HEIGHT VELOCITY CURVE for GYROPLANES

by Greg Gremminger

Deadman's zone'! – an ominously descriptive term for the Height Velocity (HV) curve for rotorcraft. Helicopter pilots are drilled on this issue and the limitations it presents for helicopter operations. Most people think that helicopters can go straight up from the ground and straight down to a landing. They can, but you won't catch a lot of helicopter pilots doing this. Ever notice how most helicopters takeoff at hover height as they accelerate along the ground before climbing out. They do this to avoid 'deadman's zone'!

What is the HV curve and why is it important to rotorcraft? The HV curve is an actual graph (figure 1) that depicts the minimum combination of height potential energy and speed potential energy required to make a safe landing if the engine is not available – if the engine QUITS! Or more accurately, it depicts the area of flight, the combination of height and velocity that should be avoided. The HV curve mostly applies if the engine quits. You might not ever get in trouble flying within 'deadman's zone', but should we really take a chance with the engines we fly?

When you see a helicopter takeoff straight up or land straight down, **understand they are betting their lives on the engine(s) not quitting** when they are within the HV curve – and they are in circumstances that absolutely require it! Some pilots have a pretty good bet IF their helicopter happens to have two engines or highly reliable turbine engines! But if there is just one engine, and that engine might quit on takeoff or landing, you will see most pilots maintain or attain adequate airspeed at lower heights until close to the ground – below the HV curve – on both takeoffs and landings! Pilot skill is also an important element in the risk equation pilots should be aware of if they are tempted to fly within 'deadman's zone'!

In some helicopter applications and circumstances, you might see the pilot actually climb straight up or set down vertically in a clearing – but that is most often with helicopters that have reliable twin turbine engines – such as military applications.

HV curves also apply to gyroplanes – they have 'deadman's zones' also! All rotorcraft require a sufficient amount of rotor rpm and airspeed to be able to raise the nose and make a safe 'deadstick' landing. If the engine is not available to provide some of this landing energy, the rotorcraft – and gyroplane – has only its potential energies of height and velocity to use up for the required energy for a safe landing. Height is a form of energy – 'potential' energy because you can convert height above the ground into landing energy of rotor rpm and airspeed. Airspeed is also a form of potential energy, and if there isn't enough airspeed for a safe landing, the pilot needs to increase airspeed by trading some height for additional velocity or applying engine power. This is the rub! If the engine is not available, all the landing energy must come from the existing airspeed and any extra height the pilot can convert into more airspeed.

All rotorcraft have different HV curves. Figure 1 is a typical HV curve for a light 2-place gyroplane – but yours may be different. Heavier, and the curve probably starts at a higher height and requires a higher airspeed close to the ground. Lighter single-seat gyroplanes might start as low as 150 ft, and maybe require only as little as 35 mph close to the ground in order to make a safe landing if the engine quits there.

Helicopters tend to have HV curves that start about twice the height above the ground as a similar gyroplane. A typical light helicopter might have its HV curve start at 400 – 500 ft above the ground. Because the HV curve of a gyroplane tends to be somewhat smaller than a helicopter, some people might be tempted to ignore the 'deadman's zone' for gyroplanes – DON'T! If your gyroplane engine quits within the prohibited area of your particular HV curve, you might have a worse day than just an emergency landing!

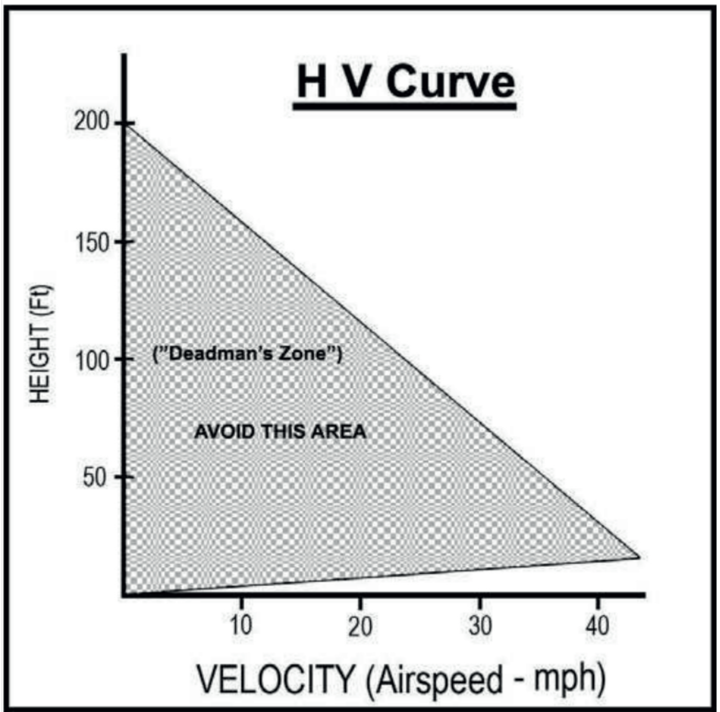

FIGURE 1

How to use the HV curve – referring to **figure 1:**

- If you are at zero mph, in a vertical descent, you must be at least 200 ft above the ground in order to be able to lower the nose and make a safe landing if the engine suddenly quit or was not available. The closer you are to penetrating this HV curve, the more skill it requires to trade the height you do have for adequate rotor rpm and airspeed to make a safe landing.
- If you are about 100 ft above the ground at approximately 25 mph, you have just barely enough speed and height energy in total to attain adequate landing rotor rpm and airspeed for a safe landing – if you do it right!
- If you are at 100 ft and less than about 25 mph, there is not enough energy to make a safe landing – no matter how good you are!
- If you are flying at 30 mph at 25 ft, you don't have enough energy if the engine quits!
- If you are flying low, close to the ground, under the lower 'ledge' of the HV curve, you probably can make a safe landing – with adequate proficiency!

How can you get into trouble with the HV curve?
Figure 2 – vertical descent:

Remember it mostly only matters if your engine is not available, or quits while you are within the HV curve. Refer to figure 2, the vertical descent scenario. This is where we see a lot of people venturing, probably unaware of the risk! It looks spectacular, really impresses the uninformed gyro crowd, but is highly dangerous! Descending at near-zero airspeed to just a few feet above the ground, and then applying power to fly out in a spectacular power-dive to ground level! Opening the throttle quickly on many engines, after a period of idle power, is just where most engines are likely to sputter, or cough – or die! If it does, you just made a pancake of you and your gyro! Go up to 1000 ft or so, establish a vertical descent with the engine at idle, and, at a noted altitude, lower the nose to attain enough airspeed to simulate flare to landing – see how much altitude you need – that is the top of your HV curve!

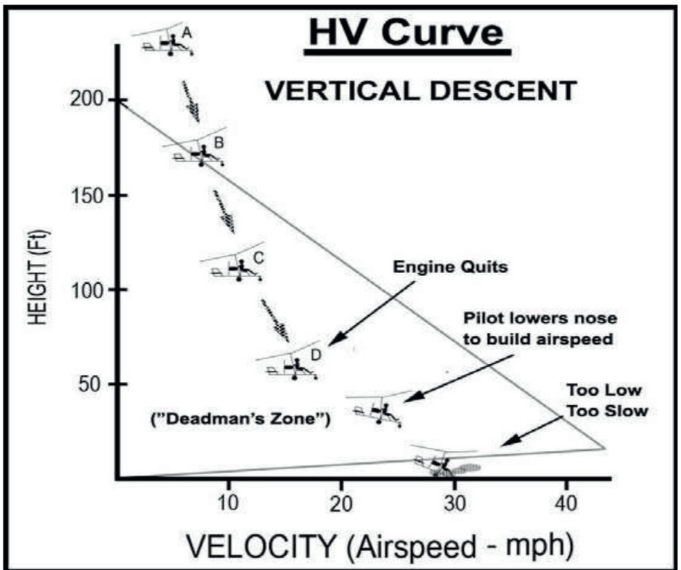

FIGURE 2

Figure 3 – show off zoom takeoff:

We see this a lot also. A major reason we teach people to accelerate in ground effect to their best rate of climb airspeed before starting to climb is to avoid climbing into 'deadman's zone.' Again, this 'hot dog' takeoff looks spectacular and wows the crowd – at least the unaware crowd! Allowing your gyro to climb into 'deadman's zone' before you attain adequate airspeed invites injury or worse, even if your engine just coughs a bit! In a steep and slow climb out, the nose is high. If the engine coughs or quits, the aircraft will slow immediately and quickly.

Pilot reaction would and should be to quickly lower the nose to maintain and restore airspeed before losing more airspeed in the climb! But, this is a particular problem for autorotating rotors – such as on our gyroplanes! The steep 'hanging on the prop' or riding the momentum of a zoom has the rotor slower than normal already. But the act of pushing the nose lower further spikes a lower G-Load on the rotor, immediately slowing the rotor rpm even more. Severe or rapid nose-down pitch, as might be executed upon engine failure in a steep, nose-up climb, can radically slow the rotor. But then, as the airframe attitude gets to level or nose lower, the rotor suddenly has full G-load presented to it – with a slow rotor!

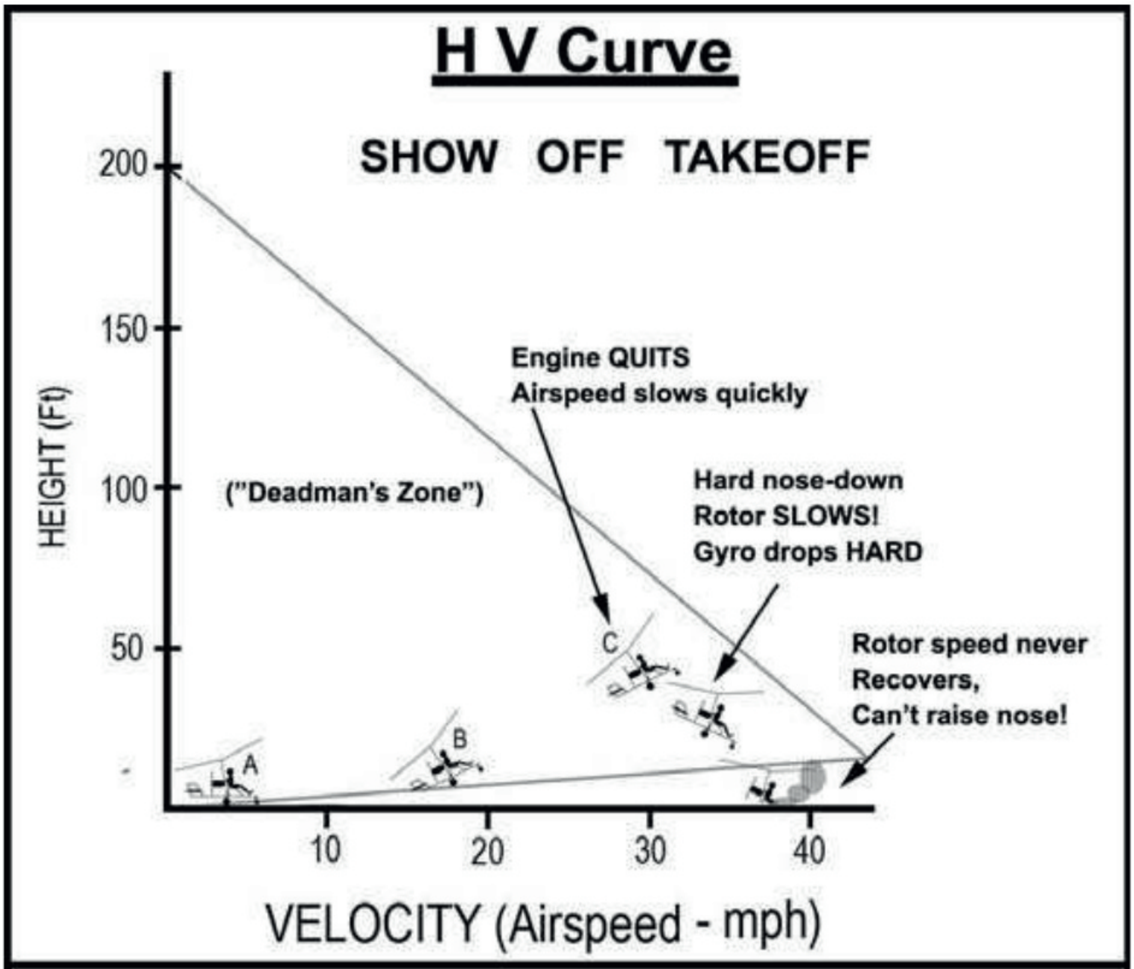

FIGURE 3

This can be essentially like 'over-running' the rotor on takeoff – the air forced through the rotor is more than the rotor can accept at that lower rotor rpm, and the rotor does not quickly restore its rpm. The result is a rather surprising rapid altitude loss – even if the pilot puts the nose down steeply to try to restore airspeed. In fact, the act of lowering the nose too quickly too far at any time can immediately lower rotor rpm and the subsequent re-loading of the rotor to full airflow and G-Load might not allow quick recovery of the rotor rpm – basically 'over-running' the rotor in flight! In the extreme, the rotor could actually violently 'flap' – hit the teeter stops!

Try this at altitude also: In power-off vertical descent, near-zero airspeed, lower the nose and see what the rotor rpm does and how much altitude it requires. Repeat this with a gradually more rapid lowering of the nose to steeper nose-down attitudes. You will discover that when you too steeply lower the nose too rapidly – to quickly recover airspeed – you may restore airspeed quickly, but the rotor rpm lags behind and the gyro continues to lose altitude, dropping like a rock until the rotor rpm catches up. In this demonstration, notice that a more gradual lowering of the nose results in less altitude loss to attain adequate rotor and airspeed energy to be able to make a safe landing flare. But in a steep and slow climb out, close to the ground, if the engine quits, not many pilots should or would gradually lower the nose!

To be able to raise the nose in a landing flare requires more than just adequate airspeed – it also requires adequate rotor rpm – or you are likely to strike the ground in a nose-down attitude – surprisingly not able to raise the nose for a flare - not very survivable! Engines don't quit often, but right after takeoff at full power is a highly likely occasion for engines to quit. I suggest you religiously avoid flying within the HV curve on all takeoffs – just not worth risking a awful day!

Figure 4 – behind the power curve:
There is nothing wrong (in most gyros) with flying ‘behind the power curve’ – nose up, lots of power, hanging on the prop – at adequate height to recover if the engine quits! Nose high, hanging on the prop, itself lowers the rotor rpm because the prop is carrying some of the weight of the gyro. If the engine were to quit, just as in figure 3 above, the rapid lowering of the nose will further lower the rotor rpm – with the same rapid altitude loss discussed above – maybe more! If you are practicing – or showing off for the crowd – with your fantastic skills to fly very slow ‘behind the power curve,’ please do so either below or above the HV curve – so you don’t personally add even more credence to the ‘deadman’s zone’ description.

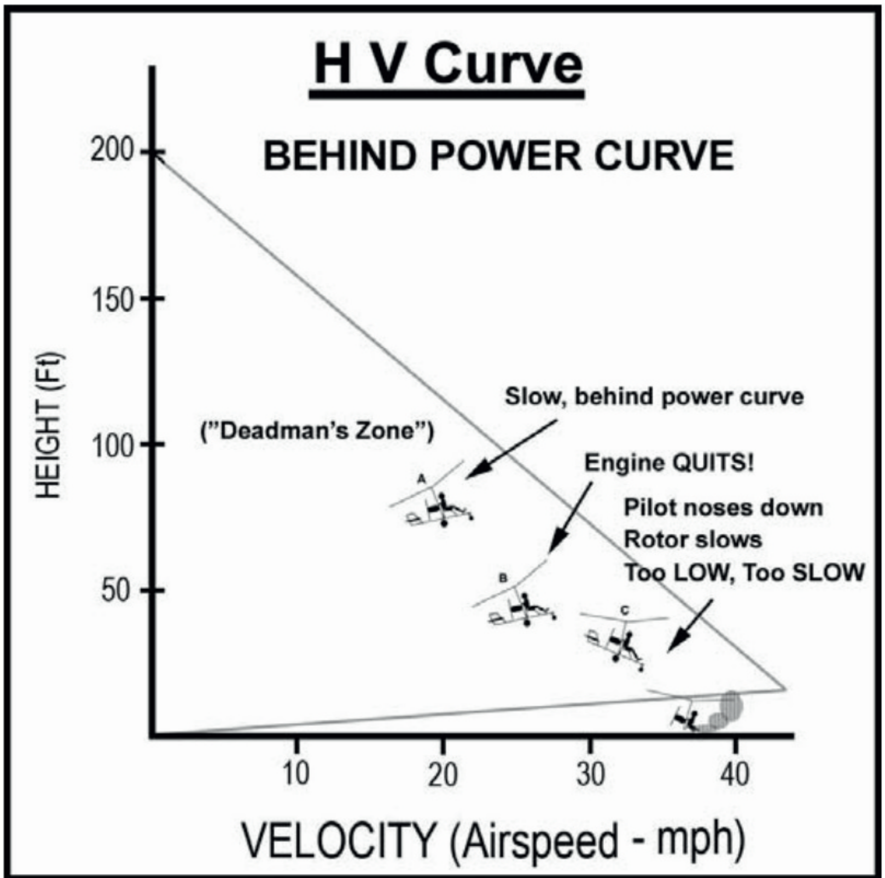

FIGURE 4

Above I mentioned several times that the HV curve applies ‘mostly’ if the engine quits or is not available. Engines quitting is the origin of the HV curve. However, the situations depicted in figures 3 and 4, recovery from a steep nose-high attitude at slow speed, does not require the engine to quit. If the engine just sputters, or the pilot is otherwise excited into a sudden nose-down input, the scenarios of reduced and slow to recover rotor rpm and rapid altitude loss – ‘dropping like a rock’ can be initiated – just from the rapid forward stick motion! So, the engine doesn’t have to QUIT to cause problems if you are flying within the HV curve – unable to recover before striking the ground.

How do I know what my HV curve is? Hopefully your gyroplane manufacturer has determined and provided the curve in your aircraft flight manual – all certified aircraft (standard or experimental) are supposed to have a Flight Manual or Pilot’s Operating Handbook (POH). If you don’t have a curve provided to you, you can go up to a safe altitude and descend at zero airspeed and see how much altitude it takes you to recover rotor rpm and airspeed for a well-simulated landing flare at altitude.

This will be the top peak of your HV curve. The highest airspeed tip of the curve might range from 35 mph for a light single-place gyro up to 50 mph for heavier gyroplanes – but, for this, your normal landing sequence would be a good representation of the lower ‘ledge’ of your curve.

When you make a normal deadstick landing, note your height above the ground and airspeed just after raising the nose to start your flare on a normal deadstick landing. This is the right ‘tip’ of your HV curve. Add a little airspeed for a conservative safety margin to account for not being perfect in a sudden surprise engine failure, and you have pretty well defined your HV curve.

In summary, please review and respect your HV curve, or a very conservative version of one. On my gyroplane, the HV curve starts at 200 ft as shown in figure 1. But I treat this very conservatively, and certainly begin to recover airspeed from a zero airspeed vertical descent at no lower than 300 feet. Allowing a little conservative safety margin minimises the necessity of doing everything perfectly in a surprise situation! You certainly do not want to discover why the HV curve is important the first time your engine sputters or quits or won’t respond to throttle.

Fly safe and have fun – Greg