14 The Divine Art of Hovering

Introduction

Having learned the fundamentals of controlling the helicopter in forward flight, the next step is hovering.

To the Hover!

In many schools, hovering is one of the last items to be taught, as it is perhaps the most difficult skill to master*.

Since it's the most difficult, it is covered after you've learned the fundamentals.

Hovering More Easily

Do you remember the first time you tried to hover? It was probably in a large, open field. (If you haven't tried hovering a helicopter yet, you probably will be put in such a place – wait for it...) It is obstacle-free, and everything is uniformly green (or brown or white - depending upon the season).

What is the typical result for the student? A lot of wandering around the field, with little real learning and lots of frustration. Why? What sort of information is there to give visual cues about movement? Not a lot. Everything is the same color and texture, so there is very little real information about what the helicopter is doing. Everywhere the student looks, there is a very small amount feedback about how he is doing with regard to trying to hover. Also, there is no real incentive to be accurate - one part of the field is as good as another. More detailed reasons as to why this makes things difficult will be given in Chapter 27,"Advanced Helicopter Flying", but for now, here is a possible solution to the problem.

The situation is much better if there is something for the pilot to look at - for hovering at 3 to 5 feet above the ground, the cues should be somewhere about 30 to 50 feet in front of the helicopter. Any further away, and the feedback of cues is too little, and the hover cannot be maintained accurately. If references closer in are used, this may give too high a feedback and overcontrolling will result. It is also necessary to have two references - one in front for lateral movement, and one slightly to the side (about the 2 o'clock or 10 o'clock position) for fore–aft movement.

I have used runway signs, marks on the runway, etc. as cues, and had good success in having non-pilots hovering reasonably (within 10 feet of the spot) within 45 minutes. The incentive of something that could be run into immediately in front, staring you in the face helped to concentrate the student on where to look. The student has an immediate cue about movements, (backwards, forward and side to side) and can make corrections very easily.

Vertical References

Vertical references are most worthwhile. What is meant by this? It is difficult to obtain information about lateral or fore–aft drift or height when hovering over a uniform surface. Some of this information can come from the horizon or distant objects, but we need to see things close by to get good overall cues. Vertical cues are subtly different - we need to have something to measure height by - and looking at an object sticking up in comparison to its background, lots of good cues can be gained. Figure 14-1 shows how this works. Note the relative distance vertically between the top and bottom edges of the sign and the things behind it, or the vertical distance between the sign and the edge of the runway. As you move up and down or back and forth, these relative

* Other things learned later are more difficult to master, but the concept of hovering is initially not easy.

distances all change, and that is how you judge perspective. When hovering OGE for example, use the sides of buildings or the tops of trees with respect to more distant objects, and so on for vertical cues.

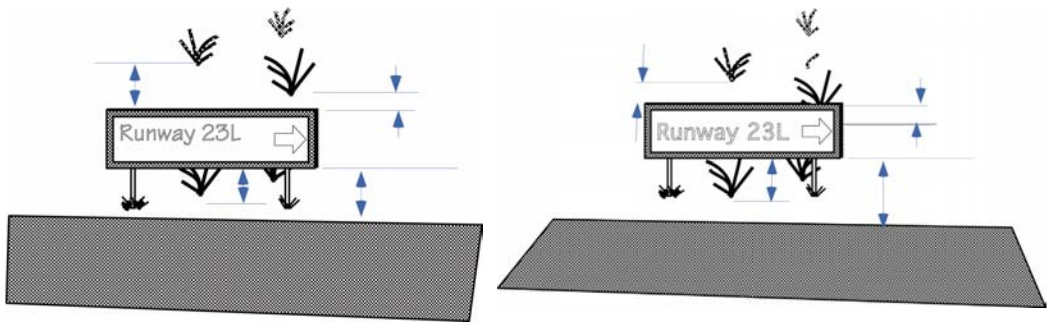

Figure 14-1 Vertical Cues

Aim of Hovering

The aim of hovering is to maintain a steady position over the ground. This means the pilot must know how accurately the hover is to be maintained, and there are sufficient visual references to be able to know you're hovering this accurately. It is nearly impossible to hover accurately over the ocean, for example, without other references to tell you if you are moving. Waves and the foam on the surface won't do, by the way, they move too. If the rotor downwash is visible, it can be used as a rough guide, but conditions need to be ideal for this.

Anytime except calm conditions the wind is going to push the helicopter around. Your task is to keep the helicopter in one place. Accept this as a fact of life. The change in wind is a change in relative airspeed, which causes a change in pitch attitude, and a movement across the ground, and a change in power required to maintain height, and a change in the torque balance, and a change in the transverse flow effect - Hey if it was easy, anybody could do it!

Correcting back to the desired position is straightforward, and consists of making adjustments in the controls to correct the attitude and stop the movement, and then further control inputs to return to the desired position.

It should be remembered that in ground effect (IGE), the collective lever is a height controller, so only very small changes in collective lever should be necessary. Changes in airspeed affect the power required to maintain height as well, further emphasizing the need to make only small changes in speed (ground and/or air speed). This is another way of saying if a large change in groundspeed is made near the hover and the collective lever isn't moved, expect the helicopter to climb or descend quite markedly.

Concepts of Hovering

A few exercises may help to get the concepts of hovering straight, but first a pesky difference in wording must be sorted out.

Hover - Zero Groundspeed vs. Zero Airspeed

Earlier we talked about the zero airspeed hover in order to simplify the aerodynamic explanations. We know full well pilots want to hover with respect to the ground, so in this part, we're going to talk about the stationary with respect to the ground hover. This means anytime there's a wind, the helicopter is affected by it.

Most of the time when you're flying, you'll be blessed with a wind, however, from time to time, the wind will be calm*, and you may notice some differences in the way the helicopter reacts. In a calm wind, you're in a zero-airspeed hover at the same time as you're in a zero-groundspeed hover.

Effects of Controls - Hover and Low Airspeed

Having described all the problems of flying the helicopter, it is time to stop making excuses and get down to making the machine do our bidding. First, we should examine the effect of the various controls. You will notice the title of this section is introduces the term 'low airspeed', so before we examine the effects of controls, we need to understand what we are talking about.

In the previous chapter, we were in forward flight, up and away from the ground. All the controlling was with respect to airspeed, heading, and altitude. Now, we're closer to the ground, and we are using different references, such as groundspeed, track across the ground and height above ground. To make a clear distinction between the two, because the controls are used in slightly different ways in the two areas, we'll call one 'forward flight' and the other area 'low airspeed'.

Forward Flight and 'Low Airspeed'

Forward Flight will be defined in this book as airspeeds above 40 KIAS, with the direction of flight roughly the same as the direction of the nose of the helicopter†, leaving 'Low Airspeed' to be anything slower, including side and rear airspeeds. The reasons for this arbitrary division are many: the pitot system doesn't function well less than 40 KIAS‡; flight at speeds slower than 40 KIAS is with reference to the ground whereas flight above this speed is with reference to airspeed and the air mass. Besides, a line had to be drawn somewhere…

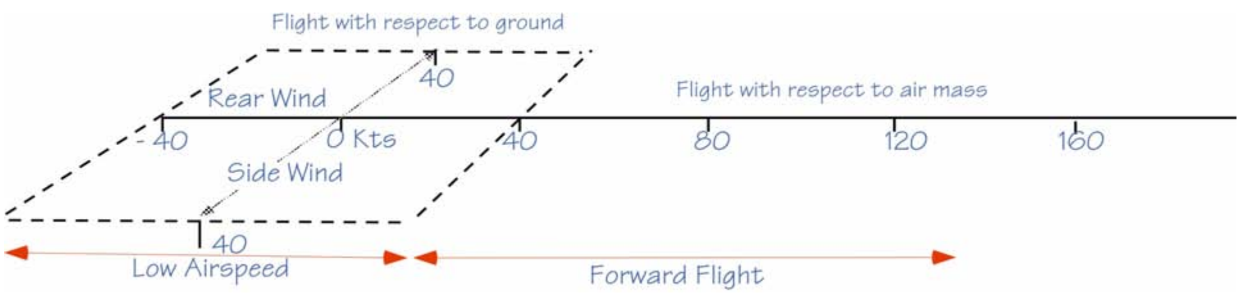

Figure 14-2 Forward Flight vs. Low Airspeed Division

Back to the effects of controls.

In simple terms, the easy way to understand how to fly the helicopter is to consider the cyclic stick as the way to control the tilt of the rotor disk (or the thrust vector), and the collective lever as the controller of the size of the thrust vector. Because it is difficult to split out axes and controls in a helicopter (there are no ailerons or elevators), the terms longitudinal and lateral cyclic stick will be used. Longitudinal cyclic stick is fore/aft cyclic, and lateral cyclic stick is left/right cyclic. The pedals are used to point the fuselage with respect to the wind or chosen heading.

* Those of you into Zen would try to figure out if the wind is coming from everywhere all at once, or going to everywhere all at once...
† …and hopefully the nose of the pilot as well.
‡ as will be shown in a later chapter.

Hover / Low Airspeed

It helps to consider the cyclic stick as the controller of position and ground speed. In a zero–airspeed hover, the rotor disk is parallel, and the thrust vector perpendicular, to the ground. If a wind is present, the rotor disk and thrust vector must be tilted into the wind to stop the helicopter moving. The collective lever controls the height above the ground.

Cyclic stick

In the hover, think of the cyclic stick as independent of the direction the fuselage is pointing. Where the cyclic stick is pointed is where the helicopter will go, regardless of the heading of the fuselage (within reason). To move to a new position, visualize a line between the top of the cyclic stick and where you want to go. The thrust vector needs to be tilted in that direction. For example, the point desired is slightly to the left front, about the 10 o'clock position. From a steady hover, apply slight pressure to the cyclic stick in that direction, and the helicopter will start moving across the ground. With zero wind, the fuselage stays pointing close to its original heading. The helicopter may slow down again, or do something that appears strange, but keep applying the slight pressure to the cyclic stick in the direction of the desired position, and you will move towards the target.

This method presupposes a good idea of where you want to be - visualization of the objective, and a good set of references to tell you when you are there all make a large difference. (Remember if you want to hover over a spot, you won't be able to see the spot when it's underneath you, so you need to pick some surrounding features to tell you when you're over it - another reason why large flat fields aren't of much help.) This may sound like an overly simplistic approach, but it works.

When nearly over the desired spot, it is natural to slow down to stop. The disk and thrust vector must be tilted slightly away from the direction of travel position in order to slow down. At the zero–groundspeed hover, the cyclic stick should be back at the same position as at the start of the maneuver. The pressure on the cyclic stick is thus initially in the direction to start (and keep) moving, a slight pressure opposite the direction of motion to slow down and a final correction to stabilize in the hover. Figure 14-3 shows the sequence of moves from start to finish of moving slowly to a new hover position.

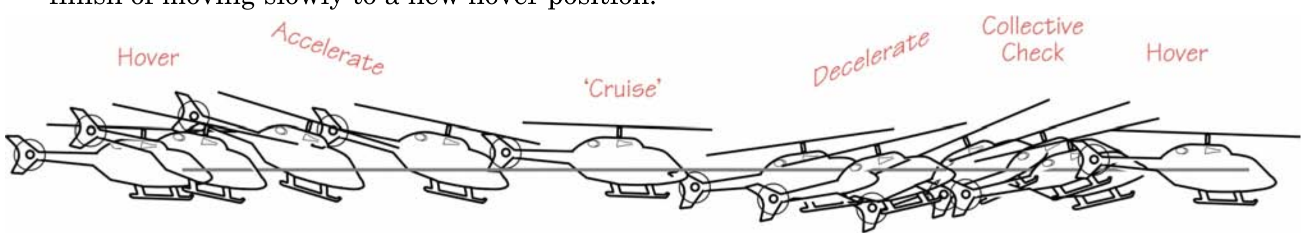

Figure 14-3 Sequence of attitudes from hover to hover

Overcontrolling in the Hover

I know you're supposed to concentrate on the positive, and not tell people the mistakes they're going to make, but learning to hover is a classical example of a problem every helicopter pilot has experienced. I'll describe the problem, as students will immediately identify with it because they've seen it, and then describe the solution.

The Problem

There is a lag between the time a cyclic stick input is make and when the machine is seen to respond to the input. While is lag is whiling away the hours, the student pilot is uncertain about what has happened - nothing seems to be going on. This is especially true in the pitch axis, which has a large inertia compared to roll.

The problem is something is going to happen, but the student doesn't know when that will be. The typical response to having put a control input in with no immediately apparent result - (nothing happened!) is to put in another input. The total input will then be so large that an opposite input will be required to correct for the first one. Unfortunately, the second input has the same lag as the first. The result is a lot of very large control inputs and increasingly large and alarming attitude changes until the instructor takes control.

You're hovering over a spot and the instructor gives you control. You start to drift forward. Here, in step-by-step fashion is what happens when you overcontrol:

- A small aft cyclic stick input is made
- Nothing seems to happen
- Since you want to stop the forward motion, a larger aft input is made
- The nose starts to pitch up, then it *really* pitches up
- Helicopter starts to accelerate backward (all too rapidly for your liking)
- You put in a healthy forward cyclic input
- Nothing seems to happen to the pitch rate or the rate of travel across the ground
- More forward cyclic stick input at about the same time as the nose starts to drop
- Helicopter starts to accelerate forward

'You have control' you yell at the instructor as you wonder if you'll ever get the hang of this game.

Sound familiar?

Now lets look at how to correct this. It's called anticipation.

- A small aft cyclic stick input is made and the stick returned to about the same place it started from.
- Nothing seems to happen, but you're cool, you know it will in just a second or so.
- Nose begins to pitch up, but not too rapidly
- The helicopter stops drifting forward
- The nose settles to the correct position

...and so on.

Much easier wasn't it.

The real question is how to learn about the anticipation. This is another of those skills only experience can teach you. If I could put this in a bottle, I'd be rich.

Cyclic Stick as a Position Controller

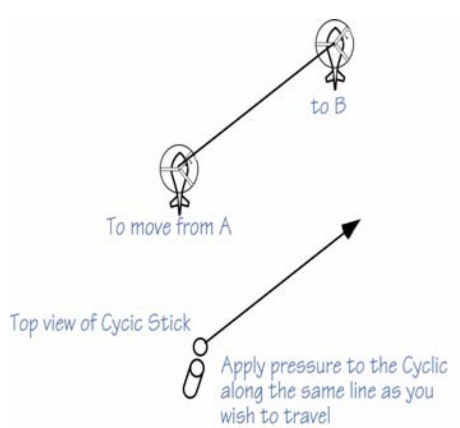

Figure 14-4 Cyclic stick vs. Direction of Travel in Low Airspeed.

The other way to look at the cyclic stick is as a controller of lateral and longitudinal position, and to a lesser extent, ground speed. When hovering along a line, lateral cyclic stick controls lateral position with respect of the line. Too far to the left? Add a bit of right cyclic stick until you are where you want to be. Similarly, longitudinal cyclic stick controls forward speed along the line. In total, the cyclic stick controls tilt of the rotor disk and thrust vector. Figure 14-4 shows this in a different sense.

Collective Lever

Collective lever control has two distinct parts in the low speed environment. The first is in the in-ground-effect (IGE) hover with zero wind; the second is the out-of-ground effect

(OGE) hover, or the IGE hover with wind. Reasons for this distinction are given in more detail in Chapter 6,"Basic Helicopter Performance". Remember, the collective lever controls the amount of thrust.

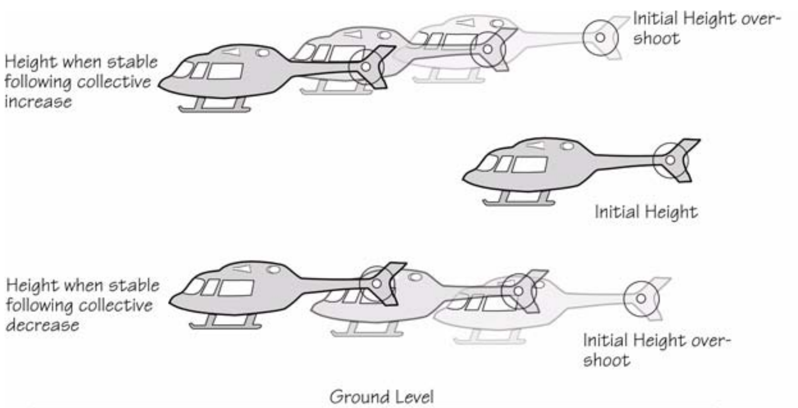

Figure 14-5 Height Change Following Collective Lever Movement - In Ground Effect

In the IGE hover, with zero wind, the collective lever controls height above ground - a small increase in collective lever increases the height, after one or two oscillations. This assumes a steady position, both laterally or longitudinally. See Figure 14-5 for a graph of this.

In an OGE hover, when you change the power, the helicopter will continue to climb or descend*.

OGE, (or if there is a wind or groundspeed when IGE), the collective lever is a rate–of–climb controller. Increase the collective lever above the power required to maintain height, and a steady rate of climb happens. Again, this assumes the airspeed hasn't changed.

Any power change causes an all–too–frequent problem when learning to hover, namely controlling heading. Any small changes in collective lever change height and introduce problems in heading control, etc. Instructors should encourage students to be very smooth about changing power when hovering close to the ground. Any variation in airspeed changes the power required to maintain height, making things worse…

Pedals

In the hover and low speed, pedals have one basic function - to keep the nose pointed where desired. In a zero wind hover, the pedals control yaw rate.

When there is a side wind in the low airspeed region, the pedals are still used to control heading of the fuselage, but have some complex effects. Hovering with a relative 225° wind in most helicopter will cause problems† which you'll see as a lot of dancing on the pedals. This is covered in more detail in Chapter 34,"Further Peculiarities of The Helicopter".

* Within reason of course. The power required to hover OGE does not change much within 500′ of the starting point, unless you descend into ground effect.

† Other–direction–of–rotation rotor systems will have a problem with relative 135° wind.