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APPROVAL OF AREA NAVIGATION SYSTEMS FOR USE IN THE U. S. NATIONAL AIRSPACE SYSTEM

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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Initiated by: AFS-260

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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: APPROVAL OF AREA NAVIGATION SYSTEMS FOR USE IN THE U.S. NATIONAL AIRSPACE SYSTEM

1. PURPOSE. This Advisory Circular provides guidelines for implementation of two-dimensional area navigation (2D RNAV) within the U.S. National Airspace System (NAS). It provides for both VOR/DME dependent systems and self-contained systems such as Inertial Navigation Systems (INS), etc. The airborne requirements for three-dimensional area navigation (3D RNAV) are specified. Implementation instructions for 3D RNAV are not included herein. They will be contained in appropriate agency orders. Until such orders are issued, use of airborne 3D-RNAV systems on 2D-RNAV procedures to stabilize flight paths, etc. is permitted provided the minimum/maximum altitudes specified in procedures are observed.

   Additional changes may be expected which reflect elements of the Industry/FAA Task Force Report as they become verified.

2. CANCELLATION. Advisory Circular 90-45, Approval of Area Navigation Systems for Use in the U.S. National Airspace System, dated August 18, 1969, and Change 1 dated October 20, 1970, are canceled.

3. REFERENCES. "U.S. Standard for Terminal Instrument Procedures (TERPs)"; AC 90-28, "Course Changes While Operating under IFR below 18000' MSL"; AC 90-63, "ATC Procedures for Random Area Navigation Routes"; AC 95-1, "Airway and Route Obstruction Clearances"; FAR Parts 21, 23, 25, 27, 29, 43, 71, 75, 91, 95, 97, 121, and 135 as applicable.

4. HOW TO OBTAIN THIS PUBLICATION.

   a. Copies of this circular may be obtained free of charge from:

      Department of Transportation
      Publications Section
      TAD-443.1
      Washington, D. C. 20590

Initiated by: AFS-260

b. Identify the publication in your order as:

FAA Advisory Circular 90-45A
Approval of Area Navigation Systems for Use
in the U. S. National Airspace System
Dated February 1975

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Acting Director, Flight Standards Service

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1. BACKGROUND AND DEFINITIONS.

a. Present navigational methods, based on the use of VOR/DME/TACAN ground facilities, result in routes or airways which lead either directly toward or away from the station. This results in limitations on the configuration and the number of routes available between two points.

b. These limitations take on even more importance considering that arrival and departure procedures are based, in large measure, on the same ground stations which serve the enroute structure. This means the funneling effect is compounded by altitude changes for traffic transitioning to or from the enroute structure.

c. The employment of airborne area navigation systems (RNAV) permits flight over predetermined tracks within prescribed accuracy tolerances without the need to overfly ground-based VOR/DME (VORTAC) navigation facilities. Area navigation has three principal applications: between any given departure and arrival points along a route structure so organized as to permit reduction in flight distances or reduction in traffic congestion; in terminal areas to permit aircraft to be flown on preorganized arrival and departure flight paths to assist in expediting traffic flow and reduce pilot and controller workload; and to permit instrument approaches within certain limitations.

d. Area navigation allows the use of routes not solely limited by air navigation facility location. These additional routes provide operational advantages for pilots and controllers by increasing route capability and flexibility.

e. Definitions of particular significance.

(1) Along-Track Distance (ATD) Fix - The ATD fix is an along-track position defined with reference to a waypoint and with geographical coordinates.

(2) Along-Track Error - A fix error along the flight track resulting from the total error contributions of the airborne and ground equipment only.

(3) Area Navigation (RNAV) - A method of navigation that permits aircraft operations on any desired course within the coverage of station referenced navigation signals or within the limits of self-contained system capability. In addition, RNAV utilizing capabilities in the horizontal plane only is 2-D while RNAV which also incorporates vertical guidance is 3-D.

(4) Area Navigation (RNAV) Equipment - Airborne equipment that provides for area navigation.

(5) Changeover Point - The point at which navigation reference is shifted from one reference facility to the next reference facility.

(6) Circular Position Error (CPE) - The probable navigation error expressed in terms of the radius of a circle centered on the desired geographic point.

(7) Cross-Track Error - A fix error to the left or right from the desired track to the present position, measured perpendicular to the desired track. This error includes airborne equipment, ground equipment, and FTE.

(8) Designated RNAV Route - An area navigation route, based on the current high altitude or low altitude VOR/DME coverage, as designated by the Administrator and published in FARs 71 and 75.

(9) Established RNAV Route - A predefined enroute segment, arrival, or departure route (including RNAV SIDs and STARs). It also includes enroute segments established with gaps in VOR/DME coverage for use of aircraft equipped with RNAV systems capable of automatic dead reckoning.

(10) Flight Path Angle - A vertical angle defining an ascending or descending path TO a specified altitude (MSL) at a specified waypoint. *

(11) Flight Technical Error (FTE) - Flight Technical Error refers to the accuracy with which the pilot controls the aircraft as measured by his success in causing the indicated aircraft position to match the indicated command or desired position. It does not include procedural blunders.

(12) Instrument Approach Waypoints - Fixes used in defining RNAV instrument approach procedures, including the INITIAL APPROACH WAYPOINT (IAWP), INTERMEDIATE WAYPOINT (INWP), the FINAL APPROACH WAYPOINT (FAWP), the MISSED APPROACH WAYPOINT (MAWP), and the RUNWAY WAYPOINT (RWY WP). *

(13) Parallel Offset Route - A desired parallel track to the left or right of the "parent" or designated route specified in whole nautical miles.

(14) Reference Facility - The ground VOR/DME facility used for the identification and establishment of an area navigation route, waypoint, or flight procedure.

(15) RNAV Instrument Approach Procedures - Instrument approach procedures based on RNAV and identified by the prefix RNAV followed by the procedure number; i.e., RNAV Rwy 21 or RNAV-A.

(16) RNAV Transition Routes for Initial Approach - Transition routes, based on RNAV, from the enroute environment to the initial approach waypoint of an instrument approach procedure. RNAV transition routes may be included in conventional approach procedures such as ILS, as well as in complete RNAV approach procedures.

(17) Route Segment - Two subsequently related waypoints (or ATD fixes) define a route segment.

(18) Slant Range - The actual distance between aircraft in flight and certain air navigational aids (radar, DME). This distance is greater than the geographical range because of the altitude of the aircraft.

(19) Slant Range Error - Slant range error is the difference between the distance of an aircraft to a point on the surface and the distance from that point along the surface to a point directly beneath the aircraft.

(20) Tangent Point - The point from which a line perpendicular to the RNAV route centerline passes through a specified VORTAC.

(21) Tangent Point Distance (TPD) - Distance from VORTAC to tangent point.

(22) Track Angle - Settings used in station oriented RNAV systems to identify prescribed routes and tracks over the ground from point to point.

(23) Turn Points - A waypoint which identifies a change from one Great Circle track to another along a given route.

(24) Vertical Navigation (VNAV) - That function of RNAV equipment which provides guidance in the vertical plane.

* (25) Vertical Path Angle - (See Flight Path Angle). *

(26) Waypoint - A predetermined geographical position used for route definition and/or progress reporting purposes that is defined relative to a VORTAC reference facility.

(27) Waypoint Displacement Area - The rectangular area formed around the plotted position of the waypoint. The rectangle is oriented along the desired track with the waypoint at its center. Its dimensions are two times (plus-and-minus) the appropriate along-track and cross-track fix displacement error values.

f. Application of area navigation equipment and procedures in the National Airspace System requires that they be compatible with the VOR/DME system on which route structure and air traffic control are based. Implementation, therefore, requires that area navigation devices employed assure proper positioning with respect to the VOR/DME route structure by reference to the geographic locations of VOR/DME ground facilities. Such systems must further permit navigation along, and within the protected airspace of, conventional VOR routes, airways, and terminal procedures.

g. 2-D Systems - To assure compatibility with existing ATC routes and procedures, 2-D area navigation systems typically compute distances, bearings, and/or command guidance signals relative to "waypoints" that are used to define RNAV route segments in relation to VOR/DME station locations. A succession of these waypoints defines the centerline of the route to be flown.

h. 3-D area navigation systems include the functions of 2-D systems with vertical guidance added. Vertical guidance includes computed deviation from desired ascending or descending path to a specified altitude at the waypoint, which is included in the route definition.

i. The advantages of area navigation are applicable to VFR as well as IFR operations. For VFR operations, straight line point-to-point navigation, bypassing of congested and restricted area, and elimination of air navigational facility overhead requirements are the principal advantages gained, and each contributes to the reduction of pilot workload and to flight safety. Installation requirements for VFR use only are shown in Appendix A, Page 13, Paragraph 4.

j. For IFR operations, area navigation offers similar benefits, but must be conducted in accordance with standards and procedures designed to ensure the safe, expeditious, and orderly movement and control of air traffic within prescribed airspace dimensions.

k. Introduction of an area navigation capability into the National Airspace System provides a means for overcoming many of the disadvantages of the VOR structure. By eliminating the requirement to fly along radials that lead directly to or from the ground station, it is possible to design routes and procedures that better facilitate the movement of traffic. Typical of the benefits that result are:

(1) Congested area bypass routes.

(2) Multiple routes to allow segregation of traffic according to speed or other operating characteristics.

(3) Pilot navigation of commonly flown radar vector paths.

(4) Improved alignment of routes.

(5) Dual routes for one-way traffic.

(6) Increased instrument approach capability.

(7) Optimum location of holding patterns.

(8) Procedures designed for STOL and helicopter operations.

1. FAA encourages the installation of area navigation equipment and has established routes and terminal procedures that are specifically designed for, and are beneficial to, properly equipped users.

m. Previous action was directed to the development of transcontinental and major hub connecting routes along with terminal procedures to serve these routes. Development of other routes and terminal procedures will be consistent with user needs whenever possible.

2. WHERE TO APPLY FOR APPROVAL.

a. Application for approval of an area navigation equipment installation other than those relating to an application for a Supplemental Type Certificate (STC) may be made to any FAA Air Carrier, General Aviation District Office, or Flight Standards District Office.

b. Application for a Supplemental Type Certificate covering an area navigation equipment installation may be made to any FAA Regional Engineering and Manufacturing Office.

c. Application for approval of new area navigation routes and instrument approach procedures should be made to the appropriate FAA regional office. Air carrier/air taxi requests should be forwarded to the appropriate Flight Standards District Office.

d. Air Carriers should advise the certificate-holding office of any application made to other offices.

3. AREA NAVIGATION EQUIPMENT. Equipment that meets the performance specifications outlined in Appendix A is suitable for use within the NAS. A single system will be considered suitable to meet these requirements. Equipment may include doppler radar, inertial, pictorial display/course line computers, or any other technique/device that will ensure compatibility with the operational procedures, route widths, vertical separation, and obstacle clearance requirements prescribed. Pictorial displays or course line computers provide one of the typical methods of operating on an area basis. This method is predicated on utilizing the signals from VOR/DME ground stations, or other facilities offering equivalent accuracy. The airborne equipment standard is the minimum for IFR. However, the NAS will recognize various levels of equipment sophistication. The more sophisticated equipment will include track

smoothing, turn anticipation, parallel offset capability, and at least a 6 waypoint storage for 2-D and at least a 10 waypoint storage capability for 3-D. They will normally use ARINC quality components which are more accurate than the minimum standards require and often utilize more than DME/VOR inputs. They typically use heading and air data or even inertial and ILS information to improve on the basic accuracy. The minimum equipment will use the published reference facility. It normally does not employ track smoothing and rarely utilizes more than two waypoints. It is the minimum for IFR approval. This level of equipment is expected to be limited ultimately in the NAS, particularly in the terminal area where the cockpit workload is such that 6 to 10 waypoint storage, parallel offset and turn anticipation features will be very desirable.

RNAV will be used in all phases of the NAS. Although current use is primarily enroute, it is expected to become increasingly important in terminal airspace. Sophisticated RNAV systems -- especially when supplemented with airborne 3-D capability -- are expected to provide the user with significantly improved instrument approach capability when compared with the non-precision approaches currently used. The minimum RNAV systems on the other hand will be of limited usefulness in the terminal area. The minimum system cannot supplant VOR/DME and localizer for use as an approach aid except under special conditions where certain geometrics can show an advantage for this level of RNAV. RNAV approach procedures which cater to the minimum equipment levels will normally not be developed in high density terminal areas except where a definite operational advantage can be the result as at an airport located over 10 miles from the reference facility or where circling minimums only apply, or where a localizer back course is unflyable; etc., or to satisfy a specific user need.

4. PROCEDURES. In order to prolong the usefulness of the minimum equipment systems, procedures will be developed, where possible, with only two required waypoints. It must be noted, however, that procedures in complex terminals may require the use of up to 6 waypoints in rapid succession for 2-D and up to 10 for 3-D. The minimum equipment systems, although sufficiently accurate to meet present RNAV requirements, will find these complex procedures unflyable because of the extremely high cockpit workload.

5. TURN ANTICIPATION. Pilots flying the system are expected to initiate a turn prior to reaching the turning point in order to intercept the next segment without overshoot. Pilots flying systems which do not automatically anticipate the turn should use a method which involves "leading" the turn by approximately one mile for each 100 knots true airspeed. Automatic coupled systems must have the capability of similar methodology.

6. GROUND FACILITIES. Throughout the text of this Advisory Circular, ground facility references are to VOR/DME. Where TACAN service is provided in the NAS, any TACAN user whose equipment meets the minimum system performance characteristics of the U.S. National Aviation Standard for VORTAC (AC 00-31) may apply TACAN to all VOR/DME references herein. *