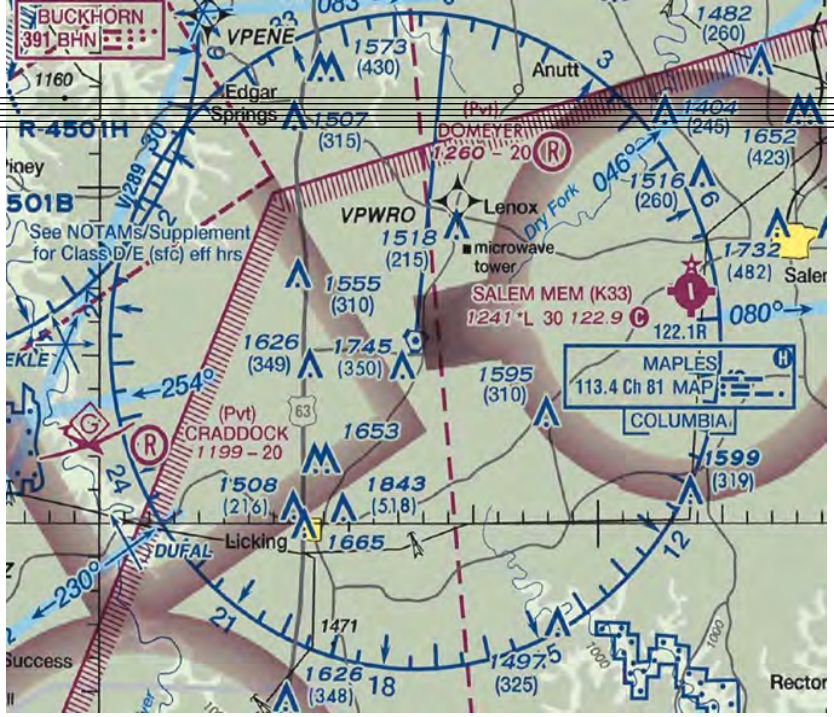
**JEFF SKILES**
**COMMENTARY /** CONTRAILS




# The VHF Omnidirectional Range

The mainstay of our national airway system

BY JEFF SKILES

**ABOUT A YEAR AGO** I wrote a column about the first organized navigational aid within the borders of the United States: the lighted airway system. While I didn't really intend for it to continue as a series, favorable reader response and my own interest in researching the subject brought further columns about the radio range, the nondirectional beacon, and the visual aural range. While I have no intention of discussing topics that I consider pure magic — like LORAN, Omega, inertial navigation, or GPS — I thought I would be remiss if I didn't wind up my on-again, off-again series with a column about the mainstay of our en route navigation system for the last 60 years, the VHF omnidirectional range (VOR).

Most of us were brought up learning to fly VOR courses. We tracked inbound and outbound on their radials on our cross-country flights for private pilot certification. We learned how individual VOR radials could combine to define airways that could transport us to new and exciting locales. And, with the addition of distance measuring equipment (DME), and a map to survey it all, we could never really be lost again. But, if you're like me, you understand how to use a VOR, but you don't really know what it is.

## THE VOR

From a historical perspective, the VOR followed very closely after the visual aural range (VAR) with which it shares a similar name. The VAR, however, could only define four fixed courses into a station, whereas the VOR is only limited by the number of degrees in a circle. Its obvious advantages, and the fact that the first VOR was deployed only two years after the VAR, limited the VAR to a few more than 60 stations in the United States and relegated it to a mere footnote in the annals of long-distance navigation.

The first VOR station was operational in 1946, and they quickly flourished with more than 1,000 eventually being built in the United States and 3,000 around the world. Like the VAR, the VOR transmits in the VHF portion of the radio spectrum. Thus, it is only a short-range navigational device limited to line-of-sight distances.

In the Unites States, VORs come in three varieties or, as the FAA terms them, service volumes. Terminal VORs are the shortest range and are designed to provide reception for only about 25 miles from the station. Low-power VORs are designed to provide reception out to 40 miles at low altitude (less than 18,000 feet). High-altitude VORs should be receivable as far as 130 nm away depending on the aircraft's altitude.



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### HERTZ, KILOHERTZ, AND MEGAHERTZ

VORs are assigned frequencies between 108.0 and 118.0 megahertz. The first four megahertz of the frequency range are shared with ILS installations. To prevent confusion, there is a structure for assigning frequencies. VORs will always have the 100-kilohertz digit as an even number: 108.2 or 110.8. ILS frequencies will have the 100-kHz digit occupied by an odd number: 110.3 or 108.7.

The concept by which a VOR works is simple enough in theory. The transmitter broadcasts both a navigational signal and a voice signal. The voice component will transmit, at the very least, the identifier of the VOR in Morse code. Some VORs, however, continually transmit a recorded voice signal containing information such as HIWAS (hazardous in-flight weather advisory service) broadcasts.

The navigational component is really two signals. A continuous omnidirectional reference signal is first broadcast — this is similar in concept to that produced by an NDB — then a second directional signal is broadcast that sweeps a complete circle many times per second. In the early years this was accomplished with a spinning mechanical antenna similar to a traffic control radar antenna. But today, the same function is accomplished by selectively energizing individual antennas in a multi-antenna array, thereby accomplishing the same end with no moving parts.

### PHASE OF THE WAVE

The omnidirectional and directional signals are only in phase (think of perfectly matched waves on the ocean) at zero degrees magnetic north. At 90 degrees (east) the directional wave is 90 degrees out of phase with the reference signal, at 180 degrees (south) the directional wave would be 180 degrees out of phase with the reference signal, and so on. The VOR receiver compares these two signals and determines a line of position or radial from the VOR and, in turn, drives a course deviation indicator (CDI), horizontal situation indicator (HSI), or a radio magnetic indicator (RMI) to give the pilot a visual indication of the course to or from a VOR station.

The proliferation of VOR stations across the United States, and indeed the world, allowed a network of airways — highways in the sky — to be developed. The four-course range and VAR anchored a rudimentary airway system, but the 360-course omnidirectional nature of the VOR allowed the airway system to expand exponentially. Within the United States, airways below 18,000 feet are designated "Victor" airways, and those above 18,000 feet are "Jet" airways.

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Many VORs are co-located with a DME station (VOR/DME) allowing pilots to determine their distance from the VOR and greatly enhance situational awareness. Airplanes with DME equipment have the capability of transmitting a unique signal to a ground-based transponder — the DME station; after a precise time delay the DME station sends a return signal recognized by the airborne receiver. These signals travel at a predictable speed, and the time between generation and reception of the return signal from the station is translated into distance displayed on a DME readout.

### MAPLES VOR

I have a familial connection with the VOR system, if such a thing is possible. My paternal grandmother was a Maples, and she grew up with her siblings on the family's hardscrabble farm in southcentral Missouri. For me, the farm was a regular destination in my early childhood when my great-grandparents were still actively farming the land. I remember the wonders of the henhouse where eggs magically appeared and the excitement of riding on a tractor driven by my great-grandfather. On occasion, my father even landed the family Tri-Pacer on the farm when we would come down from Wisconsin to visit. The Maples farmhouse sat at the intersection of two nondescript county highways, and the only other habitable structure at this crossroads was the rural area's country post office occupying the opposite corner.

This long recitation of my heritage is leading somewhere, I assure you. You see, every post office needs a name, so the little intersection of road, farmhouse, and post office became Maples, Missouri. At some point in time, the FAA, or maybe even its predecessor the CAA, decided that its master plan for the nationwide airways system demanded that a VOR should join the small assembly of buildings at this remote crossroads. So, a VOR station was built on the adjoining property. The name of this particular VHF omnidirectional range is — you guessed it — the Maples VOR!

I would imagine my family's naming rights to this particular VOR will have only a limited future. VORs are being decommissioned regularly as GPS is taking over the navigational load so long held by these round white buildings with a cone on top. But, until that day I will bask in the knowledge that few people can boast of having their very own navigational aid.

The VOR is certainly a vast improvement over the four-course range and VAR that preceded it, and has provided yeoman service for over half a century. The next few decades will harbor vast changes as satellite-based navigation systems supplant the purely ground-based navaids we have known. The VOR, however, will certainly be the most successful and prolific among them and will have a lasting legacy in the development of long-distance aerial transportation. EAA

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