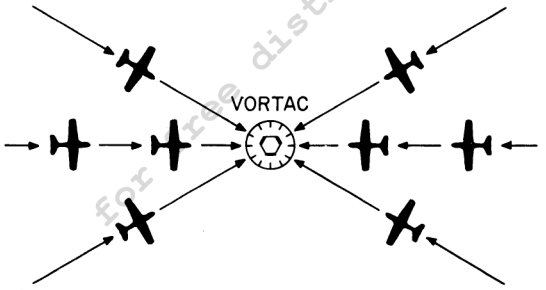
DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration

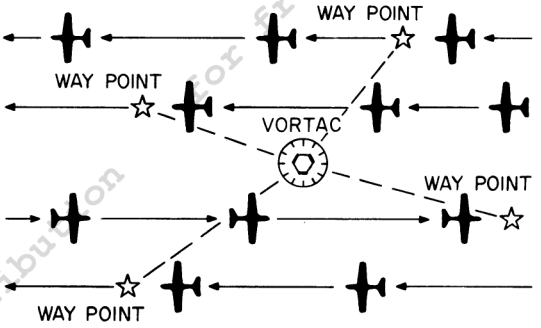
IFR PILOT EXAM-O-GRAM* NO. 30

VORTAC AREA NAVIGATION

The purpose of this Exam-O-Gram is to acquaint pilots with Area Navigation. The concept of Area Navigation is not completely new. Pilots who use VOR/DME to establish checkpoints along a course line plotted directly from departure point to destination, are practicing Area Navigation. At present, however, most aircraft using VORTAC facilities fly straight courses from one station to another. The resulting convergence or "funneling" of traffic over the station limits the number of routes between points. The illustrations below compare the present system and Area Navigation.



PRESENT SYSTEM BASED ON VOR RADIALS



AREA NAVIGATION

FIGURE 1

WHAT IS AREA NAVIGATION? This is a system of navigation which allows a pilot to fly a selected course to a predetermined point without the need to overfly ground-based navigation facilities.

WHAT ARE SOME AREA NAVIGATION SYSTEMS? Doppler radar, inertial navigation systems, and course line computers are all classified as Area Navigation Systems.

WHICH AREA NAVIGATION SYSTEM WILL MOST GENERAL AVIATION PILOTS ENCOUNTER? The system coming into most common use, is the course line computer based on azimuth and distance information generated by the present VORTAC system.

WHAT IS A BASIC ADVANTAGE OF "COURSE LINE COMPUTER" AREA NAVIGATION? This system is based on a ground navigation system (VORTAC) already in place--a system that can be used for VORTAC radial navigation by aircraft having conventional Omni and DME equipment, and for Area Navigation, by aircraft having airborne course line computers.

CAN AIRCRAFT WITH ONLY CONVENTIONAL OMNI EQUIPMENT FLY FAA APPROVED AREA NAVIGATION ROUTES? No. An aircraft must have airborne Area Navigation equipment installed. A typical airborne system consists of a waypoint selector, a guidance display, and a vector analog computer. The computer is the heart of the system.

HOW DOES THE COMPUTER SOLVE A COURSE LINE PROBLEM? Area Navigation, based on the course line computer, is also called the "Rho-Theta" system. Rho (distance) is derived from the distance measuring feature of the VORTAC, and Theta (bearing) information is derived from the azimuth feature of the VORTAC. As shown in Figure 2, the value of side (A) is the measured DME distance to the VORTAC. Side (B), the distance from the VORTAC to the waypoint, and angle (1), the bearing from the VORTAC to the waypoint, are set in the cockpit control. The bearing from the VORTAC to the aircraft, angle (2), is measured by the VOR receiver. The airborne computer compares angles (1) and (2) and determines angle (3). With the above information, the computer, by means of simple trigonometric functions, continuously solves for side (C), which is the distance in nautical miles and magnetic course from the aircraft to the waypoint. This is presented as guidance information on the cockpit display.

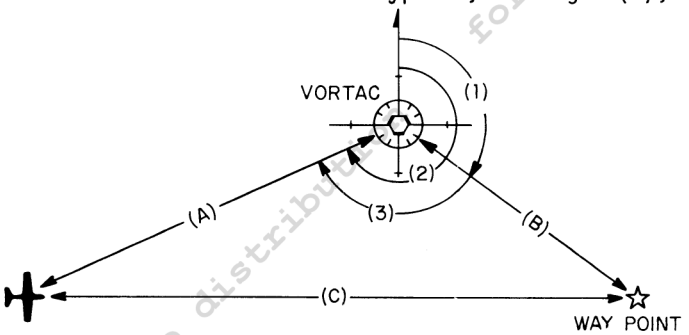
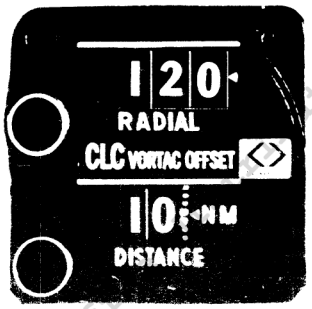


FIGURE 2. COURSE LINE COMPUTER GEOMETRY

WHAT IS A WAYPOINT? Advisory Circular 90-45, which sets forth the guidelines for the implementation of Area Navigation, defines a waypoint as... 'a predetermined geographical position used for route-definition and/or progress-reporting purposes that is defined relative to a VORTAC station position.' Waypoints are also defined by latitude and longitude coordinates for the use of airborne self-contained systems not dependent on VORTAC inputs. With his course line computer, the pilot effectively moves or offsets the VORTAC to a desired location. He creates a 'phantom station' by setting the distance (Rho) and the bearing (Theta) of the [illegible] VORTAC to the appropriate windows of the [illegible]



FIGURE

[illegible] PRESENTED TO THE PILOT?

[illegible] very. In all displays [illegible] nautical miles and not angular [illegible] Figure 4, features a symbolic aircraft [illegible] move rectilinearly, their [illegible] relationship to the vertical [illegible] of the [illegible] distance.

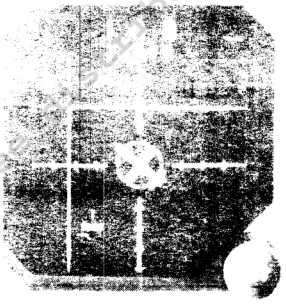


FIGURE 4

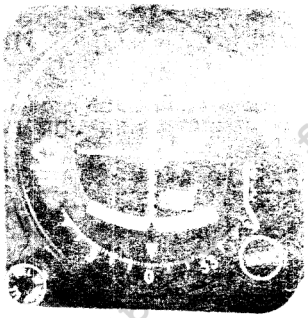


FIGURE 5

[illegible] BE ESTABLISHED FOR [illegible] Most general aviation aircraft [illegible] cross-country are following the low altitude Victor Airways. This results in traffic congestion on the airways, particularly in the vicinity of the VORTACs near metropolitan areas. A great portion of the available airspace is virtually unused. With Area Navigation equipment, the VFR pilot can fly direct from departure point to destination with the same convenient electronic guidance he has on an airway. Where he establishes his waypoints depends on VORTAC location relative to his course, VORTAC signal coverage, and flight altitude (due to line-of-sight limits of VHF signal travel). Area Navigation courses can be plotted on WAC, Sectional, or Enroute Low Altitude Charts, taking prohibited areas and controlled airspace into consideration. A pilot flying VFR from Galesburg, Ill., to Lincoln, Nebr., (Figure 6), could establish his first waypoint on the 360° radial of the Burlington VORTAC at a distance of 14 nautical miles. As the flight progresses, subsequent waypoints could be set up from Ottumwa, Lamoni, Omaha, and Lincoln VORTACs by setting frequencies into the VOR receiver and programing radials and distances into the computer. Although the waypoints shown in Figure 6 are on either the 360° or 180° radials, they could be on any radial that intersects the selected track, providing distance limits are not exceeded. On this flight, the Area Navigation course is 24 nautical miles shorter than the Omni course. Remember, the above procedure of selecting waypoints applies to VFR flight only.

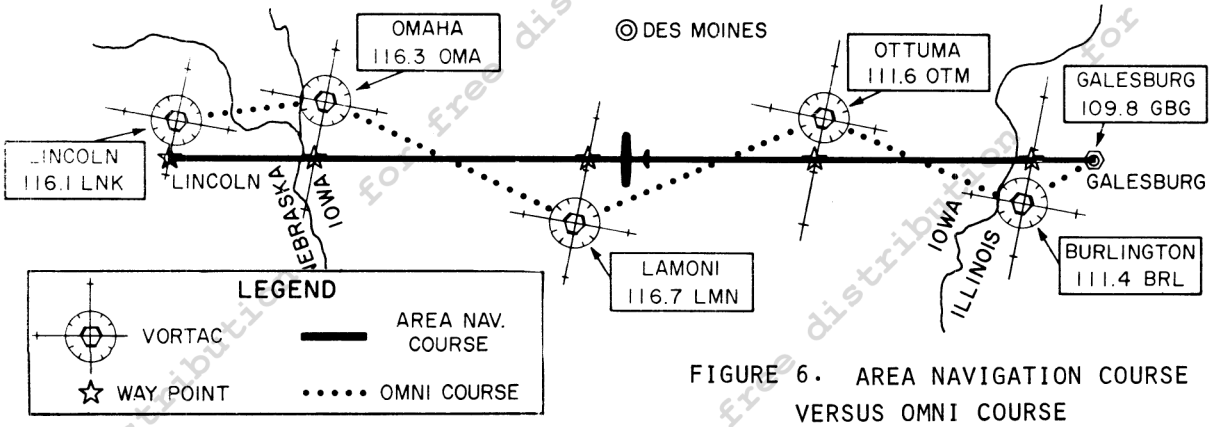


FIGURE 6. AREA NAVIGATION COURSE VERSUS OMNI COURSE

ARE AREA NAVIGATION ROUTES AVAILABLE FOR IFR FLIGHT? Yes. Series 700 (low altitude), and Series 800 and 900 (high altitude) routes, which are expected to be in frequent use by more than one user, are published on appropriate U.S. Government charts. Series 500 (low altitude) and Series 600 (high altitude) routes, which are planned for more than one user, but whose expected usage does not justify Government charting, are published in AIM, Part 4. Series 300 (low altitude) and Series 400 (high altitude) routes are established primarily for one user and are not carried on Government charts.

HOW IS WAYPOINT INFORMATION PRESENTED ON AN RNAV ENROUTE CHART? Figure 7 is an excerpt from an RNAV Enroute Chart depicting a waypoint (DIXIE), the reference facility (Shreveport VORTAC), and the identification box with waypoint data.

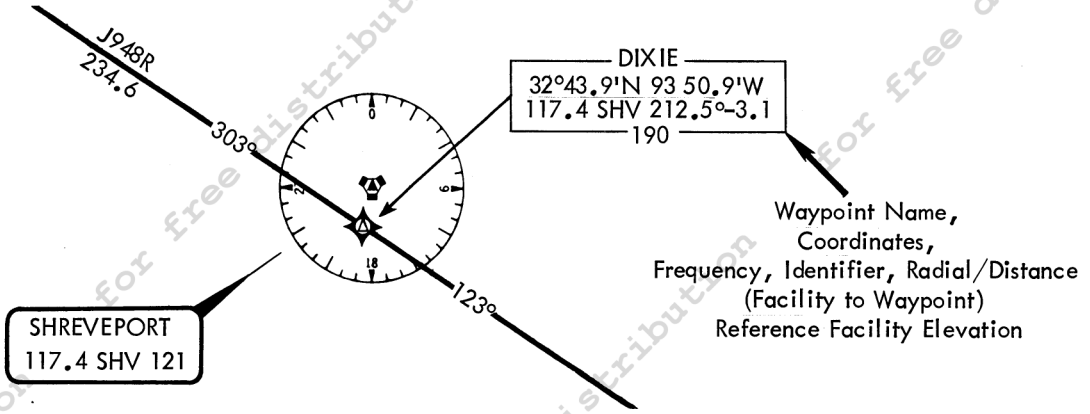


FIGURE 7. WAYPOINT (DIXIE) AND IDENTIFICATION BOX DATA

HOW SHOULD RNAV ROUTES BE LISTED ON AN IFR FLIGHT PLAN? If the airborne equipment has been approved in accordance with Advisory Circular 90-45, as is required for IFR flight, RNAV routes should be filed in the same manner as those for VOR airways. One of the following "Special Equipment Suffixes" should be entered in block 3 of the flight plan: (1) /C--Area Navigation with no code transponder, (2) /F--Area Navigation with 4096 code transponder, (3) /S--Area Navigation with 64 code transponder, or (4) /W--Area Navigation and no transponder.

IS VERTICAL GUIDANCE POSSIBLE WITH AREA NAVIGATION? Yes. For example, one manufacturer has designed an Ascent-Descent Director (ADD), which combined with the basic two-dimensional (lateral and longitudinal) Area Navigation system, provides vertical guidance information similar to a glide slope. With this device, a waypoint can be selected not only at a desired surface location but also at a desired altitude. Thus, the pilot can select and fly a pre-determined vertical profile to a pre-selected point in space. Among the benefits which ATC will derive from three-dimensional Area Navigation is the ability to: (1) establish precisely controlled "overpasses," "underpasses," and "corridors"; (2) call for pre-defined points in space at which the pilot can arrive at a specific altitude. Pilots will be able to: (1) fly pre-organized ascent and descent profiles in terminal areas as specified by SIDs and STARs; (2) create and accurately follow a computed variable glide slope for approaches. Figure 8 shows how aircraft having widely differing performance characteristics can be separated in three-dimensional corridors in or near a terminal area.

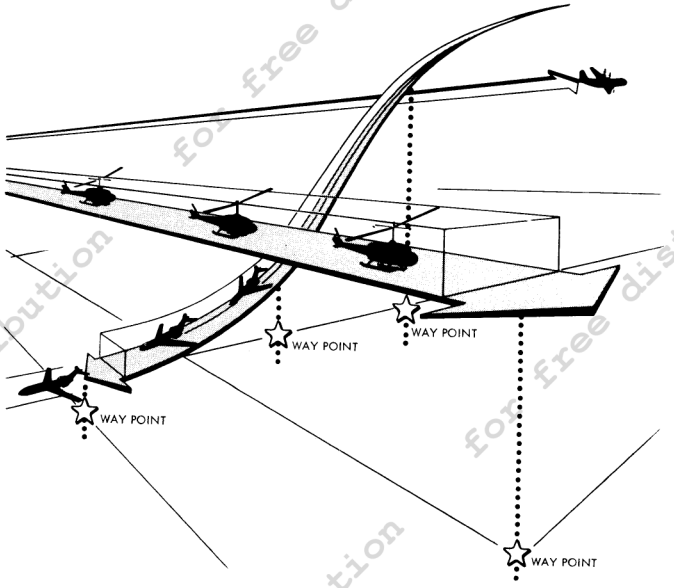


FIGURE 8. THREE-DIMENSIONAL AREA NAVIGATION

WHAT ARE THE ADVANTAGES OF AREA NAVIGATION? All the advantages described below stem from the ability of the airborne computer to, in effect, locate the VORTAC wherever convenient, if it is within reception range. The principle advantages of Area Navigation are:

(1) Pilots are able to fly accurate straight-line courses between geographical points without having to dogleg between VORTACs. On a flight of even moderate length, a significant reduction of enroute time results.

(2) Usable airspace is greatly expanded by allowing the use of routes not limited by facility location.

(3) Holding and orbiting is simplified.

(4) Course deviations for thunderstorm avoidance and traffic spacing may be accomplished more efficiently. With Area Navigation, the pilot (with ATC consent) can alter course himself without radar vectors. He is constantly aware of his position; this is not always true when being vectored.

(5) Changes in routing, such as the assignment of a parallel route, can be accomplished without radar vectors.

(6) Multiple and one-way routes may be established to reduce congestion on heavier traveled airways and to segregate traffic by aircraft speed and arrival airport.

(7) A capability is provided for instrument let-down and approach at airfields not equipped with approach facilities and for which no approach procedure is presently published.

(8) There will be a reduction in the number of communications between controller and pilot since fewer radar vectors will be required. This puts the responsibility for navigation back in the cockpit and allows the controller more time for his primary function--aircraft separation.

References:

Airman's Information Manual, Parts 1 and 4
Advisory Circular AC 90-45

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