they hated to put the sailplane's nose down and, apparently, throw height away. But it did not take them long to realize the truth. Flying slowly through sink was the best way to waste height. Penetration was the important thing.

The air between thermals is usually sinking, but like thermals themselves, the rate of movement is not uniform. Weakly sinking air demands only a slight increase in speed, very strong sink demands a very large increase in airspeed, moderate sink a moderate airspeed increase and so on. The rate of sink experienced from moment to moment in the air, requires appropriate increases and decreases of speed. The pilot has to monitor the rate of sink all the time and change airspeed accordingly. This is true for models too.

In terms of the instruments, some pilots began to carry charts in the cockpit, with sliding axes and transparent rulers. This was much too clumsy in practice. Paul MacCready (the same who developed the muscle and solar powered aircraft) was a champion soaring pilot in the nineteen fifties, and offered a convenient solution which was universally adopted.

The MacCready ring could be fitted to any dial type variometer and gave the pilot an immediate, constantly up-dated, indication of the speed to fly. As mentioned below, the MacCready theory was intended for cross country racing, requiring the pilot to set it for different expected thermal strengths. A diagram like Figure 5 here may be used to make a MacCready ring, but I will not go into that here.

For the best possible height conserving glide in sinking air, the MacCready ring is set to zero and the speed required is indicated.

The MacCready ring is still used, but with modern electronics it is usual now to incorporate, in the instrument package, a mathematical model of the polar curve. The computer compares the actual rate of sink with the airspeed and the polar curve of the sailplane. It then gives a reading to the pilot in terms of airspeed required, according to the MacCready theory. Naturally, if the sailplane enters rising air, the instrument immediately indicates that the airspeed should be trimmed back, and if the sink increases, the indication is to speed up.

It is already clear that, for the instruments to work correctly, the performance polar of the sailplane must be known, at least to a first approximation. There can be no instrument package applicable to all sailplane designs; every type needs its own.

There are some excellent software packages now which enable us to calculate the performance of any model sailplane. These probably are sufficiently accurate for us to use them as the basis for the new instruments. However, the calculated polars are not exact and since model builders too are not always perfect, we should ideally find the polar curve for each individual model by a series of careful tests in flight. The difficulties involved in this are very great and I shall not attempt to discuss them here. This might make a good topic for a whole seminar on some future occasion.

The effect of wind

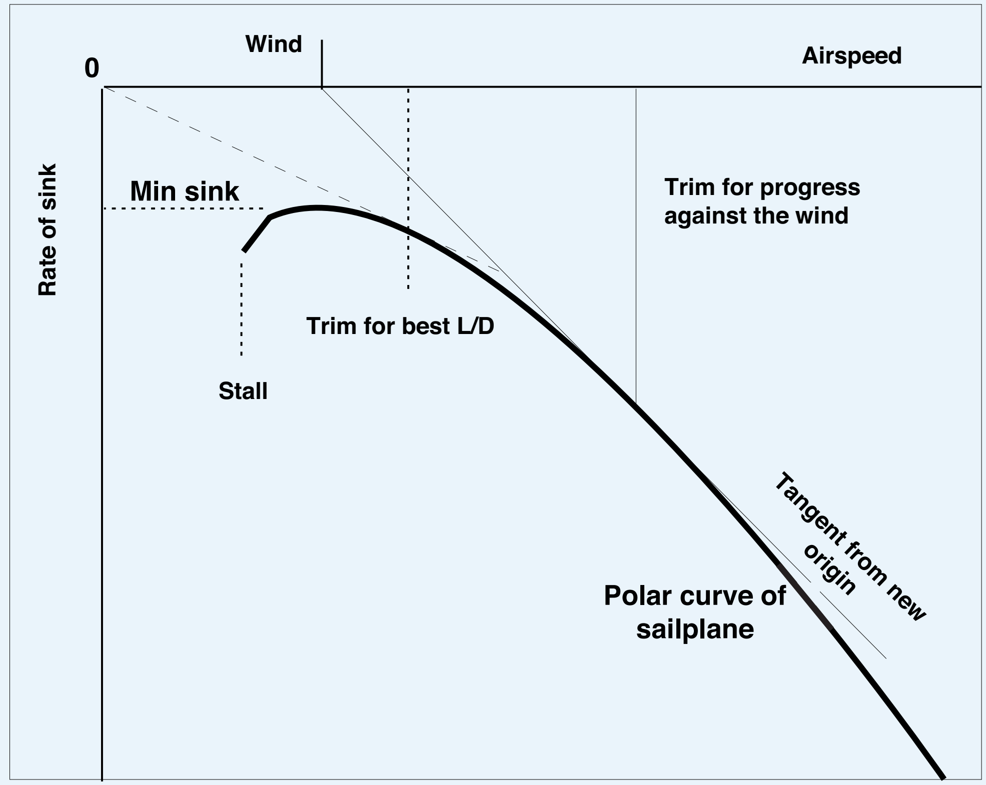
An interesting side issue arises if there is a wind. Strictly, if the only consideration is to cross the gaps between thermals with least loss of height, the wind makes no difference. Thermals and sailplane all move along with the general atmospheric drift. The instrument will give the same reading, which will be quite correct. Speed up in sink, slow down in lift, never fly at the best L/D.

However, if the pilot is aiming for some distant goal where the sailplane will land, there comes a time when the wind has to be taken into account. This is a commonplace situation for model fliers on almost any flying day. The model, in a thermal, has drifted some way, and now has to be brought home to land. What is the correct trim?

The answer, for a particular polar curve, can be found by shifting the origin of the airspeed axis (Figure 6). If the wind speed is, say, 10 mph and the sailplane is flying against it at 30 mph, the speed over the ground is 30 - 10 = 20 mph. The wind can be represented on the chart by moving the origin 10 mph. to the right. A tangent drawn from this point shows that the speed for the model to get to the goal with least height loss, is considerably more than that speed for best L/D. Flying against the wind and also trying to penetrate sinking air, demands an even higher airspeed.

The modern sailplane instrument system allows the pilot to set up the so called “final glide” situation, allowing for any wind and/or sink, together with the height on the altimeter, and then the airspeed is adjusted accordingly. Cross country model

Figure 6. Sailplane performance when flying against a headwind



sailplanes should be fitted with similar electronic instruments, all of which will need to be transmitted to the ground in comprehensible form.

MacCready flying

I shall not say much more about MacCready theory, because, so far, model cross country flying has not reached the stage where actual racing is important. It will become so, and should be anticipated. The sailplane pilot who is in a race must not linger in weak thermals but leave them as soon as possible in search of strong ones (Figure 7). To use every last shred of lift wastes time if there is better to be found. Looking ahead down the track, the pilot must estimate the strength of the next thermal to be used. This is not the next thermal that might be flown into, because that might not be strong enough. The pilot says: "The next thermal I shall use must be up to such and such a strength. Anything less, I shall not accept but shall simply fly through without circling. The only exception is if I make a bad mistake and get so low that I have to use any lift I can find."

The object is, not to enter the next thermal as high as possible, but to get to the top of the next climb in the least possible time, so achieving the best average speed. Between thermals, calculations show that the speed to fly must be faster again than the speed for least height loss.

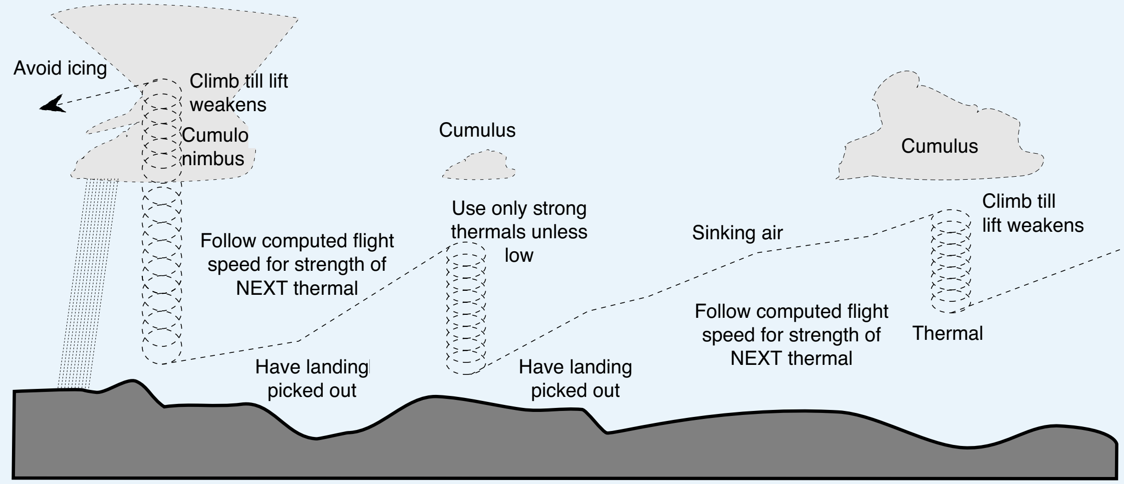


Figure 7. The MacCready style of cross country flying

Information needed: Rate of climb in present thermal (average).
Estimated average strength of next thermal (experience on the day/hour/minute).
Airspeed now and airspeed required for maximum average speed (through the air).
Altitude now and estimated altitude at next thermal.
Suitable landing areas.
Course, wind strength and direction and distance to fly to reach goal (turning point or race finish).
Final glide computer.

Instruments needed: Total energy variometer with speed to fly ring (MacCrteady ring).
Altimeter.
Air speed indicator.
Compass.
Gyro instruments if blind flying allowed (turn and slip indicator minimum, art. horizon better).
Oxygen breathing if likely to go above 10000 ft.
Maps and plan position indicator if available.

Dolphin soaring

Dolphin soaring grew directly from MacCready theory (Figure 8). Granting that not all thermals are worth circling in because of the time wasted in weak lift, good use can still be made of such rising air by flying through it slowly, without circling. Height can be gained without much loss of time. With the greatly improved performance of modern sailplanes, in recent years it has been found possible to fly at very high average speeds for long distances, through weak and even strong thermals, without circling. Crossing the sinking air still requires very high airspeeds. When lift is found the pilot pulls up, gaining hundreds of feet in the manoeuvre, then levels out to fly slowly through the lift, gaining height all the time, until on running out of it on the other side, the speed is rapidly regained in a dive and the flight continues. Only if conditions become difficult or if an exceptionally strong thermal is encountered, does the modern racing pilot circle to gain height. the passage of the sailplane through the air resembles the plunging and surfacing of a dolphin, hence the name.

Models already do some dolphin soaring, as much by luck as by judgment. With good electronic instruments, we shall do a lot more. Our chief problem will be to keep up, on the ground, with our sailplanes (Figure 9).

The sailplane

We are now in a position to consider the design of a good cross country model sailplane.

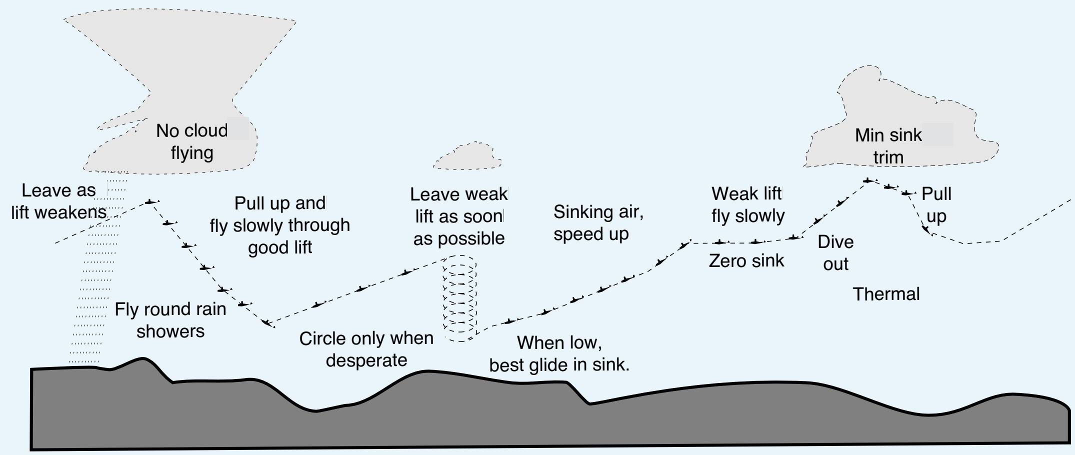


Figure 8. Dolphin soaring

Information needed: Rate of climb or sink now.
Airspeed now and airspeed required for maximum average speed (through the air).
Altitude now and estimated altitude in future.
Location of lift and pattern of thermals.
Suitable landing areas.
Course, wind strength and direction and distance to fly to reach goal (turning point or race finish).
Final glide information.

Instruments needed: Total energy variometers (several) with nav computer and averager.
Altimeter.
Air speed indicator.
Compasses (several).
Oxygen breathing if likely to go above 10000 ft.
Maps and plan position indicator.
Final glide computer (included in speed to fly comouter).

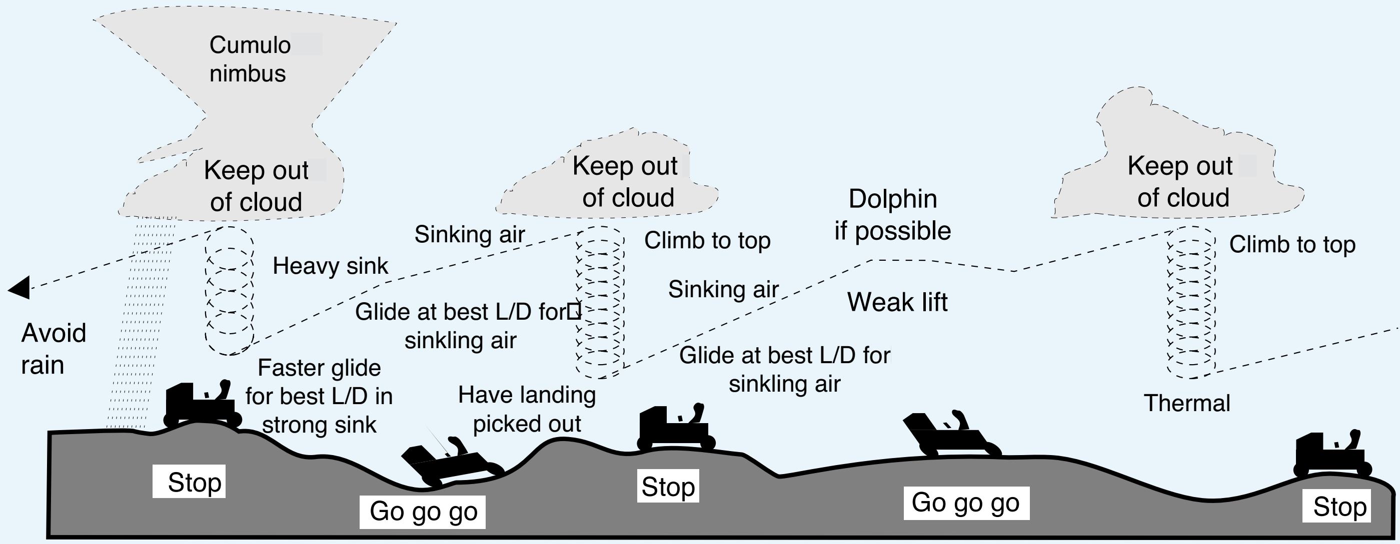


Figure 9. Cross country flying with model sailplanes: Use a large, strong sailplane!

Information needed: Climbing or sinking.
Altitude now.
Prospects of lift ahead.
Speed to fly through sink.
Suitable landing areas.
Wind speed and direction.
Hours of daylight remaining.
Battery charge information.

Instruments needed in glider, transmitting to pilot:
Total energy variometer (compensates for airseed variations).
Altimeter.
Airspeed indicator.
Plan position indicator.
Battery sensor.
Artificial pilot?

Pre-planning:
Weather forecast, lapse rates, winds, whole day.
Map out proposed route - road, tracks, rough country. (Aerial photographs? Airports?)
Food, fuel and camping prospects.

Ground equipment:
Following vehicle (pick up truck or 'ute' with good seat for pilot and helper).
Reliable driver and navigator.
Communication pilot to driver.
Binoculars.
Reserves of everything - fuel, food, drink etc.
Electronic gear to receive and convey information from glider (Pilot has earphone, info in audible form.

Not necessarily in the order of greatest importance, the model:

(1) Must be large and colorful with distinctive shape

(2) Must have capacity for large batteries, instruments etc.

(3) Must be strong

(4) Needs powerful air brakes

(5) Should be stable in circling flight

(6) Must be stable in pitch

(7) Must be capable of wide range of trims without "stick pressure"

(8) Needs a low minimum sink rate and good handling in turns

(9) Must have good penetration

We may now expand on each of these.

Size, color and shape

Build up to the largest wing area considered feasible. This gives very definite improvements in performance because of Reynolds number increases all round. Probably more importantly, a large model will be more visible at great heights and at large distances.

A two color scheme is useful - dark below, different above. Dark green and bright "rescue orange" make a good combination. The model "blinks" as it turns, which helps orientation and recognition. Some fluorescent paint is helpful. It is not wise use too many differing colors in patches, even if these are bright. The effect can become like the "dazzle" system used on First World War ships to mislead U boats. The dazzle paint caused the U Boat skippers to mistake the size, speed and course of the target - just the thing we have to avoid in flight.

Small panels of highly reflective material in a few carefully chosen places, help with orientation.

One of the worst colors is all over white, so we should not imitate full-scale plastic sailplanes in this respect for serious cross country flying. White is a good color if one is above another aircraft looking down on it. White shows up well against any surface other than snow, but head or tail on and level with the horizon or in hazy skies, such aircraft virtually disappear. Probably worse than white for a model, is light grey, matching the clouds.

Models with "character" are easier to manage at a distance than "bland" shapes. Small losses of efficiency are acceptable if the result is a model easier to identify and control. Polyhedral or tip dihedral, gull wings, pod fuselages, "Bird of Time" wings, etc., are easier to see and interpret than very slender, straight shapes.

Capacity

A slightly fatter fuselage loses very little in drag. Plenty of room inside is more important, but use a good streamlined shape. The best place for ballast is inside the wings and provision should be made for this.

Strength

The wing spars at least should be stressed for bending by calculation or practical test. High accuracy is not necessary when supported by common sense and experience, but even a rough stressing calculation will enable the wings to be made strong enough and yet light at the tips, which is desirable. Most engineers know how to make the calculations that are required (Figure 10).

The model will often fly very fast, so wing torsion becomes very important, for both strength and stiffness. Probably wing skins will be wood veneer (e.g. obechi). Glass fibre is somewhat elastic, which is good in many situations, but strips of unidirectional carbon fibre, laid diagonally, will assist torsional stiffness if the wings are skinned with glass instead of veneer. Practical tests of wing stiffness in torsion are not difficult to do, although nothing of this kind has ever been reported in the modelling press, so far as I know.

Wings should be thicker at root than outboard. This will follow automatically if the wing is tapered, but the taper in planform should not be allowed to dictate the taper in thickness. To deepen the wing root will help wing strength and stiffness and the outer panels of the wing can be thinner. There will be negligible or nil aerodynamic penalty.

Tailplane/stabilizer loads should also be considered since at high flight speeds tail loads are severe. Stiffness in the fuselage rear end is also important to prevent tail flutter. Slender glass tail booms are not the safest in this respect.

Mass balancing of control surfaces will almost certainly prove necessary, to prevent flutter.

Air brakes

The model will sometimes have to be dived very steeply to get down out of strong lift. Spoilers and "crow" flaps tend to be blown back and can even be blown off altogether. Vertical "Schempp Hirth" brakes (as on full scale sailplanes) are almost essential and are relatively easy to design and install. Alternatively, trailing edge brakes, center pivoted and balanced are effective. They make it more difficult to fit camber flaps, but this problem has been overcome in some full scale sailplanes (e.g., the Mosquito).Tail parachute air brakes are excellent but they can be deployed only once in a flight and have to be jettisoned if not required after deployment. This can be embarrassing.

The brakes, whatever type they are, must be large! It should be possible to use them proportionately, partly open, fully open, etc. so their full, drastic effects may not be needed for ordinary landing approaches. But for rapid descent out of strong thermal lift into a cloud, it is almost impossible to have brakes that are too big.

A full spin is a slow speed manoeuvre and can be used to bring a model down safely from a great height. Many model sailplanes, however, will not spin but tend to dive out into a spiral. If out of control this can destroy even a strong

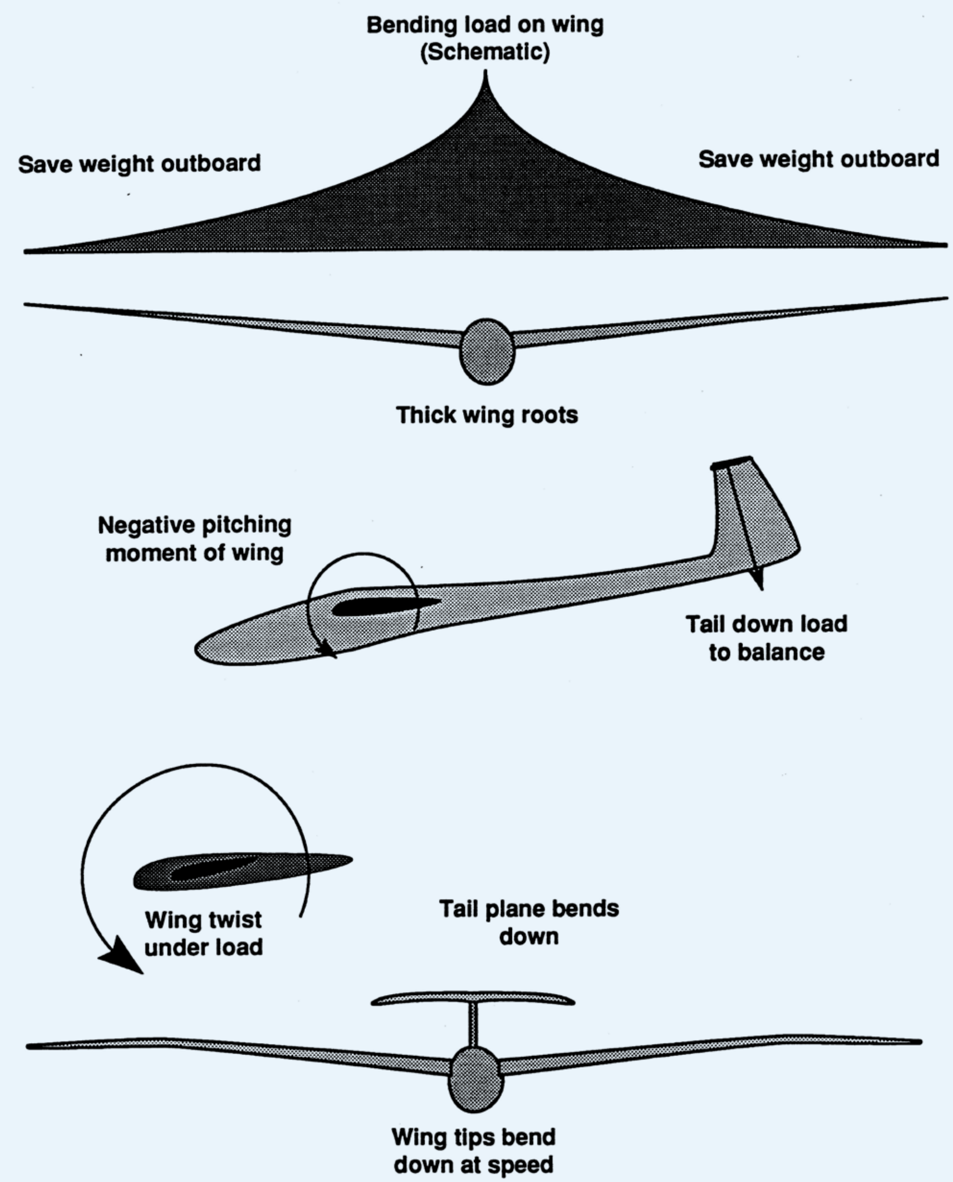


Figure 10.
Loads on the sailplane.

sailplane. It is important to distinguish in flight between genuine spinning and spiral diving.

Stability in turns

Practical tests and adjustments to the design of the model are better here than calculations. Rule of thumb methods, based on experience, seem to yield reasonably good results. The requirement is for a sailplane that, once trimmed for a desired angle of bank and airspeed, will tend to hold that rate of turn despite minor turbulence. (Major turbulence, within or on the edges of a thermal, will throw the glider about anyway.)

Usually, for a large sailplane, the required trim for a steady rate of turn at minimum sink is slightly up on the elevator. The bank angle controls the rate of turn and the turn radius. The up elevator keeps the turn going as long as the bank is on.

Some “hold off” aileron against the turn is usually necessary. In a turn, especially with a high aspect ratio, the inner wing moves through the air more slowly than the outer wing, so tends to develop less lift. This wing then tends to go down more, tightening the turn. The ailerons are used to prevent this. The effect is not to roll the model out of the turn, but to equalize the lift on the two sides, so allowing the model to hold a constant bank angle. With a “rudder elevator” model, top rudder can be used to create the same effect.

A small degree of spiral instability is not necessarily a serious fault, although when a model is far away it becomes very difficult to see what is happening and a spiral dive may develop quickly if not corrected. Hence it is worth doing a lot of testing and adjustment of vertical tail and dihedral to achieve genuine spiral stability.

The most likely result of allowing a spiral dive to continue too long, is to destroy the model. Under these conditions the airspeed rises and at the same time the “g” loads on the wing build up to such an extent that in the end something is almost sure to collapse. Even at slow airspeeds, a bank of about eighty-five degrees applies a load of about 11 g (that is, eleven times the normal load) to the wings (Figure 11). At high speeds, too, the tailplane comes under very severe down loads and may collapse. Fortunately, it is fairly easy to recognize and stop a spiral dive before it goes too far, providing the model is in sight. If there is any doubt, open the air brakes, progressively rather than suddenly, to limit the airspeed.

Pitch stability

As with stability in turns, what is needed here is a model that will hold, against minor turbulence, the attitude dictated by the position of the controls.

This is often misunderstood. A stable model is one which is always obedient to the pilot, under full control. That is, if the pilot moves the controls deliberately so that the model is upside down and then holds them and trims for inverted flight, the stable model will do its utmost to remain upside down in the chosen attitude, until the pilot changes the controls. It will then obey the new commands.

In contrast, an unstable or neutrally stable model will not stay in the position the pilot requires. It will tend all the time to obey its own whims and will require constant correction. In an aerobatic slope soaring model something like this may be desired and such a model is certainly very exciting to fly. But a cross country sailplane, flying at a distance of a mile or so and at three thousand feet, requires different characteristics.

Major turbulence, as when entering a thermal, will show up clearly and predictably if the model is stable. This, too, is contrary to some widely held beliefs. An unstable of neutrally stable model will pitch about alarmingly without warning and give false signals to the pilot constantly.

In cross country flying there is a lot of straight flying with nil bank, but to achieve best results it is very important that the airspeed, as determined by the position of the elevator and/or flap trimmers, follows the pilot’s wishes. Hence a stable model is needed but of course there must be enough response to elevator movement, to change the airspeed as frequently as required.

Assuming the model has normal proportions, almost the only important factor here is the position of the balance point or center of gravity relative to the neutral point of the whole model. For a cross country model, start with the c.g. well forward. Any location between 25% and 30% of the mean wing chord would be reasonable. This ensures a good "static margin" of pitch stability. (It also helps circling stability.) Small rearward adjustments of the c.g. may be preferred after first experience, but it is be worth calculating the actual value of the static margin before doing this. The formulae are given in most respectable textbooks.

Dynamic instability effects

Almost any sailplane which is efficient, with low drag, will exhibit some dynamic instability in pitch. This shows up as a phugoid or wave like motion, with a fairly long period (Figure 12). The model noses down, levels out, noses up, levels out, noses down, etc. This is almost inescapable because the main damping factor, aerodynamic drag, is small. The pilot may be too far away to detect this slow oscillation and in some models it may never build up to any appreciable extent and so is not a major worry.

Dynamic instability may, however, cause a steady increase in the oscillations until the model is pitching up and down seriously and eventually stalling and diving violently. Once recognised, this can easily be controlled with elevator.

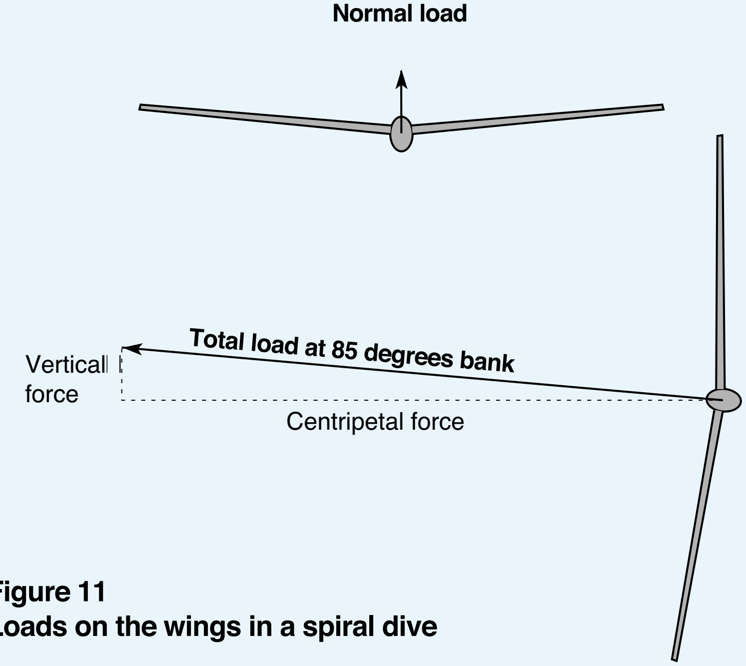


Figure 11
Loads on the wings in a spiral dive

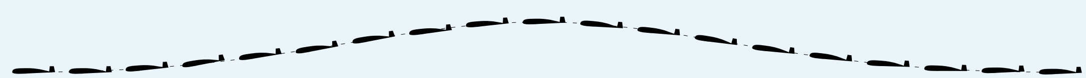


Figure 12. Dynamic instability. The phugoid oscillation

To reduce the chances of serious dynamic instability (providing model has an adequate static stability margin), keep the extremities as light as possible - especially the tail. But do not be surprised or dismayed if the model "phugoids" gently sometimes. Almost all good sailplanes do this, since it is their very efficiency which reduces the damping effect. Keeping the tail (and hence the nose) as light as possible, helps but is not likely to remove the problem completely.

Despite the many mechanical advantages of having control servos in the tail it is probably not to be recommended because they increase the dynamic instability. Even if (as may be the case) the weight of a couple or three servos in the tail, is no worse for static balance than the weight of push rods running all the way down the fuselage, the concentrated mass of the servos so far aft, is worse dynamically. In dynamic stability calculations, the cube of the mass involved enters the equations for moments of inertia, multiplied by the distance from the center of mass.

Do not suppose that reducing the static margin will overcome the dynamic instability problem. It makes it worse. An adequate static margin is effective in damping the dynamic oscillations.

Trim range

To fly fast and straight on course for long periods through sink between thermals, the model should be capable of flying "hands off" at the whatever speed is indicated by the instruments. Many models currently in use do not have sufficient trim power to get the elevator down enough.

The reverse happens when circling. Usually some up trim is required to keep the turn going steadily, hands off. There may not be enough trim action available.

Solutions that suggest themselves are:

(1) Moving the c.g. back. This defeats the major need for good pitch stability. Every backward shift of the c.g., increases elevator sensitivity but decreases the stability margin. As mentioned, this may be good for aerobatics but not for cross country work.

(2) Increasing elevator or stabilator size, preferably by increasing its span rather than merely adding extra chord. A high aspect ratio surface has a steep lift curve slope, which means that a small angular change yields a greater effect on the control power.

(3) Taking a leaf from the full-sized book we might use a separate trim tab on the elevator, operated by an entirely separate small "stick" or auxiliary slider on the transmitter. This offers itself as a simple and very effective solution which is known to work perfectly.

(4) Electronic methods - exponential control throws for the trim or perhaps a re-design of the trim potentiometer on the transmitter to give a greater range of movement, or alternative control mixers, etc. Existing transmitters do not seem to have enough flexibility in this respect.

(5) If the model has camber changing flaps (see below under Penetration), moving the flaps alone will cause substantial change of trim in the desired sense. This is perhaps the best solution. With flaps raised slightly the model will speed up and settle into a high airspeed. With flaps down, it will slow down. Note that the visible attitude of the model may not alter much. A perfect balance between flap position, drag and trim has the sailplane always flying at its correct attitude and appropriate airspeed for the flap setting chosen, without change of elevator trim at all. (This is a rare condition but can be achieved sometimes. The famous ASW 12 full scale sailplane was an example.)

Low sink rate in turns

An important point here is that for cross country flying we do not need to worry much about total weight and wing loading. Extra mass, in the form of ballast, may even prove necessary for penetration, so there is not much point in building a model excessively light. The light model may climb slightly better in a weak thermal, but after that it will not go anywhere.

We are not likely to attempt long cross country flights, with models, on days that look like being marginal for soaring. On good days, there will be strong thermals about and the vital thing is to have a good, fast, flat glide when looking for them - i.e., penetration.

But of course, even on strong thermal days there will be times when the model gets low and any sort of available lift will have to be used. For these occasions, the minimum sink rate in a turn and the ability to turn smoothly and accurately, will be important

For least sinking speed, the so called "power factor" has to be kept up, which means, for a given weight of aircraft, the drag has to be reduced.

When circling in lift, wing vortex drag is always a good deal more than all other forms of drag put together. Even a small saving here may make a big difference to the sinking rate. The requirement is a wing with tip vortex drag as small as possible, which demands, before all else, an aspect ratio as high as possible. The aspect ratio is the ratio of span to wing area, and may be found by dividing the span by the mean wing chord. Long, narrow wings have high aspect ratio.

It is well known that if the aspect ratio is too high, the narrowness of the wing chord brings some penalties in the shape of increased profile drag. (This is the Reynolds number effect.) Laminar separation bubbles form on wings as the wing chord decreases at a given airspeed (low Re). There is also an effect of more fundamental kind. As the Re is reduced, the effect of the air's viscosity becomes more significant. Even if there is no laminar separation, the profile drag of a narrow wing increases as Re falls. Hence, quite apart from structural and handling limitations, there are aerodynamic limits to the aspect ratio. For large models of the kind we are considering, the Re problem becomes much less important than for small models in the 100 inch and two metre category.

The best way available of studying this, is to experiment with different wing designs using any of the good computer programs which are now available. Some experience along these lines indicates that we shall see aspect ratios around 18 to 20, which compares with 20 to 40 for the modern full scale sailplane (the lower value here represents the span-limited 15 meter classes).

The larger the sailplane, the higher the aspect ratio can be. Even if this makes for a heavier model, the sinking speed in circling will usually be less.

Additional savings of vortex drag come from adoption of elliptical chord distributions. That is, tapering the wing so that the chord at each point is the same as the chord of a pure ellipse would be at the same spanwise location. This does not mean the wing has to be elliptical. The basis of this is to share the lifting load as evenly as possible over the entire wing surface so that every part of the wing which produces drag, is doing its fair share of lifting. The elliptical chord distribution does this.

Further, but probably slight, improvements are possible by adopting a slightly swept back or even a true crescent shape, like that used on the (full sized) Polish SZD 55 standard class sailplane. The basic elliptical chord distribution is more or less retained but the planform is sheared back towards the tips. The arguments used in support of this form began with Wil Schumann who modified his (full scale) ASW 17 along these lines and produced the so-called Schumann planform. The full sized Discus is well known, and the SZD - 55 has gone further with this and is very successful. These aircraft do not necessarily always win contests against more orthodox types such as the ASW 24; the gains are not very great.

Recent research (mostly by advanced "panel methods" of wing design by computer, but with some support from wind tunnel testing) indicates that a crescent wing with the trailing edge curved back and a rather pointed tip, is even better than the SZD 55 wing (Figure 13).

My own experience, with two crescent wing sailplane models, was not favorable since both models developed wing flutter at moderate and high airspeeds. As emphasized repeatedly above, high speed flying will be a routine requirement

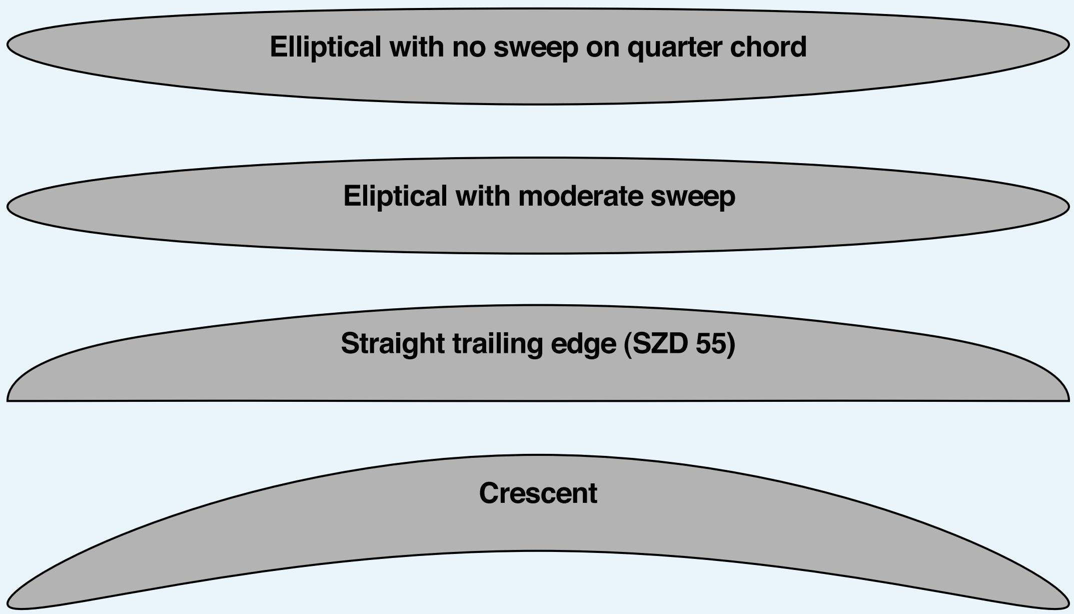


Figure 13. Idealised wing planforms

for cross country flight, so wing flutter must be avoided even if a small sacrifice is made in thermaling performance. Even on a very orthodox wing, some studies suggest that an up and back swept or "sheared" wing tip acts to some extent like a winglet and helps reduce vortex drag. I recently observed, in Seattle, a model which had been fitted experimentally with back swept wing tips of this kind. On a trial fast run, wing flutter appeared. Before the swept tips were fitted, the model never fluttered.

There may be some further advantage in fitting Whitcomb winglets, but the same effect can always be obtained by increasing the span for a given total area, i.e., increasing aspect ratio. This is less difficult than designing winglets and setting them correctly.

The rest of the drag of the model - tail, fuselage, etc., is of very minor importance at thermal circling airspeeds. Providing the model has normal proportions and the air brakes are firmly closed, the wing is what counts for the thermal.

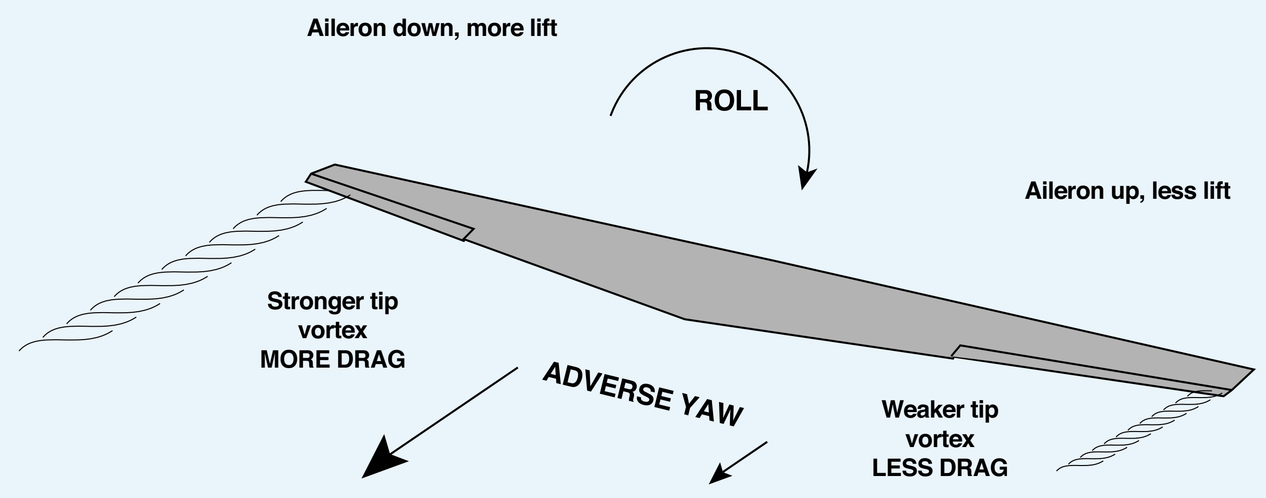
Low speed handling

The management of a stable sailplane with high aspect ratio, in circling flight, is mainly a matter of trim. As mentioned already, the elevator usually needs to be up somewhat and the ailerons or rudder positioned to "hold off" bank.

Manoeuvring a sailplane with large wing span, either to enter a turn or to come out of one, is not so easy. The long, narrow wings tend to have a high moment of inertia. They tend to prefer to stay at whatever bank angle they happen to be, and resist any change. In rough air this is an advantage since the flight tends to remain smooth, whereas a smaller span model gets disturbed more easily.

However, persuading the high aspect ratio wing to bank, or to take bank off, requires large control power. If ailerons are used, especially if they are themselves of high aspect ratio (long and narrow, e.g. flaperons) the power is available without excessive control movement. Unfortunately, adverse drag, usually called aileron drag, is inescapable. It is essential to co-ordinate the ailerons with the rudder.

Figure 14. The cause of adverse aileron yaw: tip vortex drag



There is much misunderstanding of the adverse yaw which arises when a sailplane enters or leaves a turn. In order to make a model bank, or to take bank off, one wing has to be made to generate more lift than the other. It is this imbalance that makes the model roll to the desired angle.

To create the inequality of lift between the two wings, ailerons may be used. Their effect is to reduce the camber of one wing and increase the camber of the other. The result is a lift imbalance in the required sense.

But a change of lift on a wing inevitably and invariably changes the strength of the wing tip vortex. On the wing with more lift, the tip vortex strengthens, with necessary increase in drag. There is a corresponding reduction of the tip vortex on the other wing which has less lift, and hence less drag there. The result is a considerable yawing force (Figure 14). The adverse yaw arises both ways - on entering a turn, it yaws the model against the turn, on leaving a turn, it yaws it into the turn. The basic cause is tip vortex drag imbalance and that is the necessary consequence of the lift imbalance which is necessary to alter the bank angle.

Differential linkage, with the downward ailerons geared to move less than the up going one, have some desirable effect, especially at very low flying speeds near the stall. Flow separation on the down aileron can be partly prevented by differential gearing and so this is a useful device.

To counteract the adverse yaw, the rudder, which is the primary control surface for yawing the aircraft, must move simultaneously with the ailerons, in the same sense. In full-sized soaring, this requires coordinated action by the pilot, stick and rudder pedals always together. With models, electronic or mechanical rudder-aileron coupling is the obvious solution, although it is quite possible to fly a sailplane without their aid. Pilots can get used to making coordinated turns with rudder and aileron. Quite a lot of rudder action is usually needed. With large span aircraft often full rudder is used with quite small aileron deflections.

It is important to note also that using the rudder alone, with ample dihedral or polyhedral, to turn a sailplane, does not remove the adverse yaw forces. The lift imbalance which banks the sailplane into the turn, or brings the bank off out of the turn, is still there. To get the turn to be smooth and well coordinated, heavier use of the rudder is needed than when there are ailerons.

Thus, adverse yaw, or so-called aileron yaw, is nothing to do with the downward aileron entering a region of high speed, high pressure flow, and hence suffering increased profile drag, as is so often stated. In fact, a more cambered wing surface gives less drag at high lift angles of attack. This is why well cambered wings are more efficient for flight at high angles of attack.

Tip Stalling

The fundamental cause of tip stalling is the shape of the wing planform: not the wing profile, although as explained below, profile change towards the tips can help cure the problem, if wisely done.

Without going into a lot of detail, it can be shown that any lifting wing sheds strong vortices because of the pressure difference between upper and lower surfaces and the tendency for the flow to move round the tips. The effect of a vortex is to reduce the effective angle of attack. This is called the vortex induced downwash and the whole wing, from tip inwards to root, feels this effect to greater or lesser extent..

If the wing has a rectangular planform with squarish tips, the tip vortex is strong and concentrated around the tips, much weaker inboard. Hence there is strong vortex induced downwash near the tips of such a wing. Hence while the inner wing is approaching the stalling angle, the tips are still affected by the induced downwash and do not stall. This is a safe wing. It can still be made to tip stall by clumsiness on the controls, but normally tip stalling is easily prevented, even in steep turns. A subsidiary point is that, so long as the outer wing is not stalled, the ailerons remain effective so even if a stall does begin to develop at the root, the pilot can usually keep the wings level.

However, for reasons of efficiency (reduction of tip vortex drag) and structural strength (deep wing roots), we normally taper the wings of a sailplane. This, as intended, reduces the strength of the tip vortices and improves the efficiency of the wing. The ideal, as mentioned already, is the elliptical chord distribution with, perhaps, some crescent sweep back.

The whole point of doing this is to weaken the concentrated tip vortex, and this is very effective. But now, instead of the induced downwash preventing tip stall, the entire wing tends to reach the stalling angle of attack at the same time. In this situation, the smallest error in flying, or a minor gust in a thermal, can cause the wing to stall asymmetrically with a violent wing drop.

By tapering the wing even more severely than suggested by the elliptical chord shape, the tips will always tend to stall before the roots of the wing, which is a very dangerous condition. On entering or leaving a turn, when one wing is inevitably at a higher angle of attack than the other (because of the necessary lift imbalance) tip stalling is extremely likely.

Preventing tip stall

One obvious way of reducing the danger of tip stalling, is never to taper the wing too much. A basically rectangular wing plan, with well rounded tips or with a moderate taper over the outer sixth of the span, does not lose a great deal in drag, compared with the ideal. It is likely to be much easier to fly and may perform very well for that reason even if it loses a little in terms of climb rate in thermals. Since strong tip vortices are associated with high angles of attack, the performance at high speeds (penetration) will suffer hardly at all.

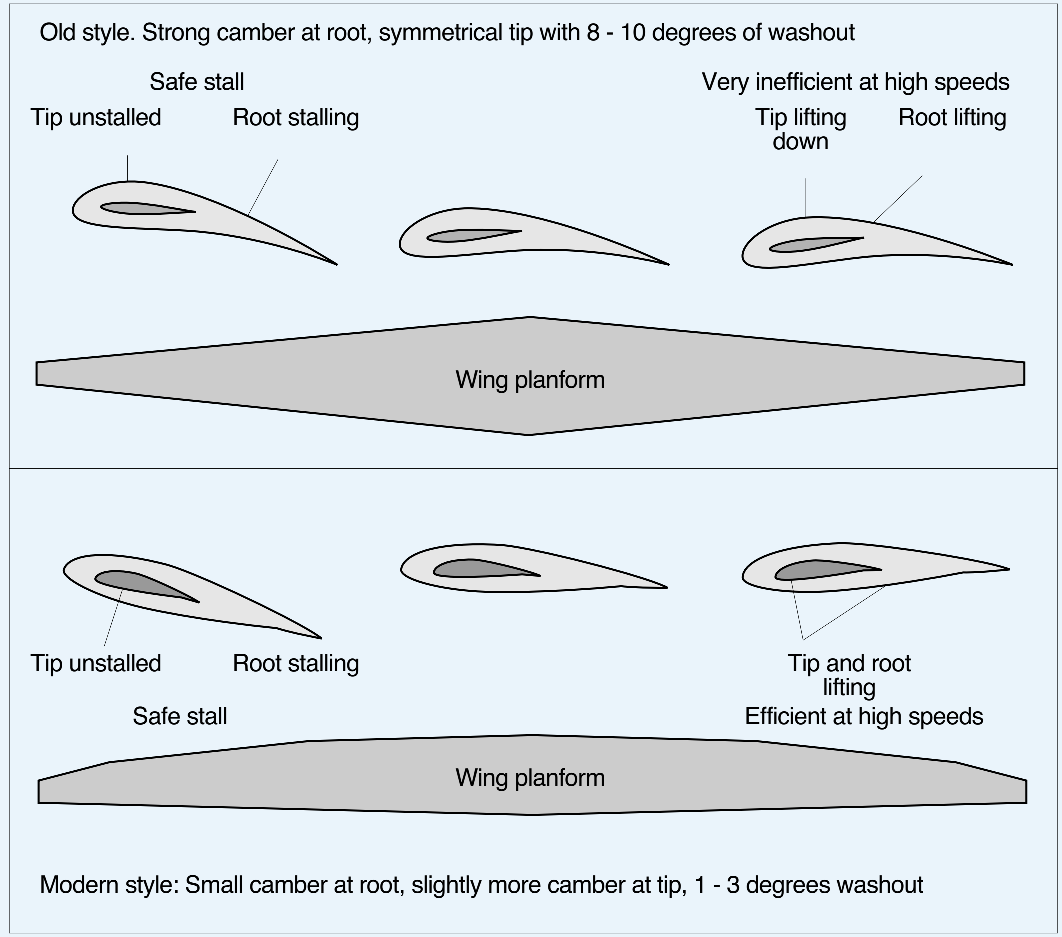
Even so, tapered wings are desirable, being structurally more efficient as well as creating a little less vortex drag.

Sixty years ago one way of preventing tip stalling was discovered. The wing section was changed progressively over the span, from strongly cambered, (6 to 7%) at the root, to symmetrical (0%) at the tip (Figure 15). This was combined with a massive, built in twist or "washout" of eight or ten degrees, starting from the root or perhaps from half way along the wing. The result was a safe, tapered wing. Very marked tapers were used, the ratio of root to tip sometimes being five or six to one. Such aircraft were very successful for slow speed flight and soaring in steeply banked circles under full control.

Unfortunately, if the airspeed was allowed to increase much above the speed for minimum rate of sink, the washed out wing tips began to operate at negative angles of attack, and lifted downwards. The result was a great increase in drag at high speeds. From the cockpit, the wing tips could be seen bending down.

(Incidentally, down bending tips often occur when the wing itself twists under the strong torsional loads which arise at high speeds, so

Figure 15. Prevention of tip stalling



forcing the outer wing to negative angles of attack. This can be seen happening on some modern model sailplanes.)

A more modern method of controlling tip stalling, is almost the opposite. Instead of running the wing out to a symmetrical tip section, the outer section is usually slightly more cambered than the root. A wing with a 2% cambered root section, for instance, may have a tip with 3% camber, or a 3% root may be matched to a 4% cambered tip.

Cambered wing profiles reach higher lift coefficients before stalling than symmetrical ones, and the more camber there is, up to a point, the higher the maximum lift coefficient obtainable. However, geometrically, the more cambered wing stalls at a lower angle of attack. Hence, with the increase of camber, a small amount of geometric washout is needed.

When the tip profile camber is correctly matched to the washout in this way, tip stalling is prevented and the undesirable down bending at high speeds also does not occur.

There are other tricks and dodges which can be used to rectify a tip stalling sailplane, once its vice has been discovered. The tip profile may be modified by adding filler to make the leading edge more rounded, for example. It is better, of course, to get the design right in the first place.

Penetration

To achieve good penetration, the model requires to be extremely "clean'. The wing aspect ratio and planform are not very important in this respect. The main sources of drag at penetration airspeeds are the wing profile and the so-called parasitic items, fuselage, tail, and any other protrusions or gaps which contribute drag without lift.

The wing profile is, as a rule, more important than the parasitic drag. With any reasonably well designed sailplane, the wing is always the most important source of drag at high speeds, as well as low. At low speeds it is the tip vortices which create most drag, at high speeds it is the wing profile.

The two most fundamental aspects of wing profile design are still camber and thickness. One is almost tempted to say that these are the only important factors, but this would be overstating the case. It is certainly wise to use a section that will not suffer from laminar separation bubbles and, thanks to the work of wind tunnel testers such as Michael Selig, John Donovan and the late David Fraser, not to forget Dieter Althaus" students in Stuttgart and the teams at Delft and Notre Dame Universities, we have a good idea now of what the best sections are in this respect.

It is still true that if camber and thickness of the wing are wrong, the performance of the sailplane will be very disappointing no matter what profile is used.

On the other hand, if camber and thickness are correctly chosen, the sailplane will perform well. Some further gains should come from a careful selection from those modern profiles which have the required camber and thickness, to gain the last few percentage points. We should also be very conscious of the need for accuracy in building and finishing these profiles.

The first consideration is camber. For cross country flying, the basic wing profile, at the root, should be cambered about 2% or perhaps less, say 1.5%. Such profiles give low drag at high speeds, which is what we require.

Thermal soaring models are often built to float gently rather than to penetrate. The result is, rather large values of camber. Some designers, nevertheless, have adopted, with success, wing profiles with much smaller camber than used to be current.

(I have found, with my own designs, that 1.5% and 2.5% camber are quite satisfactory for ordinary Sunday morning club soaring too. Such models do not fall out of the sky in weak lift, but climb just as well as some of the "floaters'. They tend to require more radius for the circling since a high airspeed has to be maintained, but in practice this rarely seems to matter. If the thermal is usable by anyone, these models climb. More importantly, they have much better penetration and enable a much wider search for lift after the first thermal. This is what is required in a cross country soarer too.)

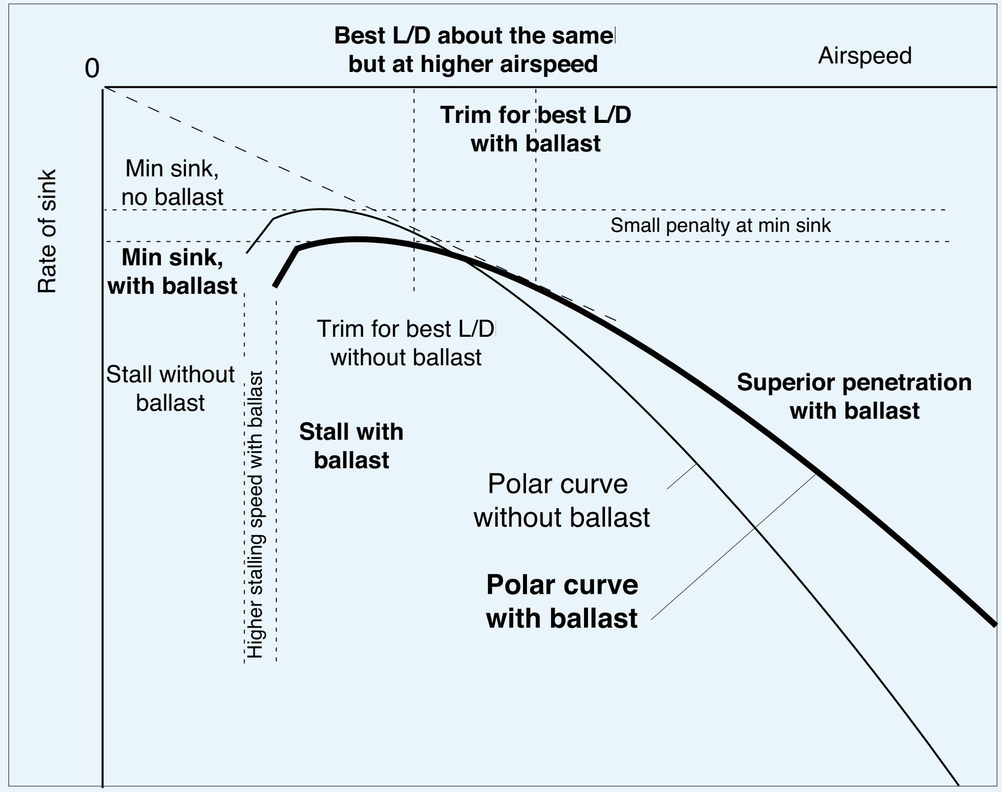
With such low cambers for the sake of high speed flight, the use of camber changing flaps and ailerons is an obvious solution to the problem of soaring in weak lift. If lift is unusually narrow, requiring a tight turning circle, then to droop flaps with ailerons slightly, will not actually improve the rate of sink much, if at all, but it will enable the sailplane to turn more tightly without stalling, and so it may be able to climb in the narrow core.

Note that using flaps without corresponding aileron movement up and down by the same amount, is worse than having no flaps at all. If the flaps go down, or up, without the ailerons, a strong vortex is created at the junction. This increases total drag much more than anything possibly gained from the flap adjustment.

Turning now to wing thickness, large models with wings of 15% and 16% thickness will fly quite successfully. I have two such currently airworthy. They are vintage scale models with thick wing sections, in accordance with the prototypes. They fly well and soar in thermals along with anything else. But these thick wings are not good at high speeds. (Apart from the drag, the camber creates quite serious torsional forces which threaten to twist the wings off if I try to fly too fast.)

Sections 10% or 11% thick seem considerably better. The figures are not exact. Small departures either way will not make much difference in practice.

Figure 16. Sailplane polar with and without ballast



Ballast

I have not so far mentioned ballast. The diagram (Figure 16) indicates the effects of ballast on the sailplane's polar. This, naturally, has to be allowed for in the computerised instrument package. There has to be a switching capability from one polar to the other, according to the total mass of the sailplane. The mathematical adjustment is not difficult.

In full scale cross country flying, it is normal these days to start the day with huge quantities of water ballast in rubber bags inside the wings. With ballast, pilot and instruments on board, a modern "open class" racing sailplane takes off at a total weight of around 3/4 of a ton. In contests, weighing machines are set up at the take off point and the sailplanes are checked to ensure that no-one is overloading the aircraft. Given the chance, some imprudent pilots would certainly do so for the sake of a few saved seconds which might win a race. They might win the race to their funeral, too.

More often than not, if the soaring conditions are even moderately good, the pilot keeps the ballast throughout the day and jettisons it only after finishing the race, just before landing. (The undercarriage is not supposed to take the landing loads with such a mass on board.)

Evidently, saving weight to enable a sailplane to scratch up in weak lift, is hardly considered any more. The pilot will not try to climb in weak thermals, but will use the extra penetration provided by the ballast, to go looking for a strong thermal. If, after all, none is found, then, and only in a desperate situation, the ballast can be dumped.

With our cross country models, I think the implication is clear. We may use ballast on good days, and adopt the same policy. But we cannot jettison the load, unless it is water or fine sand. If we do run into trouble, the model may have to land prematurely.

It is not true to say that saving weight is unimportant. As mentioned already, it is important at least to keep the extremities of tail and wing tips, light, for reasons of dynamic stability and manoeuvring. But a few saved fractions of mass here and there, in total, is not going to matter. A good cross country sailplane, built large, with high aspect ratio wings and strong, stiff structure, carrying, maybe, a substantial instrument package and extra powerful servos with large capacity batteries, is going to have a basic wing loading around the 16 ounces per square foot region, or higher. That is before adding ballast.

For this reason alone, it will almost certainly be launched by aero tow, but that is another matter for discussion.

Cross country racing

In a cross country race, it is not enough to make the best glide in terms of height lost, through sinking air. The important thing is the average speed from start to finish line. For this kind of flying, as mentioned above, the MacCready theory was developed about forty years ago. The speeds to fly between thermals come out higher again than those for least height loss.

When, rather than if, suitable electronic instruments are developed, model sailplanes will be able to carry out dolphin soaring for long distances and at average speeds so far considered beyond reach. Pre- planning, good pursuit vehicles and adequate electronic feedback from instruments in the glider, will enable this kind of soaring to develop rapidly. The most vital requirement is to develop the ability to read the sky, recognizing the pattern of the thermals, and learning to follow the lift and avoid the sink.

Where next?

We are, probably, on the brink of a revolution. We may look forward to the time when the leading world championships for model soaring will be cross country distance and speed racing tasks. These would be supreme tests of our pilots abilities, of our instruments and other equipment, and of our aircraft.

RCSD

2011 Milang F3J International

Report by Chris Adams
Photos by John Blanchard and Trevor Schultz

Report by Chris Adams

Milang, South Australia, proved again what an excellent venue it is for hosting competition gliding.

After 2 days of tough, and at times brutal, thermal competition, 27 pilots were whittled down to seven for the fly-offs. Three rounds of 15 minute fly-offs saw Dave Pratley rise to take top spot against a world-class field. Theo Arvanitakis 2nd and Marcus Stent 3rd.

Friday practice day saw 22°C deg temps, light breeze and around 20 pilots had a very pleasant day's pre-event tuning. The Western Australia team of Tim Kullack, Mike Rae (without his giant-killing Furio!), Evan Outtrim and Stephen Gleeson (with his magnificent "Gecko" custom winch) arrived late and squeezed in some valuable practice. Pilots came from all around Australia - Victoria, Tasmania, New South Wales and Western Australia.

Competition Day 1 Saturday, saw flat lifeless air of 23-25°C and gusts to 10kts. After midday lots of thermals popped and many pilots got their 10 minutes and the landings sorted out the top dogs.

Day 2 Sunday was tough. Gusting to 20kts and with massive lift/sink cycles saw many chase downwind only to land out. 1000ft altitude is usually enough to get back with, but not so for many pilots.

Ballast was utilized and several pilots resorted to F3B ships to deal with the conditions. Tim's Radical, Chris's Estrella and Bruce's Cobra got some airtime.

Airframe stresses on launch were high and Mike Rae's 3.8M Explorer was seen to flutter itself to destruction as well as Don's Espada snap a wing clean-off and try the direct route to China.

The "F3J with winches" format proved popular for pilots/spectators.

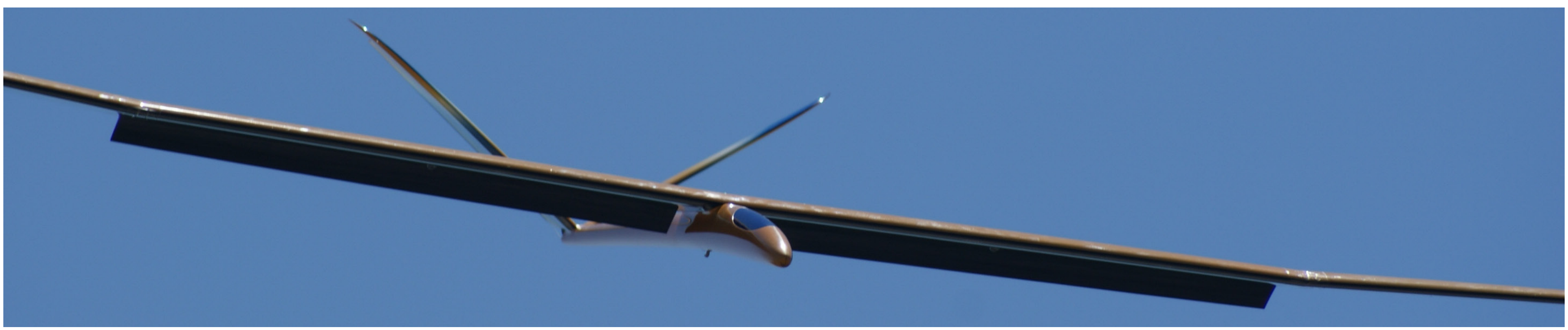
Seeing thermal ships launching and landing in unison to the dulcet tones of the recorded countown is outstanding to watch.

Dave Pratley flew a 4M Explorer, Theo his Pike Perfect, Marcus 3.5M Explorer. A couple of Espadas were evident including Alan Mayhew's Sarsparilla which is a strking combination of Espada R fuselage and Estrella DP wings.

Entertaining to watch; Carl & Theo made a pact on their last throwaway flight to launch under one second. Colourful language was evident when Carl realised Theo reneged and zoomed to the moon after five seconds on tow.

After hours entertainment Saturday night provided by Carl and Evan and Mr. Carlton Draught. Sunday's sumptuous post-mortem BBQ hosted by Bruce, Chris and Marcus at Ruby's Cottage, with thanks to Michelle and Darrel Blow for catering.

Lastly, thanks to the ground crew running the event. Debbie and Michael Abraham scoring, Rob Gunn MC, Mike O'Reilly CD, and Greg Potter andTerry and the Adelaide crew for catering, amenities and field hardware.

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