Thermal Training Notes

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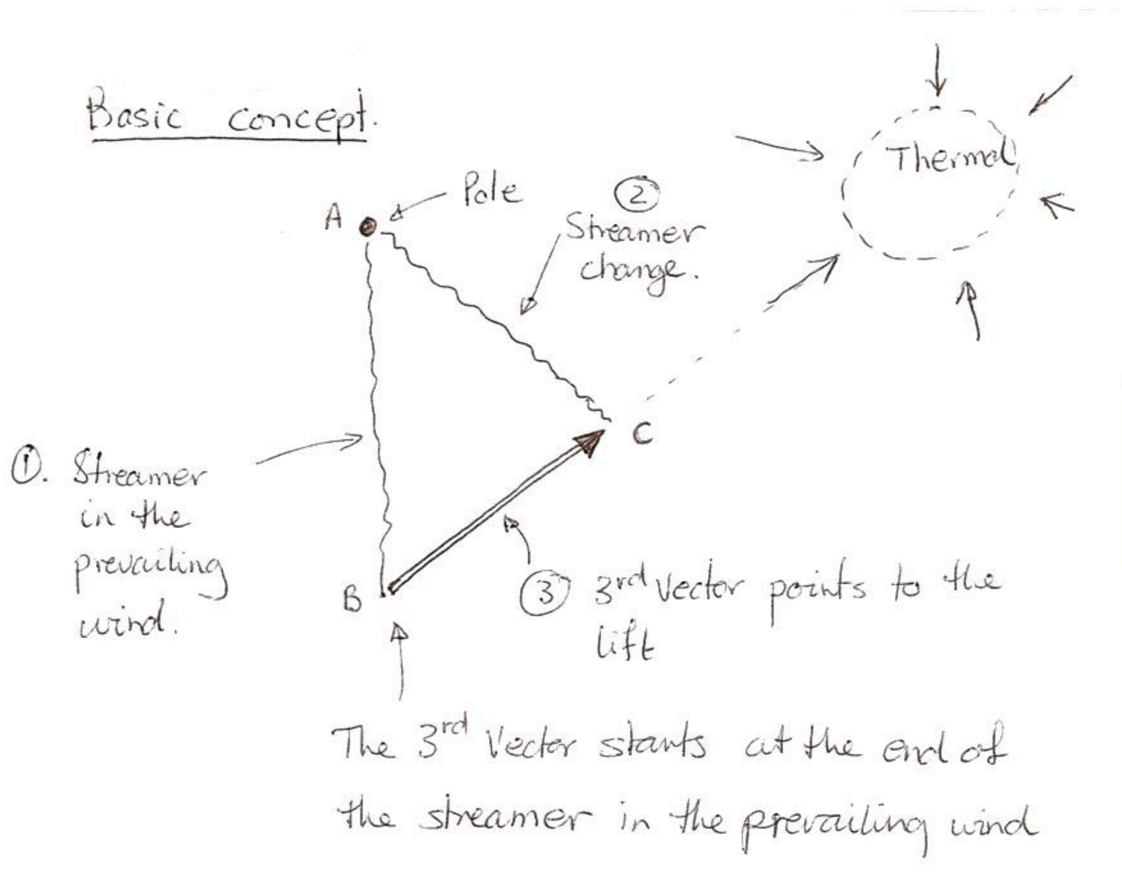
I put these training notes together to help model glider pilots improve their thermal flying skills.
Note: these notes are written for large F3J/F5J models so a couple of values/mixers will be different for F3K models.
The topics covered in these notes are:

1. Joe Wurts 3rd Vector.
2. Making the 3rd Vector work - Iterating the air.
3. Weather conditions.
4. Plane signs.
5. Thermalling.
6. Plane setup.
7. Returning from downwind.

1. Joe Wurts 3rd Vector

This concept is used to find thermals in windy conditions. Imagine a streamer being viewed from above. Point A is where the streamer is attached to the pole. Point B is the end of the streamer in the prevailing (no lift) wind. When the streamer moves (due to a thermal influence) the end of the streamer is now at point C. The third Vector is created between point B and point C and points to the thermal.



2. Making the 3rd Vector work - Iterating the air

To make the 3rd Vector work you need to be constantly iterating the air (e.g. constantly feeling the wind direction changes and wind strength changes) to get a mental picture of the surrounding air. Do this while you are setting up your plane, fetching a line or talking to other pilots. You will need to learn to multitask and it takes practice.

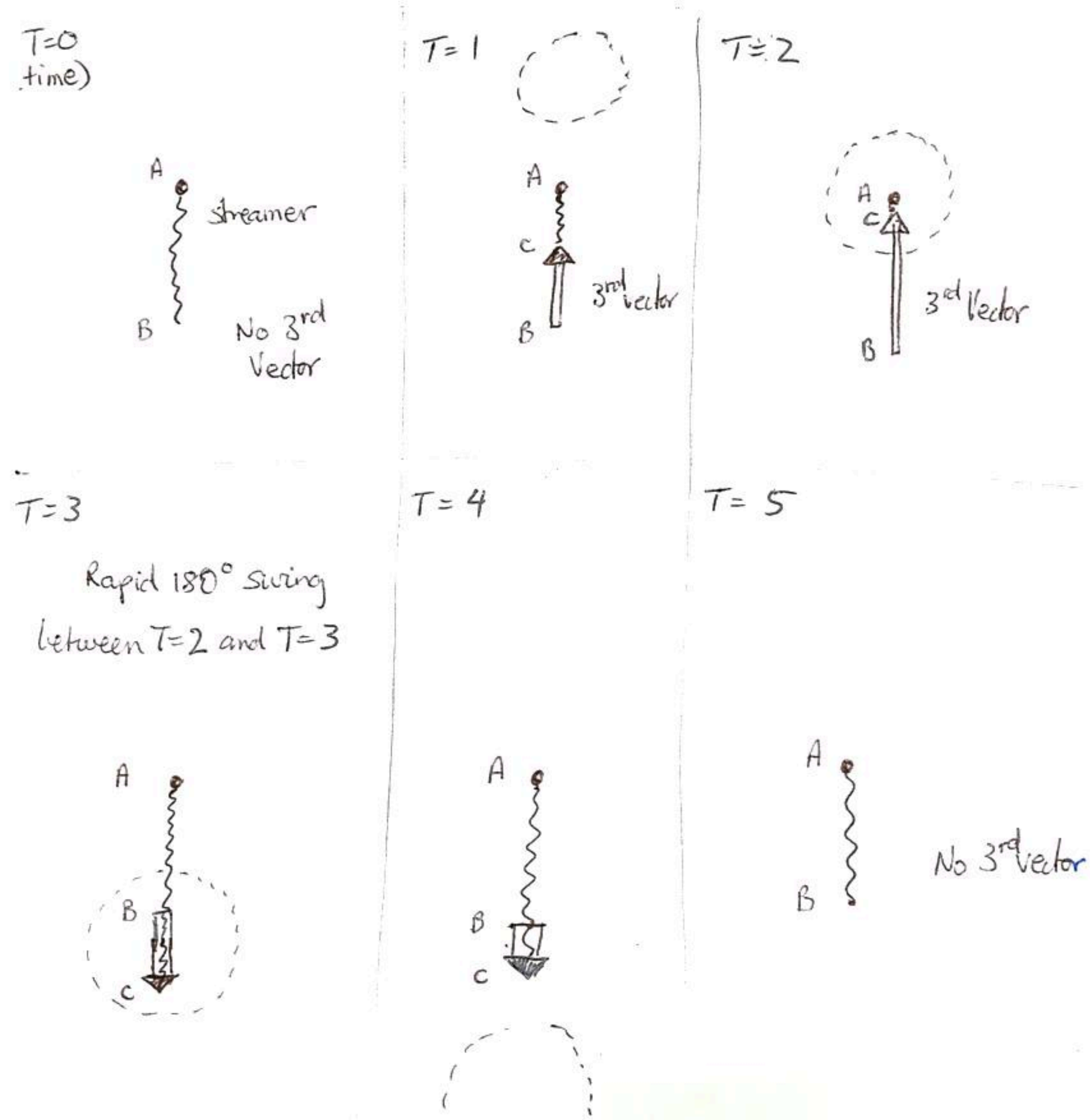
You want to feel a significant change in direction or wind speed over a period of time (min 20-30 seconds) to indicate lift or it can be just local turbulence in the air. The longer the change occurs then the stronger the indication of a thermal. Wind shifts can last several minutes with big thermals.

Every day is different and so it can take time at the start of the day to get a feel for the size and movement of the thermals. You also need to be aware of when the conditions change throughout the day to re-adjust your 3rd Vector and mental picture of the air.

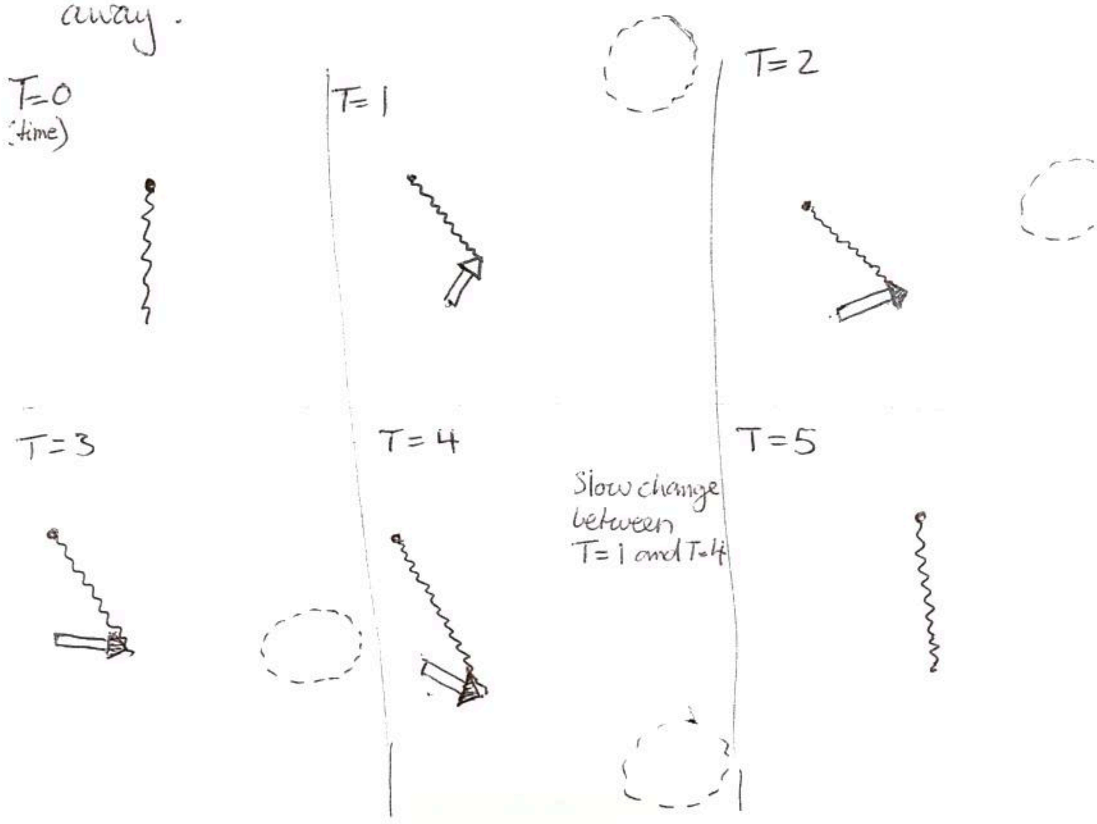
Flying a handlaunch glider is a great way to quickly validate if your reading of the air is correct or if you need to adjust your mental picture.

Here are some examples:

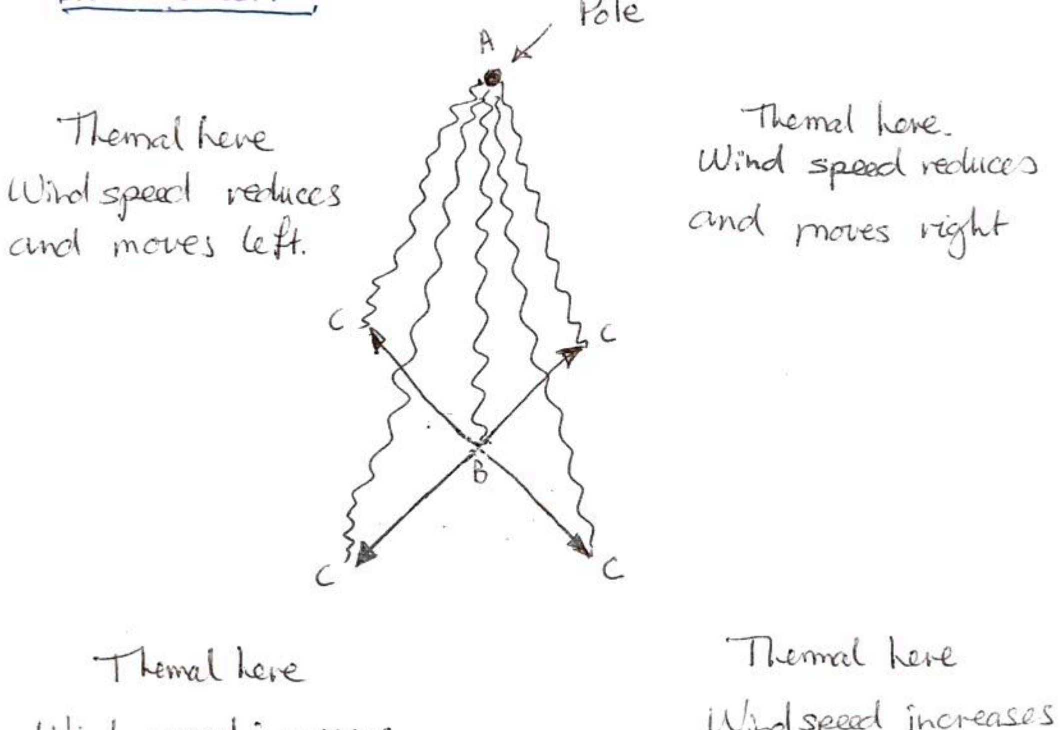
Rapid change means the thermal is close.



A slow change indicates the thermal is further away.



BASIC CONCEPT:



- If the thermal is in front of you the wind decreases. If the thermal is behind you the wind increases.

In summary:
If the 3rd Vector is large then the thermal is large or very close.
If the 3rd Vector is small then the lift is weak or it is a long way away.
If the 3rd Vector changes rapidly then the thermal is close.
If the 3rd Vector changes slowly then the thermal is far away.

Therefore between the size/strength of the wind shift and the rate/speed the wind shift changes, you can calculate where the lift is. This takes significant practice (a year or more), but once mastered it is a very powerful tool and gives you a big advantage in a competition.

3. **Weather Conditions**

I think of the air as having 4 basic types of thermal conditions and being aware of them can change the way you fly in them.

1. Classic column thermals – These are the easiest to pick and you should be aggressive in searching for them and aggressive to punch through the sink on the return leg.
2. Corridors of air – These are more common when it is windy and are caused when the thermal is blown over into horizontal lift downwind from a thermal source. Move sideways to find the lift corridor, sit in the lift for a period of time (sometimes without circling) until it decays (watch closely). Then move sideways to find the next corridor of lift. Sometimes the next corridor can be only 100-200m away and sometimes a lot further (500m+). I call this the Jon Day waffle (multiple peaks and troughs) theory because you actively move from one piece of lift (peak) to the next.
3. Light lift or buoyant air. This is more common on light winters days (like Jerilderie) where you can see planes 'holding' better than others. Do not lose height racing to this patch of air because you typical don't make back the height you lost getting there. Move slowly to the buoyant air, conserving altitude or just move downwind of the plane in buoyant air. The air can often be good at height, but non-existent at lower levels.
4. Inversion layer. This is more common on calmer winter days (like Jerilderie), but not always. This can be where you launch and there is no lift, but when you get to a certain height (e.g.50m) and then you encounter little bubbles of lift. Be careful not to circle in bumps above the inversion layer (they are typically not lift) and then be prepared to work lift when you get below the inversion layer. Also, if your bubble disappears do not waste time finding it again because it has most likely hit the inversion layer and dissipated. Immediately look for other lift as there are often more bubbles of lift a short distance away.

For options 1 and 2 be more in tune with the 3rd vector, be more aggressive and search for air.

For options 3 and 4 be more conservative and do not isolate yourself too far away from the pack as they can be very good lift indicators.

Always assessing the conditions and being able to 'change gears' depending on these changes (often a few times a day) is critical to consistent flights and competition success.

There are also other thermal signs (heat sources, trees, birds, clouds, other planes, etc.) to look for when flying so keep assessing the conditions at all times. When searching for lift you should be spending almost as much time assessing the environment around you as you are watching your plane. Joe Wurts and Carl Strautins are good examples of this and are always intently looking around more than they are looking at their plane. This is a good thing to practice.

4. **Plane Signs.**

Let's say you have launched your plane and are now following the 3rd Vector (or other indicators) towards the thermal, but you still don't know exactly where the lift is. This is when the plane signs become the most important indicators to finding the thermal and now override ALL other indicators. Here is what to do:

1. Fly in a dead straight line with absolutely minimal inputs. This way you can see any effects on the plane. You can not see the effects on the plane when you are constantly moving the sticks. Just like feeling the wind shifts on your body or seeing them on the streamer, you can see the effects of the wind shifts (from a thermal) on your plane.
2. Do NOT turn when you think you are at the lift, wait for the plane to indicate lift. Human depth perception is terrible and cannot be trusted. This is the number 1 mistake most pilots make. Wait for the plane to tell you it is in lift or close to lift.
3. If you fly directly away (or towards) yourself and you see the plane crab sideways (the whole plane moves rather than turns) then it can indicate lift close by. Turn in the same direction as the plane starts to move because the plane gets pulled towards the lift, just like a streamer gets pulled towards the lift on the ground. This is my favourite plane sign for finding lift and is highly under rated. Once practiced, you can soon tell the difference between turbulence and lift.
4. If the plane speeds up (or slows down) it can indicate lift is in front (or behind) the plane.
5. If the plane speeds up and gets positive to control, it can be in lift (the lift acts on the tail and lifts the tail because the plane rotates about the C.G and therefore speeds up).

5. **Thermalling**

Once you have used the combination of ground signs, air signs and plane signs to find the thermal, you now need to optimise your climb rate in the thermal. Generally I start circling as soon as I encounter the lift (this is a Hand Launch hangover because you are often not high enough to explore the thermal) and then I optimise my position in the thermal from there. Sometimes I find exploring the size of a weak thermal can cause me to lose contact with the thermal, especially down low.

To optimise your position in the thermal you must do a constant speed, constant bank circle and watch which side of the circle the plane rises the most. You can then extend the circle slightly in the direction the plane rose on, and then keep circling. I tend to only move half a circle size at a time to avoid the risk of losing contact with the thermal. You want to hunt the core of the thermal over a number of circles.
If you do not do a constant speed, constant bank circle (and it is more like a rollercoaster) then it is impossible to see which side of the circle the thermal is strongest.

Generally when I am thermal:

1. I don't change the direction I am turning in the thermal.

2. I rarely move in a thermal to follow other pilots and just rely on the above technique to centre my thermal.
3. Often, the less pilot interference is in the process the better. Sometime, I just do a constant speed and constant bank circle and let the thermal pull me into the core. This then lets me concentrate on where I am going to go next.

To get a constant bank, constant speed circle you need to set your plane up properly. This takes practice and makes a huge difference to being able to optimise or stay in a thermal.
I modulate the Aileron stick to control my bank angle (as needed) and Elevator stick to modulate the speed. By keeping the speed constant, it means I pull harder on the Elevator (and use more camber) in strong lift and I use less Elevator in weak lift. This optimises my climb rate while keeping my plane at its optimal flying speed for best efficiency.

6. Plane setup

Start with CG.

CG primarily determines the stability of the plane. This means how much a gust, turbulence, trim, speed change or stick input effects the plane. The optimal point is between having the plane unstable enough to show lift without losing efficiency from too many control inputs.

First I use the dive test to determine the level of stability I want. Trim the plane for normal slow flight and then dive the plane at 30 degrees and let go of the stick. You want the plane to do a loooong slow pull out. If it pulls out quickly then it is too stable. If it does not pull out it is unstable.

I like a plane more on the unstable side than the stable side of the dive test. I move my C.G. slowly back to the unstable point (no pullout in the dive test) and then move it forward slightly. I like to know how far back unstable is (and measure it), then I can get a good mental picture of how stable I am relative to this point.

Make sure you adjust your Elevator throw with C.G. change. This is often overlooked and I have heard pilots say they cannot control their plane at a rearward C.G. only to find they have huge Elevator throws from when their C.G. was too far forward. Drop you Elevator rates as your C.G. goes back. Other settings such as Aileron differential and A-R mix may need to be re-assessed with large C.G. changes.

I then fine tune my cg over a few months by experimenting. Basically I want my C.G as far back as I can get but the plane still returns from a long way down wind in windy turbulent conditions without being unstable (e.g. stays stable when flown fast from downwind). You want a hands off (trimmed) return from downwind with minimal input (e.g. I use 60% of my Elevator throw in speed mode when compared to my thermal mode to prevent my control inputs making the plane look unstable). Having a plane fly smoothly in this phase of the flight can add significant time to your flight.

Also, I don't change my c.g. for different conditions once I find a nice position. This way I always get the same response to lift no matter how windy or calm it is. Also, ballast does not change my C.G. If my C.G. is too far forward in the wind then I lose feel for the thermal and I'm not sure if I'm in lift or

Note: I have changed my view on C.G. since writing this back in 2016. I now like to run a more forward C.G. in the wind and this can be anywhere from 5 - 10mm for an F5J and 2 - 4mm for an F3K model, compared to my no wind C.G. Make sure you perform your own trials, as this will depend on your own starting C.G.. The key indicator is to be able to return smoothly from downwind in strong wind.

not. I look for consistent feel, rather than fighting a plane as the stability (C.G.) changes. The more consistent the planes response is to lift then the easier it is for me to identify lift.

Mixers

Plane mixer setup is all about being able to do constant speed, constant bank thermal turns in any conditions. Nothing else!

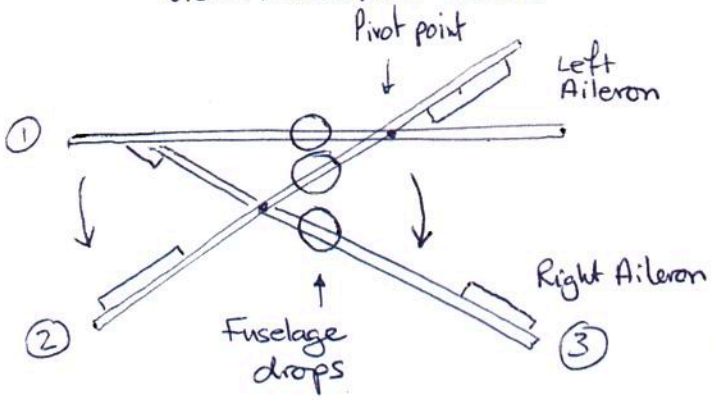
Start by setting your A-F (Aileron to Flap), E-F (Elevator to Flap) and A-R (Aileron to Rudder) mixes to zero. Just Elevator stick controls Elevator, Rudder stick controls Rudder and Aileron stick controls Ailerons. This is because all these mixers create secondary counter effects that make setting up your plane difficult and is the reason most pilots get lost tuning their planes. Set up your mixers in the following order.

Aileron differential

Set your plane up so 0 differential on you Tx means equal up and down throw (1:1 up:down) on your Ailerons and 100% differential on your Tx has 100% up movement and no down (1:0 up:down). Note, some transmitters use different terminology, so adjust my notes accordingly.

Now fly directly away from yourself and move the Aileron stick slowly side to side. The nose of the plane should not rise or fall as you roll the plane. If the nose rises as you roll then increase differential (more up than down) and if the nose drops when you roll then use less differential (more towards equal up and down). I find most modern planes fly well with between 50% (2:1 up:down) and 75% (4:1 up:down) Aileron differential.

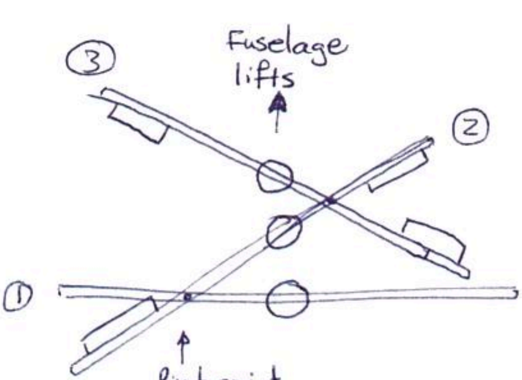
TOO MUCH + DIFFERENTIAL
VIEW FROM BEHIND PLANE



① Flying straight
② Left Aileron - fuselage nose drops
③ Right Aileron - fuselage nose drops.

Pivot point for the rotation appears to be on the wing rather than through the fuselage. Fuselage drops as Aileron is introduced.

NOT ENOUGH DIFFERENTIAL
VIEW FROM BEHIND PLANE



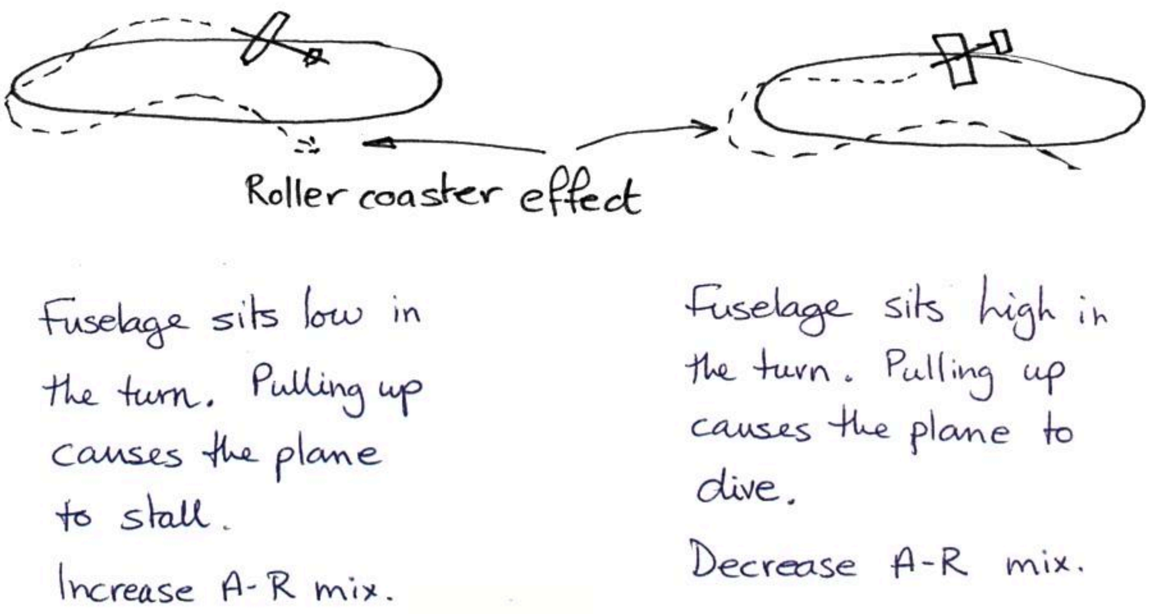
①. Fly straight
② Left Aileron - fuselage lift
③ Right Aileron - fuselage lift

Plane may stall

Again the pivot point for rotatio is on the wing. Ideal is to have rotation through fuz.

A-R Mix

To determine the correct Aileron to Rudder mix I now fly a smooth thermal circle with just Aileron input (no manual Rudder input) and some Elevator (of course) and watch the attitude of the fuselage/tail. If the tail sits low in the thermal turn then increase the A-R mix and if the tail sits high in the thermal turn then use less A-R mix. You should get the fuselage to follow the arc of the circle.



The reason this is so important is that if the tail sits low in the turn (no enough A-R mix) then when you pull Elevator to tighten the turn the plane wants to pitch up and stall (and you then get the roller coaster affect). You want to be able to pull on the Elevator and it simply tightens the thermal turn without any pitch up (stall) or down (dive).

A-F Mix

I use a standard 50% A-F mix so the Flaps move half the throw of the Ailerons. It means you use less Aileron throw for the same roll rate (because your Flaps are now helping the roll) and reduces Adverse yaw at the tip of the Ailerons and excessive Aileron drag.

Flap differential (when the Flaps are moving as Ailerons)

Flap differential from the A-F Mix is the single most important mix to get right but because the Flap down wash flows directly over the Elevator and hence effects the pitch of the plane. Therefore Flap differential is ESSENTIAL to get right. It must not make the plane pitch up or down in the turn. Just like Aileron differential, more Flap differential means the nose pitches down and less differential means the nose pitches up. Again, I find most modern planes work well with between 50% (1:1 up:down) and 75% (4:1 up:down) Flap differential, but every plane and pilot combination is different. Because most planes are set up with more Flap down travel than up travel (for brakes) this must be measured on the plane and not taken as a value from the Tx.

E-F Mix

E-F mix is more difficult to explain so for now just set 3mm of down Flap (and the same Aileron) with full up Elevator and leave it there. Do not fly without this mix because it adds a lot of efficiency to the wing and hence the turn. You can reduce the Elevator throw if the plane is now too strong in pitch, but re-check you have 3mm Flap on the E-F mix again, because most Tx's reduce the Flap throw as the Elevator throw reduces.

Other effects

I find that changing the C.G. significantly (greater than 10mm) can change a planes response to the mixers that I have set up, so I have to go through the above mixing setup process again to get the plane flying how I like it.

Practice and refine

Continue to tweak your mixer values until you can get 10 repeatable thermal turns in a row, in any conditions, without stopping or losing shape. All my planes do this without any additional manual Rudder, just Aileron and Elevator stick input, in any conditions. It keeps things simple and lets me concentrate on finding lift rather than trying to do a turn with manual Rudder (that is also hard to see at long distances). This game is about finding and climbing in lift better than your opponent and not about theoretical plane setups. This approach is highly under rated. E.g. I have seen a pilot do 10 perfect turns using a 'manual Rudder' plane setup in calm conditions, but as soon as the pressure of a competition started, they were a fair way away and it was breezy, they struggled to make smooth thermal turns and were immediately at a disadvantage. They ended up fighting their plane rather than spending their time looking for lift.

7. Returning from down wind

You have thermalled out in a big thermal and are now ready to come home.

This is where constantly iterating the wind comes into its own. While you were searching for lift and thermalling away you were still taking constant mental notes of the wind shifts right? Right! ☺ Constantly iterating the wind tells you 3 things:

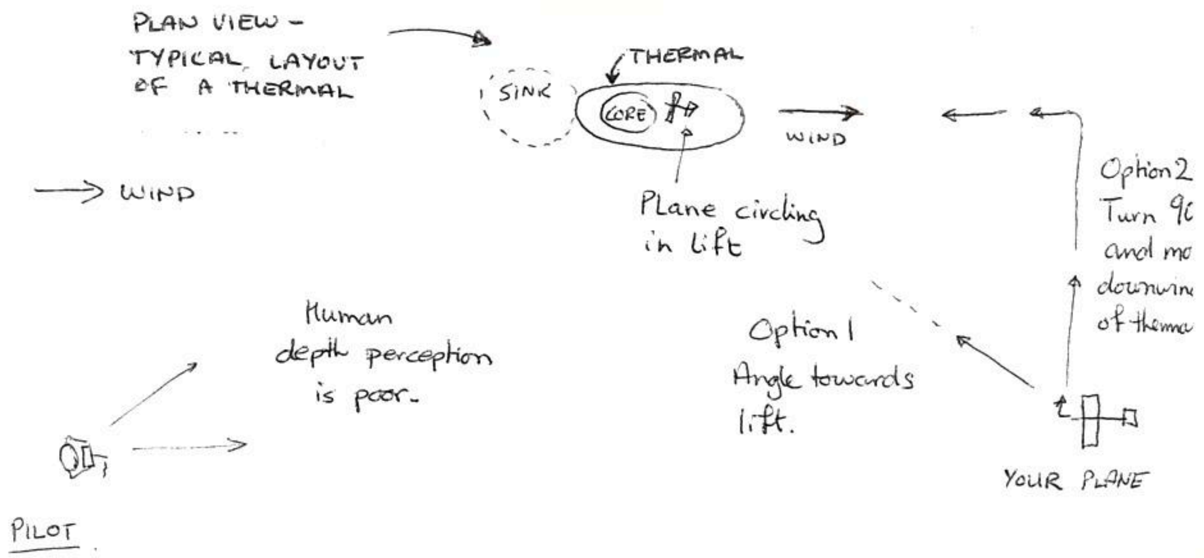
1. Which side of the field is most likely to have lift on it
2. How big the thermal/sink cycle is
3. If there is lift on the way home and where it is likely to be.

This then tells you when, how and where you will return from downwind.

1. If the wind is blowing towards one side of the field or the other, then come back on the side the wind is blowing towards.
2. If there is a single huge sink cycle following your lift (lots of strong cold wind) then take the thermal further than normal, but when you leave the thermal, move sideways a few 100 meters before returning from the thermal and return fast.
3. If you feel a few smaller thermals following your lift then you can leave your thermal earlier than normal and pick up the thermals still coming through. This can also reduce your risk of a land out.

Also, keep a constant eye on all your other thermal signs to help you with your mental picture of the air. Again, this is where having a stable (but not too stable), well-trimmed plane gives you the confidence to take your eyes off it for extended periods of time.

If you see a thermal (e.g. another pilot in lift) upwind of you and you want to move to that air, then do not angle towards the thermal because human depth perception is very poor and it is easy to miss the lift. It is better to turn 90 degrees, move downwind of the thermal and then turn in behind the thermal. It also keeps us away from the sink typically on the upwind side of a thermal.



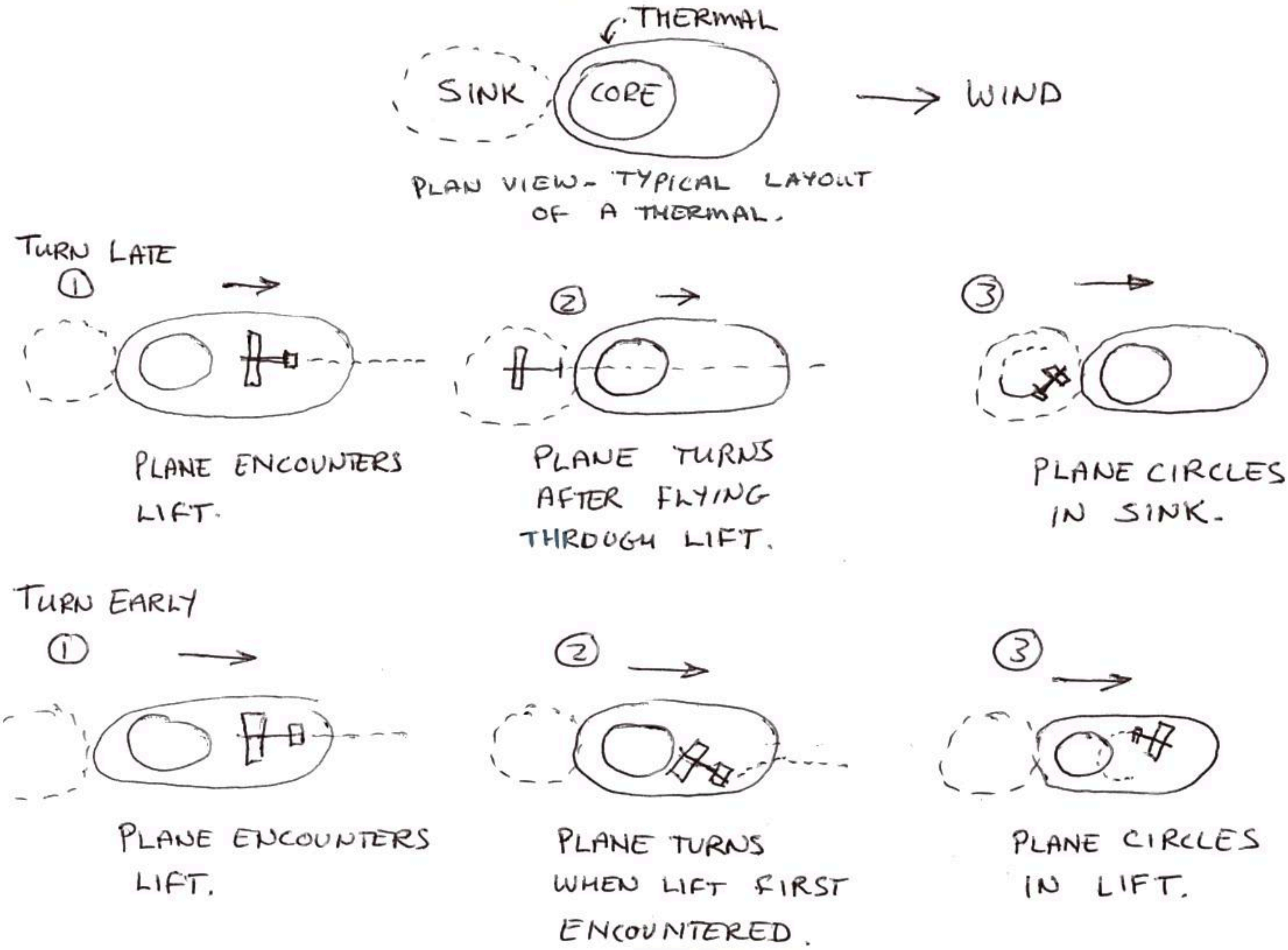
Pilot sees another plane circling in lift.
Option 1 - Try and angle towards lift. Easy to miss lift. Depth perception poor.
Option 2 · Turn 90° downwind of thermal - more likely to encounter lift.

Also, when you do hit the lift on the way home and want to take a turn in it, then turn as soon as you hit the thermal. Do NOT fly through the thermal thinking you will see how big it is because turning after you fly through it means you cannot get back into it. The reason is.

1. The thermal moves faster than you think
2. Our human reaction time is slow
3. The plane turning time is slow

These 3 things mean you are often upwind of the thermal (and in the sink) by the time you complete your turn. This is the number one mistake I see most pilots make.

By turning early, you stay in the lift and can then optimise the core within a few turns. More importantly you stay away from the sink that is often located on the upwind side of the thermal. For this reason, always enter a thermal from the downwind side in any situation.



I hope these notes help you improve your thermal flying. Remember, these notes are the things that I have found worked for me and others may find different techniques work for them, so please experiment, try different ideas and find what works for you.

Good luck and please feel free to ask any questions.

Cheers,

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