The Art Of Desktop Instrument Flying

Flying a DME Arc

SKILL LEVEL : ADVANCED

By Brent McColl

Up until the time the satellite-based Global Positioning System became available, the ground-based DME provided the greatest relief to the General Aviation pilot. Its simple presentation - providing an instant Position Fix when combined with a tracking aid like the VOR - took the guesswork out of determining your position in IMC. The humble DME may eventually go the way of the biplane in the interests of progress, but for now it is still considered one of the key ground-based navigation aids available today. Let's fire up Flight Sim and learn the art of ***Flying a DME Arc.***

Principle of Operation

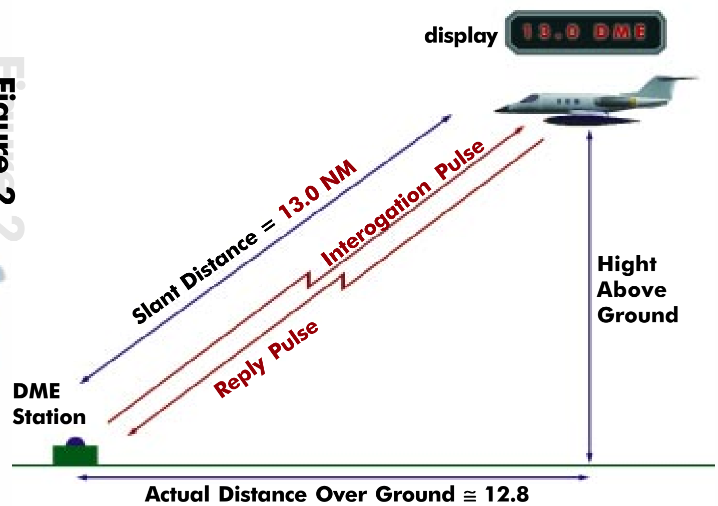
Figure 1

The DME is without doubt the most complex of the ground-based navigation aids in its operation. In order to present the pilot with a simple readout of distance, the system uses a two-way radio transmission. The airborne equipment sends an Interrogation Pulse on the appropriate DME frequency. The ground-based beacon receives this pulse and replies with a *Ranging or Reply Pulse.* The airborne equipment then measures the time interval between the two pulses to calculate a straight line distance between the aircraft and the beacon. (see fig 2)

Occasionally establishing two-way communication between the aircraft and beacon may take some time as the aircraft tries to acquire a signal (ie. 'lock on'). In extreme cases, the beacon may not respond at all. Particularly, if a large number of aircraft are interrogating the beacon at the same time. The DME beacon can become 'saturated' if more than the maximum number of aircraft it can handle attempt to interrogate it at the same time. Those already 'locked on', will be fine, but those aircraft trying to lock on to a saturated DME will have to wait for capacity to become available (or use another beacon). A typical DME can handle about 100 aircraft, so this is seldom a problem.

The only other reason you may not be able to lock onto a selected DME station is range. DME transmissions operate between 962 and 1213 MHz (UHF Band). This limits them to line-of-sight only. As a guide, the range in Nautical Miles can be determined by multiplying the square root of your height (in ft) by 1.4.

Figure 2



The Dme indicates 'Slant Distance', not ground distance. Over large distances, the effect is negligible, but within a few miles, you should consider the height of the aircraft above the beacon.

For example, consider an aircraft cruising at 10,000 ft.

Using: **1.4 x √10,000**

1.4 x 100 = 140 Nautical Miles.

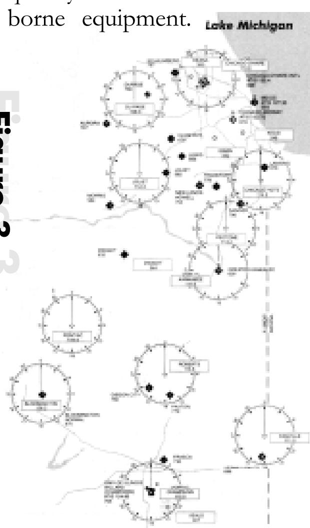
The range you could expect from a DME beacon is 140 nm at 10,000 feet.

Mountains may exist between you and the beacon, so use this as a guide only.

Selecting A DME Frequency

DME beacons are typically co-located with VOR sites, and are activated by selecting the appropriate VOR frequency. The DME frequency associated with the VOR is selected automatically by the airborne equipment.

Figure 3



Extract from page 12 of the Microsoft Flight Simulator 98 Pilot's Guide

Let's do a little tour of the DME beacons in the Chicago area. From Meigs Field, either take-off and climb overhead to about 3,000 feet, or use the {Y} key to enter Slew mode and press {F4} until you reach 3,000 feet, then hit pause. Select the **Bendix/King Radio Stack** option from the **Views|Instrument Panel** menu. This will display the frequency selectors for both NAV1 and NAV2.

Turn to page 12 of the Microsoft Flight Simulator 98 - Pilot's Guide for an extract from the Chicago Sectional Chart. Here's a portion of the chart showing some of the many VOR (and associated DME) sites around Meigs.

From Meigs, at this height you should be able to receive beacons that are 1.4 x √height in feet. Your height being the height above the DME. Well, Meigs is about 600 feet above sea level, so you are now 2,400 feet above Meigs.

So, **1.4 x √2400 = 68 nm.**

We should be able to receive the following VOR's and their associated DME readings:

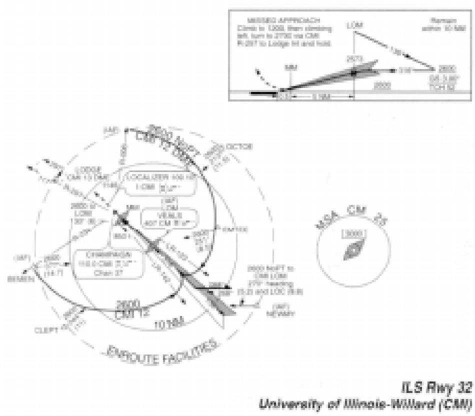
Chicago Heights	20.6 nm
Du Page	33.2 nm
Joliet	36.7 nm

However, you will find that Kankakee VOR will be out of range at your current height.

The DME as an Instrument Approach Aid

A relatively recent introduction for many Approach Procedures is the DME Arc. The DME is used, in a sense, as a tracking device. By following a fixed distance from a DME, the aircraft ends up flying an arc centred on the DME itself. Take a look at the DME Arc procedure we will be performing in this lesson. It's from the Microsoft Flight Simulator 98 - Pilot's Guide, page 13. The arc flown is a part of the Champaign Airport Runway 32 ILS procedure using the Champaign DME located at the field.

Figure 4



Extract from the Microsoft Flight Simulator 98 - Pilot's Guidebook

Notice the arc that traces a circle extending from the north of the fields around through south to the southwest. This arc represents the 12 DME distance from Champaign DME. The label CMI 12 DME around the edge of the arc shows this. Champaign DME is activated by selecting 110.0 MHz on the VOR. Set this now on Nav2. The purpose of the DME arc is to guide you into a position that allows entry onto the ILS for the remainder of the approach. Here, the arc guides you around for the Runway 32 ILS.

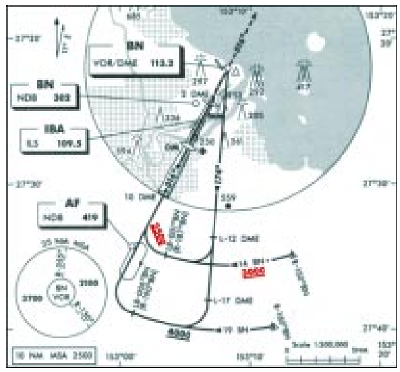
This arc can be joined from any direction within the range shown. The limits are the 006° Radial from the north, through to the 234° Radial from the southwest. These radials are shown on the chart. This design adds a lot of flexibility for entry, allowing pilots to join directly from their inbound track without having to perform complex Sector Entries.

There are two lines radiating out each side of the Localiser path, labelled LR-123 and LR-142. These are the Lead Bearings that prompt you with an indication of when to begin a turn to intercept the Localiser.

NOTE: It would appear that there is an error on our chart. The lead bearing should be the same from each side (ie the same number of degrees). However, from the north the LB is: 136° - 123°= 13°, while from the south it is: 142° - 136°= 6°. As a general rule, the LB should be about the same degrees as the arc is in miles. So it follows that from this 12 DME arc, the LB should be about 12° from the inbound course. So, I would say that the 123° LB is correct and the 142° LB needs to be 149° (13° to match the other side).

Typically, the arc specifies the minimum altitude at which it is flown, and for the CME 12 DME arc, this is shown as 2600ft. On some arcs you may also see intermediate steps in the minimum altitude. Each step will be defined by a specified bearing. On crossing the specified bearing the pilot may descend to the altitude shown for the sector.

Figure 5



DME arc with intermediate alts along the arc

Setting the Scene

Our flight today is going to have us depart from a small field to the north of Champaign called Paxton. For those readers who spend many hours in the pattern at Paxton we welcome you. Remember, if you have a particular sequence you wish covered in either this article or the Flight Instructor article, or you have a favourite home field from which you would like us to operate from in a future article, you can e-mail your request to me at bmccoll@msn.com. I look forward to your request.

Figure 6

Set up a realistic weather situation for the flight

Set yourself up at Paxton, Illinois on RWY 18. Then set the following items by selecting the **Views|Instrument Panel|Bendix/King Radio Stack:**

NAV1	109.1	Champaign RWY 32 ILS;
NAV2	110.0	Champaign VOR;
ADF	407	Veals Locator (ILS Outer Marker); and
AP Altitude	3000	Set up in preparation for the cruise down south from Paxton to CMI.

Then close the Radio Stack so as not to obscure your view.

Next, set the following on the basic panel:

Heading Bug	192°	Our outbound track to Champaign VOR;
Nav1 OBS	316°	ILS Course;
Nav2 OBS	192°	Our course Paxton to Champaign VOR; and

DME Nav1/Nav2 switch NAV2 Set by clicking to the right of the knob on the DME display.

Let's Go Flying

We have at least a good 10 minutes of flying from Paxton to our DME Arc procedure, so let's get airborne and we will discuss the procedure as we go. Depart and maintain **heading** 192° until you pick up CMI VOR. This should occur by the time you pass through about 2,500 feet. Then intercept and maintain the 192° **radial** displayed on NAV2 as you continue your climb to 3,000 feet. Select the Autopilot to maintain your course (192°) and altitude to CMI. As your DME reads down to around 13 DME we can prepare to enter the Arc by pausing the simulator while we discuss the entry to the arc. ***Try It Now***

Champaign 25 nm sector MSA 3000ft

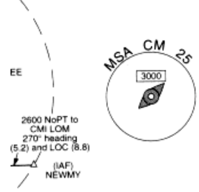


Figure 7

Entering the Arc

In order to gradually enter the Arc we must anticipate the 12 DME distance somewhat. (Similar to the anticipation required approaching a corner in a car travelling at 20kph. The driver typically begins the turn well in advance to the corner's apex.) At 120 knots, about a one mile lead will suffice. Thus, at 13 DME we begin a "rate one turn" turn (approx 15-18º) onto a tangential heading. Initially the heading to maintain the Arc will be simply 90° to your inbound course, ie 192º - 90º = 102° (or approx 100º). This heading will fly us along the initial Arc. However, if we continue on this heading we would eventually fly out from the arc. We must change our heading constantly in order to remain in the arc.

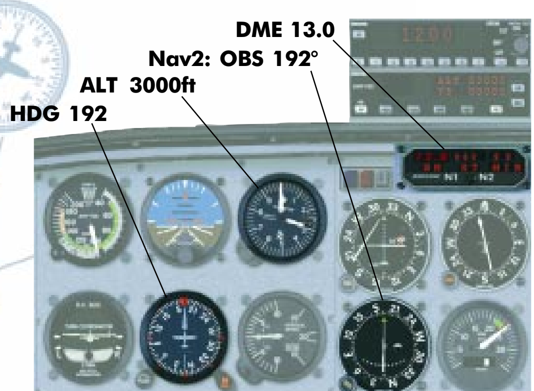


Figure 8

Here we are inbound coming up on 13 DME where we will begin our turn onto 100°. Note the bottom of the Bendix?King Radio Stack showing the transponder and autopilot controls

In the Arc

While the protected area is 4 nm either side of the 12 DME distance, it is common practice to keep within ±1 mile of the arc. This buffer (while it seems tight) gives us an opportunity to fly a series of straight legs, while keeping within 1 mile of the 12 DME distance. Heading changes of 20-30° will work quite well here.

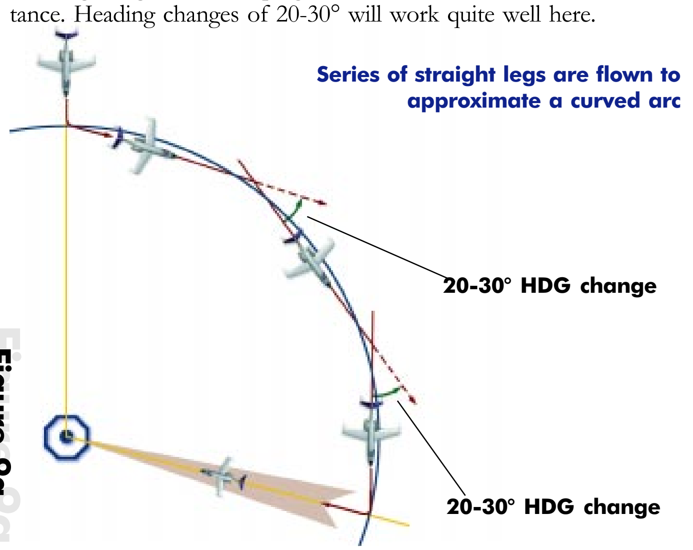


Figure 9a

To maintain the arc we can sometimes use the ADF, and simply let the needle drop to 10° behind the wing. Then turn a further 20° to put the needle 10°ahead of the wing, and then wait for the needle to fall to 10° behind the wing again.

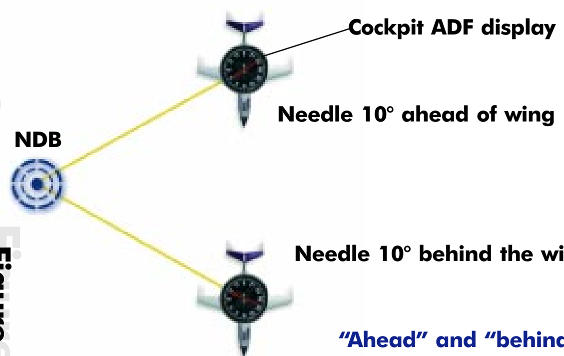


Figure 9b

"Ahead" and "behind" the wing refers to the small aircrft icon in the centre of an ADF

You would repeat this until you reached your lead bearing for the turn to intercept the ILS. Note that an ADF can only be used if the parent NDB is co-located with the VOR/DME that's being used to scribe out the DME arc. (This is crucial because the ADF needs to be providing the same azimuth info as the VOR/DME. Like the hub of a bull wheel, there can only be one centre). As there is no NDB at the centre of the Arc (Veals is about five miles south east of the DME) we will make use of the Champaign VOR instead.

Once established on the first heading (100º) simply allow the needle to move full-scale to the right. Then turn the OBS to reset the needle full-scale to the left followed by a 20°-30º heading change to the right.

The new heading will once again bring the needle from left to right. Allow the needle to pass the centre and move full-scale to the right before making another 20° heading change. Repeat these steps as you navigate the Arc, checking the DME regularly to ensure you remain within 1 mile of 12 DME.

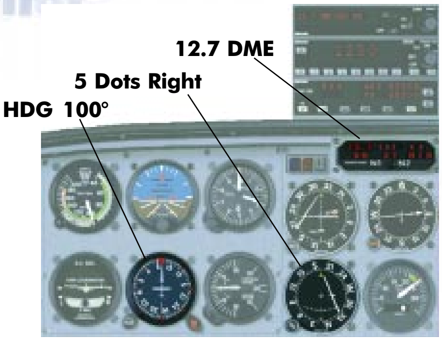


Figure 10

Display after initially turning to 100° and holding HDG until CDI bar fully to right (5 dots), DME 12.7 - begin turn to right

The screen shot below shows the indications on rollout. Our heading is our first, tangential heading 100°. I have left the OBS set at 192° from our inbound course, though it has moved a dot or two toward the right since. Note the DME shows 12.3 DME, well within the 1-mile allowance.

Figure 11

Heading=100°, OBS=192°, CDI=2.5 dots right, DME=12.3, Altitude=3000ft

Try It Now

From this point, we hold 100° until the CDI traverses full-scale to the right, 10° of movement from our inbound course indication. Then turn onto 120° and reset the CDI to show full-scale left this time.

Adjusting the Arc

Now that we are in the Arc, you have more than enough information presented to you to maintain the aircraft within the 1-mile buffer. Let's say, on maintaining the 100° heading - and waiting for the CDI to hit full-scale to the right - that our DME distance approaches 13 DME, the edge of our buffer. We are drifting too far outside our arc buffer. In this case, you should make your next heading change immediately. You may even choose to apply a 30°or 40° change to avoid drifting too far out.

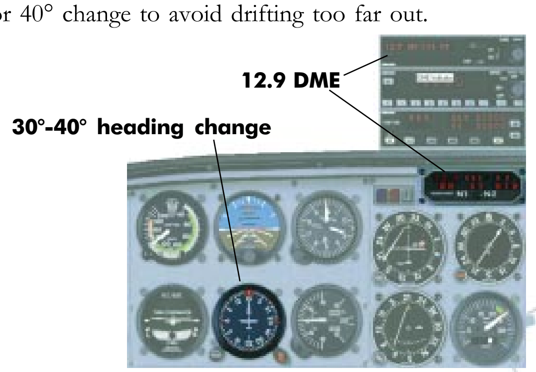


Figure 12

Aircraft at 12.9 DME. Require approx 30° heading change to correct

Ideally, you should be at 12 DME when the CDI centres. So if, when the CDI is centred, you are less than 12 DME, you should adjust the CDI as you have been, but hold your heading for a little longer before applying the 20° correction. This will send you away from the DME a little.

Figure 13

Aircraft at 12.5 DME. Require 20° heading Change to correct

Conversely, if you are say 12.5 DME when the CDI centres, then turn right 20° even before the CDI reaches the full-scale. This will bring you closer to the DME.

This cycle repeats until you select the Lead Bearing of 123°, or given that we have a TO indication on the VOR, a 303° setting on the OBS. At this point, this represents about 90° of course change, so this will take a few minutes and about four or five 20° heading changes.

Continue around the Arc using the 20° heading changes, until your OBS gets close to the 303° setting that we are waiting for, then pause the Sim. ***Try It Now.***

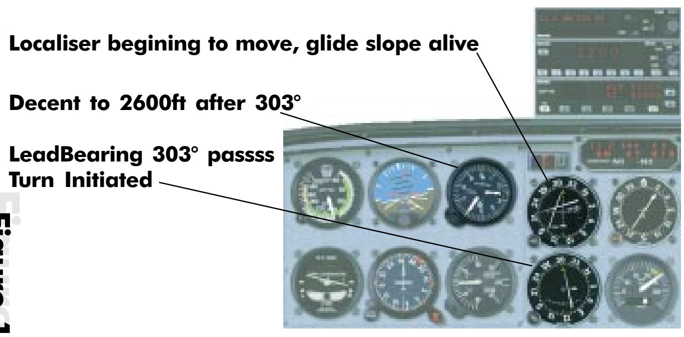


Figure 14

Just after crossing the 303° Lead Bearing, note the Localiser just starting to move. Begin a gentle turn to intercept it

Approaching the Lead Bearing

Never set the CDI past the 303° Lead Bearing in your adjustments around the Arc. Rather, set 303° when it approaches. Then hold the last heading until the CDI centres, (indicating you are crossing the Lead Bearing) and then begin a gentle turn onto a 30° intercept for the ILS course of 316° (try 286° as a start). Once the ILS (Set on Nav1) begins to move, continue your intercept of the Localiser and complete the ILS approach as normal. ***Try It Now.***

Summary

DME Arcs are quite easy to execute once you learn to use the DME in this way. We will be returning to the DME Arc in a future article where we cover a complete IFR flight from departure to arrival. I hope you have fun practicing those arcs, and remember…

Keep Flying