

CHANGE

**U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION**

**ORDER
6050.32B
CHG 3**

Effective Date:
06/11/2019

SUBJ: Spectrum Management Regulations and Procedures Manual

1. **Purpose.** The current Standard Service Volume (SSV) classes for the VOR/DME/TACAN systems are being augmented with new geometrically larger SSVs to support Performance-Based Navigation.

The purpose of this change is to update the Frequency Protected Service Volume (FPSV) dimensions in FAA Order 6050.32B to accommodate the new SSVs.

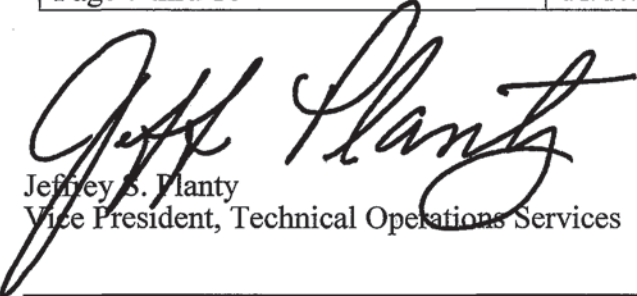
2. **Who this Change Affects.** This change is prepared for all FAA personnel, contractors and staff who utilize and employ FAA Order 6050.32B for spectrum engineering and analysis impacting aviation.

3. **Where can I find This Order.** You can find this order at www.faa.gov. Click on "Regulations & Policies" and then select "Orders & Notices." Or simply visit https://www.faa.gov/regulations_policies/orders_notices/.

4. **Disposition of Transmittal Paragraph.** The transmittal paragraph is for introduction and concept understanding only. All necessary and pertinent documentation has been elsewhere provided for the formal updates.

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CHAPTER 10. NAVIGATIONAL AID (NAVAID) FREQUENCY ENGINEERING

1000. PURPOSE. The purpose of this chapter is to present an overview of the frequency engineering necessary for ILS [including Transponder Landing System (TLS)], VOR, VHF Omnidirectional Radio Range Test (VOT), Area VOT (AVOT), Distance Measuring Equipment, Normal (DME/N), Precision Distance Measuring Equipment, Precision (DME/P), Tactical Air Navigation (TACAN), Microwave Landing System (MLS), Local Area Augmentation System (LAAS), Wide Area Augmentation System (WAAS), Automatic Dependant Surveillance - Broadcast (ADS-B) and the Global Positioning System (GPS). The detailed frequency engineering for these NAVAID facilities is discussed in Appendix 3.

1001. NAVAID FREQUENCY ALLOCATION. The concept of navigational performance involves the precision that must be maintained for both the assigned route and altitude by an aircraft within a particular area. ATC can only apply separation minima within areas where the NAVAID signal meets flight inspection signal strength and course quality standards, including frequency protection, within its designated operational service volume. Therefore, these allocations are preferential bands reserved for frequency assignments to those aeronautical radio-navigation services that fundamentally support, assist or enable the functions to navigate and to separate an aircraft from other aircraft or hazards. Additionally, the frequency protection criteria (i.e., facility separation distances) dictate the number of protected, co- and adjacent channel facility assignments that can exist within the confines of their geographical borders. That makes the frequency availability a finite resource when engineering a facility's assignment, especially for regions surrounding the busiest airports. The management of frequency availability depends on the NAVAID frequency allocations are reserved for their intended services to aircraft navigation. The use of these frequencies by systems for otherwise stated poses a flight safety risk for air traffic if it degrades navigational performance which, in turn, translates into a loss of separation minima. Plus, the stewardship of these frequencies is vital for engineering the future NAVAID frequency assignments needed to support increased signal coverages for NextGen Initiatives such as Performance-Based Navigation. NAVAID facilities are dependent upon the use of the RF spectrum. A summary of the present international and national frequency allocations for NAVAID is shown in figure 10-1.

FIGURE 10-1. NAVAID BAND USE

FACILITY TYPE	FREQUENCY BAND (MHZ)
ILS LOCALIZER (LOC)	108.1 - 111.95
LAAS	112.0 - 117.975
ILS GLIDESLOPE (GS)	328.6 - 335.40
ILS MARKER BEACON	75
ADS-B	978.0
VOR, VOT, AVOT	108.00 - 117.975
DME/N, DME/P, TACAN	960.0 - 1215.0
MLS	5031.0 - 5090.7
GPS L5	1176.45
GPS L1	1575.42

1002. BASIC PRINCIPLES OF NAVAID FREQUENCY ENGINEERING. Due to the fixed number of frequencies available for NAVAID facilities, each NAVAID frequency is reused as often as possible throughout the country. NAVAID frequency engineering provides an interference-free assigned environment for each NAVAID facility within its FPSV. Each type of NAVAID has its own characteristic FPSV, and each is defined in Appendix

3. NAVAID frequency engineering involves two frequency analyses: intersite and cosite.

a. Intersite Analysis is necessary to prevent RFI between facilities on the same and adjacent frequencies providing service in different or adjacent areas. The basic factor considered in intersite analysis is the D/U ratio, as seen at the airborne NAVAID receiver input. All NAVAID frequency assignments must meet certain D/U ratio values (see Appendix 3). For example, a VOR assignment must meet 23 dB ratio for cochannel D/U within its FPSV. The 23 dB ratio is based upon the ICAO standard of required 20 dB D/U ratio, with the addition of a 3 dB factor to allow for the facility power decreasing 3 dB before its monitor shuts it down. The required D/U ratios for each type of VHF/UHF/SHF NAVAID for cochannel and adjacent channels are provided in Appendix 3. 6050.32B

b. Cosite Analysis is necessary to prevent RFI resulting from the interaction of transmitters and receivers at or near the same site. Cosite RFI includes intermodulation products, cross-modulation, receiver desensitization (overload), adjacent channel signals, harmonics and AM/FM/TV interference.

1003. NAVAID FREQUENCY ENGINEERING METHODS. The cosite analysis procedure is discussed in Appendix 3. It will not be repeated in this chapter. As for intersite analysis, there are two basic methods for determining whether a proposed frequency meets the required D/U ratio criteria.

a. Method 1: Use of Reference Tables. A series of reference tables will be found in Appendix 3, which shows conservative worst-case separation distances required for each NAVAID type. If the proposed new facility meets all the separation requirements of appropriate reference tables, no further search is necessary, and the frequency application may be prepared. This method is discussed in detail in Appendix 3.

b. Method 2: Calculation of Required Separation. In frequency-congested areas, it is necessary to use a more accurate and detailed method of determining the required separation distance. The calculation method takes the following equipment parameters into consideration and the required D/U ratio is adjusted accordingly:

(1) **Transmitter power.**

(2) **Antenna gain.**

(3) **Antenna directivity.**

(4) **Antenna orientation.**

1004. EQUIVALENT SIGNAL RATIO (ESR). The adjusted D/U ratio is called ESR. A series of curves based on this ESR will be found in Appendix 3, showing the required separation distance. The detailed procedure for calculating the ESR and using the curves is discussed in Appendix 3.

1005. EXPANDED SERVICE VOLUME (ESV). An ESV is a special volume of airspace outside of the normally specified FPSV. Each ESV is engineered using the same criteria as for the FPSV. In addition to meeting the required D/U ratio criteria, each ESV shall also meet certain minimum signal strength requirements as prescribed in Appendix 3. Since ESVs are not registered in the NTIA GMF, Technical Operations ATC Spectrum Engineering Services maintains a separate data base within the AFM for all ESVs used in the NAS. The detailed procedures for engineering ESVs and updating the ESV data base are discussed in Appendix 3.

1006. SPECIAL ISSUES TO BE CONSIDERED.

a. NAVAID 50 kHz Assignments. Since some general aviation aircraft may not yet be equipped with 50 kHz (200-channel) navigation receivers, every effort shall be made to find a 100 kHz assignment for a NAVAID facility before assigning a 50 kHz channel.

b. Paired NAVAID Assignments. To minimize a potential safety hazard, frequency protection shall be provided for all services associated with a facility, even if only one service is installed. When an ILS LOC is assigned, the associated DME frequency shall be frequency protected even if no DME is installed. The same holds true for VOR/DME/TACAN and MLS/DME/P and MLS/DME/N.

c. Localizer Receiver Desensitization Due to In-Band Localizer Signals. Interference between localizers serving different runways at the same airport is possible depending on the configuration of the runways and the distance between the two systems. When an aircraft on approach passes through a strong radiation field of a localizer serving a reverse or an adjacent runway, the ILS siting criteria (FAA Order 6750.16) requires that a positive interlock device be installed to prevent both systems from transmitting simultaneously. FMOs may be asked to evaluate waivers to this siting policy at airports where more efficient use of runways is required. The FMO must analyze the specific situation and geometry so that airborne ILS avionics are not desensitized due to other localizers at the airport. The following policy is provided:

(1) **An undesired localizer signal** level of -33 dBm will not be exceeded within the FPSV of a collocated ILS.

(2) **Calculations** will be done using the free space formula.

d. VOR/DME/TACAN Collocation Assignments. Some VOR/DME/TACAN facilities that were in place in 1980 were engineered under criteria slightly different than that shown in Appendix 3. As such, any installations, which have passed flight inspection satisfactorily in the past, shall be considered as conforming to these criteria. However, any new facility frequency engineered shall adhere to the criteria presented in Appendix 3.

(1) **The greater distance separation** of the individual frequency paired VOR/DME/TACAN shall be used. In facilities of equal power, the criteria charts and graphs will show that the DME/TACAN required separation is greater than that of any paired VOR for most conditions.

(2) **In all cases**, the GREATER requirement shall be used as minimum separation for the frequency pair, regardless of whether both paired facilities are installed.

e. DME at ILS Locations. ILS/DMEs generally require separation distances far beyond that provided for the LOCs due to the DME's separation criteria and omnidirectional antenna pattern. Therefore, it is important to ensure that when engineering an ILS LOC frequency, its associated DME meets the required separation, even if no DME is installed. In frequency congested areas, the frequency protection for the DME may not be possible without using 50 kHz NAVAID frequencies. If the DME is not actually installed, the DME frequency protection may be waived through the normal NAS Change Proposal (NCP) process.

f. DME/P and DME/N at MLS Locations. The conditions are the same as with DME at ILS locations.

g. Potential FM/TV Interference. Because of an abundance of FM and TV high power transmitters around the country, an approach or an airway may place an aircraft over or very near one of these transmitters. Their overwhelming power, frequently on the order of a megawatt or more ERP, can cause severe overloading of the front end of aircraft receivers, and thus the loss or deterioration of NAVAID reception. A routine item to be checked for problems in a frequency study shall include the verification of nearby FM or TV transmitters. Of particular concern are the FM transmitters near the upper end of the FM broadcast band because it is immediately adjacent to the 108.0-117.975 MHz NAVAID band. All new ILS and VOR proposals will be evaluated using the AAM to determine the potential for any interference from FM and TV Broadcast stations. See Appendix 1 for further discussion of FM/TV interference.

h. Collocated NAVAIDS. At some sites, a VOR/DME/TACAN or ILS/DME paired facilities may not be

actually collocated. To meet ICAO and FAA standards, such paired facilities must be installed within the distances specified in the Appendix 3, or else the two facilities may not be frequency paired. An ILS/DME may be collocated with either the LOC or the GS transmitter.

i. Terrain Shielding. A transmitter's signal strength in space can be affected by the shielding of terrain, buildings, vegetation, etc. This can have an impact on the D/U signal ratios in space. If shielding is severe, it may be possible to provide the required D/U signal ratios with less than the recommended station separation. The use of terrain shielding, as a way to decrease the separation requirement, should be treated on a case-by-case basis through sound engineering judgment. This facility must be flight checked with satisfactory results and documented through the normal NCP process.

j. LAAS spectrum support will be referred to Technical Operations ATC Spectrum Engineering Services for engineering and assignment action.

k. ADS-B currently uses the Universal Access Transceiver (UAT) and transmits on 978.0 MHz. The UAT transmits ADS-B data air-to-air for cockpit display and air-to-ground for use by ATC. The UAT may receive ground-to-air Flight Information Service (FIS) and Traffic Information Service (TIS) data for cockpit display.

l. WAAS transmits on GPS frequency L1 from geosynchronous satellites that cover the continental U.S. (excluding Alaska).

m. GPS frequency L5 is expected to be implemented starting with the Wide Area Augmentation System (WAAS) geostationary satellites by 2007, with the GPS constellation implementation to follow in the 2010-2015 time frame. Since L5 transmits on 1176.45 MHz, it was previously considered that some TACAN/DME frequency changes might need to be made to accommodate L5. However, after considerable study it has been concluded that no TACAN/DME frequency changes will be required in the NAS to provide satisfactory L5 operation.

n. VOR Service Volumes and DME Service Volumes. Frequency requests for VOR MON and NextGen DME Service Volumes are based on the most current version of the following program requirements:

1. Very High Frequency Omnidirectional Radio Range Minimum Operational Network (VOR MON) Program Final Program Requirements Document (fPRD)
2. NextGen Distance Measuring Equipment (DME) Program Final Requirements Document (fPRD)

If any concerns with coverage or service availability are encountered when engineering NAVAID frequencies to support the VOR MON or NextGEN DME program requirements, those concerns should be coordinated through AJW-1C2 to the PMO.

1007. thru 1099. RESERVED

SECTION 2. VOR AND DME/TACAN FREQUENCY ENGINEERING

1. FREQUENCY ENGINEERING.

a. Frequency channelization. VOR, Distance Measuring Equipment (DME) and Tactical Air Navigation equipment (TACAN) frequencies are listed in figure 1. The frequencies 108.00/978 MHz and 108.05/1104 MHz are specifically designated for radio navigation test generators (ramp testers) and shall not be used for operational VOR and DME/TACAN facilities.

b. Use of paired channels. The use of paired frequencies as listed in figure 1 requires that stations be collocated in accordance with one of the following:

(1) **Coaxial collocation.** VOR and TACAN or DME antennas are located on the same vertical axis.

(2) **Offset collocation for:**

(a) **Standard VOR** used in terminal areas for approach procedures, the separation of the VOR antenna and the associated DME or TACAN antenna shall not exceed 100'.

(b) **Doppler VOR** used in terminal areas for approach procedures, the separation of the VOR antenna and the associated DME or TACAN antenna shall not exceed 260'.

(c) **Any non-terminal** procedures, where the highest position-fixing accuracy of the system is required, the antenna separation limits of subparagraphs (a) and (b) apply.

(d) **For all other procedures**, the separation of a VOR antenna and associated DME or TACAN antenna shall not exceed 2,000'.

c. FPSV's. Figure 2a shows the three station classes: Terminal (T), Low Altitude (L), and High Altitude (H). Figure 2b shows the two station classes: VOR Low (VL), and VOR High (VH). Figure 2c shows the two station classes: DME Low (DL) and DME High (DH). These volumes define the frequency protection service volumes for the VOR and/or DME/TACAN. [Note: These station class altitudes are in AGL reference to the site elevation.

(1) The DME Low (DL) and DME High (DH) are only applicable for the DME/TACAN facilities that are essential for establishing the DME-DME RNAV coverage set forth by the NextGen DME Program fPRD.

(2) The VOR Low (VL) and VOR High (VH) are only applicable for the VOR, VOR/DME, and VORTAC facilities retained by the FAA for the VOR MON Program fPRD. These two FPSV are not applicable for those facilities that are either retained only to support the DoD operational needs or any facility not operated by the FAA.

(3) When operational needs require facilities to be used beyond their station class dimensions, the authorization for additional protected signal coverage requires an ESV that must satisfy the same signal standards/tolerances/protections and ground/flight check certification.

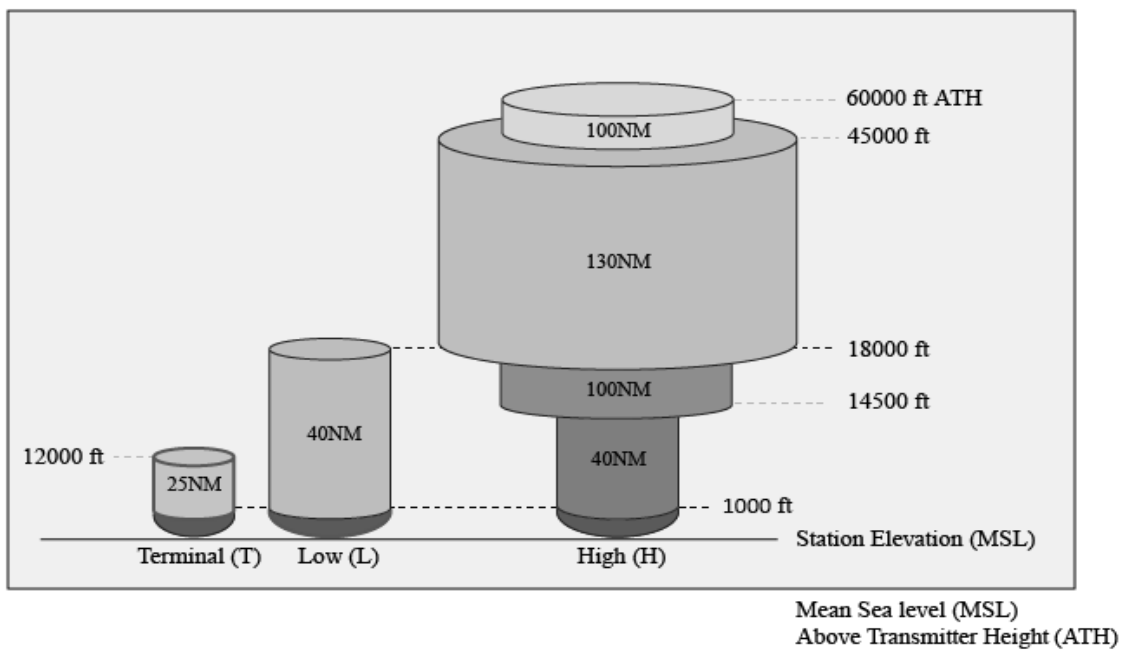
(a) The maximum allowable extension is 160-NM, and the total azimuth of coverage should be less than 120-deg from the NAVAID.

(b) If more than 120-deg is necessary, then intermediate points along the ESV's perimeter must be checked for potential adjacent channel interferers.

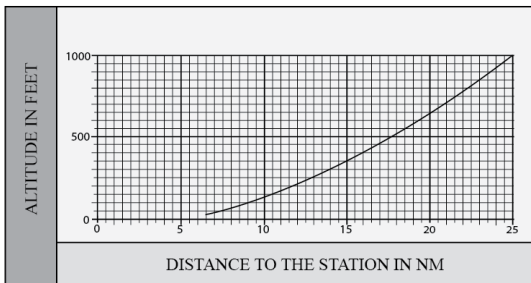
d. VOR D/U criteria. Harmful interference to VOR facilities is avoided by geographically separating cochannel and adjacent-channel assignments. Within each FPSV, the D/U ratio shall be at least the following, on a basis of 95 percent time signal availability.

Co-channel	1 st Adjacent Channel (±50kHz)	2 nd Adjacent Channel (±100kHz)
+23 dB	-4 dB Interim -31 dB Final	-43 dB

Figure 2a. Standard Service Volumes (SSV)



Terminal SSV Below 1,000ft ATH



Low and High SSV Below ATH 1,000 ft

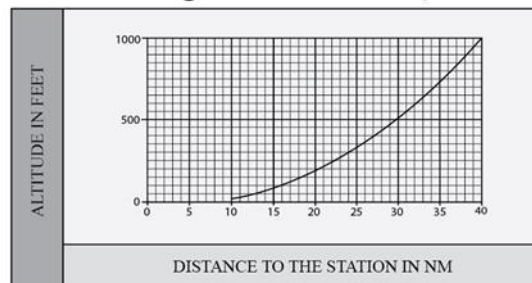
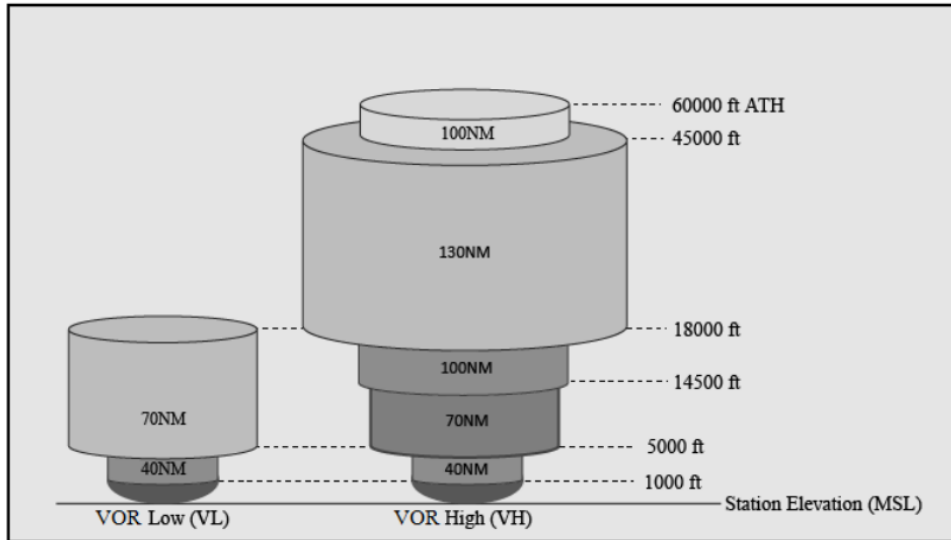
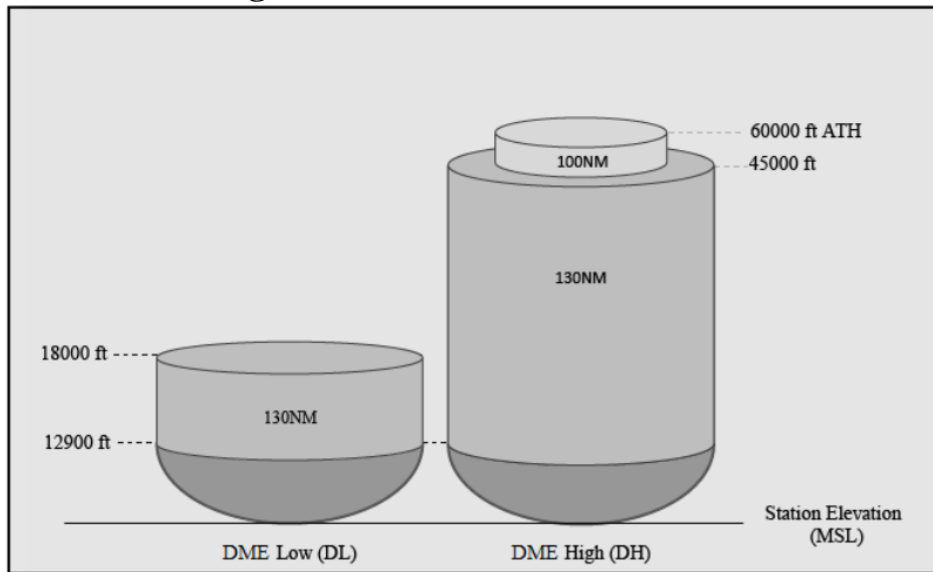


Figure 2b. VOR Service Volumes

Mean Sea level (MSL)
Above Transmitter Height (ATH)

Figure 2c. DME Service Volumes

Mean Sea level (MSL)
Above Transmitter Height (ATH)

(1) A D/U ratio of -4 dB is necessary to assure protection of 100 kHz (100 channel) navigation receivers. This -4 dB D/U ratio is referred to as the interim criterion and shall be used to protect 100 kHz assignments.

(2) A D/U ratio of -31 dB is for 50 kHz (200 channel) navigation receivers. This is referred to as the final criterion and shall be used for 50 kHz assignments.

(3) All the D/U ratio values include a value of +3 dB to take into account transmitter power degradation before system shutdown.

e. DME/TACAN D/U criteria. Harmful interference to DME/TACAN facilities is prevented in the same manner as for VOR's in subparagraph d. The +3 dB factor is included and the values are:

Co-channel	1 st Adjacent Channel (±1 MHz)	2 nd Adjacent Channel (±2 MHz)
+11 dB	-39 dB	-47 dB

2. FREQUENCY ENGINEERING PROCEDURES. To ensure that the proposed VOR-DME/TACAN frequencies would provide interference-free operations within their FPSV's, the following analyses must be performed on the proposed frequencies:

a. Intersite analysis is used to determine whether the proposed frequencies meet the assignment criteria as specified in subparagraphs 1d and 1e. There are two analysis methods, table and calculation.

b. In addition, differences in site elevation calculations are necessary.

3. INTERSITE ANALYSIS BY THE TABLE METHOD FOR VOR. Analysis for VOR facilities may be performed on a proposed VOR frequency through the use of the following tables which show conservative/worst-case separation distances required, with respect to VOR/VOR and VOR/adjacent channel LOC:

- a. Figure 3** for VOR/VOR cochannel.
- b. Figure 4** for VOR/VOR 1st adjacent channel (interim).
- c. Figure 5** for VOR/VOR 1st adjacent channel (final).
- d. Figure 6** for VOR/VOR 2nd adjacent channel.
- e. Figure 7** for VOR/LOC Undesired 1st adjacent (interim).
- f. Figure 8** for VOR/LOC Undesired 1st adjacent (final).

g. Geographical separations are not required between VOR stations and between VOR and LOC stations which differ in frequency by more than 100 kHz. Therefore, there are no tables for 3rd adjacent channel VOR separations. However, facilities that differ in frequency by 150 kHz or less should not have overlapping FPSVs.

4. INTERSITE ANALYSIS BY THE TABLE METHOD FOR DME/TACAN. DME/TACAN facility analysis may be performed on a proposed DME/TACAN frequency through the use of the following tables which show conservative/worst-case separation distances:

- a. Figure 9** for DME/TACAN cochannel, TACAN undesired.
- b. Figure 10** for DME/TACAN 1st adjacent channel, TACAN undesired.

c. Geographical separations are not required between DME/TACAN facilities separated more than 1 channel (1 MHz). There are no tables for 2nd adjacent DME/TACAN channels.

5. DME/TACAN REQUIRED SEPARATION. In most cases, DME/TACAN facilities, separation is greater than for the frequency-paired VOR facility, even though the FPSVs for like categories (H, L and T) are equal.

a. For example, look at the VOR and DME/TACAN tables of mileage separations in figures 3 and 9. From figure 3, it can be seen that two cochannel L-VORs of equal power require 180 nmi separation. From figure 9, two L-DMEs or L-TACANs of equal power require 204 nmi separation. The same holds true for T-VOR and T-DME/TACAN.

b. For most power difference levels, the same is true for H-DME/TACAN, but not all.

c. DME/TACAN spaced 63 MHz. Interference may occur between DME/TACAN spaced 63 MHz apart. Reply transmissions from Channel 17Y, for instance, could interfere with interrogation signals on Channels 80X and 80Y. This can result in receiver desensitization. To preclude this problem, DME/TACAN ground stations shall not be assigned on frequencies which differ by 63 MHz unless they are separated by at least 15 nmi (28 km).

<u>Channel</u>	<u>Interr. Frequency</u>	<u>Reply Frequency</u>
17Y	1041 MHz	1104 MHz
80X	1104 MHz	1167 MHz
80Y	1104 MHz	1041 MHz

6. USE OF THE LARGER SEPARATION REQUIREMENT. In all cases, the larger requirement shall be used, whether it be cochannel or adjacent channel. This requires that in each VOR or DME/TACAN frequency engineering project, a determination must be made as to which has the larger mileage separation requirement, and that value used for the assignment search. This procedure is mandatory whether both of the facilities or only one of them is actually installed.

7. PERMISSIBLE USE OF TABLES. If a proposed facility meets all the requirements of all appropriate tables, the frequency request may be submitted. VOR and DME/TACAN separation are shown in figures 3 through 10.

FIGURE 3. VOR/VOR COCHANNEL SEPARATIONS

(dB)	+9	+6	+3	±0	-3	-6	-9
			(nmi)				
H-VOR	370	383	390	395	398	402	406
L-VOR	138	152	167	180	195	206	212
T-VOR	090	100	110	122	134	146	161

