Foot Launching With Power

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It has been over 20 years since I took my first training hill flight, and I hope to be flying for a long time to come. But the airtime meter seems to get lower every year with more and more demands on my time. My nearest flying site is just over an hour away, but loading, set-up, wind watching and vehicle retrieval usually ensure that not much else will happen that day. And with no guarantee that I will get even a sled ride.

Richard Cobb foot-launching the NRG at Blue Sky Hang Gliding's Manquin Flight Park, near Richmond, Virginia

I became intrigued with the Mosquito motorized harness when I first heard about it, and the idea continued to grow on me, especially as the airtime meter dropped ever closer to zero. It could offer opportunities to fly closer to home, and under more conditions. There are nearby ridges facing prevailing winds that are inaccessible for launching, yet they look easily soarable if a pilot could just get up to them. But information was hard to find. Either there were glowing write-ups about wonderful flights owners had, or second and third hand stories about disastrous take-offs, broken props, and poor climb rates. Eventually I found a wealth of information in an Internet discussion list (see More Information). I searched the message archives and corresponded with individuals to get answers to my many questions.

Foot Launched Powered Hang Gliding (flphg), as it is commonly known, has become very popular in Britain and in many other places around the world, including many areas in the U.S. As one U.S. pilot wrote, "Powered hang gliding has re-invigorated our club. It has meant more airtime, and less time being ground

bound as a crew member". Their club is a "group of us (10+ Explorers, 2 mossies [Mosquitos], and 3 NRG's [new Mosquito model]) here in the flat midwestern US". A first-ever "Mosquito Meet" was held in the U.K. in 1998 with 27 flphg pilots participating [ref 1]. Tasks included duration on a fixed amount of fuel and flying an XC course on the minimum amount of fuel. There are enough flphg pilots to currently support 6 manufacturers world wide.

But there are also a number of pilots who have sad tales of blown take-offs and expensive repairs. A Wisconsin pilot ruefully admitted that, with no one from whom to learn, he had to "learn with his wallet" - breaking 4 props in his first year, although none since. One prospective flphg pilot wrote in to the list that he was interested, but had heard too many stories about broken props, to which a Brit retorted "not if you know how to fly a flphg".

Mosquito NRG hooked into the Glider and ready to fly.

Although deceptively simple on the surface, there are a number of things about a flphg that can easily cause difficulties for the beginning pilot. This article summarizes what I have been able to learn from my searches, combined with my own limited experience (I recently bought a Mosquito NRG).

Good launching skills are essential! A good run is required with smooth control of pitch angle throughout the run, similar to a Shallow Slope launch. Of equal importance are two key differences in flying a flphg that can prove surprising (and costly!) to the unwary hang glider pilot: bar position changes and decreased roll stability.

Bar Position[ref 2]

The Mosquito and other models of similar design have the engine and drive train located below the feet. Hanging in your harness without applying any bar pressure, the combined center of gravity (cg) of you and the harness will be directly beneath the hang point. Adding motor weight below your feet moves the combined cg lower on your body. Because you are now located farther forward in relation to the hang point, the control bar will appear to be further back, by about 4 to 6 inches. This apparent bar trim position change occurs *without* the addition of power. Note that the actual trim characteristics of the glider have not changed, only your position with respect to it.

Most flphg manufacturers claim a maximum propellor thrust of 90 pounds or more. Without applying any pitch pressure to the control bar, the thrust will push you forward through the bar. Although the bar is far aft of what you are used to, this is still your *trim position*! That is, under full power, the bar position corresponding to trim has moved from your chin (with a normal harness) to mid-chest (during climb with a flphg harness). Many gliders are trimmed close to minimum sink, which is just above stall, so any bar position forward of mid-chest during full power is very close to stall with greatly reduced control. Optimum climb rate and control are achieved with the bar even further back, perhaps around the pilot's waist.

It should be clear that a hang glider pilot must learn control bar positions all over again. If a pilot tries to push the bar out to a more familiar position during a full power takeoff, a painful injury in the wallet is a frequent result.

Roll Instability[ref 3]

In unpowered gliding flight there is an increased roll stability that does not occur in powered flight. When executing a constant bank, stable turn with a hang glider, both wing tips are descending at the same velocity (as is every other part of the glider). But the inside wingtip has a lower forward velocity than the outside wingtip, resulting in a higher angle of attack for the inside wingtip. Lift is a function of velocity and angle of

attack. The higher the angle of attack, or velocity, the higher the lift force. The outside wing has the lower angle of attack but the higher velocity, while the inside wing has a higher angle of attack but lower velocity – thus more or less balancing one another.

Now think about flying along with power at a constant altitude (in air that is neither rising or falling) and in a constant bank turn. The wingtips have only forward velocity components, so the angle of attack is the same for both. But the outside wing has a higher velocity and therefore higher lift than the inside wing. Thus there will be a tendency to increase the roll angle. And the steeper your bank the more pronounced this effect will be. For powered *climbing* flight this effect becomes even stronger and increases with the steepness of the climb angle.

Thus a glider that the pilot has always found to be quite stable in roll can now seem to be quite unstable once a roll has been initiated. Any departure from level flight under full power can result in a turn that wants to 'wind up' very rapidly, requiring aggressive control inputs from the pilot in order to correct. If you are a beginning flphg pilot, stick with wings-level flight under full power. If you cannot immediately correct any roll that occurs, you can release pressure on the mouth throttle to ease roll pressures. If it is very early in the takeoff, it may be better to just spit the throttle and land to try again.

Before you become too concerned about this, I should tell you that I had half-a-dozen flights before I ever noticed this effect. These flights were all on stable days and I was simply climbing on a straight course. My next flights were on some mildly thermic days, and it was here that I discovered how strong this effect could be! The first time I found myself in a mild turn shortly after take-off I let it continue for awhile (it was a direction I had planned to turn in eventually), then attempted a normal correction. The glider wanted to keep rolling steeper. Not realizing at the time how fast the glider can "wind up" into a turn under full power, I was behind events all the way until I finally decided to spit the throttle. At that point the glider leveled easily and in time to set up a landing. This increased roll tendency is similar to what I have experienced on tow, but because there was no tow line I had to follow, I had not expected it with the Mosquito.

Simply put, while climbing under full power – keep the bar pulled in and keep it level!

<u>Other Important Things to Know</u>

Climb Rate vs Climb Angle

Powered aircraft climbing performance is spoken of in terms of climb *rate* and climb *angle*. These do not occur at the same airspeeds. The maximum climb angle occurs under high angle of attack, close to stall speed. The best rate of climb occurs at higher airspeeds. Of course our bar positions are different with the change of CG location and addition of power. But if we know where min sink and best glide bar positions are with respect to the trim position in our normal unpowered flying, then the relative change in bar position for powered flight will be about the same. For example, if your glider is normally trimmed to fly at minimum sink, then the trim position under power will be approximately your best angle of climb position. Most often we are just interested in getting high as fast as we can. Using the best glide bar position will get you close to the max rate of climb. That is, if you pull in about 10 inches from trim to get your best glide, then while powered you would pull in the same amount from your powered trim position (although this will be quite a bit further back than you are used to!)

A word of caution here - there is no reason to fly best angle of climb unless you are trying to clear an obstacle. But the steeper the angle of climb, the more roll unstable the glider will be and the more likely you will need to reduce power to level the wings again, thus eliminating any advantage you may have been trying to gain by climbing at a steep angle. Better to limit yourself to sites where obstacles on take off are not a problem!

Engine Torque and Other Factors

Turning the propellor requires torque, which also creates a reaction torque on the harness. In Figure 1 the effects of this torque can be seen. The counter-clockwise rotation of the prop (seen from the rear) causes a clockwise torque on the harness. Note that the harness has rotated to where the right harness leg is nearly vertical. If the pilot were to simply hang from the harness, this torque will cause the harness to twist and rise slightly at the base of support strap, effectively balancing the torque with the pilot's weight, and no torque is

transferred to the glider. During take-off in the upright position, particularly if something has started to go wrong, a fierce grip of the downtubes may cause this torque to be transmitted through the pilot to the glider instead. Especially at low airspeeds immediately after takeoff, this can induce a roll to the right which may require a rapid decision to abort the takeoff. A light touch on the control bar can help to avoid this.

Other factors attributed to power aircraft are P-factor and gyroscopic forces, but they are not significant for a flphg. The relatively low airspeeds minimize the P-factor effect, and the gyroscopic forces are somewhat isolated from the glider in that they act directly only upon the pilot and harness.

Showing the effect of engine torque on the harness

Upright Flying Position

When flying prone it is very easy to control the direction of thrust and position of the engine because they are aligned with the harness. In the upright position (the Brits refer to this as the "gorilla position"), however, the mass of the motor and prop assembly is several feet behind us. With our legs no longer back in the harness to control side-to-side motion, this mass can take on a life of its own. To reduce this effect an additional Waist Belt is built into the harness. When this is snug the harness frame is essentially connected to our hips, allowing a reasonable amount of control over harness position. But this control is not as complete as when in the prone position. One effect I have heard described (but not experienced myself) is that while flying upright in turbulence the pilot and the motor can get into opposing oscillations, with the motor swinging in the direction opposite to the pilot's control inputs. This can significantly reduce control authority (with or without power), especially if the waist belt is not tight. Even one leg back in the harness would restore control. The biggest danger here would be if this happened at a critical time to a pilot who did not know it could happen; being aware of the problem can go a long way towards eliminating it. It is best to get at least one leg back into the harness for stabilization as soon as it is safe during takeoff, and remain there as long as possible on landing, particularly if it is bouncy. I often fly a semi-upright position on final approach, with one hand on the uprights and one on the base tube. Now I modify this to also put one leg back into the harness if I think it is required.

Altitude

There are two concerns with higher altitude density take offs - take off speed and rate of climb. Just as with an unpowered launch, you will have to be moving faster to take off at higher altitudes. Engine power and climb rate will be reduced. A more powerful engine would increase the rate of climb, but it will not reduce the take off speed. A large glider with a low stall speed is your best bet here. For 2000 ft elevation at 75 degrees F, the stall speed is increased by 16% (compared to 59 F at sea level). For 4000 and 6000 ft the stall speed increases by 25 and 35%, respectively [ref 4]. If you are starting with a fully loaded glider that has a stall speed of say, 20 mph, the stall speeds become 23, 25, and 27 mph. The need for fleet feet at higher altitudes becomes obvious! While it is not a good idea, many of us probably get away with using the slope to 'cheat' a bit on our runs on those light wind days. That is, as long as the nose is not too high, we can gain the last couple of mph by diving a bit. But if you are launching a flphg from the flats, no cheating is available – you'll have to run out every one of those mph.

Suitable Launch Areas

Most mountain launches are suitable for a flphg. I have even seen a video of a Mosquito launch from a ramp on a cliff. The surface does need to be smooth enough to allow the legs to slide easily. And because of some extra drag from the legs, you might want to give careful consideration to launching a zero wind, shallow slope with the engine off.

Flat ground takeoffs are easy, although they can be intimidating at first! You will need a large open area

where you can face directly into the wind. As with any powered aircraft, you need to be able to land safely if the power suddenly quits. Making turns close to the ground to avoid obstacles is not desirable, especially for the beginning pilot. A rule of thumb I am experimenting with is that if you could fly the reverse direction as an unpowered glide, and safely clear any obstacles, then you should have sufficient clearance for a powered takeoff. Keep in mind, of course, that altitude density will affect this, and you must have someplace to go if there is a sudden loss of power at the most inconvenient moment possible.

If you are hesitant about starting out with your first take-offs from flat ground, try a training hill or easy mountain launch. Launch normally with the engine idling, then apply power only after you are comfortably flying. You can maintain altitude or climb slowly with part throttle, then gradually work your way up to full throttle.

Turns

Old dogs need to learn some new tricks when it comes to turning under power. Many of us were taught to "lead with our feet" in making turns. This is effective for un-powered flight, but adding thrust to our feet changes things. Yawing our bodies also changes the thrust line. Adding a foot-first yawing component to the turn accentuates the powered roll instability. Better to keep your body (and thrust line) parallel with the keel.

The Doodlebug is a supine unit that uses the limit lines to keep the prop relatively stationary. As the pilot moves to one side, this arrangement moves the thrust line so that it actually opposes the turn direction. It is claimed that this is beneficial in helping to create a more stable turn. Personally, I like the freedom of being able to control the direction of thrust, and I find it gives me another way to fine tune a turn.

How About My Glider?

Mosquitos and the other models have been flown with a wide variety of gliders, and there are only a few that are not suitable. Some gliders are better than others, however. Rather than try to list specific gliders, we will just cover the desirable characteristics.

* Low Stall Speed – very important, especially for a beginner to flphg. Lower takeoff speeds are safer and less intimidating. Also good for higher altitudes. And don't forget that by adding 40 or so pounds to your normal flying weight you are increasing your free flying stall speed by about 7 or 8%.

* Easy Handling/Roll Stable - roll stability is important, especially for a beginner. A spirally unstable glider (some high performance gliders have been tuned that way to help initiate turns into thermals) will be more of a challenge while climbing under power.

* Good L/D - for maximum climb rate you want the best glide ratio. A blade wing will climb faster than a floater.

* Short to Moderate Root Chord - for propeller clearance. The Mosquito instructions say the keel should be cut off *no further* than 47 inches behind the hang point. My demo flights were on a WW Falcon [ref 5] adapted for the Mosquito. The root chord of the sail was within the limits, but the pull-back rigging for the cross bar had to be modified, as it normally attaches to the part of the keel that had to be cut off. Be sure to look at all ramifications of cutting the keel when evaluating a glider.

An ideal glider would be an intermediate model that has a low stall speed, easy handling, and good glide characteristics. On the other hand, high performance rigid wing gliders have also been flown with these power units. It may be that the control surfaces of these gliders would make the roll easier to control during climb than a normal hang glider, but that is purely speculation on my part. There are enough power units out there now that someone has probably already tried the combination you are considering.

Why Not More Power?

A frequent question is, why not more power? More power would give a higher climb rate, and would be especially useful for higher altitudes. The Mosquito and all the other models based on this original design use the Radne Rocket, a Swedish built 120cc 15 hp engine. It is reliable and gives an excellent power to

weight ratio. But there are weight limitations to the powered harness design, which is a fine balance of competing demands. More power would mean a heavier engine and an even larger change in bar positions. It would also mean greater instability in turns. A trike, which has wheels to handle added weight and increased roll authority for steeper climbs, is almost unlimited in power potential. But if you want to foot-launch with power and fly in a style as close as possible to normal hang gliding, there are greater weight and power restrictions.

Leaving Earth Under Power

A number of pilot reports have been written about flying the Mosquito, including one in Hang Gliding magazine [ref 6], so I won't go into details for a particular model. Set-up is simple, attach the harness to your hang loops, attach the fuel container to the glider, and hook up "limit lines" which prevent extreme excursions of the prop. Here are some key points for new flphg pilots:

* Fly only in smooth conditions until you have gained some experience. Early mornings, evenings, stable cloudy days. A 5+ mph breeze is ideal, as long as it is steady.

* It is very useful to do some practice runs with just the glider in very light wind conditions. Flying the glider on flat ground is a bit different than launching it from a hill, and you may find that there is only a small change in nose angle between a smoothly flying glider and pulling a drag chute. You want to learn that subtle difference without the sound and stress of a power takeoff.

* Be sure you do an engine warm-up/run-up. The bleeding procedure may not get all the bubbles out of the fuel line. Be sure it runs smoothly at full throttle and for long enough to get all the bubbles out. You don't want a coughing sputter in the middle of your take off!

* Be sure your waist belt is tight. This is what stabilizes the direction of the prop until you get your feet back into the harness.

* Face directly into the wind for take-off, and then walk forward a couple of steps to be sure the harness is lined up straight too.

* Bite down on the throttle and accelerate smoothly. Allow the glider to find its own pitch angle, and fly it on the ground as long as possible - you won't be able to stop if from climbing when it is ready. Whatever you do, do not push out!!

* For very light wind, or early attempts, a modified approach may be useful: start out running with only enough throttle to overcome the drag of the skids. You are just trying to get the glider to fly itself (as in the practice mentioned above) without taking off. Once you are sure that you have the glider flying, then smoothly increase your running speed and throttle together, without changing your pitch angle.

* Once in the air, pull in the control bar to gain speed. One pilot reported that he felt that he tended to swing forward (and push out the bar as a result) when the skids lifted off the ground - another reason to be sure the bar is pulled in adequately. Do not be in a hurry to climb, it will climb when it is ready. As soon as it is safe, get your feet back into the harness for stability.

* Once in the air, pull in the control bar to gain speed. Do not be in a hurry to climb, it will climb when it is ready. As soon as it is safe, get your feet back into the harness for stability.

* Keep the wings level! Keep the bar pulled in and be ready to aggressively correct. Remember that full power turns will become increasingly unstable with increasing roll angle. As long as your wings are level it will be easy to keep them so. The mouth throttle is your friend here - even a brief easing of the throttle can help restore control if you can't immediately level the wings. In the worst case, just spit out the throttle. Without the power it will be easy to level the wings and set up for the landing. Then go back and try again.

Flying

Once you have gained a comfortable altitude you may choose to reduce the throttle for easier control, especially in turns. Zipping up the harness also retract the legs, which are then clipped into clamps on the

side of the harness. If you find lift you may wish to shut off the engine and soar normally. So far I have flown only in marginally soarable conditions, being more concerned with becoming familiar with the power aspects. But I have worked some areas of mild lift, and did not find it to be much different than thermalling in my normal harness. The biggest difference was noticing extra mass at my feet when I would roll for a turn. With the engine either off or idling the prop free wheels. This adds drag, but a prop lock on most models can be set which will halt the spinning and greatly reduce the drag. The new Mosquito NRG and the Booster both offer folding props.

In air restarts are possible. Some pilots do them frequently, others not at all. Each engine seems to have its own quirks on how it starts best. Restarting difficulty varies with the amount of time the engine has been off and how it is tuned. You will probably need to use both hands at least briefly during the process, although some pilots claim to have rigged workable foot starters. Radne is working on an electric starter for their engines which should be coming on the market soon.

Richard Cobb climbing out from the base of the training hill where he first took lessons 20 years ago.

When landing appears likely, be sure to get ready soon enough - 1000 ft is a frequently recommended altitude. The legs have to be un-clipped as well as the harness unzipped, and it is a little more complex than a normal pod harness. Definitely not something to be trying to do on final!

Landings are easy - wait till you feel the harness legs dragging, wait a half second, and flare mildly. Your forward position and extra mass give you more flare authority than you are used to. There is one surprising part of this - after the flare and landing on my feet, I expect the landing to be over. But the mass of the motor still wants to continue forward - expect a feeling like a nudge from behind after you have landed, and be prepared to take a step or two.

Why not a trike?

Why a flphg instead of a trike? Individual preference. A flphg will add about 40-45 lbs to your normal weight, including fuel. A trike will add at least double that, making it more likely you will need a larger glider. A trike needs a smooth surface for take-offs and landing, while a flphg can be flown at almost any site you would normally fly a hang glider. At altitude, with the engine off, your flphg flying experience will be very similar to your normal prone harness. A flphg is smaller and easier to transport. However, a trike offers more comfort for us aging types, and has the option for greater power. The pilot hanging below the bar will likely provide greater roll stability during climb. And having wheels and the option for increased power make a trike suitable for higher altitude takeoffs.

New Possibilities

As I become better acquainted with my new toy, I am thinking of ways to enhance my normal hang gliding with the addition of power. I will be able to fly sites that were not possible to fly before because they were inaccessible for creating launches. All they will require with the Mosquito is a suitable LZ for take-offs.

In the flat lands I can get “virtual tows”, without a crew. Power up to a pre-selected altitude and then “release” by shutting off the motor. If I have to land I can take a break and then “tow up” again.

A recent fantasy of mine is to someday be thermalling with some other pilots and to reach cloudbase together. At this point I would fire up the motor, and proceed to climb up above the cloud, leaving the other pilots “down there” at cloudbase (got to have the camera along for that one!)

FLPHG Manufacturers

Mosquito - The original Swedish motorized harness, on the market since the late 1980's. The original models had old Keller style harnesses and 10hp motors. The power was later increased to 15hp, although they stayed with the old harness style until last year. This allowed many other manufacturer's to get into the market, as the harness style on the original Mosquito was quite cumbersome. Last year they released the NRG model which is greatly improved and has put it at least even with, if not ahead, of the competition. It is front opening with snap-buckles for the chest and leg loops, and the controls have been stream-lined and made more easily accessible. There is now a folding prop option and there are two harness sizes available. http://www.swedishaerosport.se/mosquito.htm

Explorer - An Australian copy of the Mosquito with a harness design that was a great improvement over the original Mosquito harness. An optional longer prop shaft makes this unit easier to use with long-root-chord gliders. The current exchange rate makes this glider a very good deal for buyers with US Dollars. http://www.airtimeproducts.com/

Doodlebug - This is a British supine version of the Mosquito. The pilot flies inside of the control bar, similar to the old “suprone” harnesses. There are a number of enthusiastic owners of this model, who claim it is far more comfortable for extended flights. http://www.users.zetnet.co.uk/flylight/

Booster - A British variation on the Mosquito. This unit has a hard shell that is designed to make it possible to adapt it to some existing harnesses. Other unique features of this model are a folding prop and wheels instead of skids on the legs. http://www.pegasusaviation.co.uk/booster.htm

Wasp - Another British variation on the Mosquito. It came on the market while the Mosquito was still using the old style harness, and improved upon that with an easy front entry. The harness can be custom made to your dimensions. This manufacturer also offers a kit to modify older Mosquitos to their harness for about $1k, something worth considering if you have an older Mosquito (or find a really good deal on one). http://www.waspsystems.co.uk/

DV8/Raven - An Italian model that has just come on the market. Right now it is using the DV8 name for the North American market and Raven for Europe. It uses the same Radne engine as all the others, but they claim much higher power and thrust values because of a special exhaust system and other mods. So far I have not seen any outside confirmation of the performance figures. http://www.powerplanes.com/raven.htm, http://alwaysair.com/

More Information

Foot Launched Powered Hang Gliding Discussion List - Highly Recommended! Flphg pilots from all over the world are on this list, lots of good information. Be sure to read through the archives before posting a question, you'll probably find most of your answers there.
http://groups.yahoo.com/group/flphg

US Mosquito Distributor - Bill Fifer - Traverse City Hang Gliders, (231)922-2844, tchangglider@hotmail.com

Oz Report - flying the Mosquito with the ATOS
http://www.davisstraub.com/OZ/Ozv3n86.htm

British flphg site: many links, technical info
http://www.woodleydowns.demon.co.uk/index.html

Alan Mortimer's Web Page: a British Mosquito Pilot
http://fly.to/powered-hang-glider

Brian Sanderson's Web Page: a British Mosquito Pilot:
http://www.maths.warwick.ac.uk/%7Ebjs/hangmicro.html

Tennessee Propellor: If misfortune does strike - they make nice wooden replacement props for about half the cost of the carbon fibre original. (931)455-4516
http://www.tn-prop.com

My Web page: currently a work in progress, I plan to add additional information about flphg as I learn it:
http://www.wind-drifter.com

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2. Buchan, Andy, "Powered Hang Gliders: Climbing and Airspeed", Originally published in Skywings Magazine, http://www.bmaa.org/powhang.htm
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4. Density altitude calculator on the web: http://www.printwares.com/densalt2.html
   (Percentage of stall speed is referenced to 0 feet at 59 degrees F.)
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6. Charlebois, Gerry, "Flying the Mosquito", Hang Gliding Magazine, August 1998.

About the Author: *Richard Cobb has flown a hang glider for over 20 years, and has been a USHGA Advanced Instructor and Examiner. He recently added a paraglider and a Mosquito power harness to his pile of flying toys. In his other life he has a PhD in Mechanical Engineering and works as a defense industry consultant, specializing in shock and vibration.*

(Links Updated 11/2/01)