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Paramotor Harness: High/Low Hook-in, Weight Shift?

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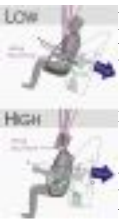
See also Hang Angle Adjustments | Suspension Systems | Harness Myths | Understanding Paramotor Torque

What's better, high or low hook-ins? A nearly religious fervor surrounds proponents of each yet I find that most pilots stick with what they learned on and enjoy it happily thereafter. Of those who do switch, just as many go from high to low as vice versa.

So what's the difference? Why choose one over another? Marketing hype can overwhelm the shopper and it's almost always just that—hype. I've now flown both types enough to know that's it's really more a case of preference. There are obviously differences, and each has benefits but, like most aspects of aviation, there are tradeoffs. I will analyze three types of systems: High, low without weight shift and low with weight shift. There's also the hybrid Mantis which goes from high attachment on launch to low attachment in flight.

It may be helpful to check out Understanding Harness Terminology.

Pivot Point



Here are some important concepts. The **pivot point** is where the wing/risers/carabiners pivot on the harness or frame. It's frequently the bottom of the carabiner but not always. If the carabiner is attached to a short piece of webbing that is free to move on the frame, then that point of motion is the pivot point. This is a critical concept because whether the thrust line pushes above, on or below this point affects behavior.

Machines with a very low pivot point wobble around more because their center of gravity is barely below the pivot point. The farther the thrust line is from the pivot point, the more changing thrust will move the machine.

Center of Gravity (CG)

Where the pilot/motor combination balances, both vertically and horizontally, is the center of gravity. It will usually be located somewhere inside the pilot near his back. The center of gravity is most important as it relates to the pivot point. If the CG is well below the pivot point then the machines will resist changes in tilt. If the CG is on or near the pivot point, the pilot will tend to wobble in pitch (fore/aft tilt back) and roll.

CG is a summation of all the weights involved. It's like a barbell—two masses on each end sum together to result in a CG at the center. On a paramotor the weight of the engine, frame and fuel tank all sum together for a *paramotor CG* then that combines with the pilot to create a *pilot/motor CG*. Pilots prefer the CG of their paramotor to be up high on their back and close. It's hard to wield a machine that sits low and aft. In almost all cases, the height on your back is a

matter of adjustment but the motor's rearward distance from the frame is a design element.

Regardless of paramotor design, the pilot/paramotor CG is almost always going to be near the same point because it's always beneficial to have it high and close.

Primary Differences

The biggest difference in flight will be hand position. The lower the hook-in, the lower your hands will be on the brakes. Soaring pilots may like this because they can fly their soaring wings without any changes to the brakes and brake positions will be similar. Of course you *can* adjust your brakes to be at that same position even on a high hook-in machine just by letting them be a bit longer.

Note that wings intended for motoring frequently come with shorter risers to accommodate high hook-in machines. Be careful if you fly motor risers on a low hook-in machine, the brakes may well be *much* lower than you expect. The greatest risk is that the wing will overfly you and you'll use too little brake to damp it. Also, you could end up needing more brake (or taking wraps) to flare.

There are two basic types of low hook-ins: those intended for weight shift and those that are not.

Launching Differences

There is precious little difference in the launching techniques or difficulty between high and low hook-ins. Launching technique for me is identical except for hand position which will be slightly lower on low attachment machines. Also, be ready to have the brakes at a lower hand position when damping the wing's inflation.

New pilots do seem to learn a bit easier on high hook-ins. The Mantis designers sure felt so—their hybrid machine lets you launch and land with high hook-in points but fly with low through a mechanical metamorphosis.

You really can get used to anything. I've spent some effort trying to determine the difference in launching difficulty with little success. A properly adjusted paramotor, and that's key, will present nearly the same ease regardless of low or high hook-ins.

One factor that can hurt your launch effort is cage size and relative position. If the cage pushes out on the D lines during inflation, then your wing will struggle to come up. It's like trying to inflate a wing with the D's pulled—you'll want to figure out a way around that. One technique is to do the *initial* inflation leaned way forward so the cage is above the lines. Then try to get the lines up past the cage quickly. That isn't always possible on every motor but is something to try for large cages. Also, the lines catching anything on the cage will torpedo the effort.

Several categories listed below include one with a launch.

Low Hook-In

All low hook-in machines share certain characteristics.

- Connecting the risers down low requires also connecting them closer to your arms. You can clip the risers to a more forward attachment point but will then risk leaning back too much. Excessive lean-back can cause riser twist on launch or in flight or other difficulty.
- In flight, the pivot point is near the CG which makes for a "busier" ride since bumps transfer more motion through the wing. Free fliers appreciate this feedback when looking for thermals, but many motor pilots prefer to minimize it.
- Full power, especially before the pilot gets seated, tends to lean the top part of the cage forward. This can put your brakes very close to the cage such that letting go of a brake can let it go into the prop, a potentially catastrophic event. This has happened about 5 times that I'm aware of although, fortunately for the pilots, the brake got cut off before it could wrap up in the prop.

Low Hook-in with*out* Weight Shift (Mid Low)

Examples: 1) Bailey 4-stroke, 2) Walkerjet, 3) Inflation tests using the Bailey

These machines are characterized by having attachment points slightly higher than their weight shift counterparts and have no pivoting bars. They *can* have the hook-in points as low as those with pivoting bars but usually don't because they're actually trying to minimize the turbulence transferred to the pilot.

This type of machine gives up weight shift in exchange for a less wobbly ride in bumps. Even so, with the CG still very close to the pivot point, there is a lot more wing motion transferred to the pilot so it will be a busier ride than a high hook-in machine but less than a low weight-shift machine. Plus, not having the pivoting bar further reduces the business in flight.

Low Hook-in *with* Weight Shift

Examples: 1) Airfer, 2) Pap (photo by Jamie Beckett), 3) Free Spirit being launched by Robert Kitilla. Other examples not shown: Fly Products (only one model), Parajet,

The majority of all low-attachment machines are of this type. They have the lowest attachment points and use pivoting bars to further increase weight shift. The intent is to mimic free flight as much as possible while still accommodating the weight of a motor.

With the CG is very near the pivot point and the pivot bar action, the machine feels very "loose" in turbulence. It wobbles around both left/right and fore/aft. It takes several flights but you most certainly get used to. After having been loaned the Fly, Airfer and HE versions for different events, I've become comfortable with the wobbling but a new or transitioning pilot will find it distracting at first.

These machines lean back the most. Even with the risers on their most aft setting there is a fair amount of lean back at my weight. That means more torque although that is also easily reduced to acceptable levels on a well designed and properly adjusted machine.

High Hook-In Attributes

Examples: 1) Pivoting J-bars on SD. 2) Launching the SD. 3) Fresh Breeze with harness-attachment above, Blackhawk also with harness attachments. 4) Fly Products with sliding webbing on a harness attachment system.

The original paramotors used overhead J-bars and high hook-in points to better balance the heavy motors in use at the time. Technology has evolved both in harness/frame design and decreased motor weight.

Nearly all high hook-in machines have the same geometry although they take different approaches. Look at suspension systems to understand the differences. Here are the attributes.

- The CG is well below the pivot point (hang point) so the motor has less tendency to move around in response to turbulence. Full power tends to angle the pilot back instead of tilt him forward.
- All high attachment systems allow the hang angle to be adjusted completely vertical, so the propeller plane is straight up and down. That's not as comfortable in flight but is generally easier to launch and minimizes torque effects. On soft mount systems, where the carabiners attach to harness webbing, the tilt-back angle can be adjusted to keep the motor anywhere from completely vertical to significantly leaned back, even to a dangerous degree.
- If the seat-to-carabiner height is too great (a maladjustment), it can be difficult or impossible to reach the brakes on wings with long risers (some soaring wings). This must be checked because pilots have launched their soaring paraglider on a high hook-in motor without checking and then been unable to reach the brakes.
- Several experienced paramotor instructors who have taught on both low and high hook-in types have concluded that high hook-in paramotors have a slight edge for new pilots to learn quickly.

Adjustment is critical on all harness systems. I've flown machines that were nearly unairworthy until changes were made, both high and low hook-ins. In one memorable case, Alan Chuculate and I were asked to give a demo for some USHPA (then USHGA) folks when they were considering adopting power. We borrowed a motor brand that we were familiar with but had never flown this particular example. On the way there, we decided it would be best to give this machine a test flight. We could barely launch it the torque turn was so bad as the wing lifted. I looked at the harness and noticed that it was attached on the the wrong side of the engine—an arrangement that allowed the motor to move to my right shoulder and cause a severe torque twist. Putting the harness/frame attachments on the other side of the motor *completely* solved the problem. The demo, it went off without a hitch.

The motor shown far left is an example of a high hook-in machine that left the risers excessively high. It used an early weight shift system that allowed the pivoting arms (comfort bars) to float upward and the pilot's body to sink deep into the seat. This same motor was later modified with a geared weight shift system that kept the pivoting arms lower therefore lowering the risers by a good 4 inches. This is why it's important to deal with someone who understands the dynamics of different harnesses and be suspicious of those who denigrate one system or another too much. They may have little experience with both.