THE MAGIC NUMBER

BY

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My student had recently acquired a Beech Baron. It was a beautiful plane representing a step up from the Bonanza that he and his father had been flying for some time. The Baron handled very much like a Bonanza, but it went faster, carried more load, and had a greater range than the single-engine Beechcraft. And of course, following an engine failure, it would carry you farther to the site of the crash.

There was no problem getting both men checked out in the plane, since the skills they had acquired in the Bonanza transferred very nicely into the twin. The son had decided that he could do more with the new airplane if he had an instrument rating, so part of the training package I was going to provide was to qualify him as a certified meter reader.

This essay is about an episode that happened during his instrument training when my student had reached the part of the syllabus in which he was going to learn to track a localizer.

In case any of my readers are not familiar with a localizer, it is a gadget that keeps an airplane aligned with the centerline of a runway, giving lateral guidance for the final part of an instrument approach, bringing the plane straight in from about five miles out, putting the airplane at the appropriate altitude at the appropriate distance from the runway threshold to accomplish a good landing, assuming that the pilot doesn't see

anything but the inside of a cloud until he is about a half-mile final at an altitude of about two hundred feet.

If the course deviation indicator (the left-right needle) is in the center during an ILS (instrument landing system) approach, it means that the airplane is located precisely on the extended centerline of the runway. If it starts moving in either direction, it means that the airplane is drifting in the opposite direction, and an appropriate heading correction is called for.

Like a VOR radial, the localizer is shaped like a wedge, becoming increasingly narrow as the airplane approaches the runway. So the needle becomes more and more sensitive as the airplane gets closer and closer to the runway threshold. The localizer course is about four times as narrow as a radial, with a full-scale deflection of the CDI happening when the airplane is only 2.5^0 off course, compared with the radial, on which you can fly 10^o off the centerline before the needle goes all the way over.

For an instrument pilot, this sensitivity of the localizer is good news and bad news. The bad news is that he must tend to his tracking and make corrections very promptly to prevent a full-scale deflection of the CDI. The good news is that the corrections he makes in heading have an immediate effect on the needle. A very small heading correction will almost instantly slow, stop, or reverse the deflection of the left-right needle.

The book (The FAA's *Instrument Flying Handbook*) recommends heading corrections on the order of +/- 2^o during the final minutes of an ILS approach. I don't know about you, but I have seldom had the skill to manage such small heading changes with precision. To tell the brutal, unvarnished truth, I

run pretty successful approaches using 5º corrections. But I'm getting ahead of my story.

As usually happens, my student got more or less established inbound on the localizer to runway 10 at our local airport, Moissant International. I had briefed him that he was not to hesitate when he saw the slightest deviation of the localizer needle.

So we started lurching down the final approach course, flying tiny "s" turns as he chased the needle left and right in increasingly large swings. Presently the needle went full-scale and we considered the approach well and truly blown. This scenario is familiar to every instrument instructor. It is a common student error known as chasing the needle. The essential flaw in the student's mindset is that he is trying to get the needle centered rather than stopped.

The cure for this problem is simple. It is known as basic tracking technique. You establish yourself on a particular course, and then make small corrections to stop the needle. You don't try to *center* the needle. You try to *stop* the needle. There is a particular heading that will keep the needle from moving. After you have established what that heading is, you can always make a correction, as small as your flying skill allows, to center the needle very slowly, then revert to the number you have already proved will keep you on course.

We engaged the autopilot on the next pass down the localizer. We went through the bracketing procedure and determined the heading needed to keep the needle from moving. As it happened, the wind was totally steady that day, and when we set the correct heading on the autopilot, the Baron tracked

the localizer down the runway, over the transmitter, and out the back course, dead on course, with the needle smack dab in the center the whole time.

It is unusual to pass over a VOR station, much less a localizer transmitter, without getting a full-scale deflection. Modern digital autopilots can do this; however it is rare that a pilot hand-flying can keep the needle in the center throughout the entire procedure.

But this autopilot was not tracking. It was simply keeping the airplane from turning, giving us a perfect demonstration of the value of holding the proper heading. I turned to my student and said, "There, you see? It's just like magic." And as I said it, I realized that I'd just invented a good name for the proper approach heading: *the magic number*.

So now that's how I teach it. Holding the magic number prevents the hunting around and needle-chasing that so often result in increasing inaccuracies in tracking when the on-course signal narrows as you approach the runway. In months and years to come, the concept of the magic number became one of my most effective tools for teaching tracking technique.

Soon I added other magic numbers to the magic heading. To run a successful ILS approach, you have to establish three things: a magic heading, a magic rate of descent, and a magic airspeed. Once you have those numbers nailed down, you don't need the localizer and glide slope needles to guide you. I commonly prove this by covering the needles with my hand when I catch my students needle-chasing. Soon they come to understand that holding those three magic numbers will pretty much keep them on course and glide path. Removing my hand

every ten or fifteen seconds, we can check the localizer and glide slope needles for an instant to see whether a small change in any of the magic numbers might be called for.

"The Book" recommends steering magic number +/- 5° until the final fix inbound, then magic number +/- 2° down to the missed approach point. As I have indicated, I have rarely attained the proficiency to make reliable 2° corrections. But knowing what the magic number *is* gives me a good reference point – a number I can correct back to, any time I may drop my pencil and find my numbers in disarray after I have interrupted my scan to pick it up. I simply restore the panel to my magic numbers, then make small corrections from there, in order to regain control to my approach. As if by magic!

"But what," I hear some of you asking, "if the wind is not nice and steady during the final approach segment? What's that going to do to your big deal magic numbers?"

Well, boys and girls, I never promised you that the magic numbers wouldn't change. Even in perfectly calm conditions, the engine is going to pick up a little over an inch of manifold pressure on the way down, forcing you to change your power setting if you want to maintain your magic airspeed. And if you want to change any of the other magic numbers on the way down, I have no problem with that, as long as you always know what it is that you are using as your default value during any part of the approach. How many times have I seen a hapless applicant for the gauge-gaping ticket jump on a localizer deflection and make a ten degree correction to bring the needle back to the center, then turn back to the previous heading, *the one that caused the needle to move off center in the first place.*

This practice is slightly better than overcorrecting and going past the initial heading; but when you've already proved that 105° moves the needle to the right, what's the point of turning back to a heading of 105° after you've got your CDI back to the center? If it was moving during the 105° era of the approach, you obviously have to adjust your magic number to a new value to stop it. Try 110°. That'll do one of three things: it will slow the needle down, it will stop it, or it will cause it to move in the opposite direction, back toward the center.

After you've held your new putative magic number for a few seconds, you'll see which of these things happens, and then adjust your heading appropriately, until you've determined the new magic number. Remember, the number you want is the one that *stops* the needle. After you have that nailed down, you can always turn a few degrees in the direction of the deflection and ease the needle back to the center.

I hope I'm not beating this horse to death, but it is the violation of basic scan rules like this that bring instrument pilots to grief, more often than not. I know I'm stating the obvious, but I have a suspicion that it's likely the obvious concepts, what they're calling *best practices* these days, that so often bedevil us when we're trying to grope our way through the clag to a nice long strip of concrete.

Of course, none of this tracking technique is going to work if you don't know how to control the airplane. If your scan is not working well enough so that you can deliberately make small corrections in heading, airspeed, and rate of descent, you shouldn't be trying to perform approaches. You should back up a few lessons in your instrument syllabus and improve those

skills before you try to maneuver the airplane through course reversals and holding patterns, let alone approaches. Of course, today is the age of the digital autopilot, commanded by a GPS navigator. Your instructor may elect to teach you some maneuvers using the autopilot before you get into hand-flying these procedures. I have used this sequence in training several students, and find it to be effective.

But sooner or later, one must come to grips with the job of taking over when the HAL 9000 says, "*I'm sorry, Dave. I don't believe I can do that."* When that time comes, using the concept of magic numbers should help keep things orderly as you make your descent toward a happy landing.