U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRWORTHINESS APPROVAL OF OMEGA/VLF NAVIGATION SYSTEMS FOR USE IN THE U.S. NATIONAL AIRSPACE SYSTEM (NAS) AND ALASKA

Date: 9/12/88
Initiated by: AIR-120

AC No: 20-101C
Change:

1. PURPOSE. This advisory circular establishes an acceptable means, but not the only means, of obtaining airworthiness approval of an Omega/Very Low Frequency (VLF) navigation system for use under VFR (visual flight rules) and IFR (instrument flight rules) within the conterminous United States, Alaska, and surrounding United States waters. Like all advisory material, this advisory circular is not, in itself, mandatory and does not constitute a regulation. It is issued for guidance purposes and to outline one method of compliance with airworthiness requirements. As such, the terms "shall" and "must" used in this advisory circular pertain to an applicant who chooses to follow the method presented. The guidelines provided in this advisory circular supersede those of AC 90-45A, Approval of Area Navigation Systems for Use in the U.S. National Airspace System, for Omega/VLF navigation equipment.

2. CANCELLATION. Advisory Circular (AC) 20-101B, dated December 1, 1980, is canceled.

3. RELATED FAR. Federal Aviation Regulations (FAR) Parts 23, 25, 27, 29, 43, and 91.

4. RELATED READING MATERIALS.

a. Federal Aviation Administration (FAA)/Technical Standard Order (TSO) C94a, Omega Receiving Equipment Operating Within the Radio Frequency Range 10.2 to 13.6 Kilohertz, and TSO C120, Airborne Area Navigation Equipment Using Omega/VLF Inputs. Copies may be obtained from the Department of Transportation, FAA, Aircraft Certification Service, Aircraft Engineering Division (AIR-120), 800 Independence Avenue, SW., Washington, DC 20591.

b. Radio Technical Commission for Aeronautics (RTCA), Document No. RTCA/DO-160B, Environmental Conditions and Test Procedures for Airborne Equipment, Document No. RTCA/DO-164A, Airborne Omega Receiving Equipment, Document No. RTCA/DO-178A, Software Considerations in Airborne Systems and Equipment Certification, and Document No. RTCA/DO-190, Minimum Operational Performance Standards for Airborne Area Navigation Equipment using Omega/VLF Inputs. Copies may be purchased from RTCA Secretariat, One McPherson Square, Suite 500, 1425 K Street, NW., Washington, DC 20005.

c. Advisory Circular 90-82, Random Area Navigation Routes. Copies may be obtained from the Department of Transportation, Utilization and Storage Section, M-443.2, Washington, DC 20590.

d. Advisory Circular 27-1, Certification of Normal Category Rotorcraft. This document should be referenced to determine if considerations beyond those contained in this advisory circular are necessary when installing an Omega/VLF navigation system in a normal category rotorcraft. If necessary, AC 27-1 will address those items peculiar to rotorcraft installations. Copies may be ordered from: Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, or from any of the Government Printing Office bookstores located in major cities throughout the United States. Identify the publication as AC 27-1, Certification of Normal Category Rotorcraft, Stock Number 050-007-00708-6.

e. Advisory Circular 29-2, Certification of Transport Category Rotorcraft. This document should be referenced to determine if considerations beyond those contained in this advisory circular are necessary when installing an Omega/VLF navigation system in a transport category rotorcraft. If necessary, AC 29-2 will address those items peculiar to rotorcraft installations.

5. BACKGROUND.

a. System Description: Omega is a radio navigation system which uses low frequency, precisely timed pulsed signals from eight round transmitting stations spaced thousands of miles apart around the world. The VLF communications system is comprised of a series of high power very low frequency transmitters comprising the U.S. Naval VLF Telecommunications Network. Omega stations transmit in a very precise phase stable format and are synchronized with each other using atomic clocks. The VLF signals are transmitted similarly, however, are not synchronized with each other as with Omega signals. Position data is derived by measuring the phase changes of signals being received. The system solves the continuously changing geometry problem and converts the phase changes being measured from several stations into distance and direction of movement since the last phase measurements were taken. The incremental changes in distance and direction are continuously combined with previously calculated positions to determine the present position. Navigation values such as distance and bearing to a waypoint are computed from the aircraft latitude/longitude and the location of the waypoint. Course guidance is generally provided as a linear deviation from the desired track of a great circle course. The desired course may be pilot selectable or may be determined by the navigation computer by computations based on the locations of succesive waypoints.

b. System Availability and Reliability.

(1) The Omega station network was created solely for the purpose of providing long-range navigation. Omega system status information is available on a telephone recording from U.S. Naval Observatory, telephone (703) 866-3801. Omega status messages are also broadcast by the National Bureau of Standards on stations WWV and WWVH at 16 minutes past each hour (WWV) and 47 minutes past each hour (WWVH).

(2) Unlike the dedicated Omega network, the VLF communications system operated by the U.S. Navy is not primarily intended for navigation use. The

Navy may shut stations down, add new stations, change frequencies, etc., with no advance warning. Information on current VLF system status is not published for the aviation user.

(3) The Omega/VLF navigation system, while it may use VLF communications stations to supplement and enhance the Omega system (increase areas of coverage, improve performance, etc.), should be capable of accurate navigation using Omega signals alone.

c. Omega Position Errors. The accuracy of Omega/VLF navigation can be degraded by errors due to phase disturbances of the signals as they propagate from the station to the aircraft, improper modeling of the signal propagation changes caused by diurnal shift, errors due to poor station/aircraft geometry, surface conductivity, etc.

d. General Operational Limitations.

(1) En Route National Airspace System (NAS) Use. An Omega/VLF system may be approved for en route navigation VFR or IFR within the conterminous United States and Alaska. Other navigation equipment (i.e., Very High Frequency Range (VOR), distance measuring equipment (DME), tactical air navigation (TACAN)) appropriate to the ground facilities along the intended route to be flown should be installed and operable.

(2) Terminal and Approach Use in the NAS. An Omega/VLF system may not be approved for terminal and approach operations.

(3) IFR Navigation Equipment. Aircraft employing Omega/VLF for IFR navigation should also be equipped with an approved alternate means of navigation.

6. DEFINITIONS.

a. En Route Operations. En route operations are those flight phases conducted on charted VOR routes designated as high or low altitude routes (Jet or Victor), direct point-to-point operations between defined waypoints, or along great circle routes as described in AC 90-82.

b. Precipitation Static (P-Static). P-static is electromagnetic noise generated by the dissipation of an electrical charge from an aircraft into the atmosphere. The aircraft becomes charged by flight through particles suspended in the atmosphere such as dust, ice, rain, or snow. Unprotected aircraft may create so much noise that the Omega/VLF receiver can no longer detect the transmitted signal.

c. Synchronization. Synchronization is the process of determining which Omega station transmits which segment of the Omega format at a specific time.

7. AIRWORTHINESS CONSIDERATIONS. Omega/VLF navigation systems have been certificated for VFR and IFR use as an area navigation system for en route navigation in the NAS. This paragraph establishes acceptable criteria for Omega/VLF systems.

a. Omega/VLF Installations Used for Operations Under VFR Only. Operators wishing to use Omega/VLF for operations limited to VFR may obtain approval of the installation by Type Certificate (TC), Supplemental Type Certificate (STC), data field approved by the FAA on an FAA Form 337, Major Repair and Alteration, or by the use of previously approved data. The approval for return to service should be signed by one of the entities noted in FAR 43; i.e., repair station, manufacturer, holder of an inspection authorization, etc. The installation verification should ensure, but is not limited to, the following:

(1) The Omega/VLF Installation Does Not Interfere with the normal operation of other equipment installed in the aircraft. This is accomplished by a ground test and flight test to check that the Omega/VLF equipment is not a source of objectional electromagnetic interference (EMI), is functioning properly and safely, and operates in accordance with the manufacturer's specifications.

(2) The Structural Mounting of the Omega/VLF equipment is sufficient to ensure the restraint of the equipment when subjected to the emergency landing loads appropriate to the aircraft category.

(3) A Navigation Source Annunciator is Provided on or adjacent to the display if the Omega/VLF installation supplies any information to displays such as a horizontal situation indicator (HSI) or course deviation indicator (CDI) which can also display information from other systems normally used for aircraft navigation.

(4) The Omega/VLF Controls and Displays are Installed with a placard(s) which states "Omega/VLF Not Approved for IFR."

(5) The Omega/VLF May be Coupled to the "Radio Nav" Function of an autopilot provided the system has a CDI or steering output that is compatible with the autopilot, and the same installation procedures normally used for the VOR coupling are used.

b. Omega/VLF Installations Used as an Area Navigation System Under IFR. The standards for navigation within the NAS are more stringent than the requirements for long-range, over-water navigation. Omega/VLF equipment produced under TSO-C94 or TSO-C94a is not necessarily appropriate for en route area navigation under IFR since these TSO's were originally written for long-range, over-water navigation. Performance standards for Omega/VLF equipment to be used in the NAS are specified in TSO-C120. Omega/VLF equipment manufactured under TSO-C94 or TSO-C94a is also suitable for en route navigation use in the NAS provided it has been shown to meet the more stringent accuracy criteria specified in paragraph 9. Criteria for area navigation (RNAV) systems based on Omega/VLF navigation are amplified in the following paragraphs. The initial certification of an Omega/VLF system requires an engineering evaluation because of the need to verify accuracy, failure indications, approved operating areas, environmental qualifications, etc. Subsequent installations of the same Omega/VLF system in other aircraft may require additional engineering evaluation, depending upon the degree of integration of the Omega/VLF system with other aircraft systems. An engineering evaluation will be necessary to change or increase approved operating areas. Omega/VLF systems for use under IFR should provide the following:

(1) Flightcrew Inputs of:

(i) Aircraft present position in terms of latitude and longitude to at least the nearest 0.1 minute.

(ii) At least three (for to-from equipment) or four (for to-to equipment) waypoint positions in terms of latitude and longitude to at least the nearest 0.1 minute.

(iii) A means to confirm correctness of input data prior to utilization of the new data by the system.

(iv) A "direct to" function to define a route segment from present position to any waypoint.

(v) The capability for operator deselection and reselection of any station or combination of stations.

(vi) A means for manual update of system position by the pilot to permit insertion of a known present position.

(2) The System Displays Should Give No Operationally Misleading Information and Should Provide:

(i) Present position in terms of latitude and longitude to at least the nearest 0.1 minute and in terms of magnetic bearing and distance to or from a waypoint to the nearest 0.1 nautical mile (nmi) (distance to the nearest 1.0 nmi is acceptable for equipment previously approved under TSO's C94 and C94a) and nearest degree. Distances of at least 260 nmi should be capable of being displayed, but distances greater than 99.9 nmi need only be displayed to the nearest nautical mile.

(ii) Waypoint position designation in terms of latitude and longitude to at least the nearest 0.1 minute or in terms of magnetic bearing and distance from present position or another waypoint. Waypoint designation in terms of magnetic bearing and distance should be to the nearest degree of bearing and to at least 0.1 nmi for distances up to 100 nmi then at least 1.0 nmi for distances of 100 nmi or more.

NOTE: Information should be provided to the flight crew to prevent the designation of waypoints by a sequence of bearings and distances (i.e., the reference position for a waypoint designated by bearing and distance should be designated by latitude and longitude).

(iii) A display of active waypoint(s) identification (not necessarily waypoint position) used to define the navigation track being flown.

NOTE: Only systems which define the desired navigation track in terms of its endpoints can be used to navigate on published airways due to changes in magnetic variation after the commissioning of the ground facility.

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