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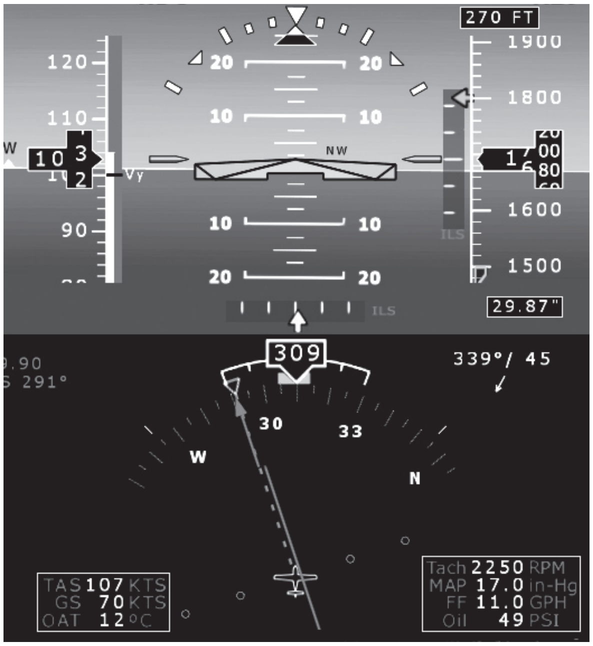

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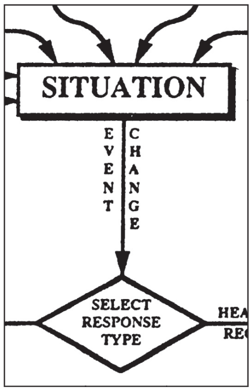

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HOW TO FLY THE HSI

When the display is digital, you can bet it's an HSI. Even a portable GPS will have one, so it's worth knowing how to use it well.

by Scott Dennstaedt

Except for turboprop singles and high-end twins, a GA aircraft equipped with horizontal situation indicator (HSI) used to be a rarity. Technically advanced aircraft (TAAs) shipping in the last 10 years have changed this forever. Primary flight displays always have HSIs and many have flight directors (FDs). Most likely, these pilots transitioning to a TAA never received any formal instrument training with either instrument.

Go to any local FBO or flight school and it's common to hear, "Once you transition to using a GPS, you'll never fly a plane without one." In a similar manner, once you fly behind an HSI, you'll wonder how you got along without one. But like GPS, it's how you utilize the HSI that makes it indispensable.

Two for One

An HSI is really two instruments in one. It combines a heading indicator (HI) and navigation source to include VOR, localizer with glideslope, and GPS. Electronic HSIs, like the Sandel and Bendix King models, and glass panels, like the Avidyne Entegra and Garmin G1000, add multiple RMI-like bearing pointers to the same HSI display. If that isn't enough, some also allow a moving map and ground-track vector to provide the pilot with the ultimate situational awareness tool.

A standard VOR display includes a knob referred to as the *omnibearing selector* (OBS). It also includes a course deviation indicator (CDI) — a.k.a., the needle. Using a VOR signal, the CDI shows the pilot the number of degrees the aircraft is off the selected course (or the number of miles off-course if the source of the navigation is GPS).

The HSI doesn't have an OBS; instead, it has a course select knob and a course deviation bar (better known as the D-bar). These perform a similar function to the OBS and CDI; however, the interpretation is a bit different.

The beauty of an HSI is that you never need to fly away from the needle (D-bar). Let's say you are northwest of the PDQ VOR and are tracking inbound on the 330 degree radial. Using a standard VOR, the OBS should be set to the inbound course of 150 degrees. If you mistakenly set the OBS to 330 degrees, the course could still be flown using the standard VOR display, but the aircraft must be flown in a direction that is opposite the movement of the needle.

When using an HSI, it doesn't matter if the inbound course of 150 degrees or the course of 330 degrees is set, you always fly toward the needle. If the D-bar is deflected to the right side of the instrument, the course is to your right. This is true no matter whether you are inbound or outbound from the VOR. When you are twisting and turning around a holding pattern in lieu of a procedure turn, you are constantly aware of your position relative to the inbound course that you remembered to set after crossing the VOR.

As a standard operating procedure, I teach all of my instrument students to always set the course on the HSI to a setting that approximates your heading (with the exception of a localizer back course — more on that later). For example, when tracking inbound on the 330 degree radial, your heading will be 150 degrees (assuming a no-wind scenario). That means that you should set the HSI course on 150 degrees.

The primary reason for this is for autopilot tracking. Many autopilots can track a VOR signal, but

***Right:** You're on the downwind for the ILS, but your intercept heading will be somewhere between the arrowhead of the inbound course (1) and the head of the fully-deflected D-bar (2).*

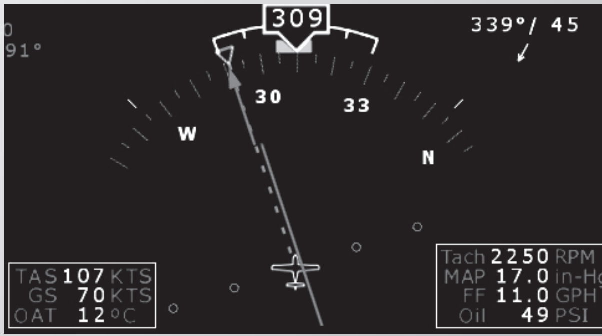
WIND CORRECTION IN THE DIGITAL AGE

The old method of tracking a VOR or localizer signal was to find a heading that stopped all needle movement. If the needle wasn't moving left or right, you were flying a wind corrected heading even if the needle wasn't centered. You then recentered the needle and resumed the magic heading.

GPS made all this much easier, but there are now several ways to get the job done. On a moving map GPS, you can simply look at the magenta line. In track-up mode, the magenta line should be straight up and down with no jagged edge. A jagged line means that your current heading will take you off the desired ground track. It's a low-tech method, but is easy to interpret and has a high glance value while hand-flying an instrument approach.

Ground-track vectors have the same effect. The Garmin G1000 has a track vector that protrudes from the front of the aircraft symbol on the MFD moving map or inset PFD map. While zoomed in on the map, simply align this arrow with the magenta line. The length of the track vector depends on your ground speed. If you're not zoomed in enough, the track vector appears as a big arrowhead in front of the aircraft symbol and there's no chance to align anything.

Avidyne integrates the ground-track vector on the HSI display. In this case, a white dashed line extends from the aircraft symbol in the center of the HSI to just outside the compass card. At the end of the dashed line is a white triangle that points back to the aircraft symbol. Here you turn the aircraft so that the triangle from the track vector is aligned with the arrowhead of the course select pointer (set to the appropriate course). If the two triangles are pointing at each other, you are flying the wind corrected heading. This works well on a GPS course. A VOR or localizer signal could be a few degrees different. — *S.D.*



you must tell the autopilot which direction you want to track on the course. Set the CDI to the direction you want to head, and you won't be wondering, "What the hell is George doing now?"

Pilots, and even instructors, too often treat the HSI as two separate instruments: an HI and a VOR display. The real bang for the buck is the ability to visualize your position relative to the course. This involves combining the two instruments.

IFR flying is all about tracking and intercepting courses, and an HSI makes this extremely easy because your course is overlaid on top of your heading. Finding the right heading to create a 45-degree intercept to the course is child's play. Ninety-five percent of my instrument-rated students do not understand this simple concept primarily because their instructors didn't know how to use an HSI.

You could do this intercepting and tracking with a moving-map and GPS. However, the moving map GPS doesn't immediately show you the exact heading needed to intercept the course. Your level of zoom in or out changes how you interpret the moving map as well. Overshooting or undershooting a course is a common error when relying solely on the moving map. The HSI takes all the guesswork out of the picture. Simply turn to the heading depicted on the HSI.

In the G1000 image from the preceding page, you're being vectored to final for the ILS Rwy 02 at Rock Hill, S.C., (KUZA). Currently, you are on a 210 heading on the downwind leg just past RALLY, the non-precision FAF. Expecting an inbound turn soon, you twist the course se-

THE HSI AUTOSLEW GOTCHA

In the olden days, we crossed over the station, looked down at the chart and spun the course knob or OBS manually to the next course. Some of the integrated cockpits will automatically change — or "slew" — the HSI course pointer to the new course after crossing over a waypoint in the GPS flight plan. If the autopilot is tracking the GPS signal, the transition is seamless.

This can give the pilot the impression that automation is happening when it really is not. The classic example is vectors to final. ATC says, "Columbia Two Three Bravo, fly heading 210, expect radar vectors to the final approach course for ILS Runway 2." You now twist the heading bug to 210 and activate vectors to final on the GPS. But what course is set on the HSI?

The answer depends if the HSI was displaying the localizer signal (VLOC) or the GPS signal (GPS) when you activated vectors to final. If the course pointer was set to display GPS, the course automatically slewed to the inbound course. You say you are doing a back-course approach? Gotcha. This will be correct for a front-course approach or VOR approach, but incorrect for a back-course approach.

If you have the localizer course (VLOC) on the HSI when you activate vectors to final, autoslew will not take place because autoslew is a GPS-only function. Here you must manually twist the course knob to the front course. The moral is that automation can make your life easier, but you still have to manage it. — *S.D.*

lect knob to the front course (016 degrees). For additional situational awareness, you also have a bearing pointer (thin double-width arrow) set to point to RALLY.

The HSI immediately shows you two things. The D-bar shows the final approach course off your left wing; eventually ATC will be issuing you a turn to the left to intercept the final approach course.

The likely final intercept heading that ATC will issue along with your clearance is bounded between the 016 degree course and 060 degrees. You know this because 060 degrees is the heading that is "pointed to" at the top of the fully deflected D-bar. ATC is likely to give you something less than a 45 degree intercept, but without doing any math, you can visualize the plan.

This method also works well for intercepting airways, joining the final approach course after a procedure turn, and turning inbound on a holding course just to name a few.

On Course

A common error is confusing the inbound course and the localizer front course. For a localizer-based approach using your vanilla VOR, you were taught that it didn't matter what course you set on the OBS (you can spin it all you want and it won't affect the needle). Your instructor probably suggested that you set the inbound course on the OBS as a reminder. Remember that?

If you were flying inbound on the front course, you were taught to always fly toward the needle. Similarly, if you were flying outbound on the back course, you were also taught to fly toward the needle. However, inbound on the back course or outbound on the front course was a different story; you were taught that you have to fly away from the needle.

With an HSI you must set the front course for all localizer-based approaches. Failure to do so may result in improper guidance on the approach. For a back-course approach, the head of the course pointer will be at the bottom of the instrument and you will track the tail of the course pointer. You can think about this as the needle giving you "reverse sensing," but the CDI is upside down so the "reverse sensing" is actually the correct steer-left or steer-right indication.

Assume the front course is 060 degrees, but you twist the course select knob on the HSI to 070 degrees. Can you still fly the approach successfully? Yes, but the D-bar will still react as if 060 degrees is set. The result is it looks like you have a massive wind correction applied. Not that I recommend this, but you can have the course set as much as 89 degrees to the front course and you will still be able to "center the D-bar." Once you cross over beyond 90 degrees to the front course, now the HSI thinks you are trying to fly the front course in the opposite direction.

On many of the mechanical (non-glass) HSIs, the glideslope needle is also presented on the side of the instrument (sometimes both sides). However, the glass panels such as the G1000 and Avidyne Entegra don't present the glideslope needle on the HSI. It appears on the attitude and air data reference display above the HSI display.

Angular vs Linear

With a VOR signal displayed on the HSI, the "dots" are an angular error off the selected course. The number of dots may vary depending on the HSI display. Full-scale deflection typically indicates the aircraft is 10 degrees or more off-course, assuming normal needle sensitivity.

When GPS is available, the HSI can display a course deviation indication of the GPS source. This is linear displacement, not angular. Instead of degrees, the difference is displayed as nautical miles. This is also known as cross track error (shown as XTE on many GPSs).

This has both positive and negative consequences. For example, assume the aircraft is 0.5 miles off the centerline of the airway. Using a VOR

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in making a poor judgment. Yet, I can honestly say that it wasn't machoism, denial, or a sense of invulnerability that was at work during that flight. Personal desire simply overruled common sense. My numbers worked out on paper when I decided to skip the stop. But as I said, I had already decided that they should.

We aren't stupid pilots. We can feel when the hairs on the back of our necks start standing up as we start contemplating how we can make this flight happen despite the current obstacle. We know we have been bitten by the get-there-itis bug.

We can try the common antidotes to counter any bad motives or impulses. Some time imagining both Seneca engines sputtering out over the Pennsylvania mountains might have done me some good. But with what will we replace the hole that is left behind? For that we once again turn to the AC.

Decisions, Decisions

The AC shows two ways we make decisions, Conventional Decision Making (CDM) and Aeronautical Decision Making (ADM). The diagrams give a visual overview. The fact that CDM culminates in the word "mishap" gives a hint which the FAA recommends.

ADM's disciplined, systematic approach to problem-solving is less likely to create errors. Studies show airline crews don't look for as much information as possible during a problem. They often stop when they conclude that they have accurately discovered the cause, despite the fact that their supposed cause may only be a symptom of something else going on. A decision-making procedure forces us to not be mislead by our more human failings.

Imagine you are sitting there during cruise and you spot the oil temperature gauge creeping into the red. What do you do?

In CDM, this change in oil temperature results in a situation that must be recognized and dealt with. Serious situations rarely involve single events. ATC, pilot sickness, a change of plan all pour into the problem. Yet, the key ingredient is awareness. If you don't recognize the change at the appropriate time, the entire situation can significantly worsen. Miss the rising temperature, and the next thing you recognize will be engine failure.

With ADM, we enhance the conventional process with an appreciation of how attitudes play into the mix. Instead of reaching for the high oil temp checklist, take a few extra seconds to check everything else. Did you accidentally bump the mixture control? Were you climbing unusually steeply due to high terrain nearby? Work your checklist, but keep in mind how your other actions or attitudes are factoring into the situation.

The FAA calls this the "learned ability to search for and establish the relevance of all information." In other words, it's natural to fixate on a simple solution. We must learn to seek the big picture.

What does this have to do with get-there-itis? Get-there-itis thrives when we focus on small details — I think I'll actually have enough fuel — rather than seeing our actions in the context of the big picture. Good ADM forces us to take into account that picture and may be a good antidote for some of our human failings.

The process will never be perfect, but maybe next time we shave an MDA just a bit, we won't be low on fuel at the same time.

Kevin Harrold almost always lands with enough fuel when flying for airlines.

QUIZ ANSWERS *(questions on page 8)*

1. **d. FAR 97.3 (D-1)**
2. **c.** Instrument Procedures handbook (C-6). FAR 97.3 (d-1).
3. **a.** AIM 10-1-2. Helicopters must limit airspeed to 90 knots or less when flying any segment of the procedure, except speeds must be limited to no more than 70 knots on the final and missed approach segments. Note: Helicopters that have a Vmini higher than 70 knots are unable to fly these approaches.
4. **a.** FAR 91.157 (b).
5. **b.** AIM 10-1-3. Point-in-space approach procedures are normally developed for heliports that do not meet the design standards for an IFR heliport.
6. **c.** AIM 10-1-3. The pilot must maintain visual contact with the landing site at or prior to the MAP, or execute a missed approach. The pilot must maintain the published minimum visibility throughout the visual segment.
7. **False.** Helicopters get a lighter sentence. FAR 91.167 (a)(3)
8. **b.** FAR 91.167 (ii)
9. **d.** Instrument Procedures Handbook C-5 and -6. For most helicopters, reaching Vmini requires one-half mile and an altitude of 100 feet.

HOW TO FLY THE HSI

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signal, this will result in a small needle deflection when you are, say, 40 miles from the VOR. As you are approaching the VOR, the angular error increases, which results in a larger deflection assuming the same 0.5-mile distance from the course.

This becomes the greatest just before and while crossing the VOR, where a full-scale deflection will occur. Even the smallest distance resulted in more than 10 degrees of error if you were close to the VOR.

If we switch the navigation source to GPS using the same 0.5-mile distance from the airway centerline, the deflection will be the same independent of the distance from the waypoint, even if that waypoint is a VOR. The amount of deflection depends on the sensitivity established on the HSI. Three levels of sensitivity are possible. Five miles for full-scale deflection en route, one mile within 30 miles of your destination waypoint, and 0.3 miles when on the final segment of an instrument approach. If the sensitivity is set to terminal level and the aircraft has a cross track error of 0.5 miles, the D-bar will show one-half-scale deflection.

More to Master

Despite the change moving maps have wrought — put the airplane on the magenta line and fly — the HSI still has a place in our high-tech cockpits. Someday it may be fully displaced by highway-in-the-sky displays. Until then, it's a great tool that's often underutilized. Once you learn all its tricks, you'll never want to fly without one.

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AIRBORNE RADAR 101

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ther too high or too low may miss convective activity brewing in the low flight levels. Because the radar image is the narrow result of seeing the world through an electronic soda straw, varying the settings periodically will best size up any weather ahead.

At altitude, during the lulls, my company advocates a technique called "en route park." Between periodic searches with the beam, we place the range at a middle setting and adjust the tilt so that ground returns just begin to tickle the edge of the scope. Ideally, the scope is blank except for the distant ground arc. If the radar paints a city or mountain, as we fly on, the object will move closer, drop below the beam, and disappear from the display. However, if a storm appears, it will travel from the edge of the scope and march closer to the airplane; its vertical height keeps it in the beam.

The other subtle benefits of en route park are that the distant ground returns verify the chosen tilt and confirm that the radar is still actually working. A blank screen may sound good, but does nothing to reveal the health of the system.

The Take Away

Mastering radar is the result of intense training and a heavy dose of experience. It's not realistic to attempt to describe radar interpretation in a short article, nor was my intent to teach weather avoidance tactics — that's another topic altogether. My aim was to introduce the quick basics. Now you could, if necessary, turn on a radar and, at a minimum, have an idea of where you're pointing it in an effort to create a useful image. Deviating 100 miles after mistaking Dallas for mesoscale convection will do little to gain cool points. The flashlight analogy is not a true representation of how radar works. Rather, it's an easy way to visualize the process.

Sure, you may not be emitting waves anytime soon, just like I'm not hanging by the phone waiting for a call from a Master Chef. But knowledge is a good thing, and the more you pack into your bag of tricks, the better off you are miles down the road.

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