by ART THOMPSON, JR. • AOPA 148789

Procedure Turns For Instrument Flying

Crosswind procedure turns can be confusing even to experts. Author offers a new rule of thumb that may help to take the error out of older theories

In order to conduct an instrument approach to an airport, a pilot must first fly over some known point so that he may begin to let down from his cruising altitude to the IFR minimums for that airport. Sometimes this descent is begun at some fix a number of miles out from the radio facility serving the destination airport. However, a common type of instrument approach consists of flying toward the airport's radio facility until directly over it. When the position of the plane has been positively determined, the pilot flies away from the radio facility on some bearing, makes his letdown, reverses course, returns to radio facility and completes the instrument approach. A typical example of such an approach is shown in Figure 1.

This turn, which allows an airplane to reverse course on a bearing, course or radial, is known as the procedure turn. Besides being used to make an instrument approach, the procedure turn is used to reverse course while en route, or to return to a runway for landing after having flown down it in the opposite direction under conditions of poor visibility.

There are quite a few different types of procedure turns in common use today, and a number of them are very simple to execute—provided there is no crosswind component to reckon with. But it is this crosswind that can make a procedure turn a confusing maneuver for the instrument pilot. Many pilots who are just beginning instrument training are surprised at how far off the reciprocal track a crosswind requiring 10° of drift correction will blow them, if not corrected for. It was my own difficulty with drift correction that started me investigating the "what for" and "why for" of the procedure turn.

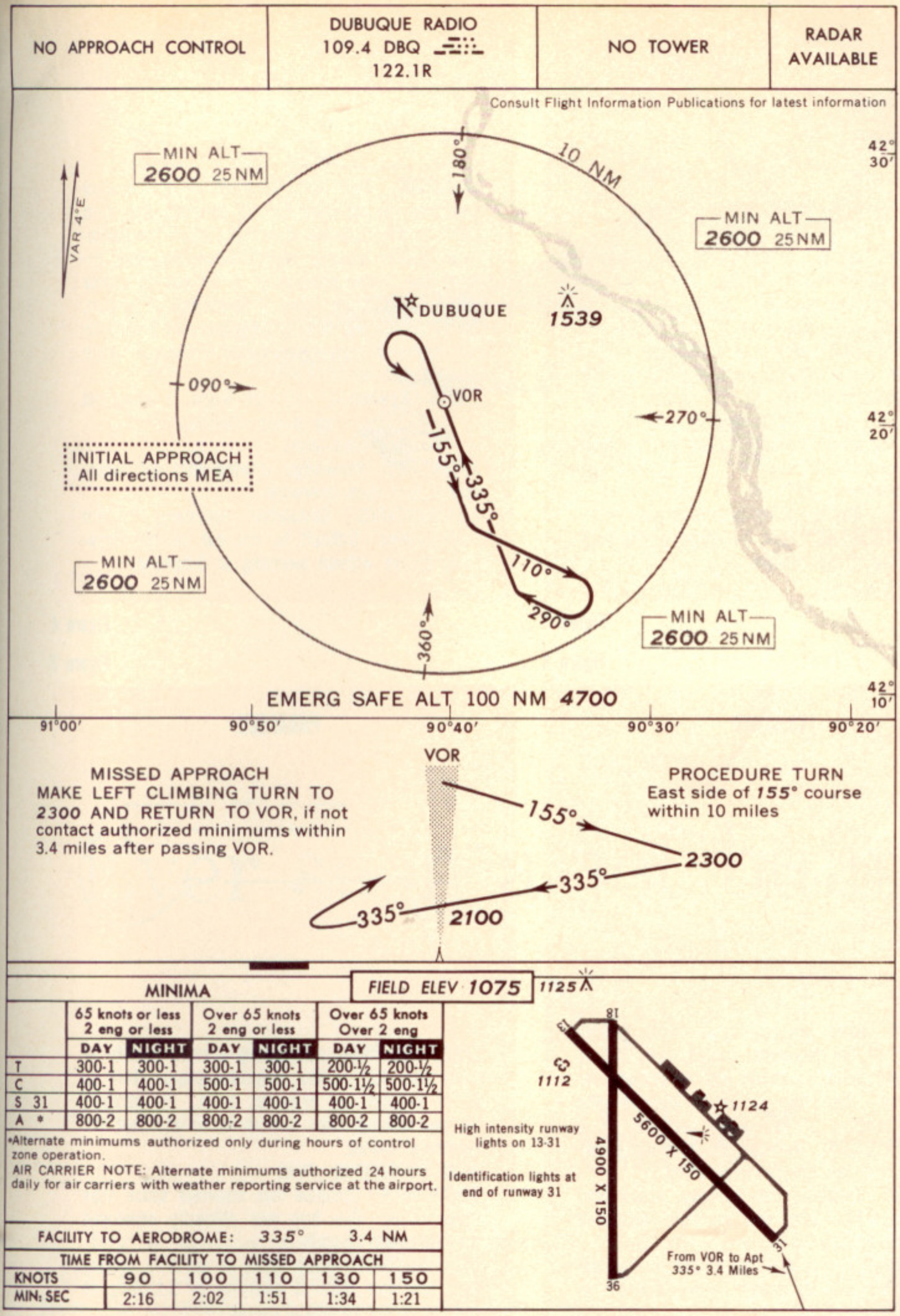


Figure 1. Typical procedure turn, allowing pilot to reverse course on a determined bearing or radial, is this 60-second turn illustrated on U.S. C&GS approach plate for Dubuque, Ia.

While practicing under the hood for an instrument rating recently, I made a number of VOR approaches with procedure turns. I elected to use the 40-second type because it is one of the most positive, with the airplane rolling right out on the reciprocal radial with no swerving or S-turning.

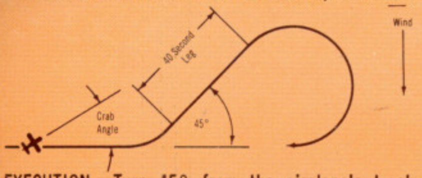
This turn consists of turning 45° to the airplane's track, flying straight for 40 seconds and then turning opposite to the first turn to intercept the reciprocal course, as illustrated in Figure 2.

All the turns discussed in this article will be two-minute turns—i.e., 3° per second, which is standard for light aircraft.

As long as there was no crosswind, the plane would usually roll out very close to the exact reciprocal course. However, I could never make a successful turn with a crosswind, no matter how religiously I applied the standard drift correction formula. The Air Force, Army and civilian training manuals all say to extend to the 40-second leg by one second per degree of crab needed to maintain the desired track if beginning the turn upwind and to shorten the 40-second leg by a like amount if turning downwind.

Out of curiosity, I drew this procedure turn on paper and plotted the drift corrections for various crab

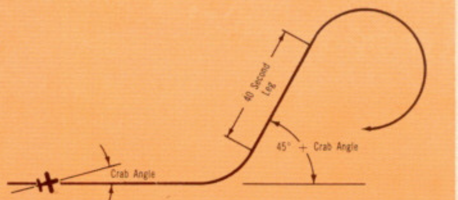
PROCEDURE TURNS—40 SECONDS, TYPE I



EXECUTION. Turn 45° from the airplane's track in the desired direction, fly straight for 40 seconds, then turn in opposite direction to the first turn until the reciprocal track is intercepted
DRIFT CORRECTION: Note the crab angle carried to maintain track. If the turn is made upwind, extend the 40-second leg by 5 seconds per degree of crab angle; if made downwind, shorten the 40-second leg by 2½ seconds per degree (An easy way to multiply by 2½ is to multiply by 5 and take half)
LIMITS: Upwind—22° crab
Downwind—16° crab
ADVANTAGES: 45° turn heading given on approach plate
DISADVANTAGES: Multiplication by 5 or 2½ required

Figure 2

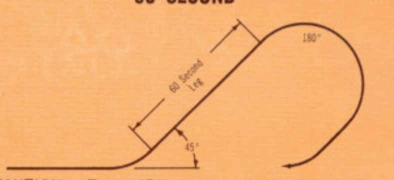
40 SECOND, TYPE II



EXECUTION: Turn 45° to the airplane's heading in the desired direction, fly straight for 40 seconds and then turn opposite in direction to the first turn until the reciprocal track is intercepted
DRIFT CORRECTION: Note the crab angle carried to maintain track. If the turn is made upwind, extend the 40-second leg by one second per degree of crab angle; if downwind, shorten the 40-second leg by one second per degree of crab
LIMITS: Upwind—10° crab
Downwind—20° crab
ADVANTAGES: Multiplication by one is easy
DISADVANTAGES: 45° must be added to the magnetic heading of the airplane

Figure 3

60 SECOND

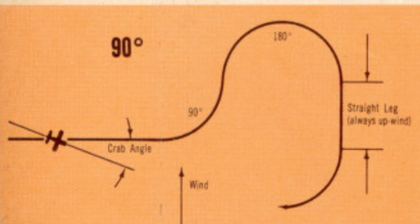


EXECUTION: Turn 45° to track in the desired direction, fly straight for 60 seconds and turn 180° in the opposite direction. When the reciprocal course appears near interception, turn toward that course attempting to roll out on course
DRIFT CORRECTION: None if downwind. If upwind, the 60-second leg must be lengthened by 5 seconds per degree of crab angle carried if the crab angle exceeds 4°
LIMITS: Upwind—4° of crab angle if 60-second leg is not extended;
Downwind—none
ADVANTAGES: Knowledge of wind drift not necessary if turn made downwind
DISADVANTAGES: Calculation necessary if turn made upwind. Difficult to roll out on the reciprocal course without swerving or S-turning

Figure 4

Figure 5

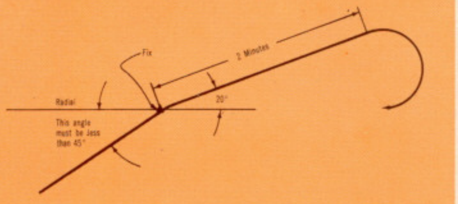
90°



EXECUTION: Turn turn 90° to the track of the aircraft in the desired direction. Upon reaching the 90° point, immediately roll into a turn of opposite direction until arriving on the reciprocal course
DRIFT CORRECTION: A straight leg, 90° to the airplane's track, of 2½ seconds per degree of crab angle is flown. This leg is always flown upwind
LIMITS: None
ADVANTAGES: This turn is particularly suited for reversing course for landing upwind after having flown over the desired runway downwind. This is because the plane will roll out of the turn closer to the end of the runway than with other turns
DISADVANTAGES: 90° must be added to the track of the airplane. More rolling in and out of turns is sometimes required

Figure 6

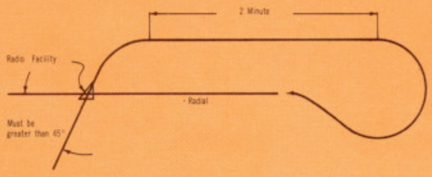
TEARDROP



EXECUTION: When approaching a radio facility within 45° of the reciprocal course, turn 20° to the outbound radial as shown and fly straight for two minutes. Then turn so as to intercept the reciprocal radial
DRIFT CORRECTION: Maintain the previously carried crab angle on the two-minute leg.
ADVANTAGES: Occupies less sideways space than other turns. This turn was primarily developed for high-speed aircraft
DISADVANTAGES: The drift correction is too approximate for use by slower speed aircraft in strong winds

Figure 7

PARALLEL



EXECUTION: When approaching a radio facility at more than 45° to the reciprocal course, turn so as to parallel the outbound radial. Fly straight for two minutes, then turn so as to intercept the reciprocal course.
WIND CORRECTION: None
ADVANTAGES: Occupies less sideways space than other turns. This turn was primarily developed for high-speed aircraft
DISADVANTAGES: Since there is no drift correction, the turn requires swerving or S-turning to roll out on the reciprocal course

angles. In every case this showed that the plane would come out well off course.

I decided to mathematically analyze the drift correction problem. The formula for the exact amount to change the 40-second (actually 38.2 second) leg was derived and plotted on graph paper. The result was two gently curving lines, one for upwind turns, the other for downwind.

The following rule of thumb sufficiently approximates the above curves for reasonable crab angles (up to 25°):

When turning upwind, extend the 40-second leg by 5 seconds per degree of crab angle carried; when turning downwind, shorten this leg by 2½ seconds per degree of crab angle.

Note that a downwind turn cannot be made when the crab angle exceeds 16°. At this point the 40-second leg is reduced to zero.

After this new rule was tested and found to work out in practice, the Air Force was contacted. They stated that the rule given in their training manual was indeed in error and also gave another method of drift correction for the 40-second turn. The trick is to make the first turn 45° to the airplane's heading (track plus crab) rather than to its track. The old one second per degree rule may now be applied

Although the growing availability of radar is gradually negating the necessity of procedure turns, the student instrument pilot still has a need to know those that are most commonly prescribed. In Figures 3 through 7 are included those in common use, along with suggestions on their execution and their relative advantages and disadvantages as they appear to me. ●

THE AUTHOR

Art Thompson, Jr., author of "Procedure Turns For Instrument Flying," first became interested in flying at the age of eight when he received a flying lesson, of sorts, in a Culver Cadet. He did not start working on a pilot's license until he was a freshman in college, however. Mr. Thompson is an aeronautical engineer and produces aircraft products through his own company, Thompson-International Aviation.