NTIA TR 91-280

ASSESSMENT OF BANDS FOR WIND PROFILER ACCOMMODATION

(216-225, 400.15-406, and 420-450 MHz Bands)

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ABSTRACT

This report presents an assessment of three candidate bands (216-225, 400.15-406, and 420-450 MHz) for the potential accommodation of Wind Profilers nationally, with consideration worldwide. The approach used to evaluate each band was based on two major factors: conformance to current regulations and electromagnetic compatibility (EMC). This report addresses current regulations, spectrum usage, and analyzes the EMC between two types of Wind Profilers and specific environmental systems for potential accommodation in three candidate bands. The results of this study can serve to indicate a suitable band and identify potential frequencies within that band to accommodate Wind Profiler operations.

KEY WORDS

216-225 MHz Band
400.15-406 MHz Band
420-450 MHz Band
Wind Profiler Radars
Electromagnetic Compatibility (EMC) Analysis

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SECTION 1

INTRODUCTION

BACKGROUND

The National Telecommunications and Information Administration (NTIA) is responsible for managing the Federal Government's use of the radio frequency spectrum. NTIA's responsibilities include establishing policies concerning spectrum assignment, allocation and use, and providing the various departments and agencies with guidance to ensure that their conduct of telecommunications activities is consistent with these policies. In discharging these responsibilities, NTIA assesses spectrum utilization, identifies existing and/or potential compatibility problems among the telecommunications systems that belong to various departments and agencies, provides recommendations for resolving any compatibility conflicts that may exist in the use of the frequency spectrum, and recommends changes to promote spectrum efficiency and improve spectrum management procedures. This report is concerned with the assessment of the 216-225, 400.15-406, and 420-450 MHz bands for possible wind profiler accommodation.

The Wind Profiler radar system provides real-time wind speed and direction values as a function of altitude. The primary role of the Wind Profiler is in weather forecasting; however, other applications have been identified including severe wind condition warnings, flight planning, space shuttle support, and pollution studies (acid rain and volcanic ash). Currently, wind speed and direction are determined by the National Weather Service (NWS) and other agencies by tracking the flight path of radiosondes which also provide information on temperature, barometric pressure, and relative humidity in the atmosphere as they rise. Radiosondes are expendable and are usually released twice daily. Although Wind Profilers are not direct replacements of radiosondes, Wind Profilers will provide regular, real-time wind speed and direction information. In addition, the Wind Profilers will also provide long-term cost savings through automated use, not requiring expendable equipment. The National Oceanic and Atmospheric Administration (NOAA), an administration within the Department of Commerce (DOC), plans to operate a national network of Wind Profilers that initially will consist of 30 units with plans for a total of 200-300 units. The Department of Defense (DoD) may share in the meteorological information obtained from the future DOC Wind Profiler network. Other Government and non-Government users of Wind Profilers are expected.

The concern with Wind Profiler operations is the selection of an appropriate operating frequency band(s). Propagation characteristics of the atmosphere require that the Wind Profiler system operate in the range 50-1000 MHz. Currently, there are three frequency ranges of particular interest: around 50 MHz, 200-500 MHz and around 900 MHz, each of which best accommodates a particular application. The Wind Profiler operations to date have been for experimental purposes at several research facilities. Since the DOC is establishing a 200-500 MHz national Wind Profiler network, all efforts to accommodate Wind Profilers have focused around that band.

No single frequency band is available to accommodate 200-500 MHz Wind Profiler operations for all users, Government and non-Government, without a change to the National Table of Frequency Allocations. Furthermore, the selection of any frequency band(s) must take into account potential international impact. For example, the Wind Profiler being developed for DOC at 404.37 MHz might be sold by its manufacturer to other countries where conscientious attempts to protect operations such as COsmicheskaya Sistyema Poiska Avariynych (COSPAS-USSR acronym for Space System for Search of Distress Vessels) and Search And Rescue Satellite-Aided Tracking (SARSAT) system (406-406.1 MHz band) may not be made. In addition, a frequency band(s) selected solely on the basis of national usage may not be suitable for international usage, and, thus, national trade may be adversely impacted. As a result, the Interdepartment Radio Advisory Committee (IRAC) has requested that NTIA conduct an assessment of the 216-225 MHz, 400.15-406 MHz, and 420-450 MHz bands to assist in determining the appropriate part of the spectrum for mid-frequency (200-500 MHz) Wind Profiler radar operations.

OBJECTIVE

The objective of this task was to assess the 216-225 MHz, 400.15-406 MHz, and 420-450 MHz bands to help determine where in the spectrum Wind Profiler mid-frequency operations could be accommodated.

APPROACH

The approach used to evaluate each band for Wind Profiler operations was based on two major factors: conformance to current regulations and electromagnetic compatibility. These factors may be described briefly as:

1) conformance - The degree to which the Wind Profiler Radar meets National and International Tables of Frequency Allocations and technical standards. The Wind Profiler is a radar assumed to require accommodation on a primary basis for all users as a radiolocation station or as a meteorological radar station. However, it is noted that for some agency requirements, secondary status could be acceptable.

2) electromagnetic compatibility (EMC) - The EMC between Wind Profilers and existing systems was assessed nationally only.

Each frequency band was assessed as being:

<u>Suitable</u> - Conformance and EMC analysis support accommodation of Wind Profilers.

<u>Conditional</u> - Conformance and/or EMC analysis indicate that Wind Profilers may be accommodated under certain conditions.

<u>Unsuitable</u> - Conformance and/or EMC analysis indicate that Wind Profilers cannot be accommodated.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

DISCUSSION OF RESULTS

This study assessed three candidate frequency bands (216-225 MHz, 400.15-406 MHz, 420-450 MHz) for the potential accommodation of Wind Profilers. While the primary concern was national accommodation, international considerations were also included. The Wind Profiler is a radar assumed to require accommodation on a primary basis for both government and non-government users as a radiolocation station or as a meteorological radar station. However, it is noted that for some requirements, secondary status could be acceptable.

Two distinct types of Wind Profilers are expected to be deployed nationally, which are referred to hereinafter as Type A and Type B. In general, Type A profilers are similar to those proposed by NOAA in their national network which is expected to eventually consist of 200-300 profilers. Type A profilers will be able to detect wind speed and direction at altitudes up to 15-20 km, depending on meteorological conditions. Type B profilers have different performance requirements and are less complex than Type A. These profilers will detect wind speed and direction at lower altitudes (i.e., 5-7 km). The expected number and overall deployment philosophy of Type B profilers is unknown. In addition, due to the larger bandwidth specified for Type B Wind Profilers (i.e., 4 MHz compared to 2 MHz for Type A), they cannot be easily accommodated in any of the three candidate frequency bands. Although several users have expressed interest in Type B profilers, spectrum certification in accordance with the NTIA Manual, Chapter 10, has not .been requested. The following paragraphs provide a discussion on the main issues involved in assessing each of the candidate frequency bands for possible Wind Profiler accommodation.

<u>216-225 MHz Band</u>

In terms of technical performance, the 216-225 MHz band offers some advantages over the use of higher frequencies. However, the significant increased cost for the antenna at these frequencies may somewhat offset the performance advantage. In terms of national and international allocation, there is no existing provision for Wind Profiler operations, as either a radiolocation or meteorological aids device. To accommodate Wind Profilers, nationally, a change to the National Table of Frequency Allocations would be necessary, either directly to the Table or by footnote. In either case, an NTIA/IRAC decision and Federal Communications Commission (FCC) rulemaking proceeding would be required. The FCC rulemaking would include involvement from many interested parties (e.g., land-mobile, maritime mobile, amateurs, and adjacent band broadcasters) as well as the impact of the current Notice of Proposed Rulemaking (NPRM) proceedings dealing with the Maritime Mobile service.[1] If accommodation in this band were pursued, a new footnote specifically tailored to allow Wind Profiler operations is more desirable than adding a new allocation in the National Table of Frequency Allocations. In addition, according to Chapter 3 of the NTIA Manual, Wind Profiler operations in this band near the U.S.-Canada border would require coordination. Since this potential allocation change would be a national issue only, the national allocation accommodation of the Wind Profiler is

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1 <u>SEE GENERAL Doc. 9056</u>, 5 FCC 1255 (March 5, 1990).

assessed as **CONDITIONAL**. However, accommodation would depend on the outcome of the rulemaking process.

Internationally, for Wind Profilers to be accommodated on a primary basis in this band, the meteorological aids service would have to be added to the international table or the radiolocation service upgraded in Region 2. In Regions 1 and 3, the meteorological aids or radiolocation service would have to be added in the allocation band 174-223 MHz. Any allocation changes would involve acceptance at a future World Administrative Radio Conference (WARC). Furthermore, due to allocation changes resulting from WARC-79[2], it would be difficult to accommodate Wind Profilers as a radiolocation or meteorological radar station. In addition, sharing of this band may be difficult since it is mostly allocated to broadcasting on a primary basis. As a result, this band is considered **UNSUITABLE** internationally.

Compatible operation of Wind Profilers in the 216-225 MHz band may be possible in some geographic areas of the US, subject to coordination and/or case-by-case EMC analysis. Based on sharing considerations, the frequency 219 MHz (2 MHz necessary bandwidth) is found to be the most suitable frequency in this range. This frequency minimizes potential interference to TV broadcast operations in the lower adjacent band and avoids sharing with the expected heavy concentration of land mobile and amateur use in the upper adjacent band. Type B profilers, due to bandwidth requirements, could not be accommodated in this band. A detailed study of the potential interference to TV-13 receivers would be required before any widespread wind profiler operations could be considered in the 216-225 MHz band. The expected expansion of the maritime mobile service in the 216-220 MHz portion also impacts sharing. The national EMC assessment of this band is considered **CONDITIONAL.**

In summary, based on the national and international allocation and national EMC assessments, the 216-225 MHz is considered **CONDITIONAL** nationally and **UNSUITABLE** internationally.

<u>400.15-406 MHz Band</u>

In terms of conformance to National and International Tables of Frequency Allocations, Wind Profilers operating as a meteorological aids device could be allocated on a primary basis worldwide for all users with only a minor change to the National Table of Frequency Allocations. This change would add Wind Profilers or delete the limitation to radiosondes, nationally. As a result, Wind Profilers accommodation, in terms of allocation is **CONDITIONAL,** nationally, and **SUITABLE** internationally.

Based on the EMC assessment, neither Type A nor Type B profilers can operate in the 400.15-406 MHz band without shutting down to prevent interference to the COSPAS/SARSAT satellites passing overhead. From a regulatory viewpoint, this shutdown is not considered to be an acceptable or effective means to ensure the necessary protection requirement for a safety-of-life service.

Several U.S. government agencies as well as various administrations (i.e., Canada and France) have requested that the 400.15-406 MHz band not be considered a candidate band for

[2] Radiolocation service was reduced to secondary status. Footnote RR627 does not allow new radiolocation systems to be added in Region 2 after January 1, 1990.

Wind Profiler operations since crucial satellite operations in the band as well as the COSPAS/SARSAT operations in the adjacent 406-406.1 MHz band may be jeopardized.

Future enhancements to the current 404.37 MHz Wind Profiler design may improve compatibility between the Wind Profiler and COSPAS/SARSAT. However, due to the potential national and international regulatory burdens associated with, 1) developing and gaining worldwide acceptance and enforcement of spectrum and operational standards to ensure compatibility with COSPAS/SARSAT, 2) adopting interference reporting and mitigation procedures, and 3) resolving equipment malfunction and human error concerns, the EMC assessment of this band is considered **UNSUITABLE.**

In summary, based on the EMC assessment, the 400.15-406 MHz is considered **UNSUITABLE,** both nationally and internationally for Wind Profiler operations.

<u>420-450 MHz Band</u>

In terms of national allocations, the 420-450 MHz band is allocated on a primary basis to the radiolocation service. However, the band is not available to all users (Government non-military and non-Government) because footnote G2 limits Government use to the military and there is no provision for non-Government use. This band is the only 30 MHz of spectrum available for military radiolocation below 1 GHz nationally. To accommodate all Wind Profiler users, a change to the National Allocation Table would be necessary, either directly to the Table or by footnote. In either case, an NTIA/IRAC decision and FCC rulemaking proceeding would be required. Adding a new U.S. footnote allowing Government and non-Government Wind Profiler operations is more desirable than adding a new allocation in the National and International Table of Frequency Allocations. Internationally, Wind Profilers could be accommodated in the 430-440 MHz portion of the band since it is currently allocated on a primary basis to the radiolocation service. For Wind Profilers to be accommodated in the 420-430 MHz or 440-450 MHz portion of the band on a primary basis, an upgrade of the current radiolocation service to primary would be required. This change may involve acceptance at a future WARC. In the band 420-450 MHz, Wind Profiler operations must be coordinated with Canada. As a result, the allocation assessment of the 420-450 MHz band is **CONDITIONAL,** nationally and internationally.

Nationally, the 420-450 MHz band is used extensively by 1) the military for radiolocation systems that are at fixed locations and mobile (including airborne), 2) the military for drone operations at various test ranges, and 3) the amateurs for various functions on a secondary basis. Large, fixed-location radars are relatively few in number; presently there are approximately seven widely dispersed throughout the country. Although these fixed-location radar operations are not restricted in location and may be operated anywhere in the future, rapid expansion is not expected. Coordinated sharing between Wind Profilers and these fixed-location radars appears practical. Sharing between Wind Profilers and airborne platforms (i.e., airborne radars and drones) poses the greatest spectrum management difficulty because of the large frequency and distance separations required. Most of the military radiolocation and drone systems have the capability to operate over all or part of the 420-450 MHz band. Discussion of the three subbands within this range is given below.

The 420-430 MHz portion of the band currently contains the highest number of Government Master File (GMF) assignments of the three sub-bands. The military has many assignments for radiolocation and drone control operations, including flight termination at

425 MHz. The band is also allocated on a secondary basis to the amateur service and used predominately for Amateur TV (ATV) operations on two channels (420-426 and 426-432 MHz). To minimize the impact to critical Government operations, this sub-band should not be considered for Wind Profiler operations nationally.

The 430-440 MHz portion of the band currently contains the second highest number of GMF assignments. This 10 MHz band is the only spectrum allocated to the radiolocation service on a primary basis below 1 GHz worldwide. Numerous military radars and drones operate in this band. Amateur operations include satellite (435-438 MHz) and other low signal level operations on a secondary basis. As a result, the 430-440 MHz band should be avoided for Wind Profiler operations both nationally and internationally.

The 440-450 MHz portion of the band currently contains the lowest number of GMF assignments. The military has assignments for radiolocation and drone control in this sub-band. The band is used on a secondary basis by the amateurs for repeater operations at 442-450 MHz and ATV operations at 438-444 MHz. To minimize the impact to the current users of the band, two candidate frequencies have been identified, each of which has advantages and disadvantages. To minimize the impact on current military operations, a frequency near the upper band edge would be more desirable. As a result, the candidate frequency 449 (2 MHz necessary bandwidth) has been identified. By selecting 449 MHz, interactions between the profiler and military radars would be minimized as compared to selection of a frequency in the middle of the band. The disadvantage of 449 MHz is the impact to the amateurs repeater operations in the 442-450 MHz band. The other candidate frequency identified is 441 MHz. The frequency 441 MHz has certain advantages, among them are: (1) minimize the impact to amateur repeater operations in the 442-450 MHz band, and (2) Canada has adopted 441 MHz for their Wind Profiler operations. The disadvantage of 441 MHz is the larger potential impact to military operations. Although two candidate frequencies have been identified for Wind Profiler operations, only one frequency should be ultimately selected. Overall, the national EMC assessment of the 420-450 MHz band is **CONDITIONAL.**

Based on the national and international allocation and the national EMC assessments, the 420-450 MHz band is considered **CONDITIONAL,** both nationally and internationally.

Summary

Table 2-1 contains a summary of the national and international allocation and the national EMC assessments for each of the three candidate bands. The Table assesses each band in terms of Suitable, Conditional, and Unsuitable.

TABLE 2-1
ASSESSMENT OF FREQUENCY BANDS 216-225 MHz, 400.15-406 MHz, AND 420-450 MHz IN TERMS OF SUITABLE, CONDITIONAL, AND UNSUITABLE FOR POSSIBLE WIND PROFILER ACCOMMODATION

Frequency (MHz)	Allocation National	Allocation International	EMC National	EMC International	Overall National	Overall International
216-225	C	U	C	-	C	U
400.15-406	C	S	U	U[a]	U	U
420-450	C	C	C	-	C	C

S - Suitable
C - Conditional
U - Unsuitable

[a] The EMC assessment for this band considered a national/international system, COSPAS/SARSAT.

CONCLUSIONS

General

The following general conclusions are based on the assessment of three candidate bands (216-225 MHz, 400.15-406 MHz, and 420-450 MHz) for possible Wind Profiler accommodation. Specifically, the conclusions are based on the assumptions, characteristics, and methods identified for the two types (Type A and B) of Wind Profilers used in the study.

1. For all Wind Profiler users to be accommodated on a primary basis, changes in the Table of Frequency Allocations would be required in any of the three frequency bands being considered for this study.

2. To date, several agencies have requested spectrum certification from NTIA for their 200-500 MHz Wind Profiler applications. Most of the Government profilers deployed to date in the 200-500 MHz band operate on an experimental basis around 404.37 MHz. None of the applications submitted have completely met the radar spectrum standards.

3. Although several users have expressed interest in Type B profilers, spectrum certification from NTIA has not been requested. Based on the Wind Profiler characteristics assumed for the study, Type B profilers have greater bandwidth requirements (4 MHz) as compared to Type A profilers (2 MHz). Type B profilers cannot be accommodated in any of the bands studied.

4. Various factors associated with Wind Profiler operations, such as performance requirements, characteristics, and number of units deployed, may vary depending on the specific user. Each one of these factors must be considered individually, as well as in combination, when analyzing compatibility with some systems.

5. Future design enhancements to Wind Profilers or siting considerations (e.g., fences or berms) may increase their compatibility with some systems.

6. If a common frequency band could be adopted both nationally and internationally for Wind Profiler operations, it may promote U.S. trade since two major manufacturers are located in the U.S.

Specific Conclusions for Each Band

7. **216-225 MHz BAND:** This band is considered **CONDITIONAL** for Wind Profilers, nationally, and **UNSUITABLE** internationally. Compatible operation of Wind Profilers in the 216-225 MHz band may be possible in some geographic areas of the U.S., subject to coordination and/or case-by-case EMC analysis. Based on sharing considerations, the frequency 219 MHz (2 MHz necessary bandwidth) is found to be the most suitable frequency in this range. This frequency minimizes potential interference to TV broadcast operations in the lower adjacent band and avoids sharing with the expected heavy concentration of land mobile and amateur use in the upper adjacent band. Type B profilers, due to bandwidth requirements, could not be accommodated in this band. A detailed study of the potential interference to TV-13 receivers would be required before any widespread wind profiler operations could be considered in the 216-225 MHz band. The expected expansion of the maritime mobile service in the 216-220 MHz portion also impacts sharing.

8. **400.15-406 MHz BAND:** Based on the EMC assessment, neither Type A nor Type B profilers can operate in the 400.15-406 MHz band without shutting down to prevent interference to the COSPAS/SARSAT satellites passing overhead. From a regulatory viewpoint, this shutdown is not considered to be an acceptable or effective means to ensure the necessary protection requirement for a safety-of-life service. Future enhancements to the current 404.37 MHz Wind Profiler design may improve compatibility between the Wind Profiler and COSPAS/SARSAT. However, due to the potential national and international regulatory burdens associated with, 1) developing and gaining worldwide acceptance and enforcement of spectrum and operational standards to ensure compatibility with COSPAS/SARSAT, 2) adopting interference reporting and mitigation procedures, and 3) resolving equipment malfunction and human error concerns, the EMC assessment of this band is considered **UNSUITABLE**, both nationally and internationally.

9. **420-450 MHz BAND:** The 440-450 MHz portion of the 420-450 MHz band is considered **CONDITIONAL** for Wind Profilers both nationally and internationally. To minimize the impact to current users of the band, two candidate frequencies have been identified, each of which has advantages and disadvantages to specific users. Specifically, the frequency 441 MHz (2 MHz necessary bandwidth) and 449 MHz (2 MHz necessary bandwidth) within the 440-450 MHz sub-band are identified as candidate frequencies for Wind Profilers operations nationally. Only one of these frequencies should be selected.

RECOMMENDATIONS

The following are NTIA staff recommendations based on the findings of this report. NTIA management will evaluate these recommendations to determine if they can or should be implemented from a policy, regulatory, or procedural viewpoint. Any action to implement these recommendations will be via separate correspondence modifying established rules, regulations and procedures.

1a. The sub-band 440-450 MHz should be considered for national Wind Profiler operations. Within that band, two candidate frequencies 441 MHz (2 MHz necessary bandwidth) or 449 MHz (2 MHz necessary bandwidth) should be considered nationally.

To accommodate Wind Profiler radars, a footnote should be incorporated into the National Allocations Table stating the following:

> USXXX - The frequency 44X MHz (2 MHz necessary bandwidth) is also allocated on a primary basis for both Government and non-Government operation of Wind Profiler systems, except to military airborne platforms, in which case they are secondary.

1b. Additionally, on a case-by-case basis, the frequency 219 MHz (2 MHz necessary bandwidth) should be considered for Wind Profiler operations in certain geographic locations, subject to successful coordination with authorized users of the band and consideration of the adjacent band channel TV-13 broadcast operations.

2. Type B Wind Profilers, due to the wider bandwidth requirement (4 MHz), should not be accommodated in any of the three candidate frequency bands addressed in this study.

3. NTIA, in conjunction with the FCC, should review and update, if necessary, the appropriate service rules and spectrum standards to address Wind Profiler operations.

4. NTIA should submit appropriate findings of this study for publication in international fora, such as the International Radio Consultative Committee (CCIR).

5. To ensure long term protection of the safety-of-life COSPAS/SARSAT system, current experimental Wind Profiler operations at 404.37 MHz should be phased out.

SECTION 3

WIND PROFILER SYSTEM

INTRODUCTION

Since the DOC is establishing a nationwide Wind Profiler network in the 200-500 MHz band, efforts to accommodate Wind Profilers has been focused in that band. Furthermore, most of the profilers deployed to date in the 200-500 MHz band operate on an experimental basis in the 400.15-406 MHz band, specifically at 404.37 MHz. In addition to considering the 400.15-406 MHz band, this study is evaluating two alternative bands (216-225 MHz and 420-450 MHz) for possible Wind Profiler accommodation. As a result, the Wind Profiler operational considerations for those bands must be addressed.

Based on a phone conversation with one manufacturer[3], it was determined that: (1) the assumed characteristics for Wind Profiler operations at 404.37 MHz would remain the same without impacting performance requirements in either of the two alternative candidate frequency bands (216-225 MHz and 420-450 MHz) being considered, (2) the preferred band of operation would be at 216-225 MHz since the attenuation effects would be a lesser problem than at 400 MHz, and (3) the cost of a Wind Profiler system may vary depending on the selection of the frequency band chosen for operation. For example, if the 216-225 MHz band is selected for Wind Profilers, the antenna currently being used for 404.37 MHz Wind Profiler operations would increase in price by about a factor of four.

Given below is a brief overview of the Wind Profiler operations as well as a discussion of the assumptions pertaining to this study regarding Wind Profiler deployments, characteristics, and design.

WIND PROFILER OPERATIONS

Research over the past 15 years has concentrated on three different frequencies for Wind Profiler operations, near 50 MHz, near 400 MHz, and near 900 MHz. The advantage of the lower frequencies are that they are less attenuated by precipitation and can "see" higher. However, the lower frequencies do not allow the higher resolution measurements close to the ground which are important for weather forecasting. Table 3-1 compares some typical performance characteristics at the three frequencies. Additional documentation delineating the specific operations of Wind Profilers is available in the literature.[4]

The Wind Profiler is a vertically oriented ground-based pulsed radar that utilizes scattering from irregularities in the index of refraction in the atmosphere to measure wind parameters in three dimensions (Figure 3-1). By transmitting pulses on sequential beams (e.g., east, north, and vertical) and processing the return signal, profiles of the wind can be obtained faster and cheaper than by balloons. Range gate and Doppler radar principles are applied to deduce the

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[3] G. Patrick, NTIA, Telephone Conversation with Vern Peterson, Chief Scientist, TYCHO Technology, Inc., March 13, 1990.

[4] NOAA, Principles of Wind Profiler Operations, Prepared for the Office of Meteorology (National Weather Service), Profiler Program NOAA/ERL Boulder, CO, March 1988.

wind parameters from signals received from each of the beam positions. By integrating the backscatter signal pulses at one beam position over a suitably long period of time (i.e., 2 minutes), it is possible to operate with very low signal-to-noise ratios (e.g., -20 dB).

The desired backscattered signals required by the Wind Profiler are very weak compared with those that would be reflected, for instance, from an aircraft passing through the beam. Because the Wind Profiler uses relatively long periods of time for integration to extract the desired return signals from the noise, any undesired returns, such as those received from reflections by aircraft or flocks of birds are usually filtered out without affecting the accuracy of the wind measurements. However, at some specific Wind Profiler locations (e.g., airports), the accuracy of the wind measurements may be affected if the profiler processes numerous momentary undesired returns for long periods of time.

TABLE 3-1
SOME TYPICAL PROPERTIES OF PROFILERS OPERATING AT COMMON FREQUENCIES

	1 GHz	400 MHz	50 MHz
Altitude Range	0.2-5 km	0.5-16 km	2-20 km
Antenna Size	3 m^2	150 m^2	10,000 m^2
Peak Power	0.5 kW	40 kW	250 kW
Beam Width	6°	4°	3°
Effect of Raindrops	Large	Moderate	Small

(The altitude range shown is representative and considerable variation can occur, depending upon meteorological conditions and operating parameters.)

These Wind Profilers will provide several useful capabilities. For example, profilers will be used to improve short and long range weather forecast, to route commercial aircraft for improved fuel efficiency, and to monitor the atmosphere for hazardous conditions prior to rocket launches. Other possible uses are for monitoring the dispersion of rocket exhausts during the tests, wind monitoring for aerostat operations and pollutant dispersal.

Although Wind Profilers may differ in design depending on the user requirements, most 200-500 MHz profilers will measure a vertical profile of the horizontal wind movements every 6 minutes. To accomplish this, the data is taken and averaged for 2 minutes (1 minute in each high and low mode) in each beam direction (east, north, and vertical). The radar "high" mode is used for measuring winds at high altitudes and a "low" mode is used for measuring winds at low altitudes. The data contained in each profile consists of the return power and radial velocity for each beam position and altitude mode. At the end of this 6 minutes, the data is transmitted over dedicated phone lines or satellite links to a computer at a center location. These six-minute profiles are considered short term. Hourly wind profiles are also generated at the central location from the transmitted 6-minute data. Using the data received in a one-hour period (10 x 6 minute profiles), a random sample consensus algorithm (4 of 10 samples) is used to produce these one-hour profiles.

In summary, profilers are sensitive Doppler radars capable of measuring winds for a variety of functions. To accomplish this, they should operate in an environment free of interference. The desired atmospheric signals the profiler must detect are continuous and very low level. The entire process to obtain profiles is susceptible to interference, since it is similar to the atmospheric signal and will be processed by the profiler as erroneous wind measurements. Continuous interference must be avoided for useful profiler operation. Low duty

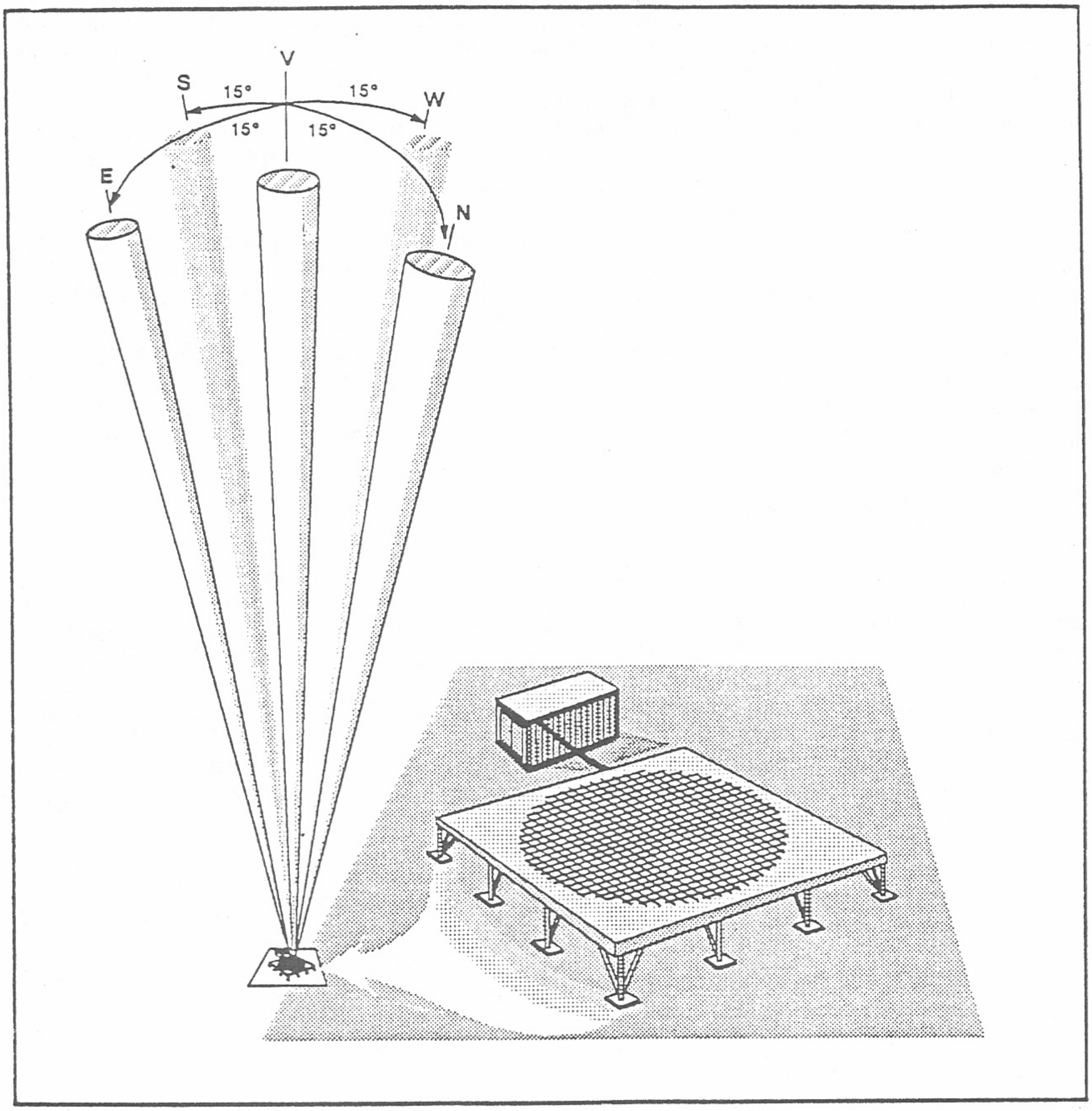

Figure 3-1. **Typical beam configuration for Wind Profilers consists of three beams: one vertical, and two tilted 15 degrees from zenith (to the east and north, for example). Under some circumstances, two additional beams are needed (such as to the south and west).**

cycle interference (i.e., pulsed transmissions with 1-3 interference episodes per hour) can be tolerated because only a few of the short term profiles are affected. The intermediate case of pulsed interference with many episodes per hour may degrade profiler operation depending on the level of the interference. As a result, continuous wave like interference received via direct path or indirect path coupling from fixed sources should be avoided. Pulsed interference received via direct path or indirect path coupling from sources may be tolerable depending on the level and the number of interference episodes occurring per hour. The type and amount of interference received by a Wind Profiler will vary depending on location. At the time of completion of this study, very limited measurements and/or studies have been available in the literature delineating the effects of interference on Wind Profilers operations.

In conjunction with obtaining wind profiles at various frequencies, a capability to obtain temperature profiles has been identified. Using the Radio Acoustic Sounding System (RASS) technique, temperature profiles with good time and height resolution are possible depending on the frequency of operation. The RASS is a promising method of remotely sensing temperature profilers by combining acoustic techniques utilizing signal processing capabilities of the Wind Profiler. It has been determined that the use of frequencies around or below 400 MHz would provide the most useful temperature profiles. The method to obtain temperature profiles would require an additional add-on feature to the current profiler design. Additional details on the RASS system and its capabilities are available in the literature.[5]

WIND PROFILER DEPLOYMENT

The number and types of Wind Profiler radars to be deployed nationally and internationally will vary depending on the particular user requirement. Internationally, plans for a European profiler network have been proposed; however, the specific details on the selection of various parameters such as frequency band, deployments, and characteristics of the European Wind Profiler network have not been selected. According to one manufacturer[6], a single Wind Profiler has been purchased by another country for research purposes. Nationally, several users (DOC, DoD, Treasury, and private sector) have stated their specific Wind Profiler requirements through fora such as Spectrum Planning Subcommittee (SPS) and Interdepartment Radio Advisory Committee (IRAC). Based on a review of these requirements, two distinct types of Wind Profilers are expected to be deployed nationally.

One type of Wind Profiler is to be used by the National Oceanic and Atmospheric Administration (NOAA) for weather forecasting and various meteorological studies (i.e., severe storms, pollution dispersal, etc.). In particular, this type of Wind Profiler will initially be used in a demonstration network of 30 Wind Profilers in the central part of the U.S. Figure 3-2 shows the initial deployment of the 30 NOAA Wind Profilers. It is estimated that once completed, the number of Wind Profilers in the NOAA network will range between 200 to 300 and will form a grid across the U.S. It is noted that this specific type of Wind Profiler may also be deployed by users other than NOAA (i.e., DoD).

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[5] May, P.T., Strauch, R.G., Moran, K.P., The Altitude Coverage Of Temperature Measurements Using RASS With Wind Profiler Radar, Wave Propagation Laboratory, ERL, NOAA, Boulder, Colorado, July 12, 1988.

[6] Patrick, G., NTIA and Vern Peterson, Chief Scientist, TYCHO Technology, Inc., Telephone conversation, March 26, 1990.

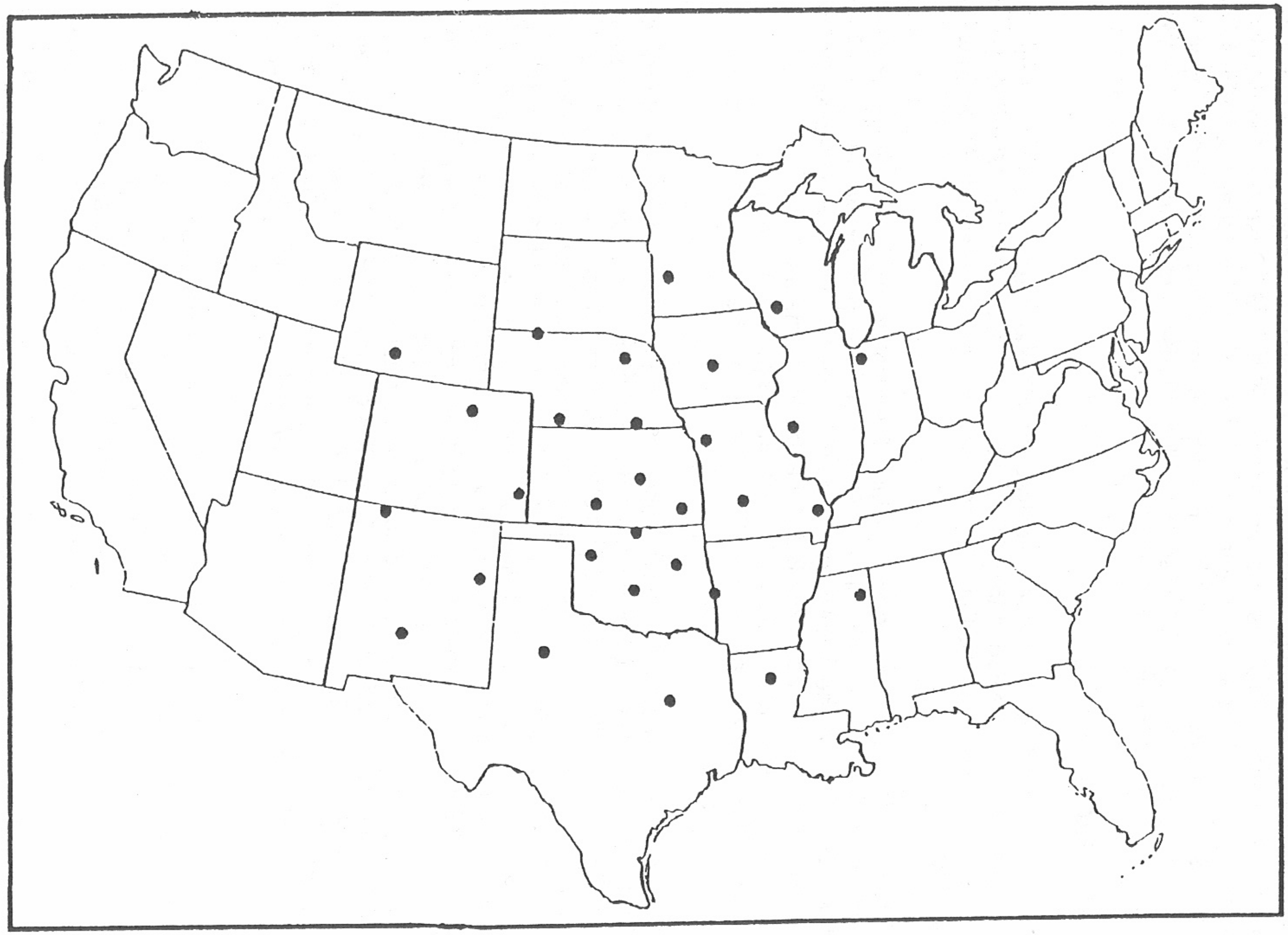

Figure 3-2. Locations of Initial 30 Wind Profilers to be deployed for the NOAA demonstration network.

A second type of Wind Profiler identified for national use will be a less complex version of the "NOAA Type" Wind Profiler with less altitude range (approximately 5-7 km compared to 15-20 km) coverage. This specific type of Wind Profiler will be used in operations such as Aerostat control, forest fire control, smog prediction, etc. The expected deployment and total numbers of these types of Wind Profilers are unknown. The U.S. Customs Service has expressed interest in deploying this particular type of profiler at six specific locations in the U.S. to aid in the operations of Aerostats.[7] In addition, Penn State University has a similar type of profiler deployed for research purposes. The assumed characteristics identified for both types of Wind Profilers are given in the following sub-section.

WIND PROFILER CHARACTERISTICS

Based on (1) applications that have been received for national spectrum support through the SPS, and (2) documentation received in the IRAC, two distinct types of Wind Profilers were identified for the study. Discussed below is the method in which the characteristics for each type of profiler was obtained.

The DOC has requested and been granted Stage 2 spectrum support for experimental operation of its Wind Profiler on 404.37 MHz. This particular profiler will be operated continuously and will be used in the NOAA experimental network initially consisting of 30 profilers (Figure 3-2) with the total number expected to reach approximately 200-300. In addition, the Navy requested and has been granted Stage 2 spectrum support for experimental operation of its Wind Profiler on 404.37 MHz. The Navy's Wind Profiler will be used for post graduate school meteorological efforts at Ft. Ord, CA.

The Wind Profilers to be used by both NOAA and Navy are similar since they will provide approximately 15-20 km range coverage; however, the designs of the two systems are different. For example, the NOAA Wind Profiler contains techniques, such as using minimum-shift keying (MSK) modulation, which makes it potentially more compatible with other systems. It is assumed that the Wind Profiler used by NOAA in the national network will represent a distinct type since there will be a large number deployed by NOAA and potentially other users. The deployed cost of this distinct type of profiler is approximately $500,000 for a single unit. The characteristics given in TABLE 3-2 are assumed to represent a typical NOAA Wind Profiler and were extracted from several sources such as SPS submissions, test measurement data, phone conversations with manufacturers, and data contained in the literature. To date, there have been no radiated test measurements to verify all the characteristics given in TABLE 3-2 that represent this specific type of Wind Profiler. This type of Wind Profiler will herein be referred to as Type A. The actual characteristics to represent a deployed NOAA profiler will be similar to those stated in TABLE 3-2. Some specific characteristics associated with the Type A profiler are discussed below.

The antenna to be used for the Type A Wind Profiler is a co-linear coaxial (COCO) type allowing high directivity in one direction. Specifically, the COCO antenna is made up of individual radiating elements. Each element is similar to a standard dipole antenna. By placing many of these dipole elements parallel and orthogonal to each other, a large-aperture antenna array is obtained. The COCO type antenna to be used for Type A profilers is a resonant coaxial

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[7] FAS Chairman, "Wind Profiler Radar," IRAC Doc. 26789/1-4.16/2.3.2, April 4, 1990.

structure and is inherently narrow band. According to the manufacturer[8], the far-out spectral energy is attenuated equivalent to a 7-pole bandpass filter with a 3 dB point at approximately 4 MHz away from resonance.

The transmitted pulses in Type A are phase modulated with a MSK waveform and pseudo random bit stream to reduce spectral sideband levels. In the high mode, there are three MSK symbols or chips per pulse, and in the low mode, there are two chips per pulse. Figure 3-3 shows the spectra of the transmitted signal out to 4 MHz for frequencies above the carrier; estimates have been made for spectral density at frequencies removed farther away from the carrier.

The antenna pattern for the Type A profiler, especially at large off axis angles from the mainbeam, is important in analyzing potential interference. To determine the off axis gain values, UNISYS conducted near-field measurements and used them to estimate the far-field gain values for each beam position.[9] The values obtained by UNISYS were further processed to determine the average gain level as a function of elevation angle gain for all beam positions.[10] The average antenna gain values contained in TABLE 3-2 represent the interpolated values from Reference 10 for off axis values between 15 and 90 degrees. A draft document available in the literature was used to determine the average off axis antenna gain value between 2.5 and 15 degrees.[11]

The characteristics assumed to represent the second distinct type of Wind Profiler were determined from several sources. Initially, this type of profiler was requested by the U.S. Customs Service, through the IRAC, to provide support of its Aerostat operations along the southern border of the U.S. and ultimately in the Caribbean area. However, the characteristics specified for this type of Wind Profiler (Reference 7) were insufficient for this study. One manufacturer indicated that a similar type of profiler is currently being used to support the atmospheric field program at the San Joaquin Valley Air Pollution Study Program, a program cosponsored by both the private sector and several state and local governments, and for the Penn State University. It was determined that the characteristics provided by the manufacturer[12] for this type of Wind Profiler represented similar characteristics to those stated for the U.S.

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[8] Hudson, E.F., UNISYS, "BANDWIDTH," MEMORANDUM TO: Dr. Hans Richner, Atmospheric Physics ETH (LAPETH), Zurich, Switzerland, March 31, 1990.

[9] Unisys (1988), "Wind Profiler Antenna Test Report," Contract No. NA-86-QA-C-101, July, 1988.

[10] Chadwick, A.B., SARSAT Interference Potential for Alaska Profiler Network, Profiler Program Office, Environmental Research Laboratories, May 24, 1990.

[11] Sullivan, T., Wolf, D., Potential Interference From Wind Profiler Radars to the COSPAS/SARSAT System (Draft), Atlantic Research Corp. (for NOAA/NESDIS), USSG 8C-303 (Rev-1), July 22, 1990.

[12] Peterson, Vern, Chief Scientist, TYCHO Technology, Inc., "TYCHO Parameters," Fax Correspondence, May 16, 1990.

Customs Wind Profiler. These characteristics, given in Table 3-2[13], were used to represent the second type of profiler, herein referred to as Type B. To date there have been no radiated test measurements to verify all the characteristics given in Table 3-2 that represent this type of Wind Profiler.

This second type of Wind Profiler is a less costly, less complex version as compared with the first type (Type A). For example, the altitude range coverage of this type of profiler is approximately 5-7 km with a peak power output of 800 Watts (59 dBm) compared to the 1520 km altitude range coverage and a peak power output of 16 kW for Type A. Currently, Type B profilers do not use MSK and pseudo random bit stream to potentially reduce spectral sidelobe levels. Although the requirements and characteristics for this type of Wind Profiler are different from those given for Type A, the process to obtain and generate wind profiles would be similar. The cost of this second type of Wind Profiler is approximately $150,000 as compared to approximately $500,000 for Type A. Spectrum certification from NTIA for this type of Wind Profiler has not been requested.

[13] The colinear coaxial (COCO) antenna for the Type B profiler is assumed to have the same properties as given for Type A (i.e., equivalent to 7-pole bandpass filter with a 3 dB point at approximately 4 MHz from resonance).

TABLE 3-2

ASSUMED CHARACTERISTICS FOR A & B TYPE PROFILERS

	TYPE A		TYPE B	
	High Mode	Low Mode	High Mode	Low Mode
Frequency (MHz)	404.37	404.37	404.37	404.37
Peak Transmitter Power (dBm)	72	69	59	59
Average Transmitter Power(dBm)	63.1	54.2	45.2	40.5
PRF (pulses per second)	6500	10,000	11000 pps	14,000 pps
Chip Width (μs)	6.67	1.67	n/a	n/a
Pulse Width (μs)	20	3.35	3	1
Pulse Duty Factor (%)	13	3.3	3.3	4.1
Mainbeam Gain (dBi)	32	32	27	27
Antenna Halfpower Beamwidth (deg.)	5	5	8	8
Antenna Type	Co-Linear Coaxial	Co-Linear Coaxial	Co-Linear Coaxial	Co-Linear Coaxial
Antenna Beam Elevation Angle (Alternating, East, North, Vertical)	90, 75 deg	90,75 deg	90,75 deg	90,75 deg
Antenna Polarization	Linear	Linear	Linear	Linear
Noise Level (dBm)	-124.9	-120.2	-110	-110
Emission Spectra[a]	Figure 3-3	Figure 3-3	Figure 3-5	Figure 3-5
IF Selectivity Response	Figure 3-4	Figure 3-4	Figure 3-6	Figure 3-6
Average Antenna Off Axis Gain Values:				
	Angle Range (deg)	Gain (dBi)	Angle Range (deg)	Gain (dBi)
	0-2.5	32	0-4	27
	2.5-15	10.7	4-15	5
	15-30	0	15-30	2
	30-60	-10	30-60	-4
	60-90	-20	60-90	-13
	[85-90][b]	-25	[85-90][b]	-20

a The emission spectra are assumed to be symmetrical about the carrier.

b The average gain at elevation angles near the horizon (less than 5 degrees, or antenna off-axis angles greater than 85 degrees) is on the order of -25 dBi and -20 dBi for Type A and Type B profiles, respectively. These are the values used for determining compatibility with surface systems.

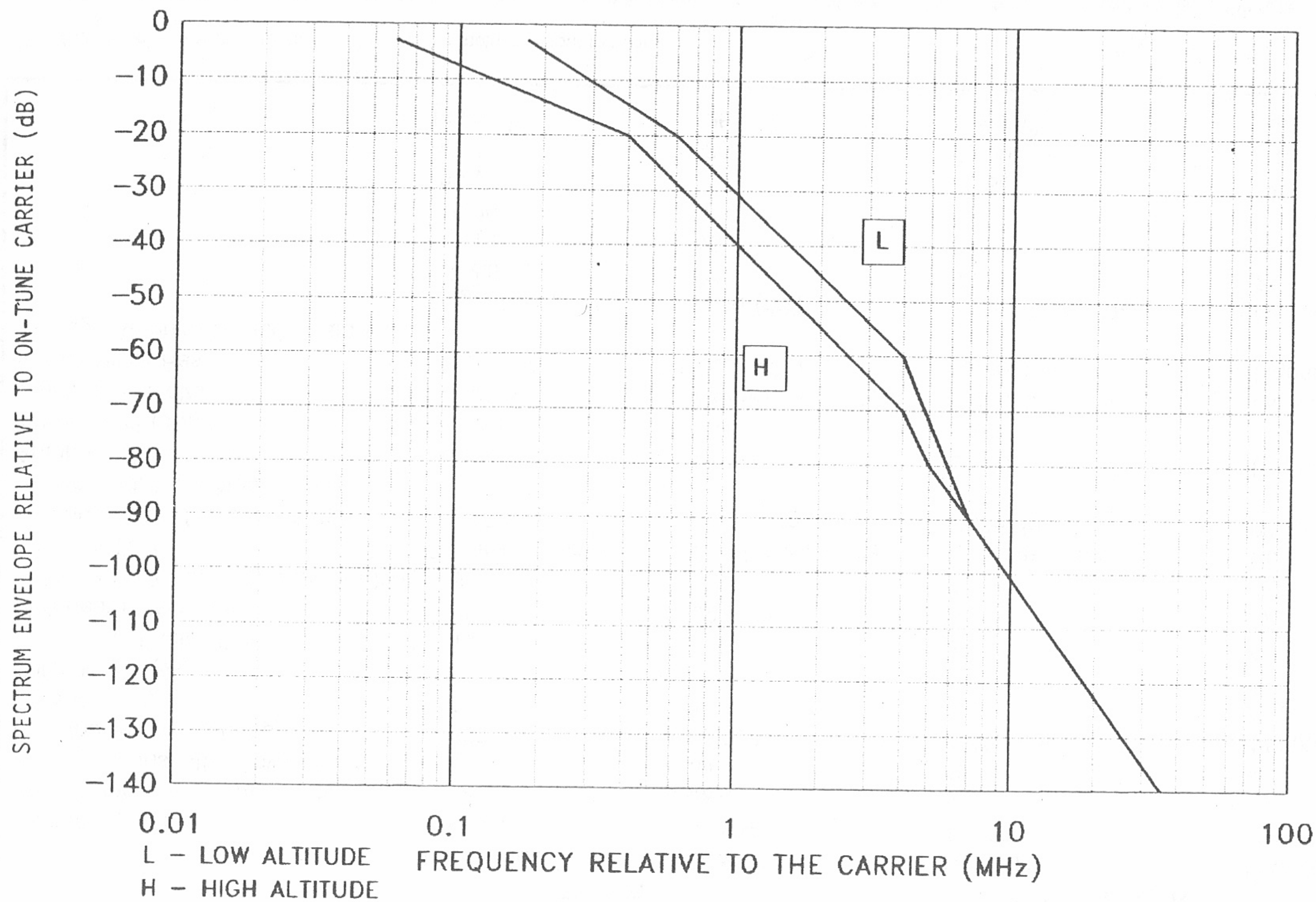

Figure 3-3. Type A Wind Profiler Emission Spectra.

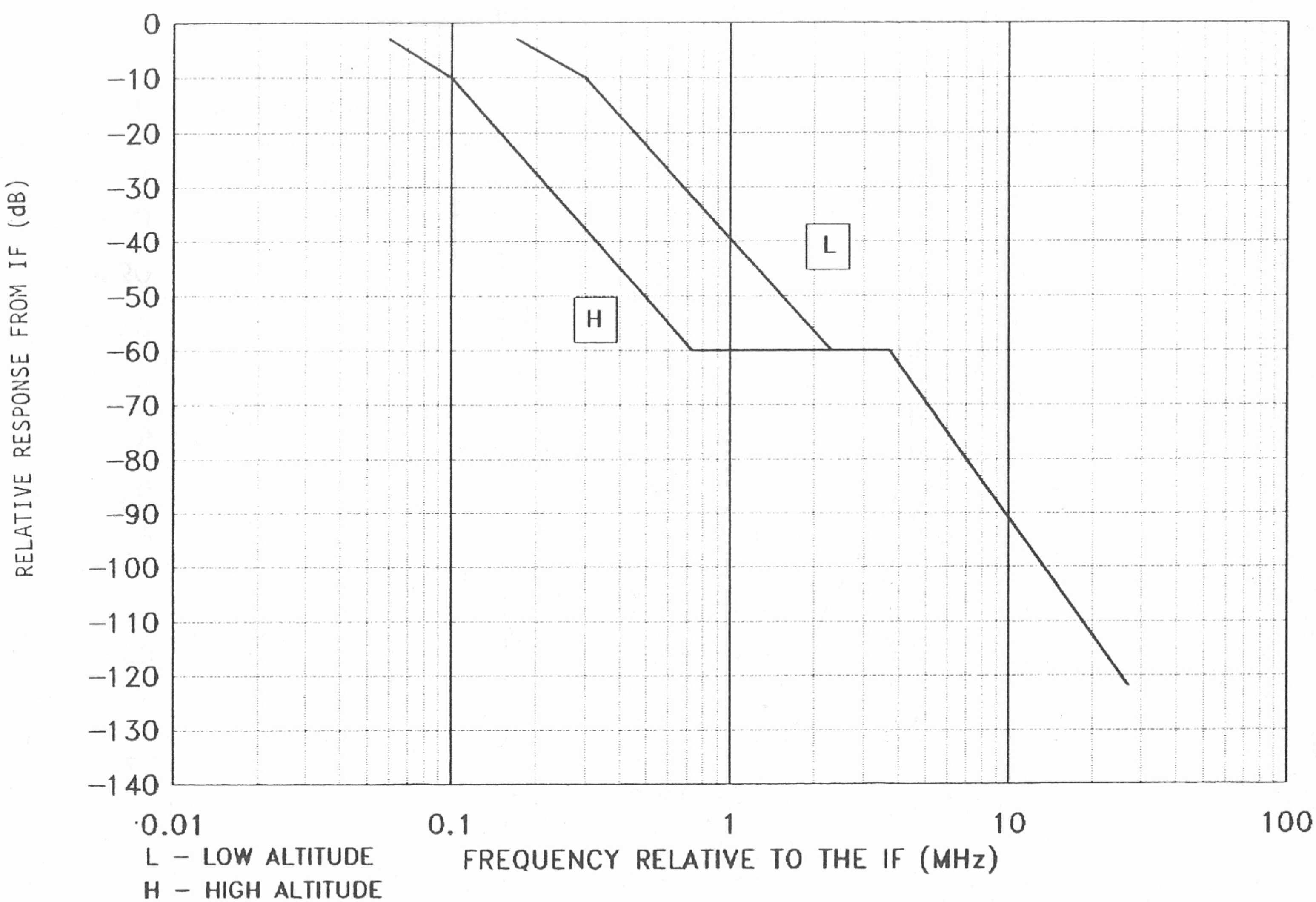

Figure 3-4. Type A Wind Profiler Selectivity.

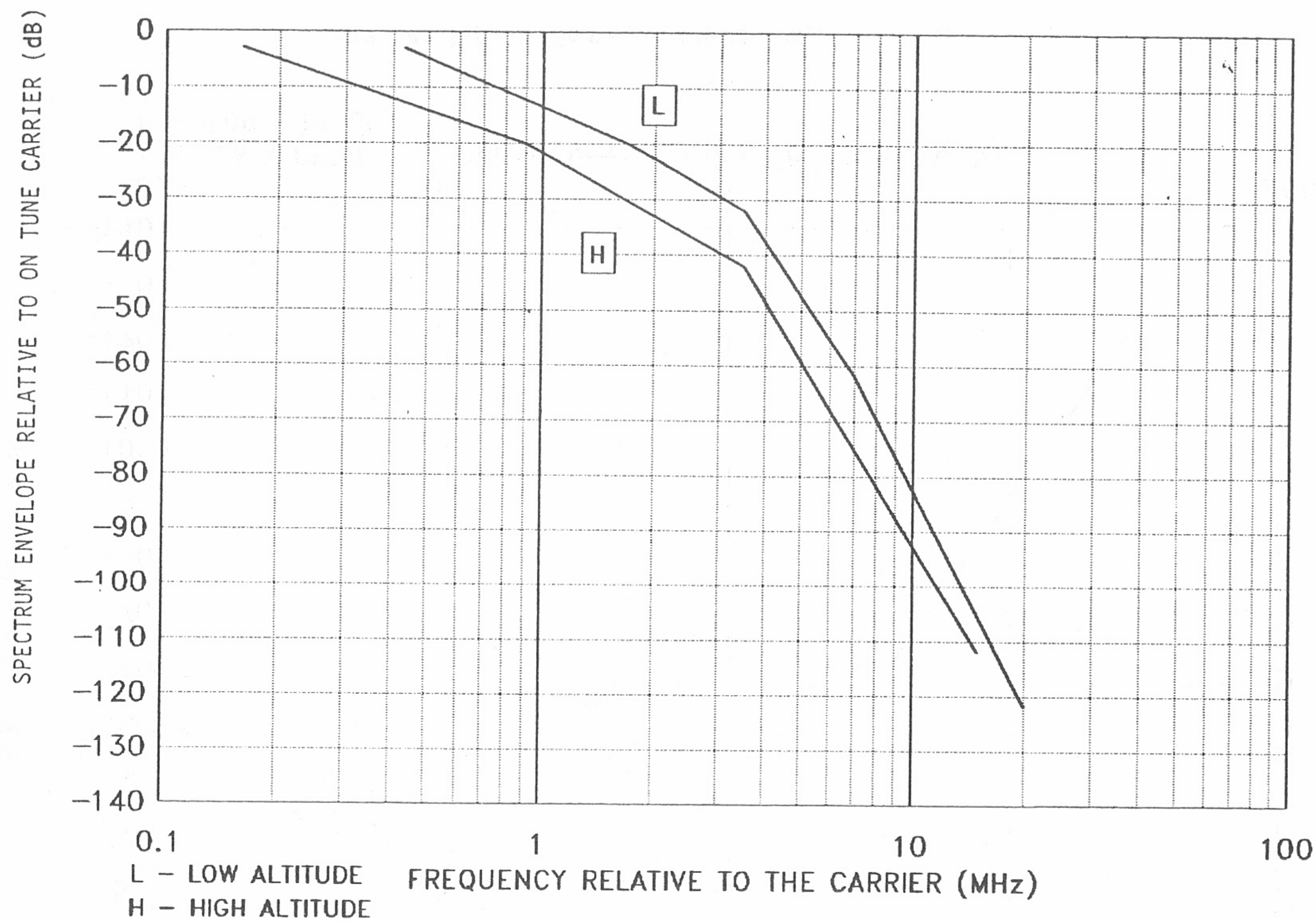

Figure 3-5. Type B Wind Profiler Emission Spectra.

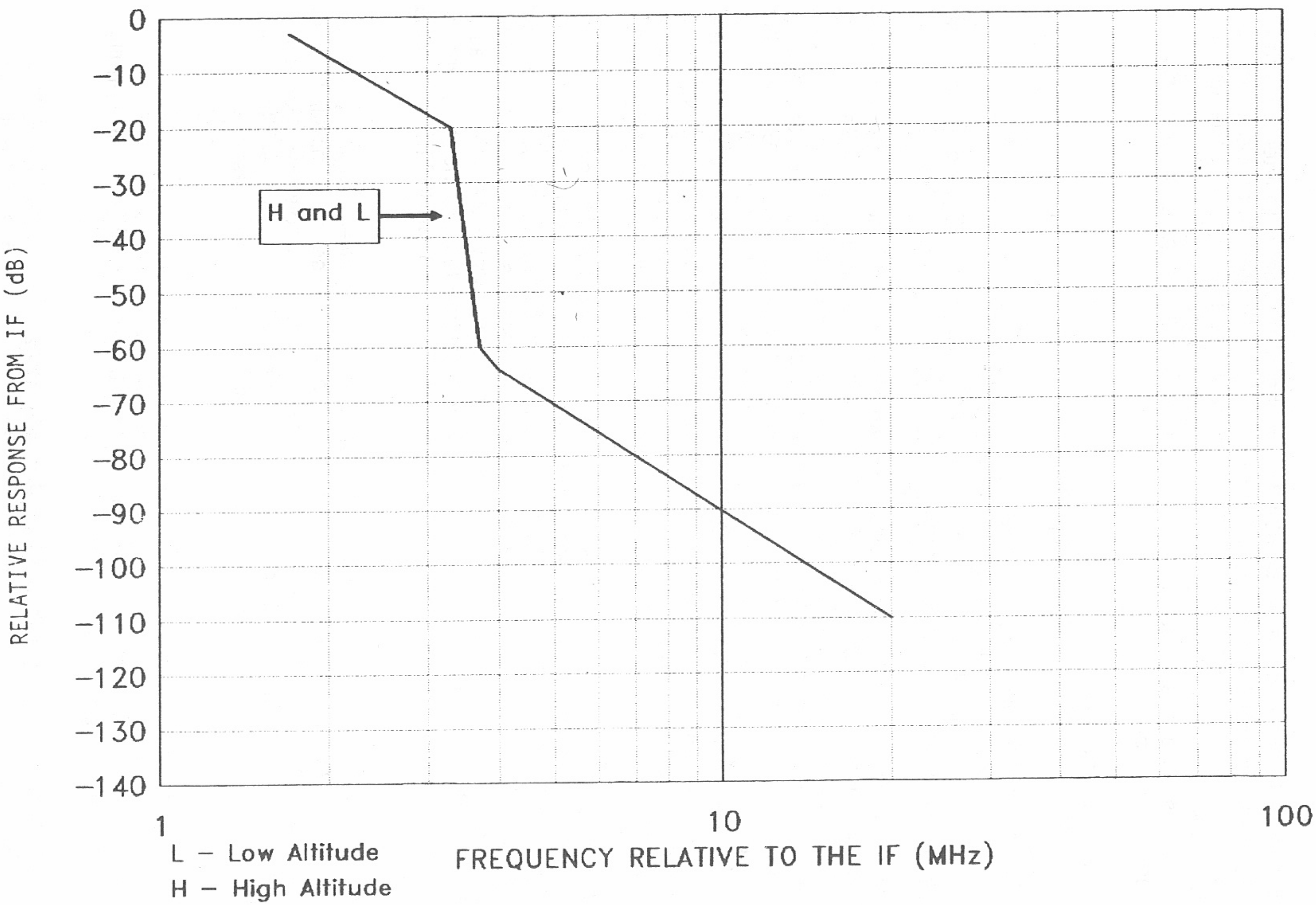

Figure 3-6. Type B Wind Profiler Selectivity.

WIND PROFILER DESIGN

Currently, Wind Profilers operating on 404.37 MHz have a potential to interfere with the COSPAS/SARSAT satellite which is a safety-of-life system. In attempting to preclude potential interference with the COSPAS/SARSAT from 404.37 MHz emissions, various enhancements were investigated and incorporated into some of the Wind Profiler designs. Specifically, various enhancement features have been incorporated into the "NOAA Type" Wind Profiler, Type A. These enhancements include:

1. Low sidelobe antenna
2. Controlled rise time transmitted pulse
3. Resonant antenna
4. Minimum shift keyed (MSK) signaling
5. Phase coding to decrease signal periodicity
6. Inhibit the transmitted signal when the COSPAS/SARSAT satellite is within approximately ±30 degrees of the profiler vertical mainbeam.[14]

Item 6 of this list regarding the shut down of the Wind Profiler is the most important factor for precluding interference to the COSPAS/SARSAT satellite. This shut down occurs when the COSPAS/SARSAT satellite is within approximately ±30 degrees of the profiler vertical mainbeam and is controlled by computer software. In addition, this shut down does not have an effect on the performance objective of the Wind Profiler users. Although this shut down may be controlled on a national basis, it is uncertain if similar procedures would be followed by other administrations. Without these features the COSPAS/SARSAT safety-of-life service may be at risk. For example, a U.S.-manufactured Wind Profiler, having the computer software techniques necessary to shutdown as the COSPAS/SARSAT satellite passes overhead, was purchased by another administration. Indications are that these shutdown techniques are not being used.

Utilizing the majority of these enhancements to the "NOAA Type Wind Profiler" (Type A), test measurements were conducted at the Goddard Space Flight Center in Greenbelt, MD[15] to determine the impact as a result of incorporating the aforementioned enhancements to the Wind Profiler deployed at Platteville, CO. The results of the test measurements indicated that the Wind Profiler's radiated emission was noticeable in the SARSAT receiver when the satellite was in close proximity of the Profiler's mainbeam. As a result, it was determined that the Wind Profiler must continue to shut down to preclude interference when the COSPAS/SARSAT is within the profiler's mainbeam.

In the future, additional enhancements to 404.37 MHz Wind Profiler design, as well as implementing siting factor considerations (i.e., fence, berm), may increase the compatibility with COSPAS/SARSAT and other systems. However, it is noted that any additional changes to existing 404.37 MHz Wind Profilers must address not only elimination of potential interference to the COSPAS/SARSAT but must take into consideration other factors such as:

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[14] This inhibit feature is assumed to be incorporated in all the various types of Wind Profilers deployed nationally at approximately 404.37 MHz.

[15] Sessions, W.B., Boyd, B.A. Measurements of Interference in the SARSAT 406 MHz Band Due to Wind Profiler Radars, Westinghouse Electric Corporation for National Aeronautics and Space Administration, May 11, 1990.

1. Cost
2. Performance Objectives
3. Number of Wind Profilers
4. Deployment of Profilers
5. Effects of Single versus Aggregate (both mainbeam and sidelobes)
6. Effects on other Satellites operating in the 400.15-406 MHz band (e.g., SARSAT receiver on the Geostationary Orbiting Exploration Satellite (GOES), ARGOS (401.65 MHz), and Data Collection Platforms (DCP's)
7. Effects on profiler operations from other systems
8. Time to implement

SUMMARY

Various factors associated with Wind Profilers operations such as performance, design requirements, characteristics, and number of units deployed, may vary depending on the specific user. Consideration must be given to each one of these factors individually, as well as the combination of these factors when analyzing compatibility with other systems.

In addition to the two types of Wind Profilers identified for the study, "other" types of Wind Profilers may be deployed as "one of a kind" or in multiple numbers. Those types of Wind Profilers may have varying characteristics regarding compatibility from those assumed for this study or may incorporate modifications to existing designs. Furthermore, some types of Wind Profilers may employ additional siting factors techniques (i.e., berm or fence) to potentially enhance compatibility with other systems. These "other" types of Wind Profilers are not considered in this report and should be considered on a case-by-case basis.

SECTION 4

CONFORMANCE TO RADIO REGULATIONS

INTRODUCTION

This section addresses the Wind Profiler's conformance to applicable rules and regulations (i.e., the Tables of Frequency Allocations, and technical standards) for operations in the bands 216-225 MHz, 400.15-406 MHz, and 420-450 MHz. International rules and regulations are addressed, in addition to applicable U.S. national rules and regulations, to identify existing provisions and potential problem areas for worldwide profiler deployments. The Wind Profiler is assumed to require accommodation on a primary basis, nationally for all users with consideration worldwide. However, for some agency requirements, secondary status may be acceptable. Since the Wind Profiler is a radar used primarily for weather prediction, it was considered as either a radiolocation station (station class LR) or as a meteorological radar station (station class WXD).

UNITED STATES - CANADA COORDINATION AGREEMENT

Wind Profiler deployment near the United States - Canada border in either of the bands 216-225 MHz or 420-450 MHz will require coordination with Canada prior to operation. Part 3.4 of the NTIA Manual contains the United States-Canada Coordination Agreement. Section 3.4.1 provides general information on the agreement and a table denoting the bands coordinated between IRAC, NTIA and Canadian Department of Communications (CDC). Section 3.4.2 is the Index to the Technical Annex which indicates for each of the five arrangements the frequency bands involved and the authorized coordination agencies or channels in each country for each band. In the frequency range 216-225 MHz, Joint Chiefs of Staff (JCS) is the coordination agency for the U.S. and Chief of Defense Staff (CDS) is the coordination agency for Canada. Arrangement C (Section 3.4.5) applies in this band. Paragraph (1) states, "It is agreed that coordination shall be effected in those frequency bands used by fixed installation radars, some of which are essential to the defence of North America, whenever there is considered to be a likelihood of harmful interference." In the frequency range 406.1-430 MHz, NTIA and the Department of Communications are the coordination agencies. Paragraph 6.6 of Arrangement E states, "Except for the state of Alaska, any future fixed installation radiolocation system proposed for United States operation within 250 km of the United States-Canada border which would normally operate in the 420-430 MHz band will be subject to prior coordination with Canada." In the band 420-450 MHz, JCS and CDS are the coordination agencies. Arrangement C applies to this band.

FREQUENCY ALLOCATIONS

In the following discussions, the conformance of the Wind Profiler operations to the Tables of Frequency Allocations[16] in the three bands is presented and possible changes necessary to accommodate profiler operations are identified. An assessment of Suitable,

[16] NTIA, Manual of Regulations and Procedures for Federal Radio Frequency Management, U.S. Department of Commerce, National Telecommunications and Information Administration, Washington, D.C., Revised January 1990.

Conditional, or Unsuitable is given regarding the potential national and international accommodation of Wind Profiler operations for each of the three frequency bands.

The only allocation change to the National Table of Frequency Allocations that was considered for this assessment was for the 216-225 MHz band. Other factors such as WARC-92 proposals and other pending FCC and NTIA allocation changes were not considered since they had not been approved at the initiation of this study.

216-225 MHz Band

Nationally, the frequency range 216-225 MHz is divided into three allocation bands: 216-220 MHz, 220-222 MHz, and 222-225 MHz. Internationally, this frequency range falls within two allocation bands: 174-223 MHz and 223-230 MHz (in Regions 1 and 3), and 216-220 MHz and 220-225 MHz in Region 2. The allocated services in the band 216-225 MHz are shown in TABLE 4-1, an excerpt of the National and International Tables of Frequency Allocations. The allocated services shown in TABLE 4-1 for the United States in bands 220-222 MHz and 222-225 MHz reflect allocation changes per IRAC Doc. 26106. The applicable footnotes to the allocation table are provided in Appendix A. The frequency range 216-225 MHz is allocated to a variety of services on different bases (i.e., primary and secondary) and on various conditions. The radiolocation service is allocated on a secondary basis in Region 2 and nationally radiolocation is limited to the military (Footnote G2); however, this allocation applies to only stations authorized prior to 1 January 1990 (Footnote RR627). Additional allocations for radiolocation are in the Radio Regulations footnotes.

To accommodate Wind Profilers, nationally, a change to the National Tables of Frequency Allocations would be necessary. The meteorological aids service would have to be added on a primary basis or the radiolocation service changed to primary status and Footnote G2 modified for this band. Alternatively, provision for Wind Profiler operations could be made by an additional US footnote. A national allocation accommodation would involve an NTIA decision and a FCC rulemaking proceeding which include involvement from many interested parties (e.g., land mobile, maritime mobile, amateur, and adjacent band broadcasters). The Notice of Proposed Rulemaking (NPRM) proceedings dealing with the maritime mobile service may also impact Wind Profiler accommodations. As a result of WARC-79, the primary radiolocation service allocation was reduced to secondary status and the footnote RR627 was introduced for Region 2 of the Allocation Table. The addition of footnote RR627 to the Allocation Table does not allow new radiolocation systems to operate in -Region 2 after January 1, 1990. The Wind Profiler would be difficult to accommodate, since the radiolocation service has been removed from the Table with the exception of existing radar systems. The national allocation accommodation of Wind Profiler operations is assessed as conditional.

Internationally, for Wind Profilers to be accommodated on a primary basis in this band, the meteorological aids service would have to be added to the international table or the radio location service upgraded in Region 2. In Regions 1 and 3, the meteorological aids or radiolocation service would have to be added in the allocation band 174-223 MHz. Accommodation by international footnote is also an option. These allocation changes would involve acceptance at a future WARC. Due to the diverse provisions of the current international table among the different regions, the present primary allocation to the broadcasting service in Regions 1 and 3, and the number of existing exceptions to the current table, the international accommodation of Wind Profiler is assessed as unsuitable in the bands 216-225 MHz.

TABLE 4-1
EXCERPTS FROM THE INTERNATIONAL AND NATIONAL TABLES OF FREQUENCY ALLOCATIONS FOR THE BAND 216-225 MHz

<table>
<tr><th colspan="3">INTERNATIONAL</th><th colspan="4">UNITED STATES</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th><th>Band MHz</th><th>Prov.</th><th>Gov.</th><th>Non-Gov</th></tr>
<tr><td rowspan="3">174-223
BROAD-
CASTING

621 623
628 629</td><td>174-216
BROAD-
CASTING
Fixed
Mobile

620</td><td rowspan="3">174-223
FIXED
MOBILE
BROAD-
CASTING

619 624
625 626
630</td><td>174-216</td><td></td><td></td><td>BROAD-
CASTING
(tele-
vision)

NG115</td></tr>
<tr><td>216-220
FIXED
MARITIME
MOBILE
Radio-
location
627
627A</td><td rowspan="2">216-220</td><td rowspan="2">US210
US229
US274
627</td><td rowspan="2">MARITIME
MOBILE
Radio-
location
Fixed
Aero-
nautical
Mobile
Land Mob
G2</td><td rowspan="2">MARITIME
MOBILE
Fixed
Land
Mobile
Aero-
nautical
Mobile

NG121</td></tr>
<tr><td rowspan="2">220-225
AMATEUR
FIXED
MOBILE
Radio-
location

627</td></tr>
<tr><td rowspan="2">223-230
BROAD-
CASTING
Fixed
Mobile

622 628
629 631
632 633
634 635</td><td rowspan="2">223-230
FIXED
MOBILE
BROAD-
CASTING
AERONAUTICAL
RADIONAV-
IGATION
Radiolocation

636 637</td><td>220-222</td><td>US243
627</td><td>LAND
MOBILE
Radio-
location

G2</td><td>LAND
MOBILE</td></tr>
<tr><td></td><td>222-225</td><td>US243
627</td><td>Radio-
location

G2</td><td>AMATEUR</td></tr>
</table>

400.15-406 MHz BAND

Nationally and internationally, the frequency range 400.15-406 MHz is divided into the four allocation bands: 400.15-401 MHz, 401-402 MHz, 402-403 MHz, and 403-406 MHz. The services allocated in these bands are shown in TABLE 4-2. The applicable footnotes to these frequency bands are listed in Appendix A. The bands are allocated to the space services and the meteorological aids service on a primary basis, worldwide. However, the U.S. meteorological aids allocation is limited to radiosondes and associated ground transmitters.

For the Wind Profiler to operate on a primary basis in this frequency range, the national limitation to radiosondes in the meteorological aids service would have to be removed or Wind Profilers added. Since this potential allocation change would be a national issue, the allocation accommodation of Wind Profiler operations is assessed as "conditional," nationally and "suitable," internationally.

420-450 MHz BAND

The frequency range 420-450 MHz is divided into three international allocation bands: 420-430 MHz, 430-440 MHz, and 440-450 MHz and is one allocation band, nationally. The services allocated to this frequency range are shown in TABLE 4-3 and the applicable footnotes to the allocation tables are listed in Appendix A. The radiolocation service is allocated in these bands on a primary basis, however, nationally, it is limited to the military (Footnote G2) and internationally, the bands 420-430 MHz and 440-450 MHz are allocated to the radiolocation service on a secondary basis. Additional allocations for radiolocation are made by footnotes from the Radio Regulations.

Nationally, for all Wind Profiler users to operate in the band 420-450 MHz, the meteorological service would have to be added to both the Government and non-Government Tables of Frequency Allocation or the radiolocation service would have to be added to the non-Government Table of Frequency Allocations and Footnote G2 would have to be removed from the Government table or modified. Specific provision for Wind Profiler operations could be made by an additional US footnote. These actions would require an NTIA decision and FCC rulemaking proceedings.

Internationally, the accommodation of Wind Profilers would involve adding the meteorological aids service to the table in the three bands, upgrading the radiolocation service to primary status in the bands 420-430 and 440-450 MHz, or adding another international footnote. Since, the proposed Wind Profiler operations would not occupy entirely any of the three allocation bands, the latter option appears to be the most feasible approach. The national and international accommodation of Wind Profiler to the allocation tables in this frequency range is assessed as conditional.

TABLE 4-2
EXCERPTS FROM THE INTERNATIONAL AND NATIONAL TABLES OF FREQUENCY ALLOCATIONS FOR THE BAND 400.15-406 MHz

INTERNATIONAL	UNITED STATES			
MHz	MHz	Prov	Government	Non-Gov.
400.15-401 METEOROLOGICAL AIDS METEOROLOGICAL-SATELLITE (Space-to-Earth) SPACE RESEARCH (Space-to-Earth) Space Operation (Space-to-Earth) 647	400.15 -401	US70	METEORO- LOGICAL AIDS (Radiosonde) SPACE RESEARCH (Space-Earth) METEORO- LOGICAL SAT. (Space-Earth) Space Oper. (Space-Earth)	METEORO- LOGICAL AIDS (Radiosonde) SPACE RESEARCH (Space-Earth) Space Oper. (Space-Earth)
401-402 METEOROLOGICAL AIDS SPACE OPERATION (Space-to-Earth) Earth Exploration- Satellite (Earth-to-Space) Fixed Meteorological-Satellite (Earth-to-Space) Mobile except aeronautical mobile	401- 402	US70	METEORO- LOGICAL AIDS (Radiosonde) SPACE OPER. Earth Explor- ation Sat. (Earth-Space) Meteoro- logical Sat. (Earth-Space)	METEORO- LOGICAL AIDS (Radiosonde) SPACE OPER. Earth Explor- ation Sat. (Earth-Space) Meteoro- logical Sat. (Earth-Space)
402-403 METEOROLOGICAL AIDS Earth Exploration- Satellite (Earth-to-Space) Fixed Meteorological-Satellite (Earth-to-Space) Mobile except aeronautical mobile	402- 403	US70	METEORO- LOGICAL AIDS (Radiosonde) Earth Explor- ation Sat. (Earth-Space) Meteoro- logical Sat. (Earth-Space)	METEORO- LOGICAL AIDS (Radiosonde) Earth Explor- ation Sat. (Earth-Space) Meteoro- logical Sat. (Earth-Space)
403-406 METEOROLOGICAL AIDS Fixed Mobile except aeronautical mobile 648	403- 406	US70	METEORO- LOGICAL AIDS (Radiosonde) G6	METEORO- LOGICAL AIDS (Radiosonde)

TABLE 4-3
EXCERPTS FROM THE INTERNATIONAL AND NATIONAL TABLES OF FREQUENCY ALLOCATIONS FOR THE BAND 420-450 MHz

<table>
<tr><th colspan="3">INTERNATIONAL</th><th colspan="4">UNITED STATES</th></tr>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th><th>Band MHz</th><th>Prov.</th><th>Government</th><th>Non-Gov</th></tr>
<tr><td colspan="3">420-430 MHz

FIXED
MOBILE except aeronautical mobile
Radiolocation
651 652 653</td><td rowspan="3">420-450</td><td rowspan="3">US7
US87
US217
US228
US230
664
668</td><td rowspan="3">RADIOLOCATION

G2 G8</td><td rowspan="3">Amateur

NG135</td></tr>
<tr><td>430-440

AMATEUR
RADIO-
LOCATION

653 654
655 656
657 658
659 661
662 663
664 665</td><td colspan="2">RADIOLOCATION
Amateur

653 658 659
660 663 664
660A</td></tr>
<tr><td colspan="3">440-450 MHz

FIXED
MOBILE except aeronautical mobile
Radiolocation
651 652 653 666 667 668</td></tr>
</table>

SUMMARY

In accordance with the provisions of the current National and International Tables of Frequency Allocations, none of the three frequency bands under consideration can accommodate all potential Wind Profiler operations on a primary basis, worldwide. Presently, the only band allocated to the meteorological aids service, of the three bands, is in the band 400.15-406 MHz; however, in the U.S., this allocation is limited to radiosondes. The radiolocation service is allocated in the bands 216-225 MHz and 420-450 MHz, but the Wind Profiler, as a new radiolocation radar station, could operate on a worldwide primary basis only in the band 430-440 MHz and, nationally, this operation would be limited to the military. Changes to the National Allocations Table would be necessary before Wind Profilers could be operated on a primary basis in any of the frequency bands being considered for this study. To accommodate Wind Profilers nationally, a new U.S. footnote would be the most feasible approach.

TABLE 4-4 provides the assessment of "unsuitable", "conditional" or "suitable" for Wind Profiler being considered in the meteorological aids or radiolocation services. For the purpose of this allocation assessment, "suitable" means presently allocated; "conditional" means currently not allocated, but accommodation possible; and "unsuitable" means not allocated and accommodation difficult and judged not possible.

TABLE 4-4

SUITABILITY

FREQ. [MHz]	NATIONAL MILITARY/NON-MIL./NON-GOV.			INTERNATIONAL REGION 1/REGION 2/REGION 3			OVERALL SUITABILITY
216-220	C	C	C	U	C	U	U
220-222	C	C	C	U	C	U	U
222-225	C	C	C	U	C	U	U
400.15-406	C	C	C	S	S	S	C
420-430	S	C	C	C	C	C	C
430-440	S	C	C	S	S	S	C
440-450	S	C	C	C	C	C	C

S - Suitable
C - Conditional
U - Unsuitable

TECHNICAL STANDARDS

GOVERNMENT TECHNICAL STANDARDS

Chapter 5 of the NTIA Manual contains the technical standards, minimum performance requirements and design objectives that are applicable to telecommunication equipment used in Government radio stations. However, within the Federal Government, any Government agency may promulgate more stringent standards for its own use.

The technical standards for Government meteorological and radiolocation radar stations depend on the date of the development and subsequent procurement contract and the frequency band of operation.

Radar Spectrum Engineering Criteria

The Radar Spectrum Engineering Criteria (RSEC) apply to all Government radar systems. RSEC specifications are contained in Part 5.3 of the NTIA Manual. The RSEC specifies certain equipment characteristics to ensure an acceptable degree of electromagnetic compatibility among radar systems, and between such systems and those of other radio services sharing the frequency spectrum. Since the initial adoption of the RSEC by NTIA, there have been several revisions to the RSEC. The RSEC is applicable to Government ground-based meteorological radar stations built after January 1, 1973 and before October 1, 1997. The RSEC C is applicable to Government ground-based meteorological radar stations effective October 1, 1977.

While the specific technical requirements of the RSEC are omitted herein, the following list identifies the radar characteristics that are considered:

(1) Emission Bandwidth
(2) Emission Levels
(3) Antenna Patterns
(4) Frequency Tolerance
(5) Tunability
(6) Image and Spurious Rejection
(7) Local-oscillator Radiation

WIND PROFILER CONFORMANCE TO GOVERNMENT TECHNICAL STANDARDS

The Wind Profiler would fall under the provisions of Part 5.1 in the NTIA Manual. Specifically, the Table of Frequency Tolerances and Unwanted Emissions contained in Part 5.1 directs the reader to Section 5.3.2 (RSEC C) if the system is considered to be a radiolocation station operating in the frequency range 100-470 MHz. The Wind Profiler may also be considered a Meteorological Aid. No guidance is given for a meteorological aids station in the Table of Frequency Tolerances and Unwanted Emissions of the NTIA Manual or the ITU Radio Regulations. For this case, RSEC C would still be the most appropriate standard.

To date, the Department of Commerce, Air Force and Navy have submitted proposals to the SPS requesting spectrum support for their Wind Profiler systems. Each of the systems reviewed does not entirely conform to RSEC C. Although the systems reviewed fall under RSEC C, a Wind Profiler with a peak power of 1 kW or less would fall under RSEC A. RSEC A presently exempts the system from the RSEC. In such a case, paragraph 5.1.3.D. of the NTIA

Manual would apply. The standards referred to in paragraph 5.1.3.D. are less stringent than that of the RSEC. In general, when there is no national guidance regarding standards, the ITU Radio Regulations are used.

WIND PROFILER CONFORMANCE TO NON-GOVERNMENT TECHNICAL STANDARDS

The Wind Profiler is assumed to fall under Part 90 of Title 47 of the U.S. Code of Federal Regulations[17] regarding technical standards. This applies to radiolocation systems, as well as meteorological aids systems, since the FCC considers meteorological radars and radiolocation radars similarly.

[17] Federal Communications Commission, Title 47 Code of Federal Regulations. Telecommunications, Part 80 to End, Office of the Federal Register, National Archives and Records Administration, Revised as of October 1, 1990.

SECTION 5

SPECTRUM USAGE

INTRODUCTION

This section provides information on current Government and non-Government spectrum usage in the bands 216-225 MHz, 400.15-406 MHz and 420-450 MHz in the U.S. Spectrum usage is developed from frequency assignments in the Government Master File (GMF), the FCC database, systems listed in the Systems Review File (SRV), agency interviews and available documents. In addition, various Government agencies were contacted to verify major systems, as well as to provide additional parameters on selected systems. The information is used to compile tables of agency/service distribution and identify typical and major systems. Data is also provided on equipment nomenclatures and types, functional uses and deployment. Experimental assignments are not discussed in detail. Spectrum usage in other countries is not considered.

BAND I: 216-225 MHz

General

In this frequency range, the study is broken into two bands: 216-220 MHz and 220-225 MHz. The effects of recent allocation changes, adopted by both the FCC and NTIA, on spectrum usage are discussed. A statistical characterization of present band usage is provided. TABLES 5-1, 5-2, and 5-3 show the agency/service distribution in the bands 216-220, 220-222 and 222-225 MHz, respectively. The tables are discussed in the following paragraphs under government and non-government usage. In a few cases where an assignment has more than one service, the assignment is counted for each service the system operates. The service category "NO SPECIFIC" applies to the experimental assignments and other assignments without a designated service. Figures 5-1 and 5-2 are maps of the distribution of GMF assignments with geographical coordinates in the bands 216-220 MHz and 220-225 MHz. Experimental assignments are excluded from the maps.

216-220 MHz Band

TABLE 5-1
AGENCY/SERVICE DISTRIBUTION OF
FREQUENCY ASSIGNMENTS IN THE 216-220 MHz BAND

	A	AF	AR	C	CG	DOE	HHS	I	J	N	NASA	NG	NSF	TRAN	TOTAL/SERVICE	PERCENT
AERONAUTICAL MOBILE			2								3				5	0.5%
FIXED			8			65		68				33			174	17.6%
LAND MOBILE						12	1					24			37	3.7%
MOBILE	2	19	4	1		20		2	5	6	10	567	6	3	645	65.3%
RADIOLOCATION					1	20				6					27	2.8%
NO SPECIFIC	2	6								12		80			100	10.1%
TOTAL/AGENCY	4	25	14	1	1	117	1	70	5	24	13	704	6	3	988	100.0%
PERCENT	0.4%	2.5%	1.4%	0.1%	0.1%	11.9%	0.1%	7.1%	0.5%	2.4%	1.3%	71.3%	0.6%	0.3%		100.0%

TABLE 5-2
AGENCY/SERVICE DISTRIBUTION OF
FREQUENCY ASSIGNMENTS IN THE 220-222 MHz BAND

	AF	AR	NG	TOTALS/SERVICE	PERCENT
FIXED		42		42	61.8%
NO SPECIFIC	1		25	26	38.2%
TOTALS/AGENCY	1	42	25	68	100.0%
PERCENT	1.4%	61.8%	36.8%		100.0%

TABLE 5-3
AGENCY/SERVICE DISTRIBUTION OF
FREQUENCY ASSIGNMENTS IN THE 222-225 MHz BAND

	AR	NASA	TOTAL/SERVICE	PERCENT
FIXED	63		63	98.4%
NO SPECIFIC		1	1	1.6%
TOTAL/AGENCY	63	1	64	100.0%
PERCENT	98.4%	1.6%		100.0%

Government Usage

In the 216-220 MHz band there is a total of 988 assignments. TABLE 5-1 shows that the majority of the assignments are for systems in the mobile services. This is followed by experimental, fixed, and radiolocation assignments. Many of the fixed and mobile assignments are for land telemetering as limited by footnote US274.

Government usage of the band 216-220 MHz is sparse. According to the GMF there are no maritime mobile operations in the band and very little aeronautical mobile use. The predominant Government users in the band are the Departments of Energy and Interior with assignments primarily for telemetry systems in the fixed and mobile service for seismology. Many of the systems are used intermittently as required by the experiment being conducted. These assignments are located throughout the U.S. The only major radar in this band is the Navy SPASUR. The SPASUR operates on the frequency 216.98 MHz (±1 Hz). The Navy has

Figure 5-1. Distribution of GMF assignments with geographical coordinates in the 216-220 MHz band.

Figure 5-2. Distribution of GMF assignments with geographical coordinates in the 220-225 MHz band.

four assignments for the SPASUR system, a bi-static radar used to collect data on satellite trajectories. It is a CW Doppler fence radar with transmitters in Alabama, Arizona and Texas and receivers in Arkansas, Mississippi, California, New Mexico and two in Georgia.

Non-Government Usage

In the lower adjacent band, there are TV channel 13 (210-216 MHz) operations throughout the U.S. which have the potential to receive interference from Wind Profilers. To date no study has been performed to assess the compatibility between Wind Profilers and TV-13 receivers. Figure 5-3 is a contour map prepared by A. D. Ring & Associates, P.C. for TV Answer Inc. which shows 170 km contours of the TV-13 transmitters throughout the U.S.

The 216-220 MHz band is allocated to the maritime mobile service on a primary basis. Footnote NG121 limits the use of this band to operations along the Mississippi River and connecting waterways, Gulf Intercoastal Waterways, and the offshore waters of the Gulf of Mexico. No maritime mobile assignments are listed in the GMF; however, there are license records for the Automated Maritime Telecommunications Service (AMTS) in the FCC database located in the areas specified by footnote NG121. Presently, there is a Notice of Proposed Rulemaking (NPRM) from the FCC regarding expanding maritime mobile service to nationwide. If the Report and Order is adopted, the footnote NG121 will be modified or deleted. The land mobile, aeronautical mobile and fixed services are all allocated on a secondary basis. In the lower adjacent band 210-216 MHz, TV-13 operates nationwide. The heaviest concentration of TV-13 locations is in the eastern half of the country. The majority of GMF assignments are non-Government assignments as shown in TABLE 5-1. The majority of the non-Government assignments are surface telemetry stations in the mobile service. Other usage includes land mobile, fixed and experimental operations. As with Government operations, the non-Government assignments are primarily for seismology. On the frequency 219 MHz, there is an experimental (XC) Wind Profiler assignment for the University of Alaska at North Star County, AK. The assignment is for research in air turbulence using the radar under Air Force contract. The system has an ERP of 40 kW and an emission designator of 2M00P0N.

220-225 MHz Band

Government Usage

In the band 220-225 MHz, there are 132 GMF assignments (68 in 220-222 MHz and 64 in 222-225 MHz). The GMF shows that all assignments are in the fixed and experimental services. All of the fixed assignments are for the Army AN/GRC-103. The AN/GRC-103 is a point-to-point communication system used for training at military installations throughout the US&P. These fixed assignments utilize one or more transportable transmitting and/or receiving stations. Due to the allocation change, these assignments operate on a Non-Interference Basis (NIB). Currently, there are no radiolocation assignments in the 220-222 MHz and 222-225 MHz bands; footnote RR627 precludes additional radiolocation assignments.

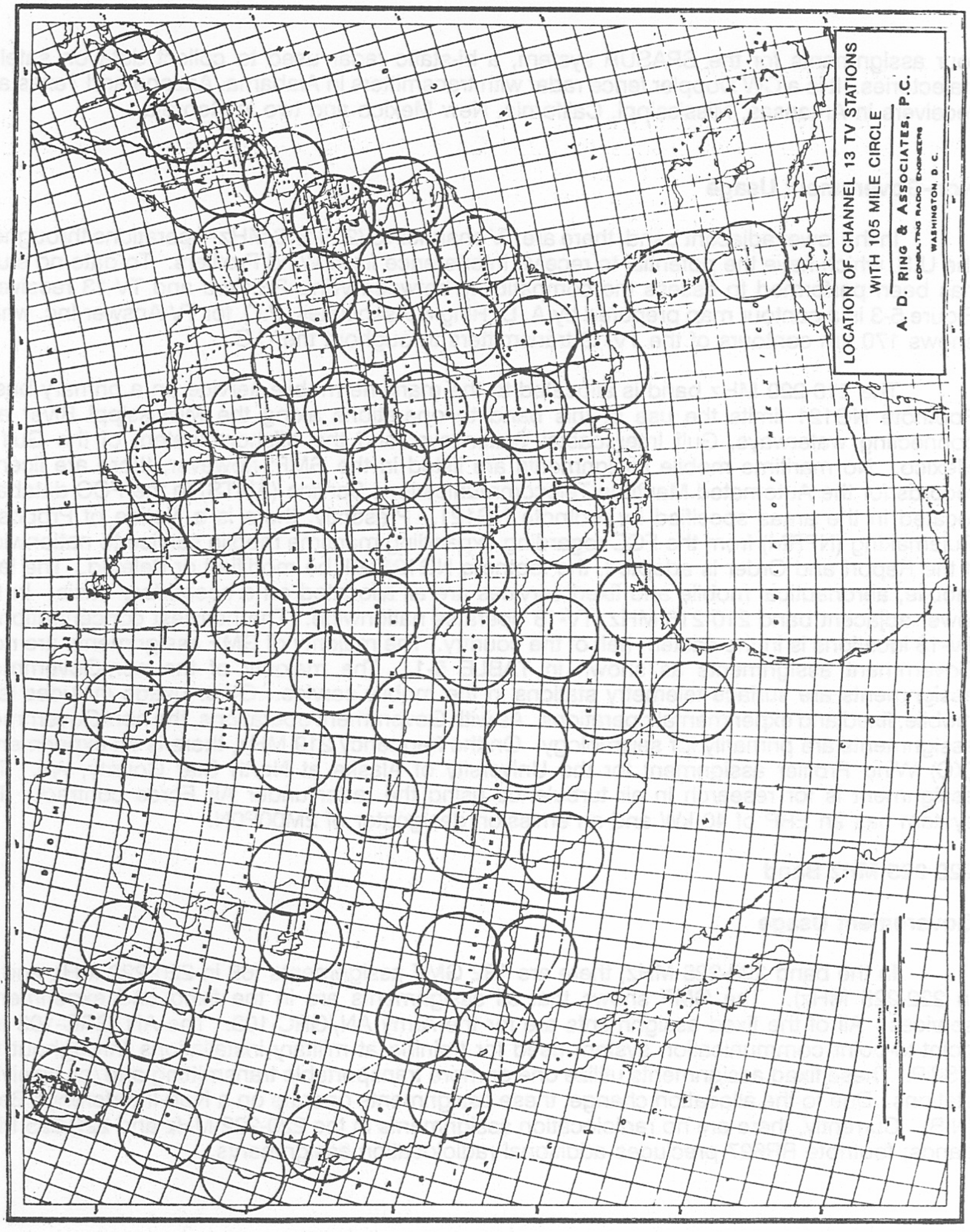

Figure 5-3. Map of TV-13 Transmitters Throughout the U.S.

Non-Government Usage

The only non-Government usage shown in the GMF are experimental assignments. Because of the allocation change, the 220-222 MHz band is only allocated to the land mobile service on a primary basis. At the present time, there are no land mobile operations in the band. It is anticipated that there will be a heavy concentration of narrow-band land mobile operations. All of the XD assignments are for the development of single and multi-transmitter system equipment or the development of Amplitude Compandored Single Side Band (ACSSB) equipment in the new band 220-222 MHz.

Other than the amateur activities in the 220-225 MHz band, the non-Government usage reflected by license records contained in the FCC database is used mainly for telemetry systems. The major usage is in the industrial area with petroleum and electric utility industries being extensive users. Other users are broadcasters, universities, steel companies, aluminum companies, heavy equipment, geology, automotive and tire test tracks and other transportation industries. The amateur service is the heaviest user of the 220-225 MHz band throughout the U.S. The 220-222 MHz band is used by the amateurs for point-to-point communications using single sideband (SSB) and frequency modulation techniques. Experiments are conducted involving propagation and long-distance communications. The 222-225 MHz portion of the band is used for FM communications involving conventional land mobile communications techniques using repeaters, base stations and land mobile units. Communications are usually within a 60 km radius of the repeater. The southern California area contains the heaviest concentration of activities.

Amateur use in the 220-225 MHz band is extracted from the American Radio Relay League (ARRL) directory, 1990-1991 edition and is provided below.[18]

220.00-220.05 MHz	EME (Earth-Moon-Earth)
220.05-220.06 MHz	Propagation beacons
220.06-220.10 MHz	Weak signal CW
220.10 MHz	Calling frequency
220.10-220.50 MHz	General weak signal, rag chewing and experimental communications
220.50-221.90 MHz	Experimental and control links
221.90-222.00 MHz	Weak signal guard band
222.00-222.05 MHz	EME
222.05-222.06 MHz	Propagation beacons
222.06-222.10 MHz	Weak signal CW
222.10 MHz	Calling frequency
222.10-222.30 MHz	General operation CW or SSB, etc.
222.34-223.38 MHz	Repeater inputs
223.34-223.90 MHz	Simplex and repeater outputs (local option)
223.94-224.98 MHz	Repeater outputs

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[18] American Radio Repeater League (ARRL), The ARRL Repeater Directory, 1990-1991 ed., p. 34, p. 37.

BAND II: 400.15-406 MHz

General

In the 400.15-406 frequency range, there are four national allocation bands. A statistical characterization of each of the bands is provided. The bands support meteorological satellites and radiosondes. This frequency range is used by both the Government and non-Government in the space services and meteorological aids service. These services are used to gather meteorological data for weather forecasting, severe storm warning, public safety, and research. The meteorological aids service is limited to radiosondes and associated ground transmitters. Numerous government agencies use radiosondes. The meteorological data is presently gathered by satellite imagery and radiosondes. Wind Profilers are also being used experimentally as identified in the following paragraphs. The DOC operates the GOES and TIROS-N satellites for weather forecasting. The SARSAT receiver, also located on these satellites, operates in the upper adjacent allocation band 406-406.1 MHz. The SARSAT system provides a safety-of-life service.

Provided in TABLES 5-4, 5-5, 5-6 and 5-7 are the agency/service distribution in the 400.15-401, 401-402, 402-403 and 403-406 MHz bands, respectively. The tables are discussed under Government and non-Government usage for each band. In a few cases where an assignment has more than one service, the assignment is counted for each service the system operates. The service category "NO SPECIFIC" applies to the experimental assignments and other assignments without a service designation. Experimental assignments are excluded from the maps.

There are 7,993 GMF assignments in this band. This is far more than any other band under consideration. These assignments are concentrated in the 401-402 MHz band which has 7,741 of the assignments. The GMF shows that the vast majority of stations are meteorological-satellite earth stations. These assignments are primarily for the Army and Interior. There are also many radiosondes and associated ground stations.

400.15-401 MHz Band

TABLE 5-4 shows that this band has 110 GMF assignments. All of the assignments have band assignments with an operating frequency range of 400.15-406 MHz. All of the assignments have the station class WXR (radiosonde) or WXRG (radiosonde ground) with the exception of one experimental (XR) NASA space system. The DOC has all except nine of the assignments. Agriculture, Energy, NASA, Navy and NSF have the rest. Eighteen of the assignments are Commerce assignments in Alaska. Other assignments are located in the continental U.S. and Puerto Rico. There are also three USA and two US&P assignments.

TABLE 5-4
AGENCY/SERVICE DISTRIBUTION OF
FREQUENCY ASSIGNMENTS IN THE 400.15-401 MHz BAND

	A	C	DOE	N	NASA	NSF	TOTAL/SERVICE	PERCENT
METEOROLOGICAL SATELLITE					1		1	0.9%
METEOROLOGICAL AIDS	1	100	3	1		2	107	97.3%
NO SPECIFIC		1			1		2	1.8%
TOTAL/AGENCY	1	101	3	1	2	2	110	100.0%
PERCENT	0.9%	91.8%	2.8%	0.9%	1.8%	1.8%		100.0%

401-402 MHz Band

TABLE 5-5 shows that this band has 7,741 assignments. The majority of assignments are for meteorological-satellite earth stations (Earth-to-space). The agencies with the most meteorological satellite earth stations (TM) are Interior (3,280), Army (3,262) and Commerce (873). Most of the TM assignments are for GOES or are in support of TIROS-N. In this band, the GOES-I will receive data from terrestrial Data Collection Platforms (DCP), which is scheduled to be launched in July 1991. There are 201 occurrences of the XR station class. The non-Government has all but one XR station class occurrence. There are four Army WXR station classes and six Navy WXRG station classes.

TABLE 5-5
AGENCY/SERVICE DISTRIBUTION OF
FREQUENCY ASSIGNMENTS IN THE 401-402 MHz BAND

	A	AF	AR	C	DOE	EPA	I	N	NASA	NG	NSF	TVA	TOTAL/SERVICE	PERCENT
EARTH EXPLORATION SATELLITE							1						1	0.0%
METOROLOGICAL AIDS		2	4					6					12	0.2%
METOROLOGICAL SATELLITE	9		3262	873	24	1	3280	1	2		3	67	7522	97.2%
RADIODETERMINATION SATELLITE				2									2	0.0%
SPACE OPERATION				3									3	0.0%
NO SPECIFIC				1						200			201	2.6%
TOTAL/AGENCY	9	2	3266	879	24	1	3281	7	2	200	3	67	7741	
PERCENT	0.1%	0.0%	42.2%	11.4%	0.3%	0.0%	42.4%	0.0%	0.0%	2.7%	0.0%	0.9%		100.0%

402-403 MHz Band

TABLE 5-6 shows that in this band, there are 10 GMF assignments. The station classes that occur in this band are TM, WXR, WXRG and XT. All of the WXR assignments are in California. The three TM assignments are for Commerce's Project Seas, a shipboard environmental data acquisition system with up to 100 units aboard commercial, research and NOAA ships. The one experimental (XT) assignment is also for Commerce. It is for a lab made Wind Profiler radar in Erie, CO. It operates on a frequency of 402.6 MHz. It has a power emission designator and gain of 1.2 MW, 1 M00P0N and 26 dBi, respectively. Also in this band, the GOES will receive from terrestrial Data Collection Platforms (DCP).

TABLE 5-6
AGENCY/SERVICE DISTRIBUTION OF
FREQUENCY ASSIGNMENTS IN THE 402-403 MHz BAND

	AF	AR	C	TOTAL/SERVICE	PERCENT
METOROLOGICAL SATELLITE			3	3	30.0%
METOROLOGICAL AIDS	2	4		6	60.0%
NO SPECIFIC			1	1	10.0%
TOTAL/AGENCY	2	4	4	10	100.0%
PERCENT	20.0%	40.0%	40.0%		100.0%

403-406 MHz Band

TABLE 5-7 shows that in the band 403-406 MHz, there are 132 GMF assignments. Nearly all of the assignments are WXR, WXRG or experimental stations.

TABLE 5-7
AGENCY/SERVICE DISTRIBUTION OF
FREQUENCY ASSIGNMENTS IN THE 403-406 MHz BAND

	A	AF	AR	C	DOE	N	NASA	NG	NSF	TOTAL/SERVICE	PERCENT
METEOROLOGICAL AIDS	2	25	30		25	21	2		12	117	88.6%
MOBILE	1									1	0.8%
NO SPECIFIC		2		3		1	1	7		14	10.6%
TOTAL/AGENCY	3	27	30	3	25	22	3	7	12	132	100.0%
PERCENT	2.3%	20.5%	22.7%	2.3%	18.9%	16.7%	2.3%	5.3%	9.0%		100.0%

There are twelve experimental GMF assignments for the Wind Profiler. On the frequency 404.2 MHz, there is an assignment for the Wind Profiler at Windsor, CT. A summary of the twelve assignments on 404.37 MHz is listed below.

LOCATION	AGC	EMS	PWR	Comments
Ft. Huachuca, AZ	C	1M00P0N	1.2 kW	WP balloon experiment. Lab made. Area assign't
Ft. Ord, CA	N	2M12P0N	35 kW	TYCHO Model 400
Vandenburg, CA	AF	2M40P0N	50 kW	
Ft. Collins, CO	NG	2M40P0N	35 kW	ERP Colorado State Univ. ERL Boulder labs.
Longmont, CO	NG	1M20P0N 2M41P0N	70 MW	For research of WPR. TYCHO Tech. Inc.
Windsor, CT	NG	900KP0N	18 MW	For development and manufacturer of WP. UNISYS Corp.
Hillsboro, KS	C	1M00P0N	100 kW	Lab made. Area assign't
Sudbury, MA	AF	1M00P0N	16 kW	Manufactured by UNISYS
Fair Haven, NY	C	2M00P0N	9 kW	Project for high resolution & analysis of winds in the stroposphere and lower stratosphere. Lab made. Area assignment.
Pt. Breeze, NY	******	Same as Fair Haven, NY		******
Watertown, NY	******	Same as Fair Haven, NY		******
State College, PA	NG	2M00P0N	280 kW	Same as Fair Haven, NY Not an area assignment. Penn State Univ.

There are two experimental assignments on the frequency 405.25 MHz listed in the GMF. They are summarized below.

Location	AGC	EMS	PWR	Comments
CO, CO	C	1M00P0N	50 kW	Lab made. Denver, CO Grand Junction, CO
Madison, CO	NG	2M00M1N	6.2 kW	Astronautics Corp. of America

The mainbeam gains range from 26-32 dBi for those assignments that listed them.

The Search And Rescue SATellite (SARSAT) receivers aboard the TIROS-N and GOES satellites will receive on uplink frequencies, 125 MHz, 243 MHz and 406.025 MHz, from Emergency Locator Transmitters (ELT) and Emergency Position Indicator Radio Beacons (EPIRB). In February 1987, NOAA released a technical memorandum on Profiler/Satellite Interference Analysis by Russell B. Chadwick.[19] This report gives an engineering analysis of

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[19] Chadwick, R.B., Profiler /Satellite Interference Analysis. NOAA Technical Memorandum ERL ESG-24, U.S. Department of Commerce, National Oceanic And Atmospheric Administration, Environmental Sciences Group, Boulder, CO., February 1987.

interference between the Wind Profiler and the GOES, SARSAT and TDCS (Tiros Data Collection System). The approach used was to quantify interference potential by determining the interference-to-noise ratio at the satellite receiver. In doing so, the most severe interference potential was found to be with SARSAT, the details of which are in the report. In the adjacent band 406-406.1 MHz, the SARSAT receives on 406.025 MHz from Coast Guard EPIRBs.

BAND III: 420-450 MHz

General

The band is presently allocated to the radiolocation service on a primary basis limited to the military. Pulse-ranging radiolocation systems may be authorized on a case-by-case secondary basis for the Government and non-Government along the shoreline of Alaska and the contiguous 48 states pursuant to footnote US217, but limited by footnote US228. The amateur service is allocated to the non-Government on a secondary basis, except where limited by footnote NG135. The land mobile service is allocated on a primary basis to the non-Government within a 50-mile radius of Detroit, MI, Cleveland, OH, and Buffalo, NY in the frequency ranges specified in footnote US230.

TABLES 5-8, 5-9, and 5-10 show the current agency service distribution in the frequency ranges 420-430 MHz, 430-440 MHz and 440-450 MHz, respectively. The tables are discussed in the following paragraphs under government and non-government usage. In a few cases where an assignment has more than one service, the assignment is counted for each service the system operates. The service category "NO SPECIFIC" applies to the experimental assignments and assignments without a designated service. Figures 5-4, 5-5 and 5-5 are maps of the distribution of GMF assignments with geographical coordinates in these bands 420-430 MHz, 430-440 MHz and 440-450 MHz, respectively. Experimental assignments are excluded from the maps.

TABLE 5-8
AGENCY/SERVICE DISTRIBUTION OF
FREQUENCY ASSIGNMENTS IN THE 420-430 MHz BAND

	AF	AR	CG	DOE	N	NG	NASA	T	TOTAL/SERVICE	PERCENT
FIXED	4		1				2		7	3.2%
MOBILE	14	4	1	3	20		1		43	19.8%
AERONAUTICAL MOBILE	32				29			1	62	28.6%
LAND MOBILE	4						1		5	2.3%
RADIOLOCATION	7	3	11		8	31		2	62	28.6%
NO SPECIFIC	5	7	1	1	13	10		1	38	17.5%
TOTAL/AGENCY	66	14	14	4	70	41	4	4	217	100.0%
PERCENT	30.4%	6.5%	6.5%	1.8%	32.3%	18.9%	1.8%	1.8%		100.0%

TABLE 5-9
AGENCY/SERVICE DISTRIBUTION OF FREQUENCY ASSIGNMENTS IN THE 430-440 MHz BAND

	AF	AR	CG	N	NASA	NG	NSF	T	TOTAL/SERVICE	PERCENT
FIXED	2								2	1.4%
AERONAUTICAL MOBILE	3			14					17	12.2%
MOBILE	9	3		2	1				15	10.8%
RADIOLOCATION	4	14	3	8	1	48		3	81	58.3%
NO SPECIFIC	8	9		5		1	1		24	17.3%
TOTAL/AGENCY	26	26	3	29	2	49	1	3	139	100.0%
PERCENT	18.7%	18.7%	2.2%	20.9%	1.3%	35.3%	0.7%	2.2%		100.0%

TABLE 5-10
AGENCY/SERVICE DISTRIBUTION OF FREQUENCY ASSIGNMENTS IN THE 440-450 MHz BAND

	AF	AR	CG	I	N	NASA	NG	T	TOTAL/SERVICE	PERCENT
FIXED	1	1	1						3	3.1%
AERONAUTICAL MOBILE	6				19				25	25.5%
LAND MOBILE				1					1	1.0%
MARITIME MOBILE			1						1	1.0%
MOBILE	1	4			5				10	10.2%
RADIOLOCATION		3	2		6		13	2	26	26.5%
NO SPECIFIC	6	8			14	1	3		32	32.7%
TOTAL/AGENCY	14	16	4	1	44	1	16	2	98	100.0%
PERCENT	14.3%	16.3%	4.1%	1.0%	45.0%	1.0%	16.3%	2.0%		100.0%

Figure 5-4. Distribution of GMF assignments with geographical coordinates in the 420-430 MHz band.

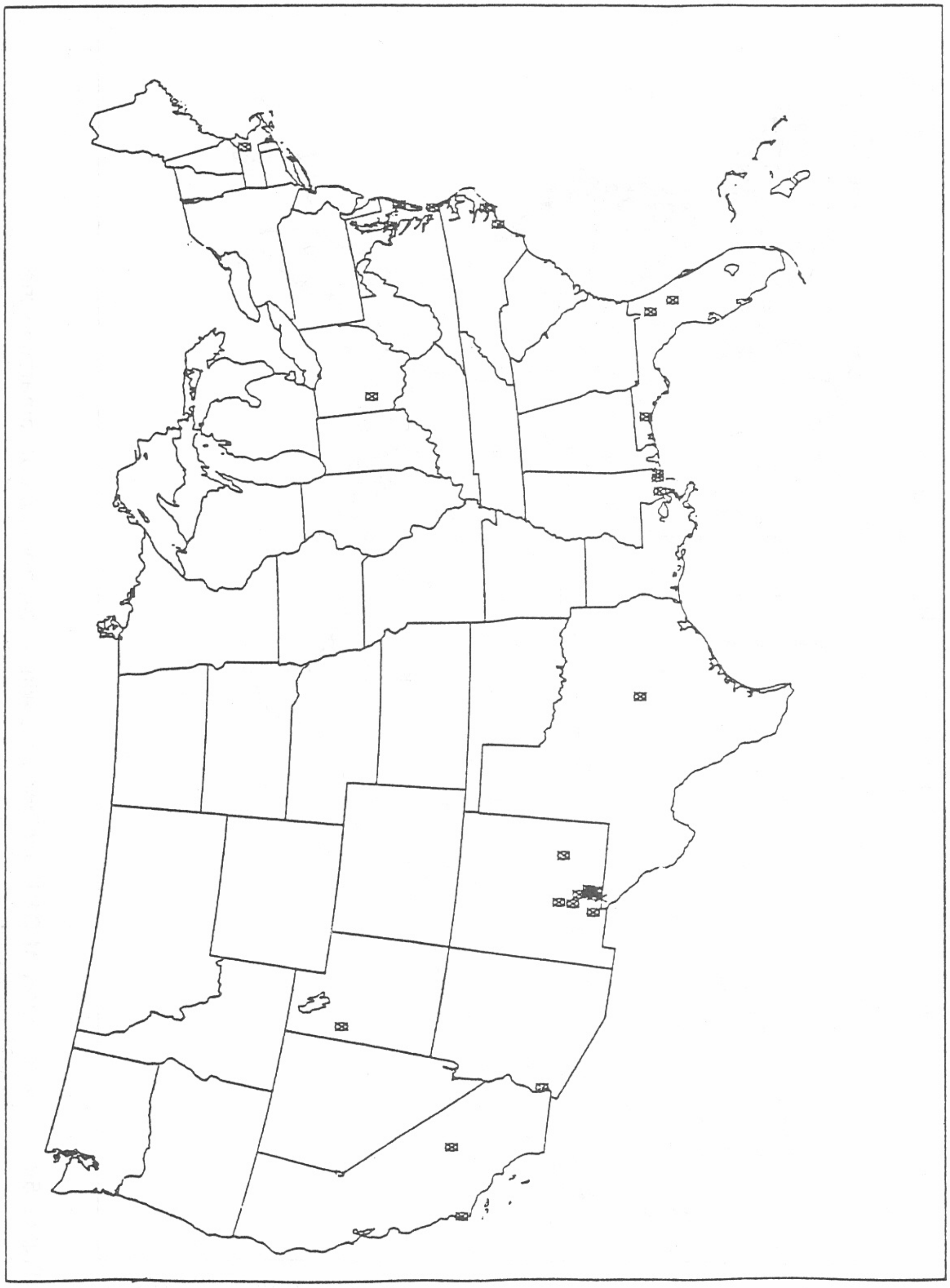


Figure 5-5. Distribution of GMF assignments with geographical coordinates in the 430-440 MHz band.

Figure 5-6. Distribution of GMF assignments with geographical coordinates in the 440-450 MHz band.

There are 454 GMF assignments in this band. Most of the stations are in the radiolocation service. The majority of assignments are for the DoD and the non-Government. The military has several high-powered early warning radar systems with band assignments. The non-Government band assignments are for several companies and corporations (e.g., Chrysler, Ford and General Motors in Michigan). For this band, the number of assignments in the GMF does not correspond to the number of equipments. Some systems have one assignment for a large number of equipments. Another system may have several assignments showing specific operating frequencies for a set of equipments.

The military currently uses the radiolocation service in the band 420-450 MHz primarily for long-range air and space surveillance on land based, shipborne and airborne platforms. It is noted that this 30 MHz is the only band allocated for military radiolocation below 1 GHz. As a result, it is expected that any new radar system will be considered for operations in this band. This band is used by the military for two reasons: (1) the propagation characteristics - at these frequencies there is low attenuation of the signal in bad weather, and (2) exclusive use of the band allows 24 hour operation of their surveillance radars. The land based radars are at widely dispersed geographic locations in the United States with fixed site installations. The shipborne and airborne radars are mobile. The shipborne radars operate in coastal waters, port areas and at sea. The airborne radars may operate anywhere in the country or at sea in support of fleets. Many of the flights are over inland testing and training routes and along the U.S. border. Most of the radars have the capability to operate in all or part of the band. Given in the following section are the representative land based, shipborne, and airborne characteristics to be used in the study.

Telecommand of drones (low power remote control) accounts for about one-fifth [94 (experimental assignments excluded) of 454] of the GMF assignments in the band. The Navy and Air Force mainly utilize the frequency band for telecommand of aerial drones, missiles, balloons and land mobiles. Many of the areas of operation have assignments throughout the band. Therefore, one deployment may have more than one assignment. The drones are operated at military installations throughout the country, many of which are on the coast. The coastal regions of the U.S. that are most affected are Southern California, Southern Nevada, Arizona, New Mexico, Florida, Puerto Rico and the Virgin Islands. Typical remote control operations have a power and bandwidth of 100 W and 600 kHz, respectively. Also common is a power of 600 W and bandwidth of 70 kHz. These characteristics account for approximately 49% and 14% of the total 95 telecommand assignments, respectively.

Government Usage

Nearly half (217) of the assignments in the 420-450 MHz band are in the frequency range 420-430 MHz band. This frequency range is used primarily for low power remote control (telecommand) of drones and some long range radars. The majority (62) of the drone control assignments are in this band. The telecommand aeronautical stations (FAD) and the telecommand land stations (FLD) are used for drone control and flight termination. As shown on the deployment map, the majority of assignments are on the Gulf Coast, the Chesapeake Bay, the North Carolina coast, Southern California, and the Southwest area. The Air Force submitted to the IRAC (Doc. 26736/1-2.4.2/6.2) on March 2, 1990 a proposal for a new U.S. footnote, USXXX, on 425 MHz $\pm$300 kHz. The proposal would require that all users of the frequency 425 MHz in the vicinity of White Sands Missile Range, NM coordinate with the DoD Area Frequency Coordinator prior to transmission. Most of the assignments on 425 MHz are for flight termination.

In the 430-440 MHz frequency range there are 139 assignments. This frequency range is used primarily for military long range radars that operate throughout the band and military telecommand drone control. There are 17 drone control assignments. There are also a few assignments for balloon operations. The distribution of assignments is heaviest along the Chesapeake Bay, the coast of North Carolina, the mouth of the Mississippi and southern New Mexico.

In the 440-450 MHz frequency range, there are 98 assignments. The frequency range 440-450 MHz is used primarily for Government radiolocation, drone control, long range radars that operate throughout the band and experimental stations. There are 25 drone control assignments. The majority of assignments are along the Chesapeake Bay, the coast of North Carolina, southern New Mexico and southern California.

Non-Government Usage

In the band 420-450 MHz, there are over 800 frequency assignments for fixed and land mobile operations that appear only in the FCC database. The fixed and land mobile assignments are mainly located in the vicinity of Detroit, Michigan; Buffalo, New York and Cleveland, Ohio. There are non-Government frequency assignments to private corporations that perform radiolocation services in the geophysical (petroleum) industry. Most of the radiolocation assignments list the location as U.S. There is heavy amateur usage in this band nationwide. Most of the satellite and weak signal amateur operations are in the 430-440 MHz frequency range.

Amateur use in 420-450 MHz band extracted from the ARRL repeater directory, 1990-1991 edition, is provided below. (See Reference 18)

420.000-426.000 MHz	ATV repeater or simplex with 421.25 MHz video carrier, control links and experimental
426.000-432.000 MHz	ATV simplex with 427.250 MHz video carrier frequency
432.000-432.070 MHz	EME (Earth-Moon-Earth)
432.070-432.080 MHz	Propagation beacons
432.175-433.000 MHz	Weak signal CW
432.100 MHz	70-cm calling frequency
432.100-432.125 MHz	Mixed mode and weak signal work
432.125-432.175 MHz	OSCAR inputs
432.175-433.000 MHz	Mixed mode and weak signals
433.000-435.000 MHz	Auxiliary and repeater links
435.000-438.000 MHz	Satellite only (Internationally)
438.000-444.000 MHz	ATV repeater input with 439.250 MHz video carrier frequency and repeater links
442.000-445.000 MHz	Repeater inputs and outputs (local option)
445.000-447.000 MHz	Shared by auxiliary and control links, repeaters and simplex (local option)
446.000 MHz	National Simplex Frequency
447.000-450.000 MHz	Repeater inputs and outputs (local option)

SECTION 6

ELECTROMAGNETIC COMPATIBILITY

INTRODUCTION

For the frequency ranges 216-225 MHz, 400.15-406 MHz and 420-450 MHz, an EMC analysis between Type A and B Wind Profilers and various environmental systems (Government and non-Government) was performed. The assumptions and characteristics for each type of profiler are given in Section 3. Details of the parameters pertaining to the systems selected are given as they are encountered in this section. .

To determine EMC in the 216-225 MHz and 420-450 MHz bands, frequency-distance (F-D) curves were generated between each of the two types of Wind Profilers and each of the environmental systems identified. A discussion of the method used to create F-D curves is given in Appendix B. A number of assumptions concerning equipment parameters were used in assessing EMC. For example, when the parameters of systems were similar, a typical system was used to represent all the systems in a class of related types; when system parameters and equipment vary widely, only major systems were considered. In addition, some services/systems were excluded from the study for various reasons, which are discussed. Although the answers obtained may not be a final quantitative result, they are useful in evaluating the relative EMC potential of Wind Profiler operations with the various systems or classes of systems considered. No experimental assignments were considered for the study.

F-D curves were generated using an Interference-to-Noise Ratio (INR) approach assuming the coupling between a single Wind Profiler and each environmental system identified from the 216-225 MHz or 420-450 MHz bands. The environmental systems were categorized into two types, surface and airborne. For surface systems, the Wind Profiler 85-90 degree off-axis antenna gain values (-25 dBi and -20 dBi for Type A and B, respectively) were used. For airborne systems, the Wind Profilers 60 to 90 degree off-axis antenna gain values (-20 dBi and -13 dBi for Type A and B, respectively) were used. These values represent the antenna coupling most expected to occur between Wind Profilers and environmental systems. Additional assumptions for the 216-225 MHz and 420-450 MHz study are given in Appendix B.

The results shown in Appendix B provide the frequency-distance separations necessary to preclude interference between each type of Wind Profiler and selected environmental systems in the 216-225 MHz and 420-450 MHz bands. The actual frequency and distance separations may be smaller when factors such as signal processing and terrain are considered. In addition, time sharing may be an alternative solution when F-D separation is not possible, if 24 hour operation of the profiler is not necessary. Although these factors are not included in the study to obtain the F-D values, they are considered when addressing the suitability of the band for possible Wind Profiler accommodation.

To determine the EMC in the 400.15-406 MHz band, a different approach was taken. The only system considered was the COSPAS/SARSAT, which operates in the upper adjacent band 406-406.1 MHz. Both single and aggregate effects of Wind Profiler emissions on the COSPAS/SARSAT were assessed. Details of the approach as well as the various assumptions are discussed within.

As was the case for the other assessment categories in this study, the final results of the EMC assessment were assigned one of three ratings to each class of equipment: Suitable, Conditional, or Unsuitable. In assigning these ratings, various factors such as F-D curves, INR values, deployment, number, and type of platform were considered.

BAND I: 216-225 MHz

216-220 MHz Band

TABLES 6-1 and 6-2 below show the services considered for the EMC analysis and the characteristics assumed to represent each service or system.

GOVERNMENT SYSTEMS

The major Government systems in this band are surface mobile telemetry systems used for seismology, land mobile and the Navy SPASUR system used to track satellites. The telemetry systems were selected because of their number and distribution throughout the band. The technical parameters for these telemetry systems vary only slightly; therefore, the systems are treated as a class. There are a few fixed assignments also used for seismology with parameters similar to those of the surface telemetry systems. The fixed systems were not studied separately due to their relatively low number of assignments and similar characteristics to the mobile telemetry assignments; however, the results of the analysis with surface telemetry assignments should be valid for the fixed systems. The SPASUR system was selected because of the protected status of the system and its uniqueness compared to other systems in the band. The maritime mobile and aeronautical mobile services were not considered because there are no maritime mobile assignments and only five aeronautical mobile assignments with secondary status. The F-D curves are shown in Appendix B.

Government Telemetry

Generally small frequency and distance separations are necessary to preclude potential interactions between Type A and B profiler and telemetry systems. For co-channel operations, distance separations of 10 km are necessary.

TABLE 6-1
SERVICES CONSIDERED FOR EMC WITH WIND PROFILERS

SERVICES	GOVERNMENT	NON-GOVERNMENT
MARITIME MOBILE	No	Yes
Radiolocation	Yes (SPASUR only)	N.A.
Fixed	No	No
Land Mobile	Yes	Yes
Aeronautical Mobile	No	No

TABLE 6-2
ASSUMED CHARACTERISTICS FOR SYSTEMS IN THE 216-220 MHz BAND

	Maritime Mobile	Land Mobile	Surface Telemetry	SPASUR
Power	53 dBm	53 dBm	33 dBm	88.8 dBm
Emission Designator	16K0F3E	16K0F3E	16K0F2D	2H00N0N
Antenna Gain	3 dBi	3 dBi	3 dBi	13 dB (SL)
Emission Curve	-3 dB 3 kHz -20 dB 16 kHz -40 dB 18 kHz -60 dB 25 kHz	-3 dB 3 kHz -20 dB 16 kHz -40 dB 18 kHz -60 dB 25 kHz	-3 dB 3 kHz -20 dB 16 kHz -70 dB 30 kHz	-3 dB 0.4 Hz -20 dB 2.0 Hz -40 dB 10 Hz -60 dB 20 Hz
IF Selectivity Curve	-3 dB 16 kHz -20 dB 25 kHz -40 dB 28 kHz -60 dB 32 kHz	-3 dB 16 kHz -20 dB 25 kHz -40 dB 28 kHz -60 dB 32 kHz	-3 dB 16 kHz -20 dB 25 kHz -60 dB 32 kHz	-3 dB 30 kHz -20 dB 32 kHz -60 dB 36 kHz
Noise Level	-120 dBm	-120 dBm	-120 dBm	-131 dBm
Antenna Type	Vertical collinear	Vertical collinear	Yagi	Linear Phased Array
Antenna Height	30 meters	30 meters	2 meters	2 meters

Government Land Mobile

Distance separations of 40 km are necessary to preclude potential co-channel interactions between Type A and B profilers and land mobile systems.

Navy SPASUR

Distance separations of 170 km are necessary to preclude potential co-channel interactions between Type A and B profilers and the SPASUR. The SPASUR has only three transmitter locations and six receiver locations; therefore, frequency or distance separation would normally preclude interference. Since Wind Profilers and SPASUR both orient their beams vertically, sidelobe-to-sidelobe coupling was used to obtain these results.

NON-GOVERNMENT SYSTEMS

The major systems considered in this band are in the mobile service, (i.e., maritime, surface telemetry and land mobile). A typical system was used to represent each class since the parameters do not vary widely. Since the parameters of non-government telemetry and land mobile systems are similar to government systems, the same typical systems were used. In the lower adjacent band 210-216 MHz, TV channel 13 operates throughout the country with the heaviest concentration of stations in the eastern half of the country. A study of potential interactions between Wind Profilers and TV receivers was not addressed in this study. A detailed study of the potential interference to TV-13 receivers would be necessary before widespread Wind Profiler operations could be considered in the 216-220 MHz band.

Non-Government Telemetry

The parameters of a non-Government telemetry system are assumed to be the same as a Government system, thus, co-channel distance separations of 10 km are necessary to preclude interference for Type A and B profilers.

Non-Government Land Mobile and Maritime Mobile

The parameters of a maritime mobile system are assumed to be similar to that of a Government or non-Government land mobile system. The frequency and distance separations necessary to preclude potential interactions between Type A and B profilers and land mobile and maritime mobile systems are small. For co-channel operation, distance separations of 40 km would be required.

220-225 MHz Band

TABLES 6-3 and 6-4 show the services considered for the EMC analysis and the characteristics assumed to represent each service or system.

TABLE 6-3
SERVICES CONSIDERED FOR EMC WITH WIND PROFILERS

SERVICES	GOVERNMENT	NON-GOVERNMENT
	220-222 MHz Band	
LAND MOBILE	No	No
Radiolocation	No	N.A.
	222-225 MHz Band	
Radiolocation	No	No
AMATEUR	N.A.	Yes (Repeaters only)

TABLE 6-4
ASSUMED CHARACTERISTICS FOR SYSTEMS IN THE 220-225 MHz BAND

	AN/GRC-103	Amateur Repeater
Power	44 dBm	50 dBm
Emission Designator	750K00F9W	16K0F3E
Antenna Gain	12 dBi	9 dBi
Emission Curve	-3 dB 0.65 MHz -20 dB 0.75 MHz -60 dB 3.50 MHz	-3 dB 16 kHz -20 dB 20 kHz -40 dB 26 kHz -60 dB 30 kHz
IF Selectivity Curve	-3 dB 0.75 MHz -20 dB 2 MHz -60 dB 4.2 MHz	-3 dB 16 kHz -20 dB 20 kHz -40 dB 26 kHz -60 dB 30 kHz
Noise Level	-110 dBm	-120 dBm
Antenna Type	Corner Reflector	Vertical collinear
Antenna Height	2 meters	60 meters

GOVERNMENT SYSTEMS

In this band, the Army's AN/GRC-103 fixed point-to-point communication system is the only major system identified. Due to the change in the Allocation Table, the 220-222 MHz band will be used for narrow-band land mobile operations and existing radiolocation operations. In the 222-225 MHz band, only existing radiolocation will be allocated. The radiolocation service was not considered in this study because of no assignments. There are currently no land mobile assignments in the 220-222 MHz band.

Army Fixed AN/GRC-103 Communication System

The required distance separation necessary to preclude potential interactions between Type A and B profilers and the AN/GRC-103 is 30 km for co-channel operations. To preclude potential interactions between Wind Profilers and the AN/GRC-103, frequency coordination may be the most effective way to promote compatibility, since the AN/GRC-103 is capable of operating on any frequency in the band.

NON-GOVERNMENT SYSTEMS

In this frequency range, the Amateurs currently operate throughout the band on a primary basis. The Amateurs have several different operations (see Section 5). As a result of the FCC change to the Allocation Table, the band will be used for narrow-band land mobile operations in the 220-222 MHz. The 222-225 MHz portion of the band will continue to be allocated to the amateur service. There are currently no land mobile assignments in the 222-225 band.

Amateur Repeater

Based on the F-D curves, a distance separation of 50 km is required to preclude Type A and B Profiler interactions with amateur repeaters if the systems operate co-channel.

EMC SUMMARY OF THE BAND 216-225 MHz

The results of the EMC analysis show that Wind Profilers are compatible with the systems in the environment in the 216-225 MHz band with regard to present and future use nationally. However, it will be difficult to accommodate either type of Wind Profiler due to the expected heavy concentration of land mobile and amateur repeaters in the 220-225 portion of the band on a primary basis. Type A Wind Profilers may be accommodated in the 216-220 MHz portion of the band with the following option. Within the 216-220 MHz, the frequency 219 MHz (2 MHz bandwidth) should be considered for Type A Wind Profiler operations in some geographic locations, subject to successful coordination with authorized users of the band and consideration of adjacent band TV-13 broadcast operations. A study would be required to determine the actual compatibility of Wind Profilers and TV receivers. Because of the characteristics assumed for the Type B profiler, it will not be possible to accommodate Type B in the frequency range 216-225 MHz. Internationally, since most of Region 1 and 3 is allocated to broadcasting, it is assumed not to be compatible with Wind Profiler operations. The national EMC suitability of this band is considered "conditional."

SUMMARY OF RESULTS FOR THE 216-225 MHz BAND

TABLE 6-5 below provides the co-channel distance separations required to preclude interference between Type A and B profilers and all the unclassified systems considered for this study in the band 216-225 MHz. F-D curves are given in Appendix B.

TABLE 6-5
CO-CHANNEL DISTANCE SEPARATIONS REQUIRED TO PRECLUDE INTERFERENCE BETWEEN WIND PROFILERS AND SYSTEMS OPERATING IN THE 216-225 MHz

	TYPE A PROFILER				TYPE B PROFILER			
	TO WP		FROM WP		TO WP		FROM WP	
ENVIRONMENTAL SYSTEMS[a]	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE
SPASUR[b]	170 km	120 km	30 km	20 km	80 km	80 km	20 km	10 km
TELEMETRY	5 km	5 km	10 km	10 km	5 km	5 km	5 km	5 km
LAND & MARITIME MOBILE	40 km	40 km	30 km	20 km	30 km	30 km	20 km	10 km
AN/GRC-103	10 km	10 km	30 km	20 km	10 km	10 km	20 km	10 km
AMATEUR REPEATER	50 km	50 km	50 km	30 km	40 km	40 km	30 km	20 km

[a] Wind Profiler sidelobe (85°-90° region) and environmental system mainbeam coupling unless otherwise noted.
[b] Wind Profiler sidelobe (85°-90° region) and SPASUR sidelobe coupling.

BAND II: 400.15-406 MHz

INTRODUCTION

Test measurements made at Goddard Space Flight Center in Greenbelt, MD (Reference 15) have indicated that Wind Profilers emissions may cause potential interference to certain satellite operations. In general, polar-orbiting satellites are more susceptible to the potential interference from Wind Profiler emissions than the geostationary satellites.

The potentially affected polar-orbiting satellites are NOAA 9 and 10, and three Soviet satellites. The operational geostationary satellites affected are GOES East and West. All the satellites carry sensitive receivers used to locate low-power emergency beacons from downed aircraft and ships in distress. The U.S. version for this system is named Search and Rescue Satellite-Aided Tracking (SARSAT) and operates on an adjacent frequency 406.0-406.1 MHz. A similar system is used by the Soviets called COSPAS and operates on the same frequency as SARSAT. Both the COSPAS and SARSAT operations are considered safety-of-life. Since Wind Profilers will transmit high power radar signals vertically, these signals will have the potential to interfere with the safety-of-life COSPAS/SARSAT operations. As a result, the EMC study for the 400.15-406 MHz band will first consider the interference potential to the COSPAS/SARSAT receiver aboard polar-orbiting satellites from Wind Profilers emissions at 404.37 MHz. The approach used to quantify the interference potential was to determine the interference-to-noise ratio at the IF portion of the COSPAS/SARSAT receiver from a single Wind Profiler as well as effects from multiple Wind Profilers in the deployment.

The characteristics for the two types of Wind Profilers assumed for this study are given in TABLE 3-2. These characteristics are representative of the two distinct types expected to be deployed, nationally. The characteristics assumed for the COSPAS/SARSAT receiver are given in TABLE 6-6.

TABLE 6-6
ASSUMED SYSTEM CHARACTERISTICS OF COSPAS/SARSAT

Frequency (MHz)	:	406.1
Height (km)	:	850
IF Selectivity	:	Figure 6-1
Bandwidth (3dB)	:	35 kHz
Gain (dBi)	:	-6
Noise Temperature (K)	:	1000
Antenna Polarization	:	Linear

All assumptions and references made to SARSAT equipped satellites (supplied by the U.S.) apply equally to the COSPAS equipped satellites.

As the COSPAS/SARSAT passes over the Wind Profiler deployment, it will receive power from all the Wind Profiler radars within its field of view. The amplitude of each signal will be determined by the gain of the satellite receiving antenna, the distance to the radar, and the gain of the radar transmitting antenna. The power received from any individual radar will fluctuate greatly due to the lode structure of the radar antenna, but the aggregate power from all the radars may be approximated by assuming that all radar antennas have the average gains that are given in TABLE 3-2.

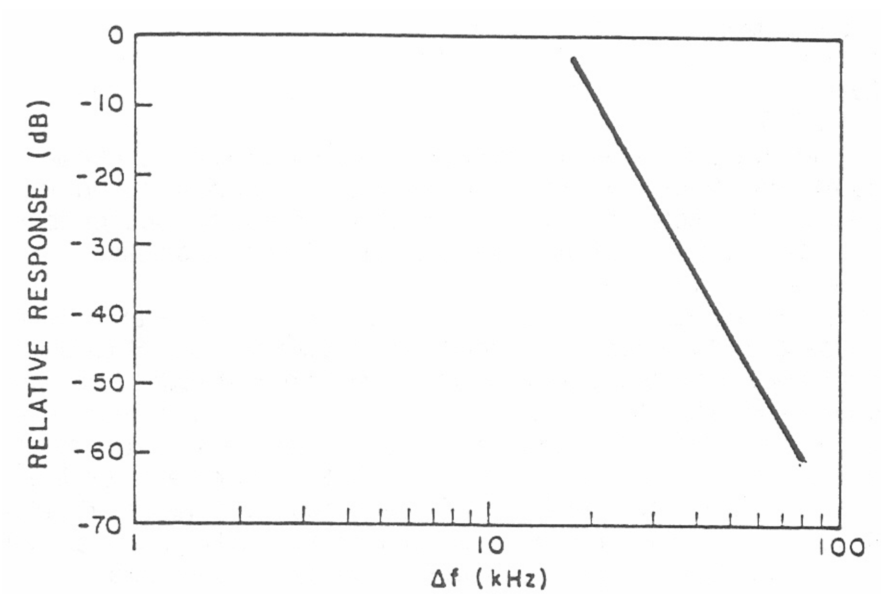


Figure 6-1. SARSAT 406 MHz receiver IF selectivity.

Single Case (mainbeam coupling)

Since the COSPAS/SARSAT receiver can be aboard polar orbiting satellites, it will eventually pass through the mainbeam of a single Wind Profiler. The maximum duration of a mainbeam exposure is approximately ten seconds. As the density of Wind Profilers increases, the potential number of mainbeam occurrences over any one orbit will increase. Under certain conditions mainbeam coupling from more than one Wind Profiler may occur if the profilers are separated by less than approximately 75 km. If this condition exists, the results stated in this section would have to be adjusted to take into account this occurrence. This can be approximated by the factor 10 log N, where N is the number of Wind Profilers having mainbeam coupling with the COSPAS/SARSAT. Equation (1) gives the various terms of the interference equation to determine the interference-to-noise ratio assuming the Wind Profiler is operating at 404.37 MHz and SARSAT operating at 406.1 MHz.

$$INR = P_t + G_t + G_r - L(d) - L_s - L_a - FDR\,[\Delta f] - N_s \qquad (1)$$

where:

P_t = The peak transmitting power of the Wind Profiler in dBm.
Type A - low mode 69 dBm, high mode 72 dBm
Type B - low and high mode 59 dBm

G_t = The Profiler gain towards the satellite (dBi) at nadir.
Type A = 32, Type B = 27

G_r = The Satellite antenna gain in dBi, -6 at nadir.

L(d) = The free space propagation loss in dB.

L(d) = 20 log d + 20 log F + 32.45
d is in kilometers and F is in MHz
= + 143.2

L_s = Waveguide and Insertion Loss, assumed 2 dB.

L_a = Loss due to cross polarization for mainbeam coupling.

FDR = Frequency-Dependent Rejection in dB.
= OTR + OFR, where OTR is the On-Tune rejection. OTR can be approximated by 20 log Bt/Br.
Type A - low mode 20 dB, high mode 11 dB
Type B - low mode 28 dB, high mode 19 dB
OFR can be approximated by from Figures 3-3 or 3-5 depending on Type A or B, high or low mode, respectively. For the case of Wind Profiler operating at 404.37 MHz and COSPAS/SARSAT operating at 406.1 MHz, the values are as follows:
Type A - low mode 40 dB, high mode 49 dB
Type B - low mode 20 dB, high mode 31 dB

N_s(dBm) = Satellite receiver noise level.
= -123.2 dBm

INR(dB) = Interference-to-Noise Ratio Assumed - 12. This value includes 25% of the aggregate permissible from all Wind Profilers to be accepted from all Wind Profilers combined.

and:

$$N_s = KTB_r \qquad (2)$$

where:

K	=	Boltsman constant 1.38 X 10^{-23} Joule per Kelvin.
T	=	Noise Temperature of the satellite receiver in Kelvin, 1000 K.
B_r	=	Satellite receiver bandwidth in Hz

Substituting the Wind Profiler characteristics for the Type A (low mode) and the COSPAS/SARSAT characteristics contained in TABLE 6-6 into equation 1 yields:

$$INR = 69 + 32 - 6 - 143.2 - 2 - 0 - [20 + 40] + 123.2$$
$$= 13$$

Additional INR values for Type A (low mode), Type B (high and low mode) can be obtained in a similar matter by substituting the values into Equation 1. These values are summarized in TABLE 6-7.

TABLE 6-7
INR VALUES FOR TYPE A and B WIND PROFILERS
(MAINBEAM COUPLING)

	TYPE A	TYPE B
Low mode	13	10
High mode	16	8

The computed INR values contained in TABLE 6-7 for the Wind Profiler mainbeam coupling condition indicates that the required INR (-12 dB) is exceeded by 20 dB to 28 dB, depending on type of profiler and mode selected.

In addition to computing the INR for Wind Profiler mainbeam coupling, the frequency separation values to prevent interference into the COSPAS/SARSAT receiver for Wind Profiler emissions can also be determined for a given INR threshold. This required frequency separation to preclude interference can be determined by rearranging the terms given in Equation (1) into the following equation and solving for the OFR value.

$$OFR = P_t + G_t + G_r - L(d) - L_s - L_a - OTR - N_s - INR(-12) \quad (3)$$

The required OFR values for each type of Wind Profiler can be obtained by substituting the appropriate characteristics into the equation (3). From these OFR values, the appropriate distance separations can be determined for each type of Wind Profiler (Low and High Mode) from Figures 3-3 or 3-5, respectively. TABLE 6-8 summarizes the OFR values and required frequency separations to preclude interference from each type of Wind Profiler (low and high mode) to the COSPAS/SARSAT receiver. The values contained in TABLE 6-8 indicate that for the single Wind Profiler mainbeam coupling condition, the frequency separation required varies from 4.1 MHz to 4.7 MHz depending on the type of profiler and mode selected.

TABLE 6-8 CALCULATED OFR VALUES AND REQUIRED FREQUENCY SEPARATIONS FOR TYPE A AND B PROFILERS (Mainbeam Coupling)				
	Type A		Type B	
	OFR(dB)	ΔF(MHz)	OFR(dB)	ΔF(MHz)
Low Mode	65	4.5	42	4.4
High Mode	77	4.7	51	4.1

Multiple Case

In addition to considering the emissions from the mainbeam of a single Wind Profiler, the power received at the COSPAS/SARSAT receiver must also consider sidelobe emissions of other Wind Profilers in the deployment. The number of Wind Profiler radars seen by the satellite will depend on the number in the deployment.

Stated in a previous section was a discussion on the deployment philosophy for each of the two types of Wind Profilers assumed for this study. For Type A profilers, the "NOAA Type," the initial deployment will consist of 30 (Figure 3-1) with expected numbers to reach approximately 200-300 to form a grid across the U.S. The number of radars as seen by the COSPAS/SARSAT satellite will vary depending on the central Earth's angle, measured at the Earth's center between the satellite and the radar. A draft report (Reference 11) delineates one method of determining the number of "NOAA type" radars as a function of Central earth angle. For this study it is assumed one-half of the number of radars given in Reference 11 will be deployed as a function of Central earth angle. TABLE 6-9 summarizes the Type A Wind Profiler's Angle Range, the Antenna gain, Central earth angle, and number of Radars of "NOAA Type" radars as a function of Central Earth angle. No radars are considered beyond 15 degrees central Earth angle because that is approximately the extent of the region (continental US and southern Canada). For Type B profilers, the expected deployment of this type of profiler is unknown. As a result, the numbers of Type B profilers to be seen by COSPAS/SARSAT satellite as a function of Central Earth angle are assumed to be the same as those given for Type A. TABLE 6-10 summarizes the Type B Wind Profiler's Angle Range, the Antenna gain, Central earth angle, and number of radars as a function of Central Earth angle.

TABLE 6-9 NUMBER OF TYPE A PROFILERS TO BE DEPLOYED AS A FUNCTION OF CENTRAL ANGLE (excluding mainbeam)			
Angle Range (deg.)	Gain (dBi)	Central Earth Angle (deg.)	Number of Radars
2.5-15	10.7	0.3-1.8	2.7
15-30	0	1.8-3.8	9.6
30-60	-10	3.8-10.1	74.7
60-90	-20	10.1-15.0	104

TABLE 6-10 NUMBER OF TYPE B PROFILERS TO BE DEPLOYED AS A FUNCTION OF CENTRAL ANGLE (excluding mainbeam)			
Angle Range (deg.)	Gain (dBi)	Central Earth Angle (deg.)	Number of Radars
4-15	5	.47-1.8	2.7
15-30	2	1.8-3.8	9.6
30-60	-4	3.8-10.1	74.7
60-90	-13	10.1-15.0	104

The approach used for the multiple case was to quantify the interference potential by determining interference-to-noise ratio at the satellite receiver from sidelobe emissions of Wind Profilers. This approach was similar as described for the mainbeam case. However, it is noted that the results obtained for the multiple emitter case represent an upper bound since the effects of pulse overlap due to multiple emitters was not included. The inclusion of considering pulse overlap would result in lower values than computed for the upper bound. Using Equation (1), the variable terms in the equation depend on the location of the radars with respect to the satellite. The COSPAS/SARSAT receiver antenna gain variation with nadir angle compensates for the increase in path loss due to the increasing distance, so that the variation in the power received from the radar is completely (within 1 dB) determined by the radar antenna gain. This allows equation (1) in determining the INR to be simplified for each step of the central Earth angle by multiplying the number of radars assumed for that angle:

$$INR = P_t + G_t + 10 \log N + G_r + - L(d) - L_s - L_a - FDR [\Delta f] - N_s \qquad (4)$$

where:

N = number of Wind Profilers being considered as a function of Central Earth Angle.

Using Equation (4), the INR values can be computed for each of the Central Angles given in TABLES 6-4 and 6-5. For example, the INR for the Central Angle .3 - 1.8 for the Type A profiler (low mode) can be computed by substituting the Wind Profiler characteristics for Type

A (low mode) contained in TABLE 3-2, the COSPAS/SARSAT characteristics contained in TABLE 6-1, and the number of Wind Profiler radars given for the Central Angle .3-1.8 (2.7) contained in TABLE 6-9. The equation yields:

$$INR = 69 + 10.7 + 4.3 - 6 - 143.2 - 2 - 0 - [20 + 40] + 123.2$$
$$= -4$$

Additional INR values as a function of Central Earth Angle for Type A (low mode) and Type B (high and low mode) profilers can be obtained in a similar manner by substituting the appropriate values into Equation 4. These values are summarized in TABLES 6-11 and 6-12, respectively.

TABLE 6-11
INR VALUES FOR TYPE A PROFILERS
(SIDELOBE COUPLING)

Central Earth Angle (deg.)	INR Values Low Mode	High Mode
.3 - 1.8	-4	-1
1.8 - 3.8	-9.2	-6.2
3.8 - 10.1	-10.3	-7.3
10.1 - 15	-18.9	-15.9
OVERALL	-2.0	0.95

TABLE 6-12
INR VALUES FOR TYPE B PROFILERS
(SIDELOBE COUPLING)

Central Earth Angle (deg.)	INR Values Low Mode	High Mode
.47 - 1.8	-7.7	-9.7
1.8 - 3.8	-5.2	-7.2
3.8 - 10.1	-2.3	-4.3
10.1 - 15	-9.9	-11.9
OVERALL	0.65	-1.3

The computed overall INR values contained in TABLES 6-11 and 6-12 for the sidelobe Wind Profiler coupling condition indicate the required INR (-12 dB) will be exceeded between 10 and 13 dB, depending on the type of profiler selected and mode of operation.

In addition to computing the overall INR due to the sidelobe emissions of Wind Profilers contained in the deployment, the required frequency separation to prevent interference into the COSPAS/SARSAT receiver can also be determined in a similar method as was done for the mainbeam Wind Profiler emissions. This required frequency separation to preclude interference can be determined by rearranging the terms given in Equation (4) into the following equation and solving for the OFR value.

$$OFR = P_t + G_t + 10 \text{ Log } N + G_r - L(d) - L_s - L_a - OTR(\Delta F) - N_s - INR(-12) \quad (5)$$

where:

N = number of Wind Profilers being considered as a function of Central Earth Angle.

The required OFR values for each type of Wind Profiler can be obtained by substituting the appropriate characteristics into the equation (5). From these OFR values, the appropriate frequency separations can be determined for each type of Wind Profiler (low and high Mode) from Figures 3-3 and 3-5, respectively. TABLES 6-13 and 6-14 summarize the OFR values and required frequency separations to preclude interference from each type of Wind Profiler (low and high mode) to the COSPAS/SARSAT receiver as a function of Central Earth Angle. From TABLES 6-13 and 6-14, the overall required frequency separations to preclude interference to the COSPAS/SARSAT for the sidelobe coupling condition varied from 1.3 MHz (54.5% of Wind Profiler radars 104/191) to 3.0 MHz (39.1% of Wind Profiler radars 74.7/191), depending on the type of profiler and mode being considered.

TABLE 6-13
CALCULATED OFR VALUES AND REQUIRED FREQUENCY SEPARATIONS FOR TYPE A PROFILERS
(Sidelobe Coupling)

Central Earth Angle (deg.)	Low Mode OFR (dB)	Low Mode ΔF(MHz)	High Mode OFR (dB)	High Mode ΔF(MHz)
.3 - 1.8	48	2.7	60	2.9
1.8 - 3.8	42.8	2.0	54.8	2.2
3.8 - 10.1	41.7	1.9	53.2	2.1
10.1 - 15	33.1	1.3	45.1	1.5

TABLE 6-14
CALCULATED OFR VALUES AND REQUIRED FREQUENCY SEPARATIONS FOR TYPE B PROFILERS
(Sidelobe Coupling)

Central Earth Angle (deg.)	Low Mode OFR (dB)	Low Mode ΔF(MHz)	High Mode OFR (dB)	High Mode ΔF(MHz)
.47 - 1.8	24.3	2.2	33.3	2
1.8 - 3.8	26.8	2.6	35.8	2.2
3.8 - 10.1	29.7	3.0	38.7	2.6
10.1 - 15	22.1	2.0	31.1	1.9

Combination of Mainbeam and Sidelobe Wind Profiler Emissions

When the COSPAS/SARSAT receives signals from both the mainbeam and sidelobe of the various profilers in the deployment, the signals received from the mainbeam of any particular Profiler will dominate. As a result, when this condition exists, the INR and required frequency separation values stated for the mainbeam condition can be used.

Combination of Various Types of Profilers

The previous section calculated INR and required frequency separation values for both single and multiple Wind Profiler emissions from each of the two types of Wind Profilers (including high and low mode) assumed for the study. Since an actual deployment will consist of both types of Profilers assumed for this study as well as other types of Profilers with characteristics differing from those given in this study, the computed INR and required frequency separation values would have to be adjusted to take into account the combination of the various types of profilers to be deployed.

EMC SUMMARY OF THE 400.15-406 MHz BAND

Based on the assumptions and methods used for this study to determine EMC with the safety-of-life COSPAS/SARSAT system at 406-406.1 MHz, it was determined that Wind Profilers operating in the 400.15-406 MHz band would not be compatible. Moreover, it is noted that Wind Profilers having characteristics similar to those assumed for Type B are less compatible with COSPAS/SARSAT operations than those given for Type A.

A possible method to operate compatibly with the COSPAS/SARSAT would require the Wind Profiler to shut down as the COSPAS/SARSAT passes overhead. Although this shut down method may be controlled as well as enforceable on a national basis, it is uncertain if similar procedures would be followed by other administrations. As a result, the COSPAS/SARSAT safety-of-life service may be at risk.

At this time, due to the incompatibility with COSPAS/SARSAT operations, the 400.15-406 MHz band is determined to be unsuitable for Wind Profiler operations both nationally and internationally. As a result, no other systems operating in the 400.15-406 MHz band were investigated for compatibility with Wind Profiler operations.

It is recognized that more detailed studies may show improved compatibility with COSPAS/SARSAT. In addition, future design changes to existing 404.37 MHz Wind Profilers may increase compatibility with COSPAS/SARSAT. Any changes to existing 404.37 MHz Wind Profilers to eliminate the potential interference to COSPAS/SARSAT must also take into consideration other factors such as:

1. Performance Objectives
2. Number of Wind Profilers
3. Deployment of Profilers
4. Effects of Single versus Aggregate (both mainbeam and sidelobes)
5. Effects on other Satellites [e.g., SARSAT receiver on GOES (geostationary), ARGOS (401.65 MHz) and Data Collection platforms (DCP's)]
6. Effects on profiler operations from other systems
7. Time to implement
8. Potential equipment malfunction or human error
9. Development, adoption and enforcement of spectrum standards.

However, due to the potential national and international regulatory burdens associated with, 1) establishing and ensuring the Wind Profiler design which would ensure the compatibility with the COSPAS/SARSAT and other systems, and 2) the potential liability associated with a safety-of-life service, the 400.15-406 MHz band would remain unsuitable for Wind Profiler operations.

BAND III: 420 - 450 MHz

TABLES 6-15 and 6-16 below show the services considered for EMC analysis and the characteristics assumed for each service or system considered.

TABLE 6-15
SERVICES CONSIDERED FOR EMC WITH WIND PROFILERS

SERVICES	GOVERNMENT	NON-GOVERNMENT
RADIOLOCATION	Yes	N.A.
Radiolocation (Pulse-ranging)	No	No
Low Power Remote Control	Yes	N.A.
LAND MOBILE	N.A.	Yes
Amateur	N.A.	Yes (Repeaters and TV only)

GOVERNMENT SYSTEMS

This band is used by the DoD primarily for radiolocation and low power remote control of drones. To determine the compatibility with radiolocation systems, representative systems were identified for each type of installation: ground-based, shipborne, and airborne platforms. The F-D curves are provided in Appendix B.

To determine compatibility with drone control operations, a typical drone system was used to represent all drone control operations since their parameters are similar. The F-D curves are provided in Appendix B.

Pulse-ranging radars were not considered because of the limited areas of operation and secondary status.

Major Radiolocation (Radar) Systems

Land based Radars

Land based radar sidelobe to profiler sidelobe coupling requires co-channel distance separations of 100 km. Although moderate frequency and distance separations are necessary to preclude potential interactions between the Wind Profilers and these radar systems, other

TABLE 6-16
ASSUMED CHARACTERISTICS FOR SYSTEMS IN THE 420-450 MHz BAND

	LAND BASED RADAR	AIRBORNE RADAR	SHIPBORNE RADAR	DRONE
Power	98 dBm	93 dBm	86 dBm	50 dBm
Emission Designator	2M00P0N	7M00P0N	3M00P0N	900K00F2D
Antenna Gain	0 dBi (SL/BL)	22 dBi (MB) 0 dBi (BL/SL)	0 dB (median)	5 dBi (MB) (Ground) 0 dB (SL) (Drone)
Emission Curve	-3 dB 1 MHz -20 dB 2 MHz -70 dB 34 MHz	-3 dB 5 MHz -20 dB 7 MHz -70 dB 30 MHz	-3 dB 2 MHz -20 dB 3 MHz -70 dB 20 MHz	-3 dB 0.6 MHz -20 dB 0.9 MHz -60 dB 1.8 MHz -70 dB 2.0 MHz
IF Selectivity Curve	-3 dB 7 MHz -60 dB 20 MHz	-3 dB 3 MHz -83 dB 20 MHz	-3 dB 2 MHz -103 dB 20 MHz	-3 dB 0.6 MHz -20 dB 0.9 MHz -60 dB 1.8 MHz -70 dB 2.0 MHz
Noise Level	-109 dBm	-104 dBm	-106 dBm	-120 dBm
Antenna Type	Phased Array	Broadside Array	Parabolic Reflector	Corner reflector Dipole Array
Antenna Height	30 meters	20,000/40,000 ft.	9 meters	3 meters (ground) 20,000 ft.

TABLE 6-16 (Continued)
ASSUMED CHARACTERISTICS FOR SYSTEMS IN THE 420-450 MHz BAND

	AMATEUR TV	AMATEUR REPEATER	LAND MOBILE
Power	47 dBm	50 dBm	53 dBm
Emission Designator	6M0C3FNN	16K0F3E	16K0F3E
Antenna Gain	10 dBi	9 dBi	3 dBi
Emission Curve	-3 dB 4.2 MHz -20 dB 4.75 MHz -60 dB 6.0 MHz	-3 dB 16 kHz -20 dB 20 kHz -40 dB 26 kHz -60 dB 30 kHz	-3 dB 3 kHz -20 dB 16 kHz -40 dB 18 kHz -60 dB 25 kHz
IF Selectivity Curve	-3 dB 5 MHz -43 dB 50 MHz	-3 dB 16 kHz -20 dB 20 kHz -40 dB 26 kHz -60 dB 30 kHz	-3 dB 16 kHz -20 dB 25 kHz -40 dB 28 kHz -60 dB 32 kHz
Noise Level	-100 dBm	-120 dBm	-120 dBm
Antenna Type	Vertical collinear (some horizontal)	Vertical collinear	Vertical collinear
Antenna Height	60 meters	60 meters	30 meters

factors may aid in precluding interference, such as signal processing that is incorporated in both the Wind Profilers and the radars, and anti-jam circuitry incorporated by most radars. In addition, the actual F-D curves may be smaller when terrain factors are considered. Since many of the radars frequency hop through the band, frequency separation may not preclude interference. Therefore, adequate distance separations between Wind Profilers and land based radars may be the best way to preclude potential interference between these systems.

Shipborne Radar

For shipborne radars which may scan 360 degrees in the horizontal plane, a median gain to profiler sidelobe gain coupling requires a co-channel distance separation of 50 km. Its typical operations are offshore, at sea and at naval sea ports for test and maintenance. Frequency and/or distance coordination should preclude interactions with shipborne radars. During testing and maintenance of the shipborne radars in port or offshore, interference would be short-term and intermittent.

Airborne Radar

Based on the assumptions, characteristics, and methods to determine compatibility, airborne radars pose the greatest potential interference problem compared to land based and shipborne. Airborne radars require greater F-D separations compared to surface radars. Based on the study to preclude interference, the necessary co-channel distance separations for Type A profilers varied from 250 km to 630 km depending on altitude of airborne radar, mode of operation, and antenna coupling. Signal processing and anti-jam circuitry may aid in precluding potential interference. Since many of the radars frequency hop through the band, frequency coordination could be used to preclude potential interactions when an airborne radar is in vicinity of a Wind Profiler if the airborne radar can notch-out channels.

Drone Control

Interactions with drone control operations should be manageable through frequency coordination, since their operations are limited to military installations which are primarily coastal. A distance separation of 10 km is required to preclude co-channel interference to the Wind Profilers by the ground telecommand transmitter. A distance separation on the order of 320 km is required to preclude interference to an airborne drone at an altitude of 20,000 ft. from the Wind Profiler when there is co-channel coupling.

Drone systems are capable of operating on any selected frequency in the band for normal drone control. The frequency 425 MHz is often used for flight termination in case of a malfunction of the drone. The frequency 425 MHz should be avoided by Wind Profilers since it is considered a safety-of-life function.

NON-GOVERNMENT

This band is allocated to the amateur service for various operations throughout the U.S. except as stated in footnote NG135 -- North of line A as defined by Section 2.1 [also defined in Arrangement D of the Canada-United States Coordination Agreement (Chapter 3 of the NTIA Manual)] in the frequency range 420-430 MHz. The frequency range 420-430 MHz is allocated to the land mobile service within a 50 mile radius of Detroit, MI; Cleveland, OH; and Buffalo, NY. The land mobile systems have parameters similar to those in the 216-220 MHz band. The amateurs have various operations in this band that are on a secondary basis (see Section 5).

Pulsed-ranging radars were not considered because of the limited areas of operation and secondary status.

Amateur

The frequency range 430-440 MHz is used by the amateurs on a secondary basis for weak signal operations, such as EME, and amateur satellite systems. These systems were not studied but may be affected. The frequency ranges 420-426, 426-432, and 438-442 MHz are used by the amateurs on a secondary basis for amateur TV (ATV) operations. Co-channel distance separations of 40 km are necessary to preclude interference between profilers and ATV. The amateur repeaters operate on a secondary status in the band 442-450 MHz and have parameters similar to those in the 222-225 MHz band. Co-channel distance separation of 50 km is necessary to preclude interactions between the Wind Profiler and the amateur repeaters.

Land Mobile

For co-channel operation with land mobile, distance separations of 40 km are necessary. Due to the mobile nature of the land mobile service, potential interference may be intermittent; however, heavy land mobile usage may make frequency assignments of Wind Profilers in the vicinity of these cities prohibitive and should be coordinated to avoid interference to police, fire and rescue operations.

EMC SUMMARY OF THE BAND 420-450 MHz

Based on the assumptions, characteristics, and methods to determine compatibility, it was determined that there is no frequency(s) available in the 420-450 MHz band to be interference free for the mutual operation of Wind Profiler and other systems that operate nationally in the band. Specifically, the level of interference between Wind Profilers and other systems as well as the F-D separations necessary to avoid potential interference will vary depending on the specific system (i.e., radars, amateurs) being considered. Although it was determined there is no one particular frequency(s) that Wind Profilers could operate interference free, a discussion on the various factors associated with determining a candidate frequency to minimize interference between Wind Profilers and other systems in the 420-450 MHz band is given.

In general, the band is used nationally by (1) the military for radiolocation systems, (2) the military for drone operations at military bases and test ranges, and (3) amateurs. The military operations have primary status and amateur operations have secondary status. In addition, this band is the only 30 MHz of spectrum available for military radiolocation below 1 GHz nationally. Due to the altitudes of airborne platforms (i.e., airborne radars and drones), they pose the greatest interference potential for interactions (i.e., largest F-D separations) with Wind Profilers. The majority of the military radars have the capability to operate throughout a portion or over the entire band. Although there are only a few high powered fixed land based radars widely dispersed throughout the country, fixed radar operations are not limited in location and may operate anywhere in the future. In addition, the frequency 425 MHz is primarily used by the military for flight termination of drones; therefore, it should be avoided since this function is considered safety-of-life. In the future there may be more drone control operations including flight termination throughout other parts of the 420-450 MHz band.

The 420-430 MHz portion of the 420-450 MHz band currently contains the highest number of GMF assignments of the three sub-bands. The military has many assignments for radiolocation and drone control operations, including flight termination (425 MHz). Land mobile operates within a 80.5 km (50 miles) radius of Detroit, MI; Cleveland, OH; and Buffalo, NY. The band is used on a secondary basis for amateur TV operations in various areas of the country. Specifically, two ATV channels (420-426 and 426-432 MHz) are designated by the amateurs. Since the 420-430 MHz sub-band is the most congested and has flight termination for drones, it is not considered the most suitable candidate sub-band for Wind Profiler operations.

The 430-440 MHz portion of the band currently has the second highest number of GMF assignments. This band is the only 10 MHz of spectrum allocated for military radiolocation below 1 GHz outside the U.S. Furthermore, if the military had to blank out channels to minimize interference, the 430-440 MHz seems to be the least likely candidate band since it is the middle portion of the 420-450 MHz. The 430-440 MHz sub-band also contains sensitive amateur receiver and satellite operations. As a result, the 430-440 MHz band should be avoided for Wind Profiler operations, both nationally and internationally.

The 440-450 MHz portion of the band currently contains the lowest number of GMF assignments. The military has assignments for radiolocation and drone control in this sub-band. The band is used on a secondary basis by the amateurs for repeater operations at 442-450 MHz and ATV operations at 438-444 MHz. To minimize the impact to the current users of the band, two candidate frequencies have been identified, each of which has advantages and disadvantages. To minimize the impact on current military operations, a frequency near the band edge would be potentially more acceptable than a frequency closer to the center or lower end. As a result, the candidate frequency 449 MHz has been identified. By selecting 449 MHz, interactions between the profiler and military radars would be minimized as compared to selection of a frequency in the middle of the band. Furthermore, to ensure compatibility with military airborne platforms, Wind Profilers would be required to operate on a secondary basis. The disadvantage of 449 MHz is the impact to the amateurs repeater operations in the 442-450 MHz band. The other candidate frequency identified is 441 MHz. The frequency 441 MHz has certain advantages, among them are: (1) to minimize the impact to amateur repeater operations in the 442-450 MHz band, and (2) Canada has adopted 441 MHz for their Wind Profiler operations. The disadvantage of 441 MHz is the potential impact to military operations. Although two candidate frequencies have been identified for Wind Profiler operations, only one frequency should be ultimately selected to aid in spectrum conservation. If possible, once the frequency has been determined nationally for Wind Profiler operations, the same frequency should be pursued internationally.

Nationally, EMC suitability of the band 420-450 MHz is conditional.

SUMMARY OF RESULTS FOR THE 420-450 MHz BAND

TABLE 6-17 provides a summary of the co-channel distance separations required to preclude interference between Type A and B profilers and all the unclassified systems considered for this study in the band 420-450 MHz. F-D curves are given in Appendix B.

TABLE 6-17
CO-CHANNEL DISTANCE SEPARATIONS REQUIRED TO PRECLUDE INTERFERENCE BETWEEN WIND PROFILERS AND SYSTEMS OPERATING IN THE 420-450 MHz BAND

	TYPE A PROFILER				TYPE B PROFILER			
	TO WP		FROM WP		TO WP		FROM WP	
ENVIRONMENTAL SYSTEMS[a]	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE
LAND MOBILE	40 km	30 km	30 km	20 km	30 km	30 km	10 km	10 km
AMATEUR REPEATER	50 km	40 km	40 km	30 km	40 km	40 km	30 km	20 km
AMATEUR TV	30 km	30 km	40 km	40 km	30 km	30 km	40 km	40 km
LAND BASED RADAR[b]	60 km	70 km	40 km	30 km	100 km	100 km	30 km	30 km
AIRBORNE RADAR[c]								
Gain = 22 dBi								
Alt. 20,000 ft.	360 km	370 km	350 km	340 km	520 km	520 km	320 km	320 km
Alt. 40,000 ft.	490 km	490 km	460 km	450 km	630 km	630 km	440 km	440 km
Gain = 0 dBi								
Alt. 20,000 ft.	290 km	310 km	270 km	260 km	360 km	360 km	250 km	250 km
Alt. 40,000 ft.	400 km	420 km	380 km	370 km	480 km	480 km	360 km	360 km
SHIPBORNE RADAR[d]	30 km	40 km	20 km	20 km	50 km	50 km	20 km	20 km
DRONES[e]	10 km	10 km	320 km	300 km	10 km	10 km	290 km	270 km

[a] Wind Profiler sidelobe (85°-90° region) and environmental system mainbeam coupling unless otherwise noted.
[b] Wind Profiler sidelobe (85°-90° region) and land based radar sidelobe coupling.
[c] Wind Profiler sidelobe (60°-90° region) and airborne radar mainbeam (22 dBi) and sidelobe (0 dBi) coupling.
[d] Wind Profiler sidelobe (85°-90° region) and shipborne median coupling.
[e] Wind Profiler sidelobe (60°-90° region) and drone (airborne) sidelobe coupling.

APPENDIX A

The following are the international and national footnotes for the three bands 216-225 MHz, 406.15-406 MHz, and 420-450 MHz.

INTERNATIONAL

621 - Additional allocation: in the Federal Republic of Germany, Austria, Belgium, Denmark, Finland, France, Italy, Liechtenstein, Monaco, Norway, the Netherlands, the United Kingdom, Sweden, Switzerland and Yemen (P.D.R. of), the band 174-223 MHz is also allocated to the land mobile service on a permitted basis. However, the stations of the land mobile service shall not cause harmful interference to, nor claim protection from, broadcasting stations, existing or planned, in countries other than those listed in this footnote.

622 - Different category of service: in the Federal Republic of Germany, Austria, Belgium, Denmark, Spain, Finland, France, Israel, Italy, Liechtenstein, Luxembourg, Monaco, Norway, the Netherlands, Portugal, the United Kingdom, Sweden, Switzerland, and Yemen (P.D.R. of), the band 223-230 MHz is allocated to the land mobile service on a permitted basis (see No. 425). However, the stations of the land mobile service shall not cause harmful interference to, nor claim protection from, broadcasting stations, existing or planned, in countries other than those listed in this footnote.

623 - Additional allocation: in the Congo, Ethiopia, Gambia, Guinea, Kenya, Libya, Malawi, Mali, Uganda, Senegal, Sierra Leone, Somalia, Tanzania and Zimbabwe, the band 174-223 MHz is also allocated to the fixed and mobile services on a secondary basis.

625 - Additional allocation: in Australia and Papua New Guinea, the bands 204-208 MHz and 222-223 MHz are also allocated to the aeronautical radionavigation service on a primary basis.

626 - Additional allocation: in China, India and Thailand, the band 216-223 MHz is also allocated to the aeronautical radionavigation service on a primary basis and to the radiolocation service on a secondary basis.

627 - In Region 2, the band 216-225 MHz is allocated to the radiolocation service on a primary basis until 1 January 1990. On and after 1 January 1990, no new stations in that service may be authorized. Stations authorized prior to 1 January 1990 may continue to operate on a secondary basis.

627A - Additional allocation in Canada, the band 216-220 MHz is also allocated to the land mobile service on primary basis.

628 - Additional allocation: in Somalia, the band 216-225 MHz is also allocated to the aeronautical radionavigation service on a primary basis, subject to not causing harmful interference to existing or planned broadcasting services in other countries.

629 - Additional allocation: in Oman, the United Kingdom and Turkey, the band 216-235 MHz is also allocated to the radiolocation service on a secondary basis.

630 - Additional allocation: in Japan, the band 222-223 MHz is also allocated to the aeronautical radionavigation service on a primary basis and to the radiolocation service on a primary basis and to the radiolocation service on a secondary basis.

631 - Different category of service: in Spain and Portugal, the band 223-230 MHz is allocated to the fixed service on a permitted basis (see No. 425). Stations of this service shall not cause harmful interference to, or claim protection from, broadcasting stations of other countries, whether existing or planned, that operate in accordance with the Table.

632 - Additional allocation: in Saudi Arabia, Bahrain, the United Arab Emirates, Israel, Jordan, Oman, Qatar and Syria, the band 223-235 MHz is also allocated to the aeronautical radionavigation service on a permitted basis.

633 - Additional allocation: in Spain and Portugal, the band 223-235 MHz is also allocated to the aeronautical radionavigation service on a permitted basis until 1 January 1990, subject to not causing harmful interference to existing or planned broadcasting stations in other countries.

634 - Additional allocation: in Sweden, the band 223-235 MHz is also allocated to the aeronautical radionavigation service on a permitted basis until 1 January 1990, subject to agreement obtained under the procedure set forth in Article 14, and on condition that no harmful interference is caused to existing and planned broadcasting stations in other countries.

635 - Alternative allocation: in Botswana, Lesotho, Namibia, South Africa, Swaziland and Zambia, the bands 223-238 MHz and 246-254 MHz are allocated to the broadcasting service on a primary basis subject to agreement obtained under the procedure set forth in Article 14.

642 - The frequency 243 MHz is the frequency in this band for use by survival craft stations and equipment used for survival purposes.

647 - Additional allocation: in Afghanistan, Saudi Arabia, Bahrain, Bulgaria, Colombia, Costa Rica, Cuba, Egypt, the United Arab Emirates, Ecuador, Hungary, Indonesia, Iran, Iraq, Israel, Kuwait, Liberia, Malaysia, Nigeria, Oman, Pakistan, the Philippines, Poland, Qatar, Syria, the German Democratic Republic, Romania, Singapore, Somalia, Sri Lanka, Czechoslovakia, Thailand, the U.S.S.R. and Yugoslavia, the band 400.05-401 MHz is also allocated to the fixed and mobile services on a primary basis.

648 - Additional allocation: in Canada, the bands 405.5-406 MHz and 406.1-410 MHz are also allocated to the mobile-satellite, except aeronautical mobile-satellite, service (Earth-to-space), on a primary basis, subject to agreement obtained under the procedure set forth in Article 14.

651 - Different category of service: in Australia, the United States, India, Japan and the United Kingdom, the allocation of the bands 420-430 MHz and 440-450 MHz to the radiolocation service is on a primary basis (see No. 425).

652 - Additional allocation: in Australia, the United States, Jamaica and the Philippines, the bands 420-430 MHz and 440-450 MHz are also allocated to the amateur service on a secondary basis.

653 - Additional allocation: in China, India, the German Democratic Republic, the United Kingdom and the U.S.S.R., the band 420-460 MHz is also allocated to the aeronautical radionavigation service (radio altimeters) on a secondary basis.

654 - Different category of service: in France, the allocation of the band 430-434 MHz to the amateur service is on a secondary basis (see No. 424).

655 - Different category of service: in Denmark, Libya, Norway and Sweden, the allocation of the band 430-432 MHz and 438-440 MHz to the radiolocation service is on a secondary basis (see No. 424).

656 - Alternative allocation: in Denmark, Norway and Sweden, the bands 430-432 MHz and 438-440 MHz are allocated to the fixed and mobile, except aeronautical mobile, services on a primary basis.

657 - Additional allocation: in Finland, Libya and Yugoslavia, the bands 430-432 MHz and 438-440 MHz are also allocated to the fixed and mobile, except aeronautical mobile, services on a primary basis.

658 - Additional allocation: in Afghanistan, Algeria, Saudi Arabia, Bahrain, Bangladesh, Brunei, Burudi, Egypt, the United Arab Emirates, Ecuador, Ethiopia, Greece, Guinea, India, Indonesia, Iran, Iraq, Israel, Italy, Jordan, Kenya, Kuwait, the Lebanon, Libya, Liechtenstein, Malaysia, Malta, Nigeria, Oman, Pakistan, the Philippines, Qatar, Syria, Singapore, Somalia, Switzerland, Tanzania, Thailand and Togo, the band 430-440 MHz is also allocated to the fixed service on a primary basis and the bands 430-435 MHz and 438-440- MHz are also allocated to the mobile, except aeronautical mobile, service on a primary basis.

659 - Additional allocation: in Angola, Bulgaria, Cameroon, the Congo, Gabon, Hungary, Mali, Mongolia, Niger, Poland, the German Democratic Republic, Romania, Rwanda, Chad, Czechoslovakia and the U.S.S.R., the band 430-440 MHz is also allocated to the fixed service on a primary basis.

660 - Different category of service: in Argentina, Colombia, Costa Rica, Cuba, Guyana, Honduras, Panama and Venezuela, the allocation of the band 430-440 MHz to the amateur service is on a primary basis (see No. 425).

660A - Additional allocation in Mexico, the bands 430-435 MHz and 438-440 MHz are also allocated on a primary basis to the land mobile service, subject to agreement obtained under the procedure set forth in Article 14.

661 - In Region 1, except in the countries mentioned in No. 662, the band 433.05-434.79 MHz (center frequency 433.92 MHz) is designated for industrial, scientific and medical (ISM) applications. The use of this frequency band for ISM applications shall be subject to special authorization by the administration concerned, in agreement with other administrations whose radiocommunication services might be affected. In applying this provision, administrations shall have due regard to the latest relevant CCIR Recommendations.

662 - In the Federal Republic of Germany, Austria, Liechtenstein, Portugal, Switzerland and Yugoslavia, the band 433.05-434.79 MHz (center frequency 433.92 MHz) is

designated for industrial, scientific and medical (ISM) applications. Radiocommunication services of these countries operating within this band must accept harmful interference which may be caused by these applications. ISM equipment operating in this band is subject to the provisions of No. 1815.

663 - Additional allocation: in Brazil, France and the French Overseas Departments in Region 2, and India, the band 433.75-434.25 MHz is also allocated to the space operation service (Earth-to-space) on a primary basis until 1 January 1990, subject to agreement obtained under the procedure set forth in Article 14. After 1 January 1990, the band 433.75-434.25 MHz will be allocated in the same countries to the same service on a secondary basis.

664 - In the bands 435-438 MHz, 1,260-1,270 MHz, 2,400-2,450 MHz, 3,400-3,410 MHz (in Regions 2 and 3 only) and 5,650-5,670 MHz, the amateur-satellite service may operate subject to not causing harmful interference to other services operating in accordance with the Table (see No. 435). Administrations authorizing such use shall ensure that any harmful interference caused by emissions from a station in the amateur-satellite service is immediately eliminated in accordance with the provisions of No. 2741. The use of the bands 1,260-1,270 MHz and 5,650-5,670 MHz by the amateur-satellite service is limited to the Earth-to-space direction.

665 - Additional allocation: in Austria, the band 438-440 MHz is also allocated to the fixed and mobile, except aeronautical mobile, services on a primary basis.

666 - Additional allocation: in Canada, New Zealand and Papua New Guinea, the band 440-450 MHz is also allocated to the amateur service on a secondary basis.

667 - Different category of service: in Canada, the allocation of the band 440-450 MHz to the radiolocation service is on a primary basis (see No. 425).

668 - Subject to agreement obtained under the procedure set forth in Article 14, the band 449.75-450.25 MHz may be used for the space operation service (Earth-to-space) and the space operation service (Earth-to-space).

GOVERNMENT

G2 - In the bands 216-225,420-450 (except as provided by US217), 890-902, 928-942, 1300-1400, 2300-2450, 2700-2900, 5650-5925, and 9000-9200 MHz, the Government radiolocation is limited to the military services.

G6 - Military tactical fixed and mobile operations may be conducted nationally on a secondary basis; (1) to the meteorological aids service in the band 403-406 MHz; and (2) to the radio astronomy service in the band 406.1-410 MHz. Such fixed and mobile operations are subject to located coordination to ensure that harmful interference will not be caused to the services to which the bands are allocated.

G8 - Low power Government radio control operations are permitted in the band 420-450 MHz.

NON-GOVERNMENT

NG121 - The maritime mobile use of this band is limited to operations along the Mississippi River and connecting waterways, the Gulf Intercoastal Waterways, and the offshore waters of the Gulf of Mexico.

NG135 - In the 420-430 MHz band the Amateur service is not allocated north of line A. (def. S 2.1).

UNITED STATES

US7 - In the band 420-450 MHz and within the following areas, the peak envelope power output of a transmitter employed in the amateur service shall not exceed 50 watts, unless expressly authorized by the commission after mutual agreement, on a case-by-case basis, between the Federal Communications Commission Engineer in Charge at the applicable District Office and the Military Area Frequency Coordinator at the applicable military Base:

(a) Those portions of Texas and New Mexico bounded on the south by latitude 31° 45' North, on the east by 104° 00' West, on the north by latitude 34° 30' North, and on the west by longitude 107° 30' West; ,

(b) The entire State of Florida including the Key West area and the areas enclosed within a 200 mile radius of Patrick Air Force Base, Florida (latitude 28° 21' North, longitude 80° 43' West), and within a 200 mile radius of Eglin Air Force Base, Florida (latitude 30° 30' North, longitude 86° 30' West);

(c) The entire State of Arizona;

(d) Those portions of California and Nevada south of latitude 37° 10' North, and the areas enclosed within a 200 mile radius of the Pacific Missile Test Center, Point Mugu, California (latitude 34° 09' North, longitude 119° 11' West).

(e) In the State of Massachusetts within a 160 kilometer (100 mile) radius around locations at Otis Air Force Base, Massachusetts (latitude 41° 45' North, longitude 70° 32' West).

(f) In the State of California within 240-kilometer (150 mile) radius around locations at Beale Air Force Base, California (latitude 39° 08' North, longitude 121 ° 26' West).

(g) In the State of Alaska within a 160-kilometer (100 mile) radius of Clear, Alaska (latitude 64° 17' North, longitude 149° 10' West). (The Military Area Frequency Coordinator for this area is located at Elmendorf Air Force Base, Alaska.)

(h) In the State of North Dakota within a 160 kilometer (100 mile) radius of Concrete, North Dakota (latitude 48° 43' North, longitude 97° 54' West). (The Military Area Frequency Coordinator for this area can be contacted at: HQ SAC/SXOE, Offutt Air Force Base, Nebraska 68113.)

(i) In the States of Alabama, Florida, Georgia and South Carolina within a 200 kilometer (124 mile) radius of Warner Robins Air Force Base, Georgia (latitude 32° 38' North, longitude 83° 35' West).

(j) In the State of Texas within a 200 kilometer (124 mile) radius of Goodfellow Air Force Base, Texas (latitude 31° 25' North, longitude 100° 24' West).

US70 - The meteorological aids service allocation in the band 400.15-406 MHz does not preclude the operation therein of associated ground transmitters.

US87 - The frequency 450 MHz, with maximum emission bandwidth of 500 kHz, may be used by Government and non-Government stations for space telecommand at specific locations, subject to such conditions as may be applied on a case-by-case basis.

US210 - Use of frequencies in the bands 40.66-40.70 and 216-220 MHz may be authorized to Government and non-Government stations on a secondary basis for the tracking of, and telemetering of scientific data from, ocean buoys and wildlife. Air-borne wildlife telemetry in the 216-220 MHz band will be limited to the 216.000-216.100 MHz portion of band. Operation in these two bands is subject to the technical standards specified in (a) Section 8.2.42 of the NTIA Manual for Government use, or (b) in Section 5.108 of the Commission's Rules for non-Government.

US217 - Pulse ranging radiolocation systems may be authorized for Government and nongovernment use in the 420-450 MHz band along the shorelines of Alaska and the contiguous 48 States. Spread spectrum radiolocation systems may be authorized in the 420-435 MHz portion of the band for operation within the contiguous 48 States and Alaska. Authorizations will be granted on a case-by-case basis; however, operations proposed to be located within the zones set forth in US228 should not expect to be accommodated. All stations operating in accordance with this provision will be secondary to stations operating in accordance with the Table of Frequency Allocations.

US228 - Applicants of operation in the band 420 to 450 MHz under the provisions of US217 should not expect to be accommodated if their area of service is within the following geographic areas:

(a) Those portions of Texas and New Mexico bounded on the south by latitude 31° 45' North, on the east by longitude 104° 00' West, on the north by latitude 34° 30' North, and on the West by longitude 107° 30' West.

(b) The entire State of Florida including the Key West area and the areas enclosed within a 200 mile radius of Patrick Air Force Base, Florida (latitude 28° 21' North, longitude 80° 43' West), and within a 200 mile radius of Eglin Air Force Base, Florida (latitude 30° 30' North, ILongitude 86° 30' West).

(c) The entire State of Arizona;

(d) Those portions of California and Nevada south of latitude 37° 10' North, and the areas enclosed within a 200 mile radius of the Pacific Missile Test Center, Point Mugu, California (latitude 34° 09' North, longitude 119° 11' West).

(e) In the State of Massachusetts within a 160 kilometer (100 mile) radius around locations at Otis Air Force Base, Massachusetts (latitude 41° 45' North, longitude 70° 32' West) .

(f) In the State of California within a 240 kilometer (150 mile) radius around locations at Beale Air Force Base, California (latitude 39° 08' North, longitude 121° 26' West).

(g) In the State of Alaska within a 160 kilometer (100 mile) radius Clear, Alaska (latitude 64° 17' North, longitude 149° 10' West). (The Military Area Frequency Coordinator for this area is located at Elmendorf Air Force Base, Alaska).

(h) In the State of North Dakota within a 160 kilometer (100 mile) radius of Concrete, North Dakota (latitude 48° 43' North, longitude 97° 54' West). The Military Area Frequency Coordinator for this area can be contacted at HQ SAC/SXOE, Offutt Air Force Base, Nebraska 68113.)

(i) In the States of Alabama, Florida, Georgia and South Carolina within a 200 kilometer (124 mile) radius of Warner Robins Air Force Base, Georgia (latitude 32° 38' North, longitude 83° 35' West).

(j) In the State of Texas within a 200 kilometer (124 mile) radius of Goodfellow Air Force Base, Texas (latitude 31° 25' North, longitude 100° 24' West).

US229 - Assignments to stations in the fixed and mobile services may be made on the condition that no harmful interference is caused to the Navy SPASUR system currently operating in the southern United States in the frequency band 216.88-217.08 MHz.

US230 - Nongovernment land mobile service is allocated on a primary basis in the bands 422.1875-425.4875 and 427.1875-429.9875 MHz within 50 statute miles of Detroit, MI and Cleveland, OH, and in the bands 423.8125-425.4875 and 428.8125-429.9875 MHz within 50 statute miles of Buffalo, NY.

US243 - In the band 220-225 MHz, stations in the radiolocation service have priority until 1 January 1990.

US274 - In the 216-220 MHz band, fixed aeronautical mobile and land mobile and land mobile stations are limited to telemetering and associated telecommand operations.

APPENDIX B

EMC RESULTS

The following gives a discussion of the method used to determine compatibility between Wind Profilers and environmental systems in the 216-225 MHz and 420-450 MHz bands. Specifically, the method to aid in determining compatibility was to generate Frequency-Distance (F-D) curves between Type A and B profilers and environmental systems. Given below is a discussion of the method to generate F-D curves, a sample calculation showing the F-D results obtained from the representative fixed land based radar to the Type A Wind Profiler (High Altitude Mode), and a summary of the F-D curves for Type A and B Profilers and environmental systems.

Frequency-Distance Separation

Frequency-distance separation curves were calculated for Type A and B profilers and environmental systems in the 216-225 MHz and 420-450 MHz bands as discussed in the EMC section of the report, (Section 6). The frequency-distance curves show graphically the relationship between the distance separation (d), and off-tuning or frequency separation (ΔF) necessary to limit the interference level at the receiver IF output to some specified value. The frequency-distance curves do not take into account signal processing circuitry, such as pulse integrators or sliding window detectors. For example, post processing may suppress synchronous pulsed interference and permit closer frequency-distance separations than those given here. The frequency-distance separation relationships were obtained using the FDRCAL program[20] which implements the following algorithm:

$$L(d) + FDR(\Delta F) = P_t + G_t + G_r - L_s - L_a - INR - N \quad \text{(B-1)}$$

Where: L(d) = Median propagation path loss between receiver and transmitter
FDR (ΔF) = Frequency-dependent-rejection, in dB
P_t = The peak transmitter power of the potential interfering radar, in dBm
G_t = The nominal gain of the potential interfering radar, in dBi
G_t = Receiving antenna, in dBi
L_s = Waveguide and coupler insertion losses, assumed 2 dB.
L_a = Loss due to cross polarization for mainbeam coupling.
INR = Interference-to-Noise Ratio at the receiver input to preclude performance degradation, assumed INR=0.
N = Receiver, inherent noise level referred to the RF input, in dBm.

The principle of the frequency-distance computer model is that the parameters on the right hand side of Equation B-1 are considered as constants and the parameters on the left hand side as variables. That is, the propagation loss, L(d), is a function of distance separation and frequency-dependent-rejection, FDR (ΔF), is a function of frequency separation between receiving and interfering systems. The left hand side of Equation B-1 is essentially the required loss to obtain a specified INR at the receiver IF output. The FDRCAL model was used to generate these curves.

[20] Newhouse, Paul D., The Frequency-Dependent Rejection (FDR) Concept and Its Application to EMC Analysis, Technical Note, ECAC-TN-86-007, Department of Defense, Electromagnetic Compatibility Analysis Center, Annapolis, MD, June 1986, p. 4-8 through 4-15.

Using the FDRCAL program, a sample calculation showing the F-D values necessary to preclude interference from representative fixed land based radar operating in the 420-450 MHz band to the Type A Wind Profiler (High Altitude Mode) is given. The input values used in Equation B-1 to represent the Type A Wind Profiler (High Altitude Mode) characteristics are given in TABLE 3-2 and Figure 3-4. The representative fixed land based radar characteristics are given in TABLE 6-16. The specific input values used in Equation B-1 are as follows:

P_t	=	98 dBm	Representative Fixed Land Based Radar peak power
G_t	=	0 dBi	Representative Fixed Land Based Radar antenna gain
G_r	=	-25 dBi	Wind Profiler antenna gain (85-90 degrees region)
L_s	=	2 dB	Waveguide and insertion losses
L_a	=	0 dB	Cross polarization loss
INR	=	0 dB	INR threshold
N	=	-124.9 dBm	Type A Wind Profiler (high altitude mode) noise level

Substituting these values into Equation B-1 yields a L(d) + FDR (ΔF) = 195.9 dB. Using the calculated required loss value of 195.9 dB as well as the Wind Profiler selectivity curve (Figure 3-4) and representative fixed land based emission characteristics (TABLE 6-16) results in a co-channel distance separation of 64.4 km to preclude interference. TABLE B-1 shows the output of the FDRCAL program which contains both the inputs used as well as the results obtained for this specific case.

Other F-D results showing the distance required to preclude interference between Wind Profilers and environmental system were obtained in a similar method. Figures B-1 through B-15 summarizes the results.

```
>> THE SECURITY CLASSIFICATION OF THIS FILE IS:  UNCLASSIFIED
>> THE PROGRAM THAT CREATED THIS FILE IS: FDRCAL v.1.0
>> NUMBER OF LINES PER PAGE IS: 60
1
                       TRANSMITTER : FIXED LAND BASED RADAR
             TRANSMITTER ID NUMBER :    1
        TRANSMITTER 3-DB BANDWIDTH :  1.000E+03 KHZ
  EMISSION CURVE LEFT EXTRAP SLOPE :     10. DB/DECADE
 EMISSION CURVE RIGHT EXTRAP SLOPE :     10. DB/DECADE
   NUMBER OF EMISSION CURVE POINTS :     9
     FDR MODIFICATION SIGNAL TYPE :     RADAR
                    SPECTRAL BOUND :     NO
                       PULSE WIDTH :     .88 MICROSECONDS

                          RECEIVER : WP-AH
                RECEIVER ID NUMBER :    1
           RECEIVER 3-DB BANDWIDTH :  120.     KHZ
 SELECTIVITY CURVE LEFT EXTRAP SLOPE :    70. DB/DECADE
SELECTIVITY CURVE RIGHT EXTRAP SLOPE :    70. DB/DECADE
 NUMBER OF SELECTIVITY CURVE POINTS :    13
```

0 EMISSION CURVE :

(KHZ)	(DB)
-100000.000	-70.0
-17000.000	-70.0
-1000.000	-20.0
-500.000	-3.0
.000	.0
500.000	-3.0
1000.000	-20.0
17000.000	-70.0
100000.000	-70.0

SELECTIVITY CURVE :

(KHZ)	(DB)
-25000.000	120.0
-10000.000	90.0
-3750.000	60.0
-750.000	60.0
-100.000	10.0
-60.000	3.0
.000	.0
60.000	3.0
100.000	10.0
750.000	60.0
3750.000	60.0
10000.000	90.0
25000.000	120.0

```
0         RECEIVER ANTENNA HEIGHT :      6. FEET
       TRANSMITTER ANTENNA HEIGHT :    100. FEET
  TRANSMITTER ANTENNA POLARIZATION :       V
    TRANSMITTER PRIMARY FREQUENCY :   435.00 MHZ
                    REQUIRED LOSS :   195.9 DB
                     REFRACTIVITY : 300.0319
                     PERMITTIVITY :  14.7911
                     CONDUCTIVITY :    .0096 MHO/METER
           PROPAGATION LOSS MODEL :   IPS
   MAX ITERATIONS FOR INVERSE LOSS :      20
  RELATIVE ERROR FOR INVERSE LOSS :    .0010
OON TUNE REJECTION :      9.0 DB
+
```

OTR & OFR BASED ON AVERAGE SIGNAL POWER

DELTA F (KHZ)	RECEIVER FREQ (MHZ)	OFR (DB)	FDR (DB)	LOSS (DB)	DIST (MI)	DIST (NMI)	DIST (KM)	DIST (FT)	PROP MODEL
.000	435.000	.0	18.1	177.8	40.0	34.8	64.4	211349.3	STGW1
500.000	434.500	3.4	21.4	174.5	37.5	32.6	60.3	197980.8	STGW1
1000.000	434.000	19.5	37.5	158.4	25.9	22.5	41.7	136681.3	STGW1
1500.000	433.500	26.9	44.9	151.0	20.9	18.1	33.6	110270.4	STGW1
2000.000	433.000	31.9	50.0	145.9	17.6	15.3	28.3	92989.1	STGW1
2500.000	432.500	35.8	53.9	142.0	15.3	13.3	24.6	80598.8	STGW1
3000.000	432.000	38.9	56.9	139.0	13.5	11.7	21.7	71143.0	STGW1
3500.000	431.500	41.4	59.5	136.4	12.1	10.5	19.4	63643.6	STGW1
4000.000	431.000	43.7	61.7	134.2	10.8	9.4	17.4	57122.4	STGW1
4500.000	430.500	45.9	63.9	132.0	9.7	8.4	15.6	51253.3	STGW1
5000.000	430.000	47.8	65.9	130.0	8.7	7.6	14.0	46036.3	STGW1
5500.000	429.500	49.6	67.7	128.2	7.9	6.9	12.7	41797.6	STGW1
6000.000	429.000	51.2	69.3	126.6	7.2	6.2	11.5	37884.8	STGW1
6500.000	428.500	52.7	70.7	125.2	6.6	5.7	10.6	34772.0	STGW1
7000.000	428.000	54.0	72.1	123.8	6.0	5.2	9.7	31895.9	STGW1
7500.000	427.500	55.2	73.3	122.6	5.6	4.8	9.0	29379.3	STGW1
8000.000	427.000	56.4	74.5	121.4	5.2	4.5	8.3	27222.2	STGW1
8500.000	426.500	57.5	75.5	120.4	4.8	4.2	7.7	25424.6	STGW1
9000.000	426.000	58.5	76.6	119.3	4.5	3.9	7.3	23986.5	STGW1
9500.000	425.500	59.5	77.5	118.4	4.3	3.7	6.9	22548.4	STGW1
10000.000	425.000	60.4	78.4	117.5	4.1	3.5	6.5	21469.9	STGW1

0***** WARNING - THE USER SHOULD CHECK FOR THE POSSIBILITY OF A COSITE OR NEAR-FIELD CONDITION EXISTING, IN WHICH CASE THESE RESULTS ARE NOT VALID *****

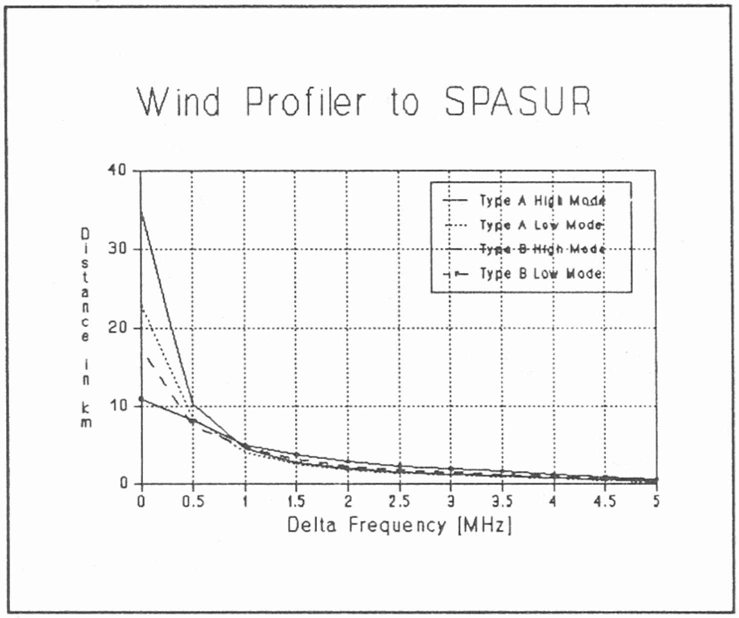
TABLE B-1. Sample F-D Results for Land Based Radar to Type A Wind Profiler (High Mode).

EMC Results

The F-D curves that are given in this section show the frequency versus distance necessary to preclude interference between the Type A and B profilers and each system selected in the 216-225 and 420-450 MHz bands. TABLE B-2 lists the appropriate figures for each of the bands.

TABLE B-2
FIGURES SHOWING THE SUMMARY OF
F-D CURVES FOR SELECTED SYSTEMS
IN THE 216-225 MHz AND 420-450 MHz BANDS

SYSTEM	FIGURES	BANDS
SPASUR	FIGURE B-1	216-220 MHz
TELEMETRY	FIGURE B-2	216-220 MHz
LAND MOBILE and MARITIME MOBILE	FIGURE B-3	216-220 MHz
LAND MOBILE	FIGURE B-4	420-450 MHz
AN/GRC-103	FIGURE B-5	220-225 MHz
AMATEUR REPEATER	FIGURE B-6	222-225 MHz
AMATEUR REPEATER	FIGURE B-7	442-450 MHz
AMATEUR TV	FIGURE B-8	420-450 MHz
LAND BASED RADAR	FIGURE B-9	420-450 MHz
AIRBORNE RADAR		420-450 MHz
Gain = 22 dBi		
Alt: 20,000 ft.	FIGURE B-10	420-450 MHz
Alt: 40,000 ft.	FIGURE B-11	420-450 MHz
Gain = 0 dBi		
Alt: 20,000 ft.	FIGURE B-12	420-450 MHz
Alt: 40,000 ft.	FIGURE B-13	420-450 MHz
SHIPBORNE RADAR	FIGURE B-14	420-450 MHz
DRONES	FIGURE B-15	420-450 MHz



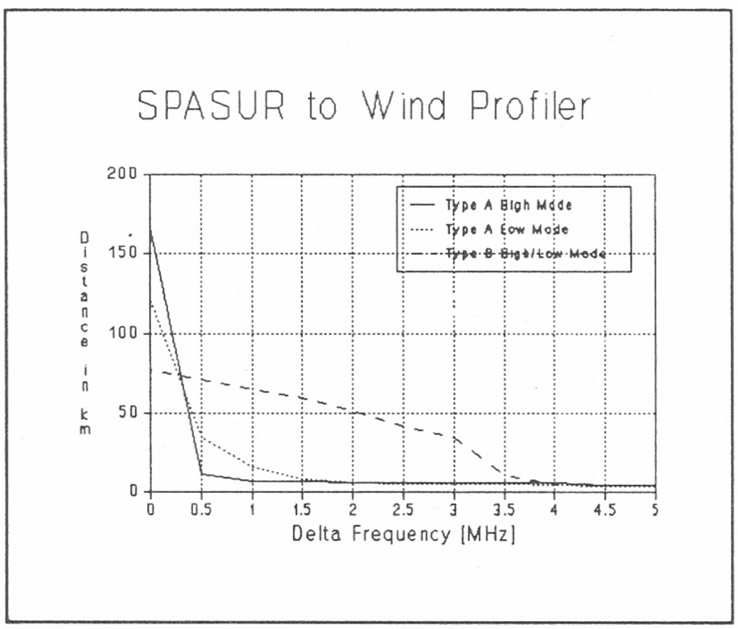
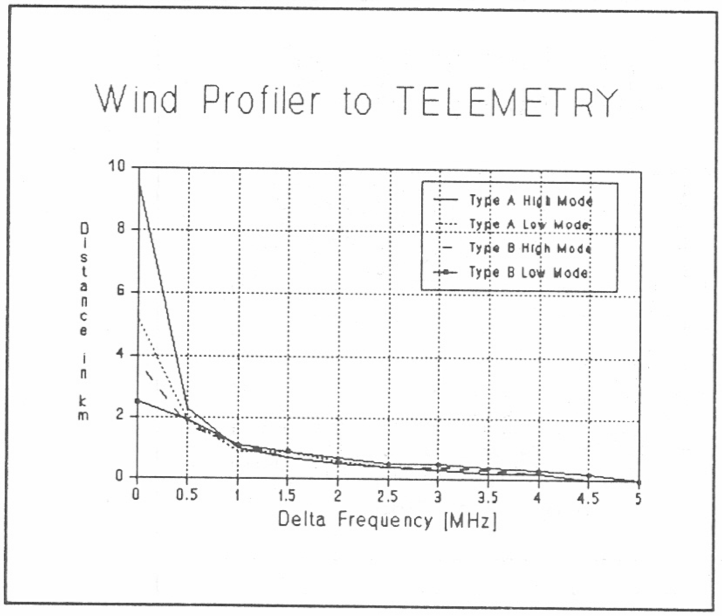


Figure B-1. F-D curves for Wind Profilers and SPASUR. (Wind Profiler sidelobe (85°-90° region) and SPASUR sidelobe coupling.)



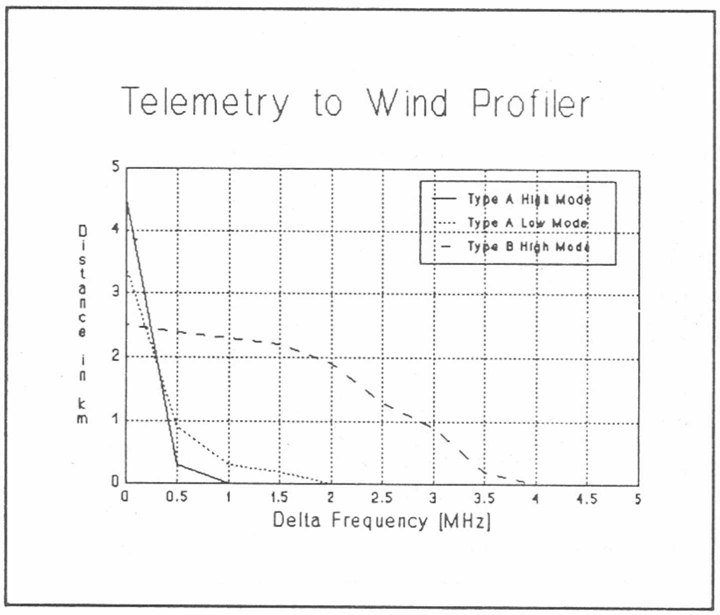


Figure B-2. **F-D curves for Wind Profilers and Telemetry. (Wind Profiler sidelobe (85°-90° region) and telemetry mainbeam coupling.)**

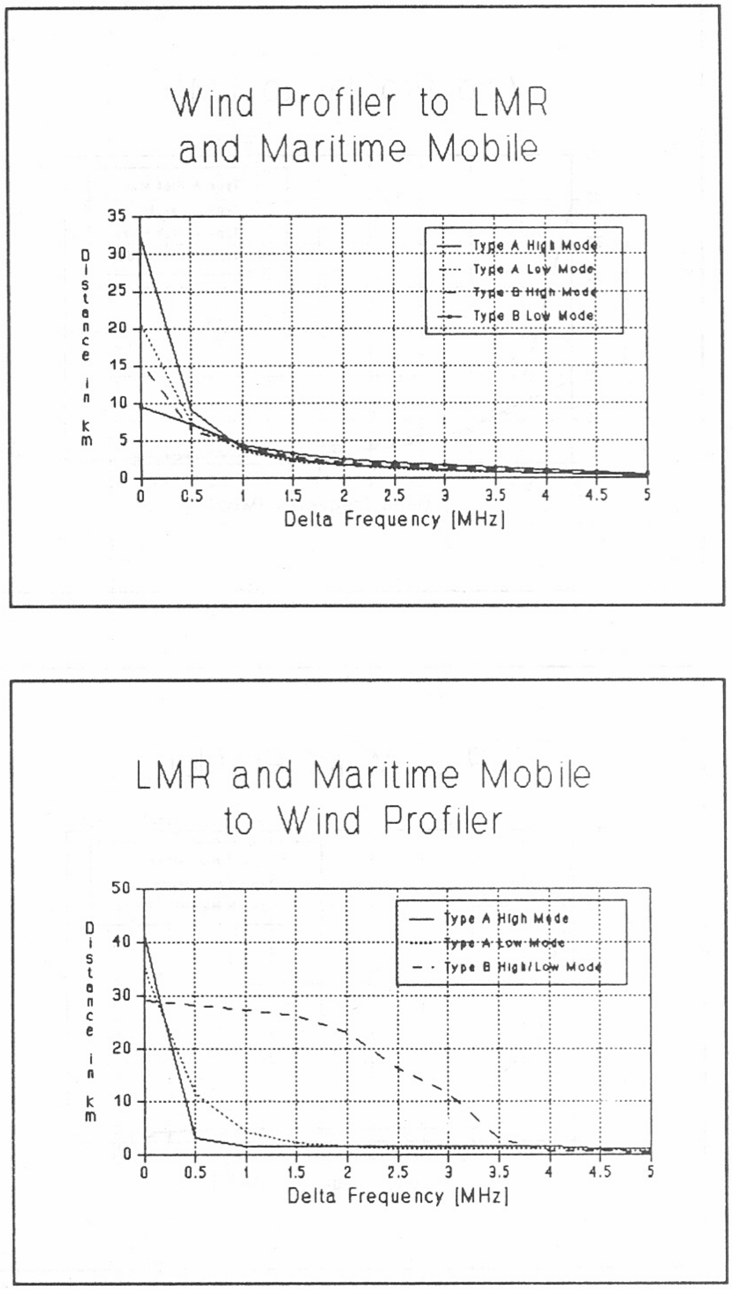
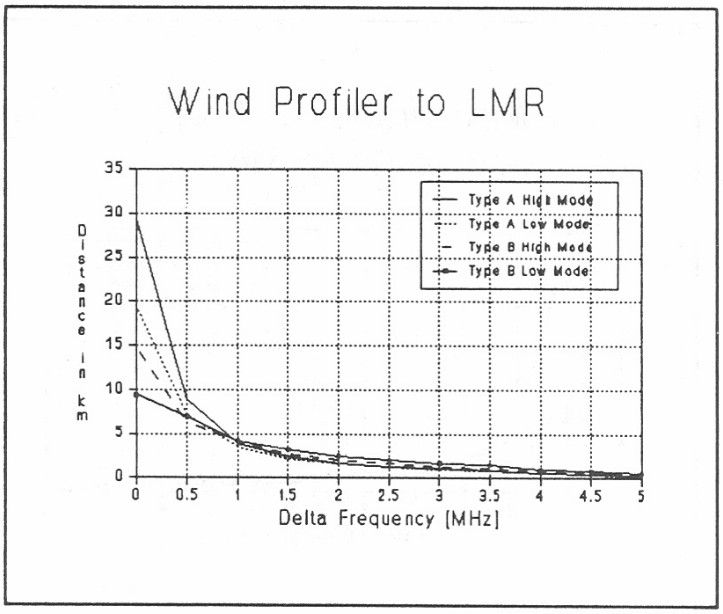


Figure B-3. **F-D curves for Wind Profilers and Land Mobile and Maritime Mobile (216-220 MHz band). (Wind Profiler sidelobe (85°-90° region) and land mobile and maritime mainbeam coupling.)**



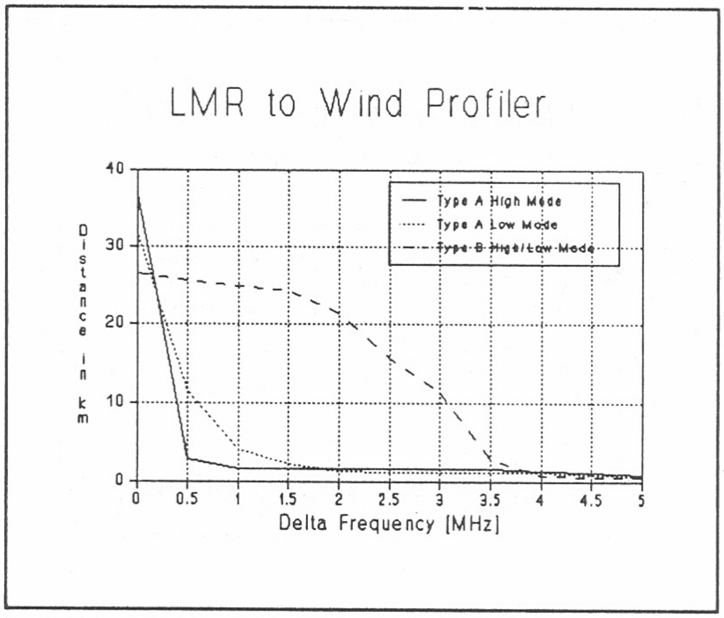
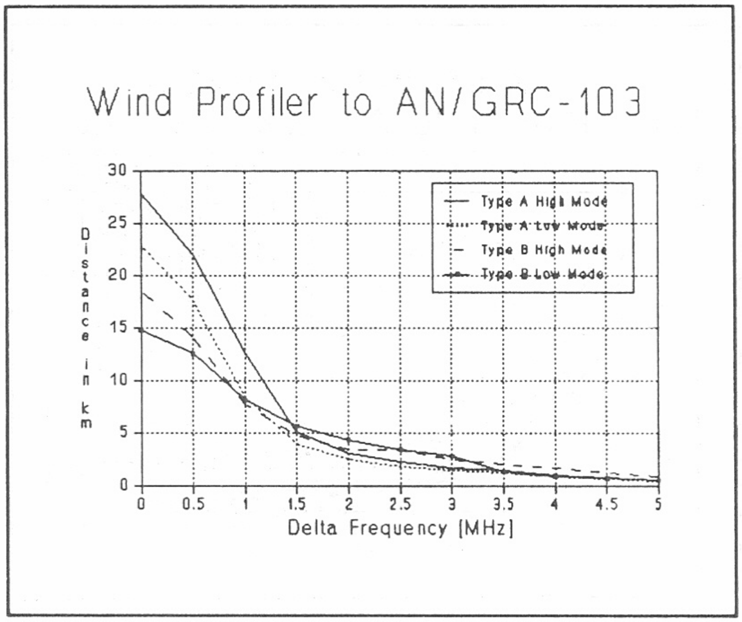


Figure B-4. F-D curves for Wind Profilers and Land Mobile (420-450 MHz band). (Wind Profiler sidelobe (85°-90° region) and land mobile mainbeam coupling.)



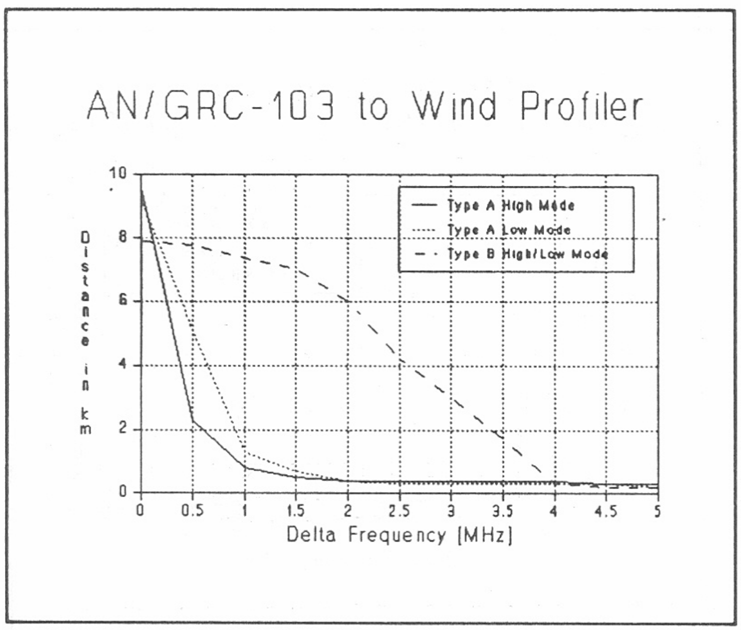
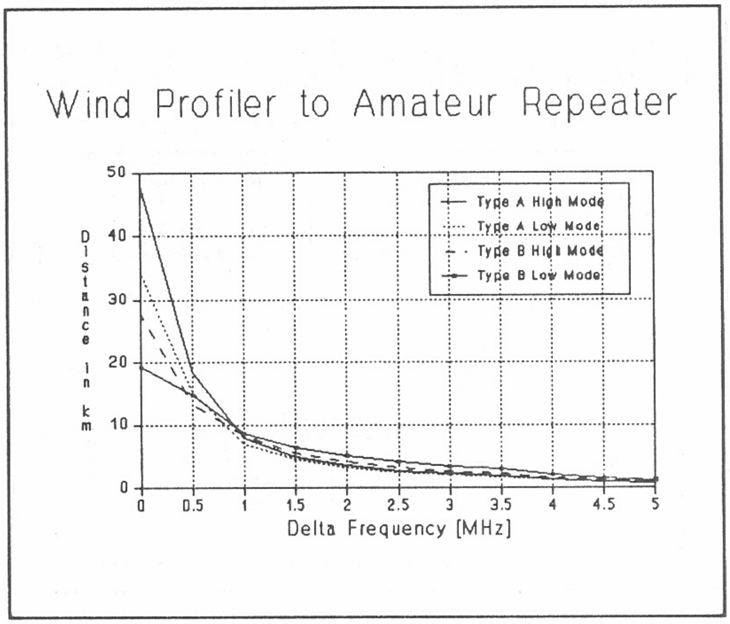


Figure B-5. **F-D curves for Wind Profilers and AN/GRC-103. (Wind Profiler sidelobe (85°-90° region) and AN/GRC-103 mainbeam coupling.)**



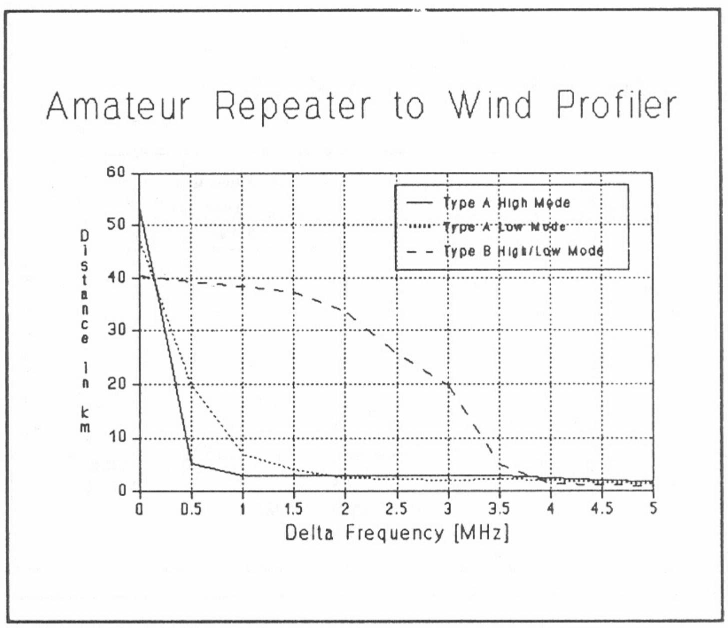
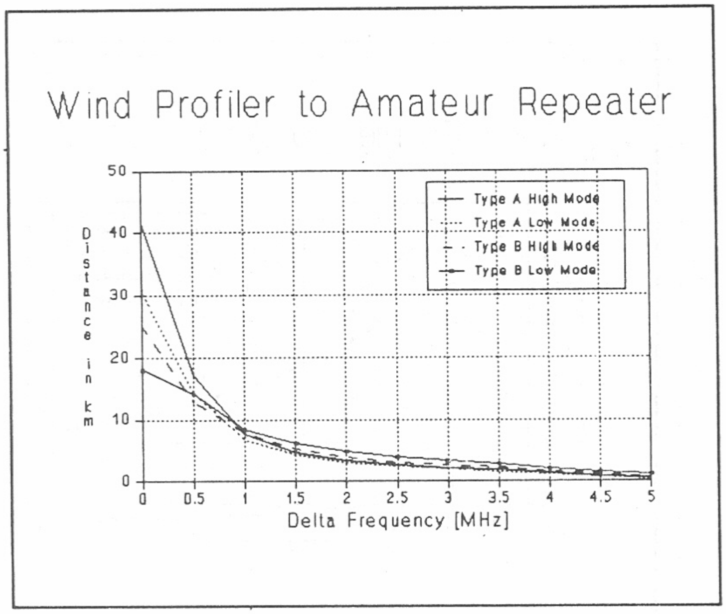


Figure B-6. **F-D curves for Wind Profilers and Amateur Repeater (222-225 MHz band). (Wind Profiler sidelobe (85°-90° region) and amateur repeater mainbeam coupling.)**



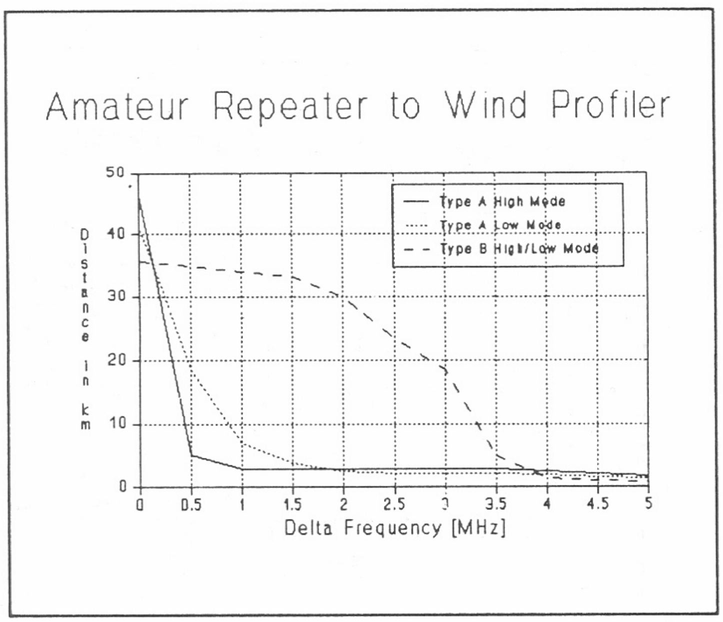
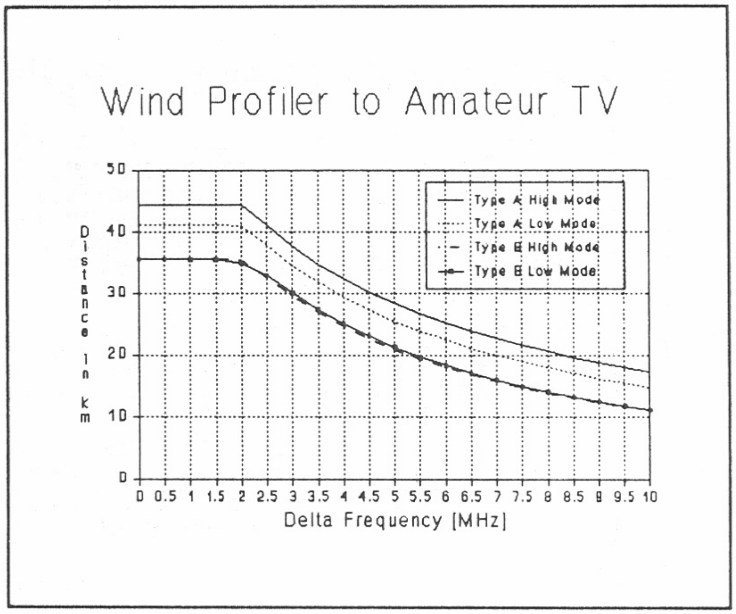


Figure B-7. F-D Curves for Wind Profilers and Amateur Repeater (442-450 MHz band). (Wind Profiler sidelobe (85°-90° region) and amateur repeater mainbeam coupling.)



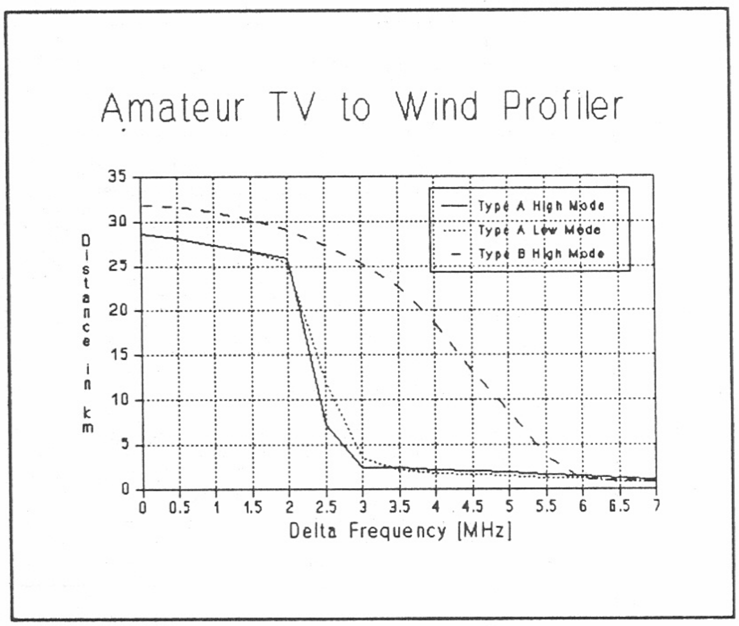
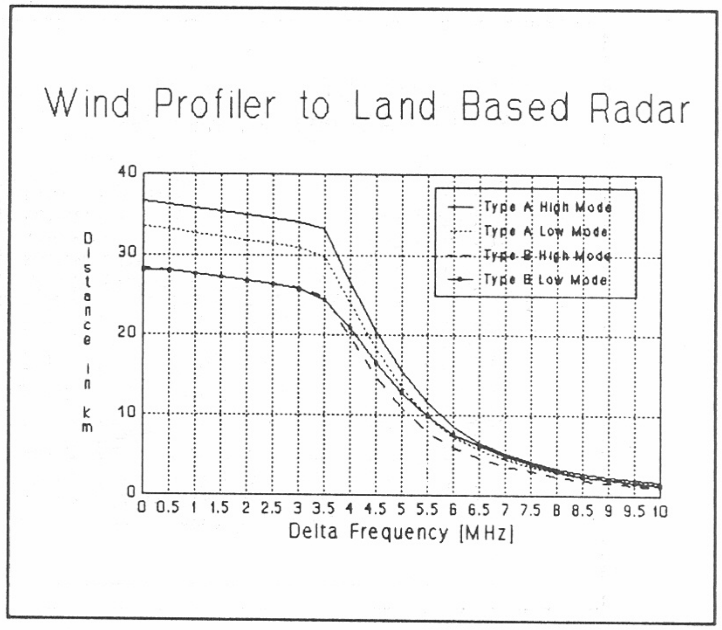


Figure B-8. **F-D curves for Wind Profilers and Amateur TV. (Wind Profiler sidelobe (85°-90° region) and amateur TV mainbeam coupling.)**



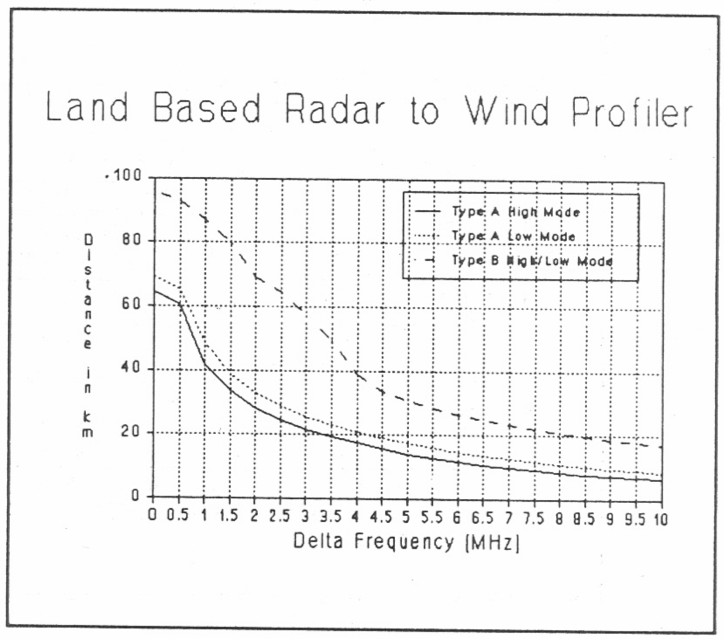
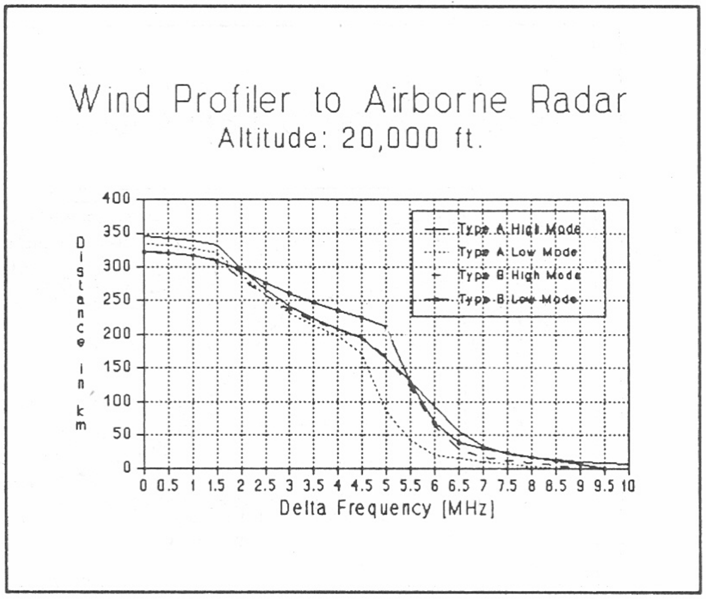


Figure B-9. F-D curves for Wind Profilers and Land Based Radar. (Wind Profiler sidelobe (85°-90° region) and land based radar sidelobe coupling.)



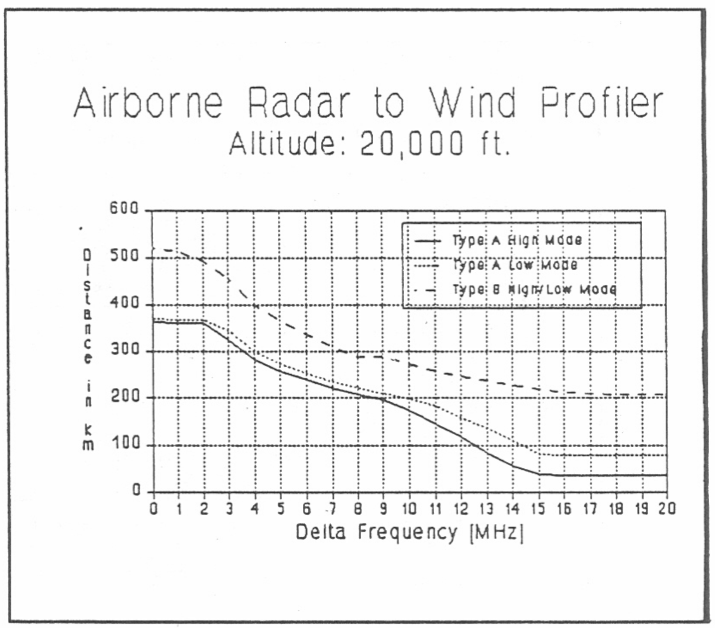


Figure B-10. **F-D curves for Wind Profilers and Airborne Radar with 22 dBi gain at an altitude of 20,000 ft. (Wind Profiler sidelobe (60°-90° region) and airborne radar mainbeam coupling.)**

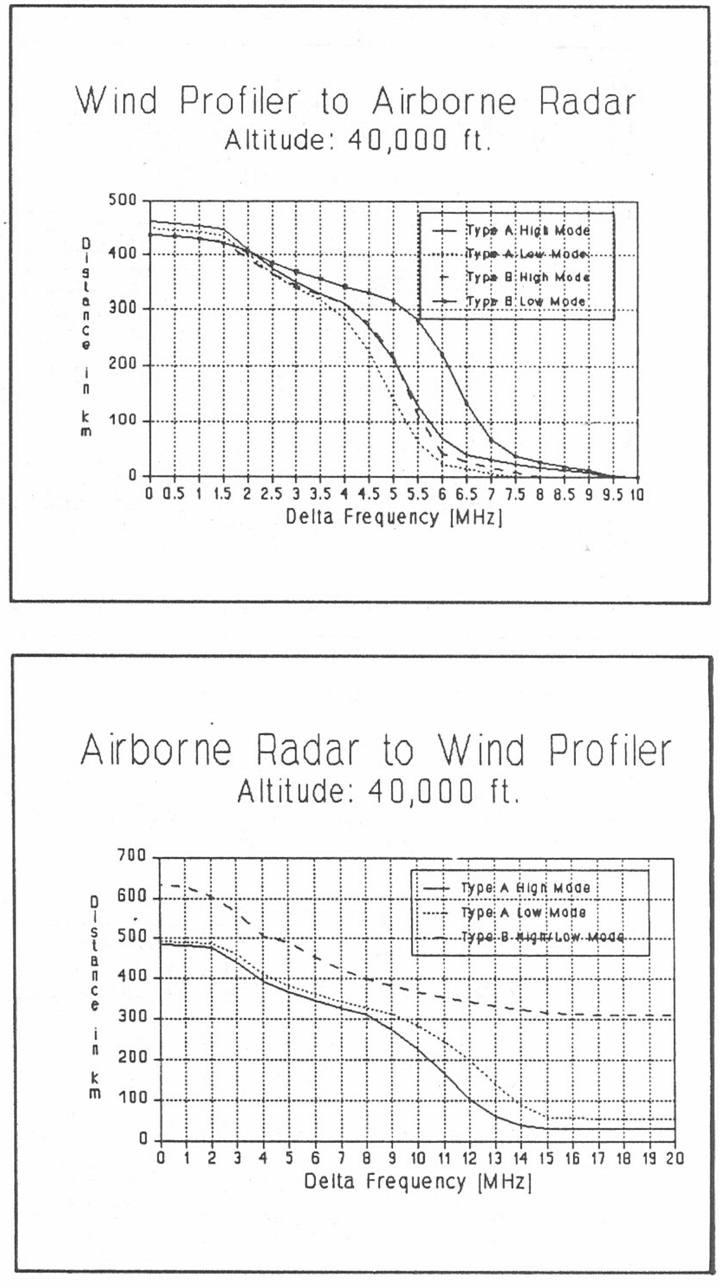
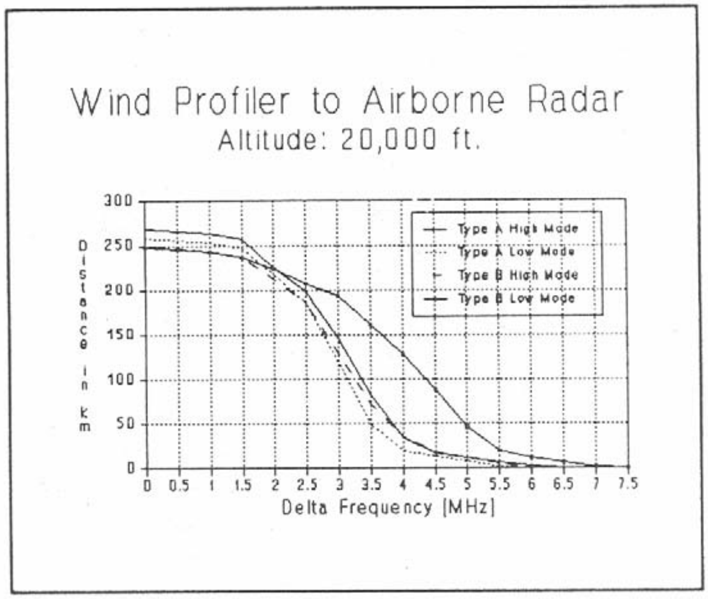


Figure B-11. F-D curves for Wind Profilers and Airborne Radar with 22 dBi gain at an altitude of 40,000 ft. (Wind Profiler sidelobe (60°-90° region) and airborne radar mainbeam coupling.)



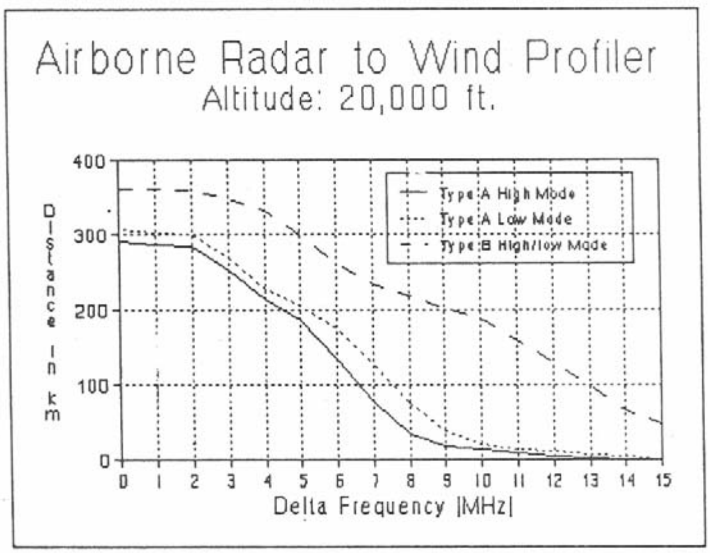
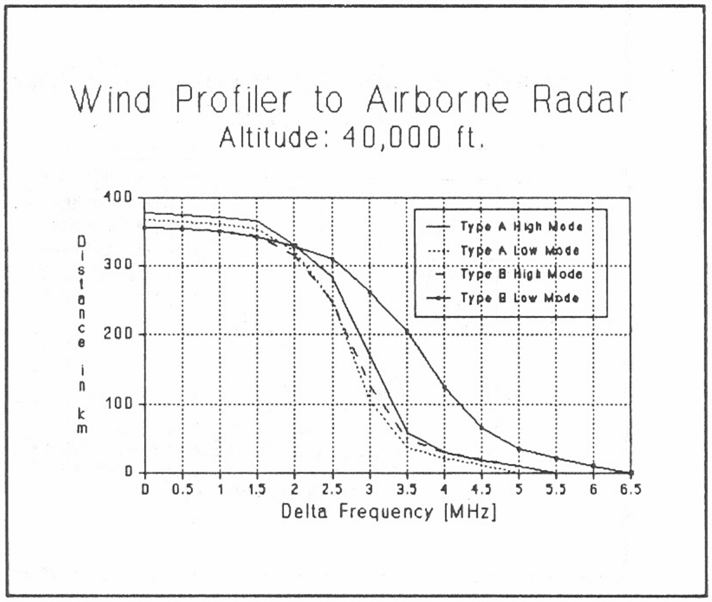


Figure B-12. F-D curves for Wind Profilers and Airborne Radar with 0 dBi gain at an altitude of 20,000 ft. (Wind Profiler sidelobe (60°-90° region) and airborne radar sidelobe coupling.)



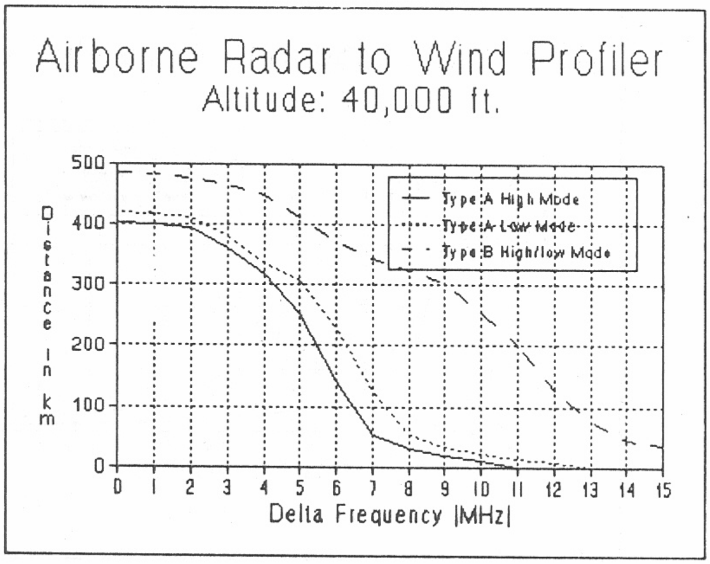
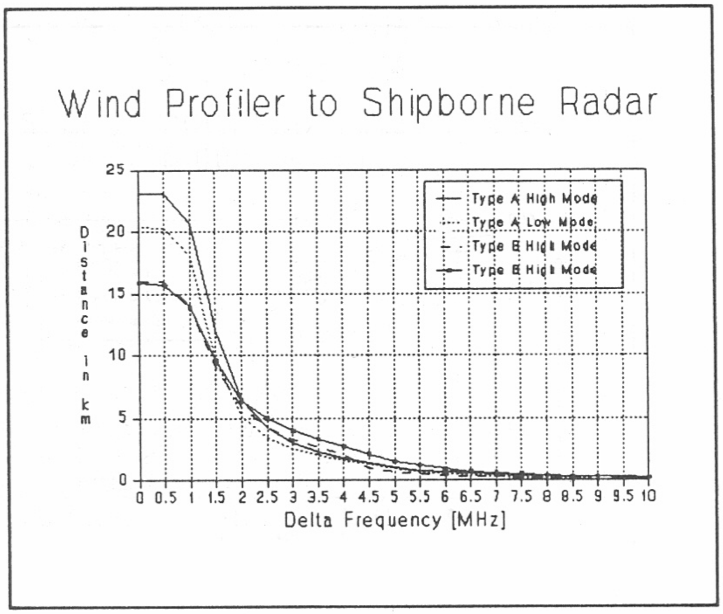


Figure B-13. F-D curves for Wind Profilers and Airborne Radar with 0 dBi gain at an altitude of 40,000 ft. (Wind Profiler sidelobe (60°-90° region) and airborne radar sidelobe coupling.)



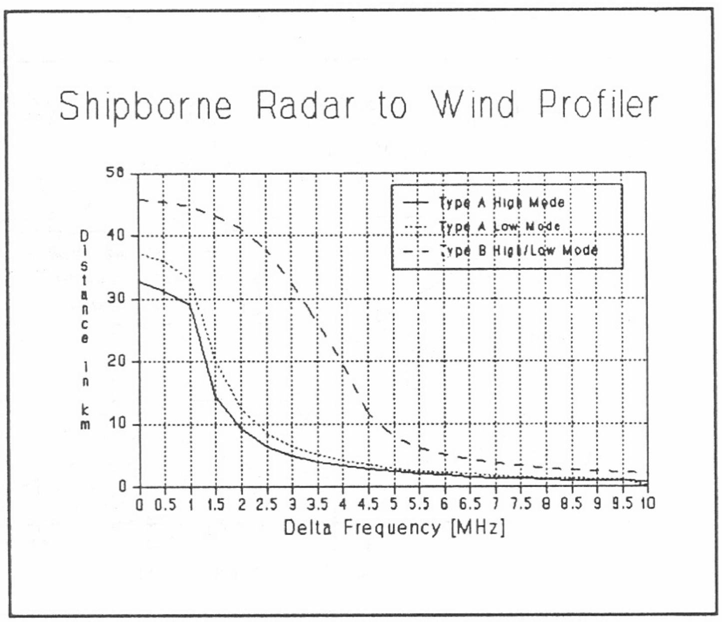
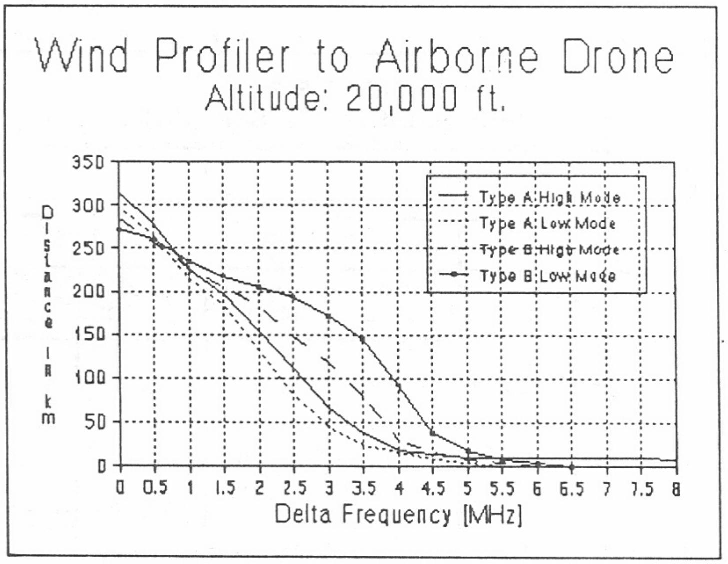


Figure B-14. F-D curves for Wind Profilers and Shipborne Radar. (Wind Profiler sidelobe (85°-90° region) and shipborne radar median coupling.)



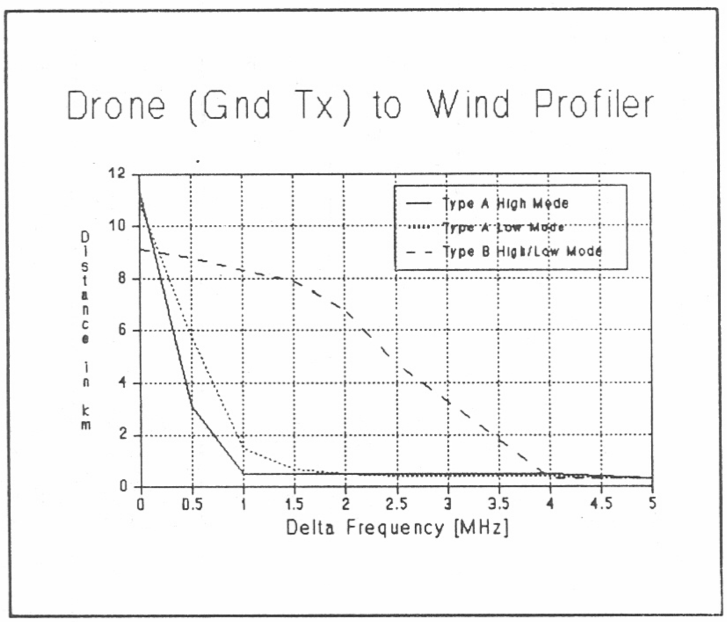


Figure B-15. F-D curves for Wind Profilers and Drone (Airborne) and drone (Ground). (Wind Profiler sidelobe (60°-90° region) and drone (airborne) sidelobe coupling. Wind Profiler sidelobe radar (85°-90° region) and drone (ground) mainbeam coupling.)

TABLE B-3 below provides the co-channel distance separations between Type A and B profilers and environmental systems in the bands 216-225 MHz and 420-450 MHz.

TABLE B-3
CO-CHANNEL DISTANCE SEPARATIONS

	TYPE A PROFILER				TYPE B PROFILER			
	TO WP		FROM WP		TO WP		FROM WP	
ENVIRONMENTAL SYSTEMS[a]	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE	HI-ALT MODE	LO-ALT MODE
SPASUR[b] (216-220 MHz)	170 km	120 km	30 km	20 km	80 km	80 km	20 km	10 km
TELEMETRY (216-220 MHz)	5 km	5 km	10 km	10 km	5 km	5 km	5 km	5 km
LAND MOBILE & MARITIME MOBILE (216-220 MHz)	40 km	40 km	30 km	20 km	30 km	30 km	20 km	10 km
LAND MOBILE (420-450 MHz)	40 km	30 km	30 km	20 km	30 km	30 km	10 km	10 km
AN/GRC-103 (220-225 MHz)	10 km	10 km	30 km	20 km	10 km	10 km	20 km	10 km
AMATEUR REPEATER (222-225 MHz)	50 km	50 km	50 km	30 km	40 km	40 km	30 km	20 km
AMATEUR REPEATER (442-450 MHz)	50 km	40 km	40 km	30 km	40 km	40 km	30 km	20 km
AMATEUR TV (420-450 MHz)	30 km	30 km	40 km	40 km	30 km	30 km	40 km	40 km
LAND BASED RADAR[b] (420-450 MHz)	60 km	70 km	40 km	30 km	100 km	100 km	30 km	30 km
AIRBORNE RADAR[c] (420-450 MHz)								
Gain = 22 dBi								
Alt. 20,000 ft.	360 km	370 km	350 km	340 km	520 km	520 km	320 km	320 km
Alt. 40,000 ft.	490 km	490 km	460 km	450 km	630 km	630 km	440 km	440 km
Gain = 0 dBi								
Alt. 20,000 ft.	290 km	310 km	270 km	260 km	360 km	360 km	250 km	250 km
Alt. 40,000 ft.	400 km	420 km	380 km	370 km	480 km	480 km	360 km	360 km
SHIPBORNE RADAR[d] (420-450 MHz)	30 km	40 km	20 km	20 km	50 km	50 km	20 km	20 km
DRONES[e] (420-450 MHz)	10 km	10 km	320 km	300 km	10 km	10 km	290 km	270 km

[a] Wind Profiler sidelobe (85°-90° region) and environmental system mainbeam coupling unless otherwise noted.
[b] Wind Profiler sidelobe (85°-90° region) and environmental system sidelobe coupling.
[c] Wind Profiler sidelobe (60°-90° region) and airborne radar mainbeam (22 dBi) and sidelobe (0 dBi) coupling.
[d] Wind Profiler sidelobe (85°-90° region) and shipborne median coupling.
[e] Wind Profiler sidelobe (60°-90° region) and drone (airborne) sidelobe coupling.

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report presents an assessment of three candidate bands (216-225, 400.15-406, and 420-450 MHz) for the potential accommodation of Wind Profilers nationally, with consideration worldwide. The approach used to evaluate each band was based on two major factors: conformance to current regulations and electromagnetic compatibility (EMC). This report addresses current regulations, spectrum usage, and analyzes the EMC between two types of Wind Profilers and specific environmental systems for potential accommodation in three candidate bands. The results of this study can serve to indicate a suitable band and identify potential frequencies within that band to accommodate Wind Profiler operations.

16. Key Words *(Alphabetical order, separated by semicolons)*

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400.15-406 MHz Band
420-450 MHz Band
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