The only way from A to B is sometimes a circle

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Flying the DME Orbit

■■ Of all the black boxes in an airplane, the DME ranks as one of the simplest to use. All a pilot has to do is glance occasionally at the slowly changing numbers to determine his slant-range distance from a given VORTAC. But when he is confronted with having to maintain a circling track at a specific distance from the station, DME usage assumes an entirely different complexion. Tracking DME arcs can be a new and frustrating experience especially when winds aloft are strong.

A few years ago, DME arcs were relatively uncommon, and IFR pilots didn't have to worry much about them. But times are changing; the FAA has been increasing the use of DME arcs as prescribed paths to be followed during the initial phases of IFR approaches.

The Feds have even gone so far as to create an IFR approach procedure incorporating a *final* approach that is defined by the 24 DME arc of a nearby VORTAC. That's right, the "straight-in," VOR/DME approach to Runway 10 at NASA Wallops Station at Chincoteague Island, Va., requires flying a circular track all the way from the intermediate approach fix to the runway threshold.

Since this may be the only such approach in the world, it alone doesn't dictate an urgent need to become proficient in flying DME arcs. But the proliferation of DME arcs as "initial" IFR approaches does.

A DME arc is simply a circular course at a specific slant range (DME distance) from a given VORTAC. An arc typical of the type most likely to be encountered is shown in Figure 1, which is a simplified view of a back course approach to Runway 21 at Amarillo, Tex. A pilot who arrives at the initial approach fix (IAF) south of the AMA VORTAC (aircraft No. 1) and is then "cleared for the approach" is expected to track along the 8 DME arc (a radius of 8 miles from the DME) until near the localizer. Since his only navigation receiver must be tuned to the AMA VORTAC while tracking the arc, a pilot needs to be warned when nearing the localizer to prevent him from unknowingly flying through the final approach course.

This warning is provided in the form of a "lead radial," which, in this case, is the AMA 056° radial. After tracking the 8 DME arc and upon reaching the lead radial, the pilot should simultaneously tune in the ILS and turn to intercept the localizer.

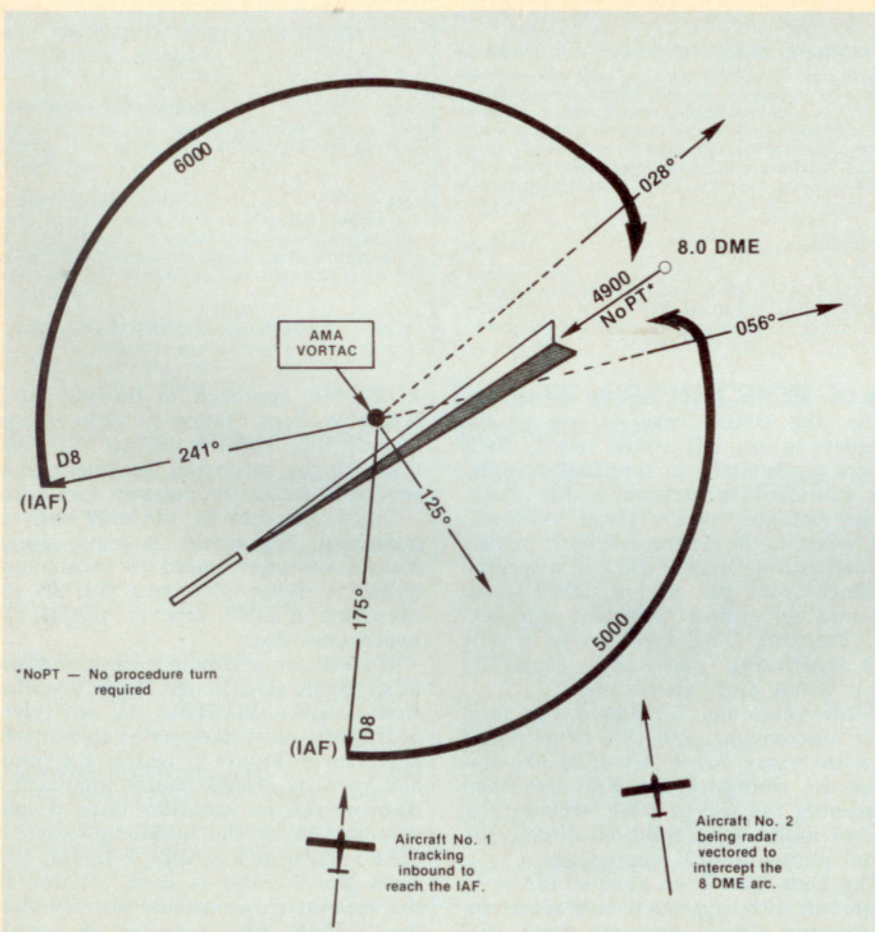


Figure 1

It is also possible that a pilot might be radar-vectored to intercept the DME arc at a point other than at an IAF. Aircraft No. 2 in the diagram has been cleared to maintain a given heading and intercept the 8 DME arc at which point he should begin orbiting the VORTAC as shown on the approach plate.

It is interesting to note that each circular initial approach, like conventional initial approaches, is provided a minimum en route altitude (MEA). The arc northwest of the AMA localizer, for example, has an MEA of 6,000 feet while the southeastern arc has an MEA of 5,000 feet. It is imperative when tracking such an arc that a pilot does not descend to the applicable MEA unless either "cleared for the approach" or cleared to the specified altitude. Otherwise, he must maintain the last assigned altitude.

Assume that a pilot has been cleared for the approach and is tracking the northwesterly arc at 6,000 feet. Upon crossing the 028° lead radial, he begins an inbound turn to intercept the localizer. Is he then free to descend to 4,900 feet, which is shown on the plate as the MEA when inbound from the "8.0 DME" fix along the localizer course? Emphatically not! Descent must be delayed until the localizer has been *intercepted*. Crossing a lead radial is not an authorization to descend; intercepting the localizer is.

Another requirement for arc flying is shown in Figure 2, a simplified view of the VOR-A approach to Cheyenne, Wyo. Lead radials are not needed to warn a pilot that he is nearing the final approach course because the same navaid (CYS VORTAC) is used throughout the entire procedure.

Pilots should be aware that when DME arcs are used as initial IFR approaches, maximum obstacle protection is provided only when within four miles of the arc. In other words, when tracking a 17 DME arc, for example, a pilot must remain between the 13 and 21 DME arcs that provide him with an eight-mile-wide band of maneuvering protection.

Additionally, as the DME radius becomes shorter and the circle becomes smaller, flying the arc becomes more

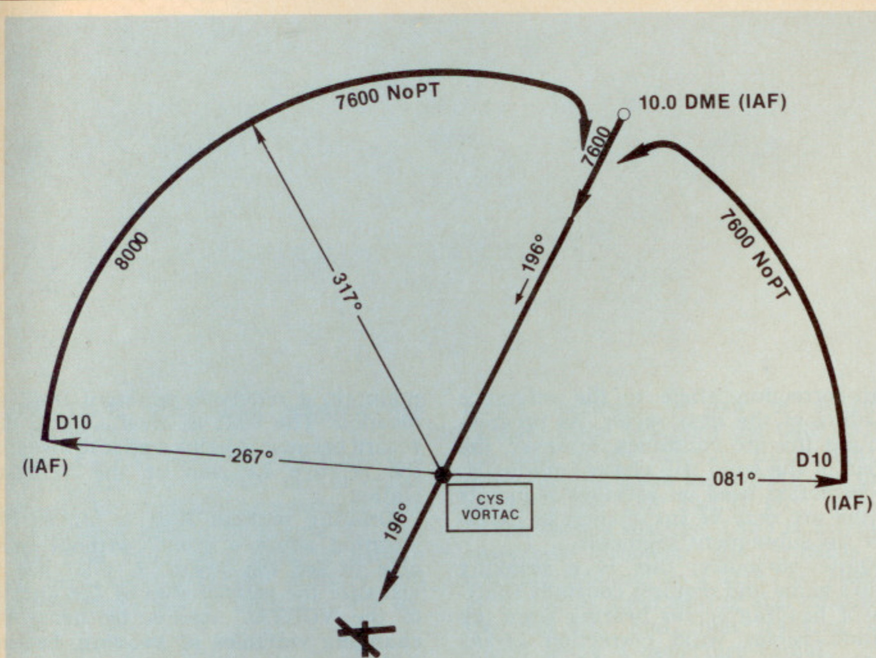


Figure 2

difficult. To prevent imposing too much of a workload on pilots, FAA limits DME arcs to a minimum radius of seven nm (for civilian aircraft).

At first glance, tracking a DME arc appears to be a relatively simple affair. It's just a matter of flying a wide, sweeping circular track in such a way as to keep the indicated distance relatively constant.

Maintaining a *precise* track along a DME arc on a windless day theoretically requires an extremely shallow banked turn with an almost infinitesimal turn rate. For example, if a pilot were tracking an arc with a 30 DME radius while flying at a true airspeed of 100 kt, 1.9 hours would be required to fly the 188-nm circumference. To do so while constantly turning would require a turn rate of only one-twentieth of a degree per second. Only an electronic computer is capable of such excruciating precision.

In practice, therefore, tracking an arc necessitates flying a series of short, straight segments each of which spans a 10° sector of the arc. The result is a 36-side polygon that approximates a circle.

To intercept the 20 DME arc shown in Figure 3, for example, the pilot tracks inbound on the 140° radial (as shown). When approximately one-half mile from the arc (20.5 DME), the pilot turns to a heading perpendicular to the inbound course (either 050° or 230° in this case, depending upon the desired direction of flight).

Since the pilot in the illustration plans to fly a counter-clockwise arc, he

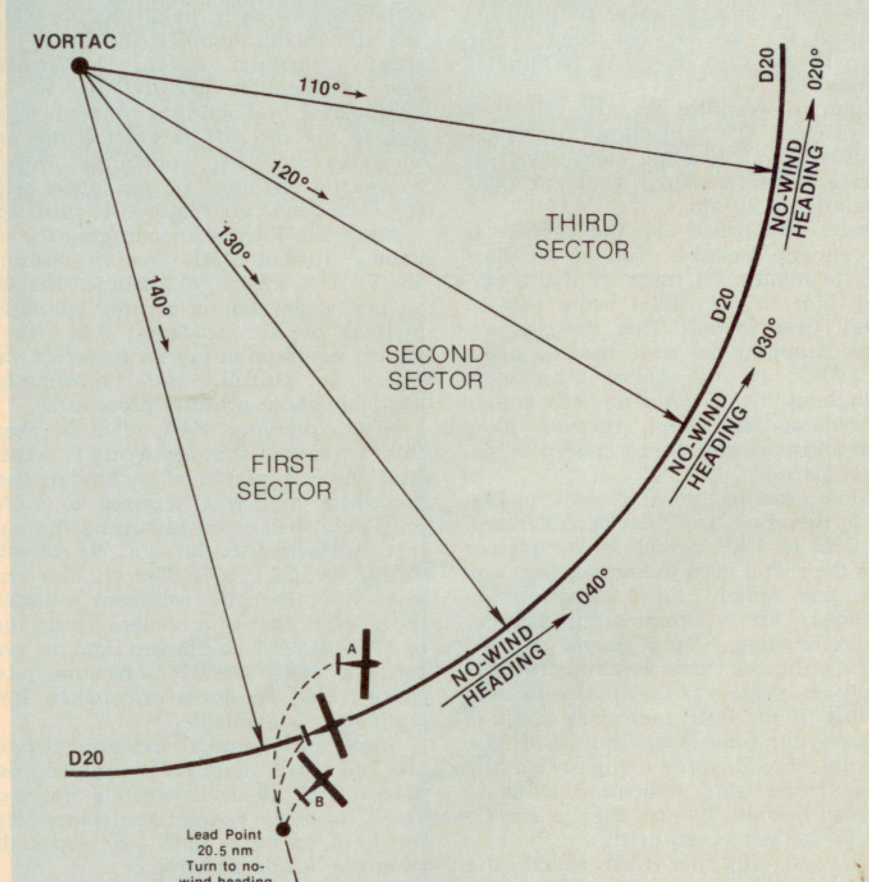


Figure 3

turns 90° right to a heading of 050°. This results in an initial track very nearly the same as the desired course. (A one-half-mile lead usually prevents overshooting the arc and is satisfactory for aircraft with airspeeds of 150 kt or less; proportionately larger leads are required for faster aircraft.)

During the latter part of the intercepting turn, closely monitor the DME. If the DME indication is something less than 20 nm (aircraft A), the arc has been overshot and the turn should be continued beyond 90° to reintercept it. If the DME indicates more than 20 nm (aircraft B), the arc has been undershot, and the turn should be terminated prematurely.

Upon intercepting the arc, return to the original 050° heading and make whatever small heading corrections are necessary to maintain a constant DME indication of 20 nm.

Once established on the arc, it is theoretically possible (on a windless day) to remain on track by flying perpendicular to the radial being crossed at any given instant. This, however, requires changing the omni bearing selector (OBS) in one degree increments throughout flight along the arc and is an arduous procedure. Instead, it is satisfactory to use radials spaced 10 degrees apart.

While crossing the first sector in Figure 3, therefore, the pilot should rotate the OBS to 130°, which is 10 degrees from the radial used to intercept the arc.

As this radial (130°) is being approached, an approximately perpendicular heading (040°) should be used to track the arc. This heading, 040°, is simply a guide—a no-wind reference heading. If the DME indication tends to decrease, the pilot is drifting inside the arc and should correct slightly to the right. If the DME indication tends to increase beyond 20 nm, then a correction to the left is required.

After crossing the 130° radial, the OBS should be set to 120°. The new reference heading while traversing the second sector is 030° and is perpendicular to the newly selected 120° radial.

If it is determined that a crosswind necessitates crabbing while crossing one sector, don't neglect to apply a similar drift-correction angle to the reference heading of the next sector. As progress around the arc continues, however, the effect of the wind will change gradually. A correction used on previous segments of the arc may be insufficient or excessive on subsequent segments.

Quite obviously, this is a thinking man's game and requires constant analyses of heading *versus* bearing from the station *versus* wind correction *versus* distance from the station. All these factors must be considered continuously to maintain a reasonably circular track. When the winds are strong, the mental gymnastics compound proportionately.

Orbiting in a strong wind can be simplified somewhat by flying slightly inside the arc. In this manner, the arc is constantly "turning" toward the aircraft and interception usually can be accomplished by holding a constant heading. If the aircraft is outside the arc, the curved course constantly "turns" away from the aircraft, and larger heading corrections are required to intercept.

Since the FAA is encouraging the expanded use of DME arcs in terminal areas, it is logical to assume that the agency is developing a more simplified method of arc tracking. Yes, it's a logical assumption but an incorrect one. There is pitifully little information available about orbiting procedures.

After querying FAA officials about this, I was told that arc flying is considered more a matter of technique than procedure and was referred to FAA's only published work regarding the subject, Advisory Circular (AC No. 90-62), dated Jan. 23, 1973. The circular contains a noteworthy comment: "Unless the pilot is highly proficient in the use of [VOR DME] equipment and in performing [DME arcs], it is recommended that [orbits] be flown only when RMI equipment is available."

Since most general aviation aircraft are not so elaborately equipped, this places most of us between a flat rock and a hard place when confronted with the need to fly a DME arc, especially when the winds are strong.

The RMI, of course, does simplify orbiting. With a needle that points to a VOR station the way an ADF needle points to a radio beacon, all a pilot must do is keep the needle pointed approximately toward the inside wingtip while making small heading corrections to maintain a relatively constant DME indication. The RMI is invaluable in this regard because it helps a pilot to visualize the relative location of the VORTAC station.

Orbiting without RMI is almost like "turning about a point" without being able to see the pylon. A pilot has to visualize the relationship of the aircraft to the VORTAC station by using the changing variables of heading, bearing and distance.

Flying a DME arc was once simpler than it is now. An early model Narco DME receiver incorporated an orbit indicator, a left-right needle that assisted a pilot in precisely tracking a given DME arc. But that function did not meet expectations and was quietly dropped from future models. The concept, however, was excellent, and perhaps now that DME arcs are being used more, avionics manufacturers will give thought to an improved version of Narco's orbiter.

In the meantime, most pilots are left to deal with DME arcs using only raw data. Although the difficulty of the maneuver increases in proportion to the wind velocity, it is something the average instrument-rated pilot copes with, especially when considering that he has an eight-mile-wide band within which to bracket and maneuver.

Tracking a DME arc is one of those maneuvers that is probably easier to perform than to describe, but before it can be executed proficiently, considerable practice is required. Fortunately, this can be done in VFR conditions and requires neither a hood nor an IFR clearance. But before embarking on a practice mission, one additional piece of equipment is required: a competent observer to watch for traffic. Orbiting can be a mentally distracting affair, and the student of DME arcs rarely has time to both concentrate on the problem and watch for traffic.

Initially, a pilot should practice with a large-radius arc, one at least 20 DME from the station. Arcs of large radii have relatively "flat" curves and are easier to track. Also, maintain relatively slow ground speeds during the orbit; fast ground speeds require more skill because of the greater rate of course deviation and correction.

After the large arc has been mastered a pilot should increase ground speed and tackle DME arcs with progressively shorter radii.

Once a pilot can accurately encircle a VORTAC along a 7 DME arc at cruise airspeed, he is ready to graduate into the exercises shown in Figure 4.

The first (4a) is a holding pattern used occasionally by the military and requires flying the 7 DME arc, for example, between a pair of specified radials. Upon reaching the 040° radial, the pilot in the diagram turns right to intercept and track the 8 DME arc until reaching the 130° radial, etc.

The second exercise (4b) is a typical entry/exit problem and consists of tracking inbound to a VORTAC along a given radial, intercepting and orbiting a specified arc and then tracking outbound along a departure radial.

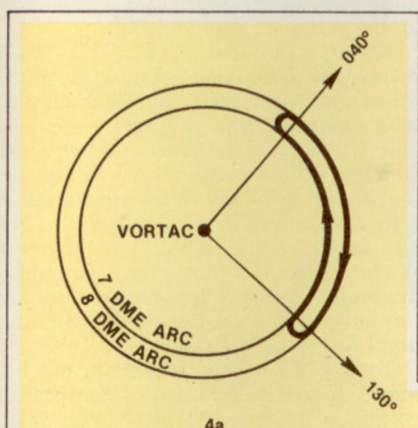
The final, seemingly sadistic maneuver (4c) is an excellent exercise that not only develops orbiting skills, but also forces a pilot to simultaneously plan impending courses of action, such as might be required when orbiting a station in preparation for an actual IFR approach.

When these skills have been developed, a pilot is ready to practice under a hood on a windy day. Those who scoff at the *apparent* simplicity of orbiting have probably never flown a short-radius DME arc under the demanding and difficult conditions that can arise during an actual IFR approach.

Speaking of DME, here's a tip that can save considerable aggravation when confined to the rigors of a conventional holding pattern. Instead of timing the inbound and outbound pattern legs to arrive at a one-minute inbound leg to the holding fix (when at or below 14,000 feet), ask ATC for permission to fly 3 DME legs, for example. Such a request is almost always granted in a radar environment.

Then instead of timing each leg, simply fly to the fix (which may be at 30 DME, for example), execute a 180-degree turn, and fly outbound until reaching 33 DME, for example. Then, turn again, track inbound and repeat the process. This saves considerable mental wear and tear.

In the meantime, practice getting into orbit; flying in circles may not be the shortest way from A to B, but it could be the only way. □



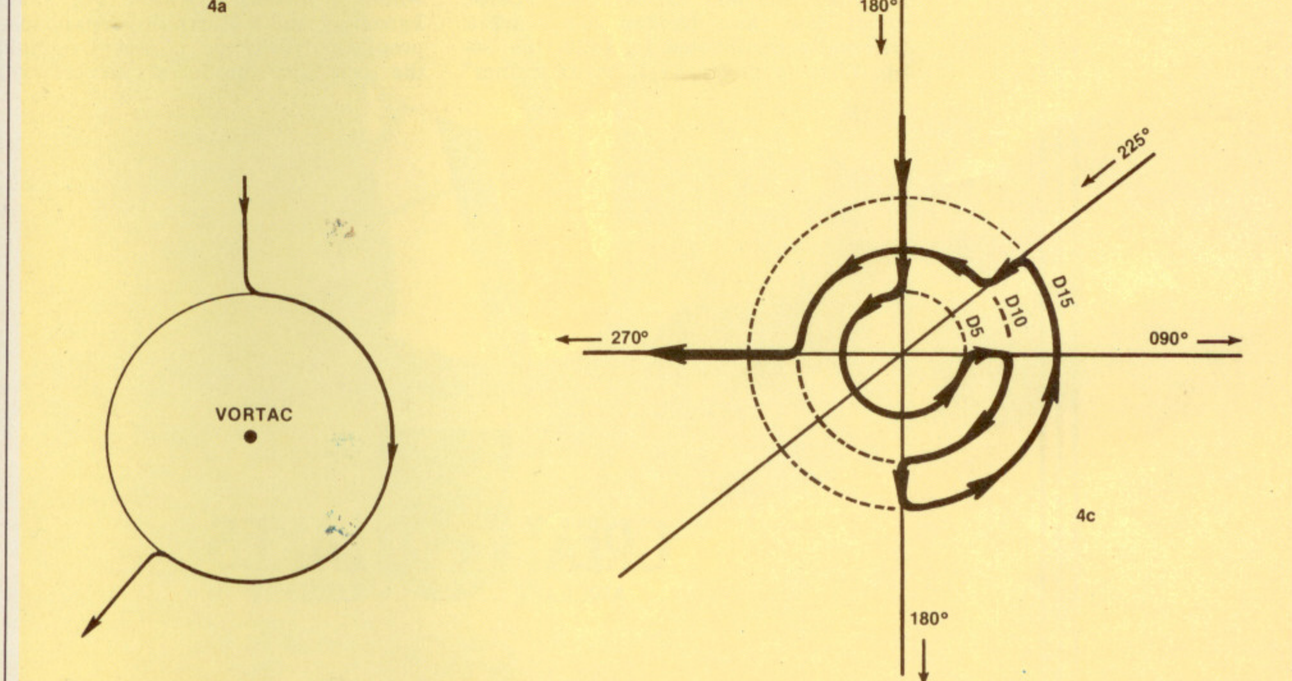


Figure 4