VLA Electronics Memorandum No. 139

RESULTS OF EMI SURVEILLANCE

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A. INTRODUCTION

Over the past twelve months a considerable quantity of monitoring information has been compiled. It is the purpose of this report to present this data in a concise and realistic format to permit an understanding of the interference potential to the present and future operation of the VLA telescope.

B. BANDS OF INTEREST

EMI monitoring has been concentrated on the following bands:

1300 to 1700 MHz	(21 cm)
4500 to 5000 MHz	(6 cm)
100 to 1000 MHz	(UHF)

Total power measurements were made in these bands with the aid of calibrated receivers and preamplifiers, a spectrum analyzer, and a control and data acquisition computer.

Each band was monitored continuously from a few hours to several days. The peak level and approximate frequency of each detected signal were recorded on digital magnetic tape, with a time resolution of one hour, so that the necessary signal characteristics could later be evaluated.

Band	Total Hours of Observation Presented Herein
21 cm	1712
6 cm	885
UHF	325

On a short term basis, unidirectional horn antennas (21 cm and 6 cm) and a log periodic (UHF) were used to determine signal origins (compass bearings). Omnidirectional antennas were used to study amplitude and frequency variations and trends in signal activity.

C. DATA PRESENTATION AND ANALYSIS

The most useful of the present data presentations relates the percent probability of signal occurrence at a specific frequency in the band of observation (Figures 1 through 4). All signals above the surveillance receiver's minimum detectable level are counted here.

The minimum detectable level for all bands is approximately 10^{-13} watts/m^2. The weakest signal which will affect the VLA is probably between 10^{-14} and 10^{-13} watts/m^2 (Hogg and Dolan, 1973; Thompson, 1975; Napier, 1973). Thus this curve represents the probability, as a function of frequency, of the occurrence of an interfering signal that will produce a measurable effect on the data produced by the VLA. This is the absolute worst case, since the data recorded is actually the peak level of detected signals, in many cases pulsed radars and telemetry transmitters.

1. 1300 to 1800 MHz

For the 1300 to 1800 MHz band, ignoring the segment 1700 to 1800 MHz which is erroneous due to amplifier and filter roll-off, only two signals exceet a 10% probability. These are the Albuquerque FAA radar transmitters at 1310 and 1330 MHz. Several FAA radars are operational in the 1300 to 1350 MHz aeronautical radio location band. A few of them are as follows:

Albuquerque, New Mexico	1310, 1330 MHz
Silver City, New Mexico	1307, 1317 MHz
Washington Pass (Gallup, NM)	1307, 1317 MHz
El Paso, Texas	1307, 1317 MHz
Isleta, Texas	1307, 1317 MHz

Equipment used in the above radars is capable of tuning a very wide range of frequencies in the 1300-1350 MHz band at power levels near 2 megawatts ERP.

It is probable that these stations contribute to the overall increase in noise level (seen in Figure 1) in the 1300-1350 MHz band.

The segment 1350 to 1400 MHz is allocated to government radio locations. Apparently the only activity here is from army and air force radars operating at Kirtland AFB, Holloman AFB, and WSMR. Several notifications have been received from Mr. Hungate at WSMR of radars at Fort Bliss, Texas operating in this band.

A significant dip in the noise level can be seen only in the upper portion of the 1400 to 1427 MHz radio astronomy protected band. The exact reason for this is unclear. However, instances of army radars operating illegally in this segment have been reported by Mr. Hungate. Upon their detection, they have been ordered shut down, but there is no knowledge of how many similar operations have transpired in the past.

No operations are known in the New Mexico area with emissions in the 1427 to 1600 MHz band segment. U.S. allocations do exist for mobile and aeronautical satellite telemetry and communications, so that the potential does exist for sporadic signal detection.

Detected signals in the 1600 to 1650 MHz segment originate from radio altimeters aboard USAF aircraft flying continuously throughout the state. (F4 Phantom altimeters operate FM-CW swept over 1615 to 1645 MHz at a 30 to 1500 Hz rate depending on altitude.)

The remainder of the signals above 1650 MHz undoubtedly originate from meteorological balloons and related equipment. Several meteorological balloons are launched daily from White Sands Missile Range, and two daily at the Albuquerque Sunport by the National Weather Service. They are generally centered about 1680 MHz, but have been observed from 1676 to 1686 MHz.

There is a potential for a great number of interfering signals originating at Kirtland Air Force Base, Sandia Laboratories, White Sands Missile Range, and NMIMT. A list furnished by the DOD Area Frequency Coordinator, WSMR of government frequency allocations (current 27 May 1975) reveals the following facts:

Agency	Number of Allocations 1300-1700 MHz
Kirtland AFB	11
Sandia Laboratories	12
WSMR	64
FAA	5
NMIMT	1

These allocations are mostly for low powered telemetry operation, a few for communications, and a few for radio location (radar).

Few of them have been detected and identified by our surveillance equipment, either due to infrequent use or extremely low amplitude at the VLA.

Figure 5 relates the intensity distribution of detected signals over the 1300 to 1800 MHz band. The probability of a signal occurring above a given level is plotted for four discrete levels.

2. 4500 to 5000 MHz

There have been very few detectable signals in this band. Only one signal was present for more than a fraction of a percent of the total observation time. Figure 2 shows this signal at 4700 MHz with a probability of about 15%.

This signal has not been identified despite much investigation. It originates somewhere to the east and is very weak when detected.

The band 4400 to 4990 is allocated by the Office of Telecommunications Policy for Fixed and Mobile Operations, which covers a multitude of services and transmission modes.

3. 100 to 1000 MHz

Observations have been made in the 100 to 1000 MHz band to verify the expected high level UHF clutter associated with the metropolitan Albuquerque community. A determination of the feasibility for radio astronomy observations below 1000 MHz can be made from this data (see Figures 3 and 4).

Many signals are present from aeronautical-fixed radio communications services. Several television and FM broadcasting stations are very strong in our vicinity (channels 4, 5, 7 and 13 television). The measurements show that anywhere in the 100 to 500 MHz band, the VLA would receive significant interference at least 10% of the time. One television translator exists above 500 MHz (channel 74, 830-836 MHz). Above 725 MHz it should be possible to find observing bands virtually free from significant interference.

D. INTERFERENCE PREDICTIONS (21 cm)

As in forecasting the weather, it is difficult to predict the exact condition of the environment very far into the future. The goal for EMI surveillance has been to amass a large quantity of data over a long period of time on the characteristics of signals in the bands of interest. Thus reasonable extrapolations can be made into the future interference potential. They must be made with qualifications, however, because the potential exists for greatly increased activity at WSMR, ERDA in Albuquerque, and on Magdalena Mountain (NMIMT).

It should be possible to observe anywhere from 1350 to 1700 MHz with an interference potential of less than about 6%. Airborne radars and radiosondes give an interference of 5 to 6% in the bands 1615 to 1630 and 1660 to 1700 MHz.

The best area for continuum observation would be between 1400 and 1600 MHz, preferrably in the upper 100 MHz.

Any interference to observations in the 1400 to 1427 MHz radio astronomy band should be reported to Mr. G. Hungate (DOD Area Frequency Coordinator WSMR) for investigation. A greater potential exists for a mis-tuned military radar at WSMR or Holloman AFB than anything else. Several have been reported in the past. It is possible to request notification of meteorological radiosonde operation on Magdalena Mountain from NMIMT to coordinate observations in the OH band.

Since no quiet zone protected area exists in New Mexico as it does in West Virginia, it will be difficult to expect the many varied services to respect the needs of the VLA in observing outside the few radio astronomy bands.

It will be necessary to simply know what activity exists and work around it. Contact must be maintained with the nearby users so that they will bother to inform us of any operations they think might trouble our system.

E. FREQUENCY ALLOCATIONS

Figure 6 is included to reference the particular FCC allocations across the 1300 to 1800 MHz band with respect to our actual EMI observations.

Figure 7 is an extracted list of the OTP allocations for the same frequency band (to 1700 MHz).

GAB:cb

References:

D. Hogg and J. Dolan, February 1973; *VLA Scientific Memo No. 104.*
A. R. Thompson; January 1975; *VLA Electronics Memo No. 129.*
P. Napier, March 1973; *VLA Electronics Memo No. 110.*

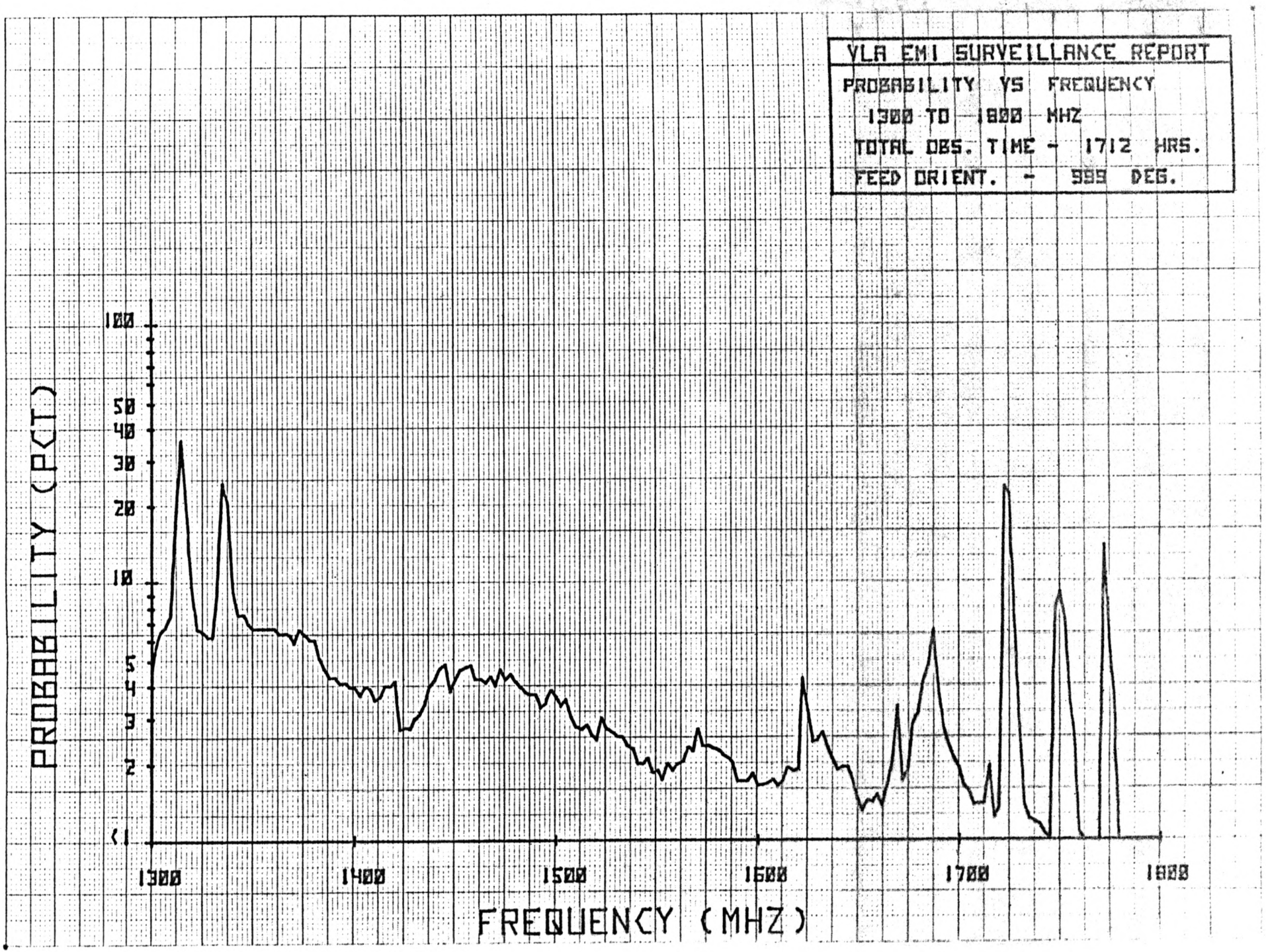
VLA EMI SURVEILLANCE REPORT
PROBABILITY VS FREQUENCY
1300 TO 1800 MHZ
TOTAL OBS. TIME - 1712 HRS.
FEED ORIENT. - 999 DEG.
PROBABILITY (PCT)
100
50
40
30
20
10
5
4
3
2
<1
1300
1400
1500
1600
1700
1800
FREQUENCY (MHZ)

Figure 1

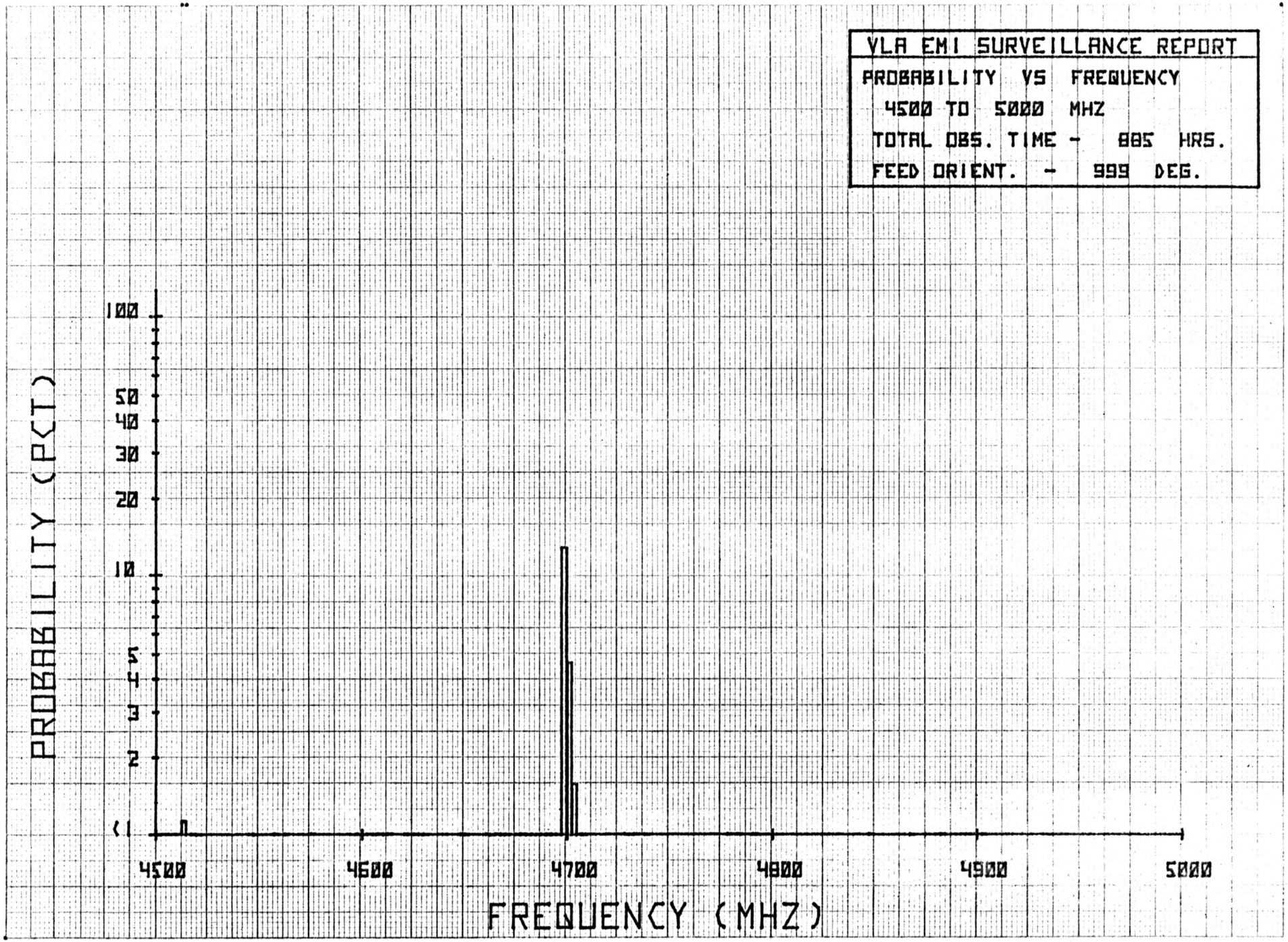
VLA EMI SURVEILLANCE REPORT
PROBABILITY VS FREQUENCY
4500 TO 5000 MHZ
TOTAL OBS. TIME - 885 HRS.
FEED ORIENT. - 999 DEG.
PROBABILITY (PCT)
100
50
40
30
20
10
5
4
3
2
(1
4500
4600
4700
4800
4900
5000
FREQUENCY (MHZ)

Figure 2

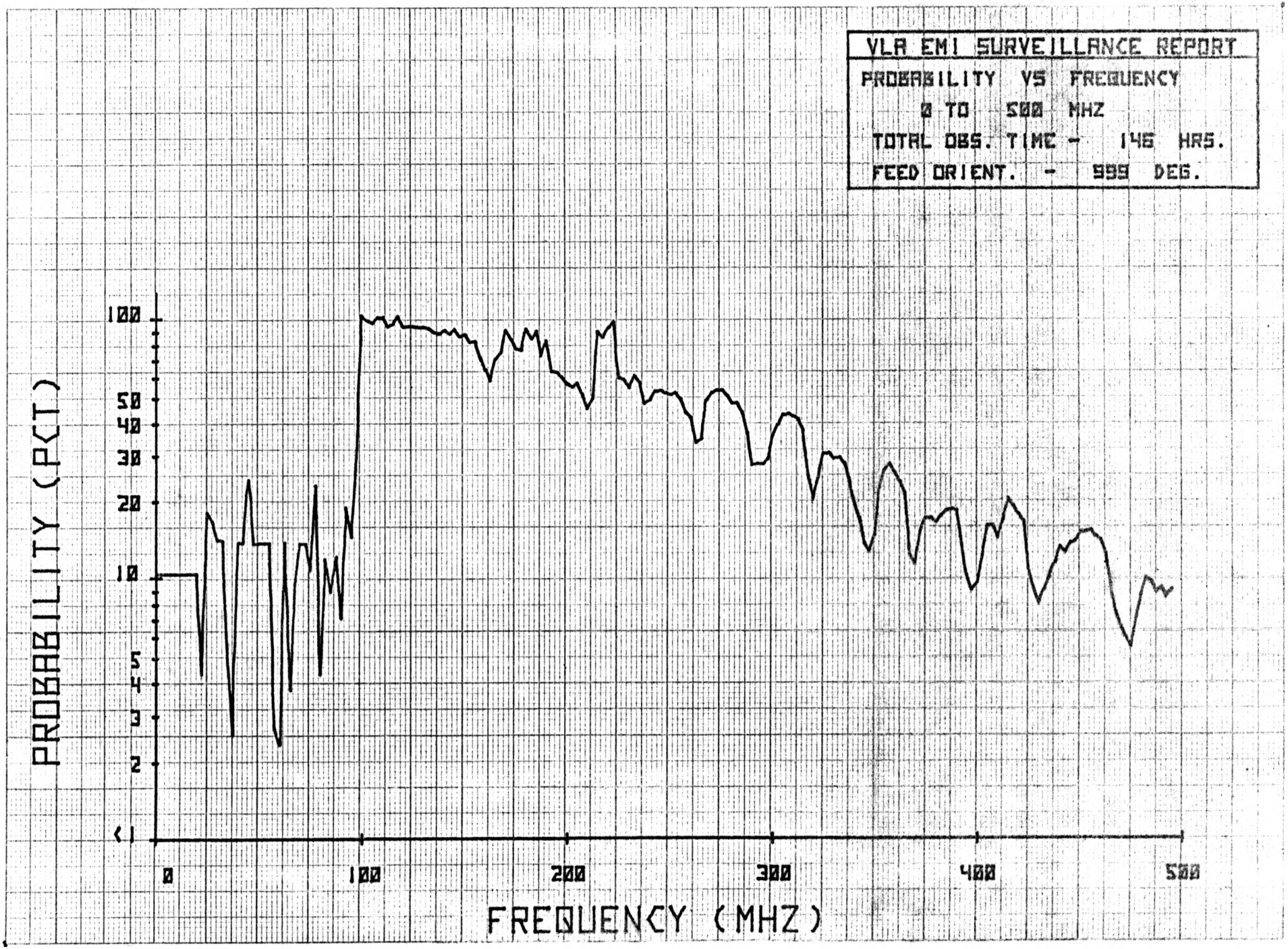
VLA EMI SURVEILLANCE REPORT
PROBABILITY VS FREQUENCY
0 TO 500 MHZ
TOTAL OBS. TIME - 146 HRS.
FEED ORIENT. - 999 DEG.
PROBABILITY (PCT)
100
50
40
30
20
10
5
4
3
2
<1
0
100
200
300
400
500
FREQUENCY (MHZ)

Figure 3

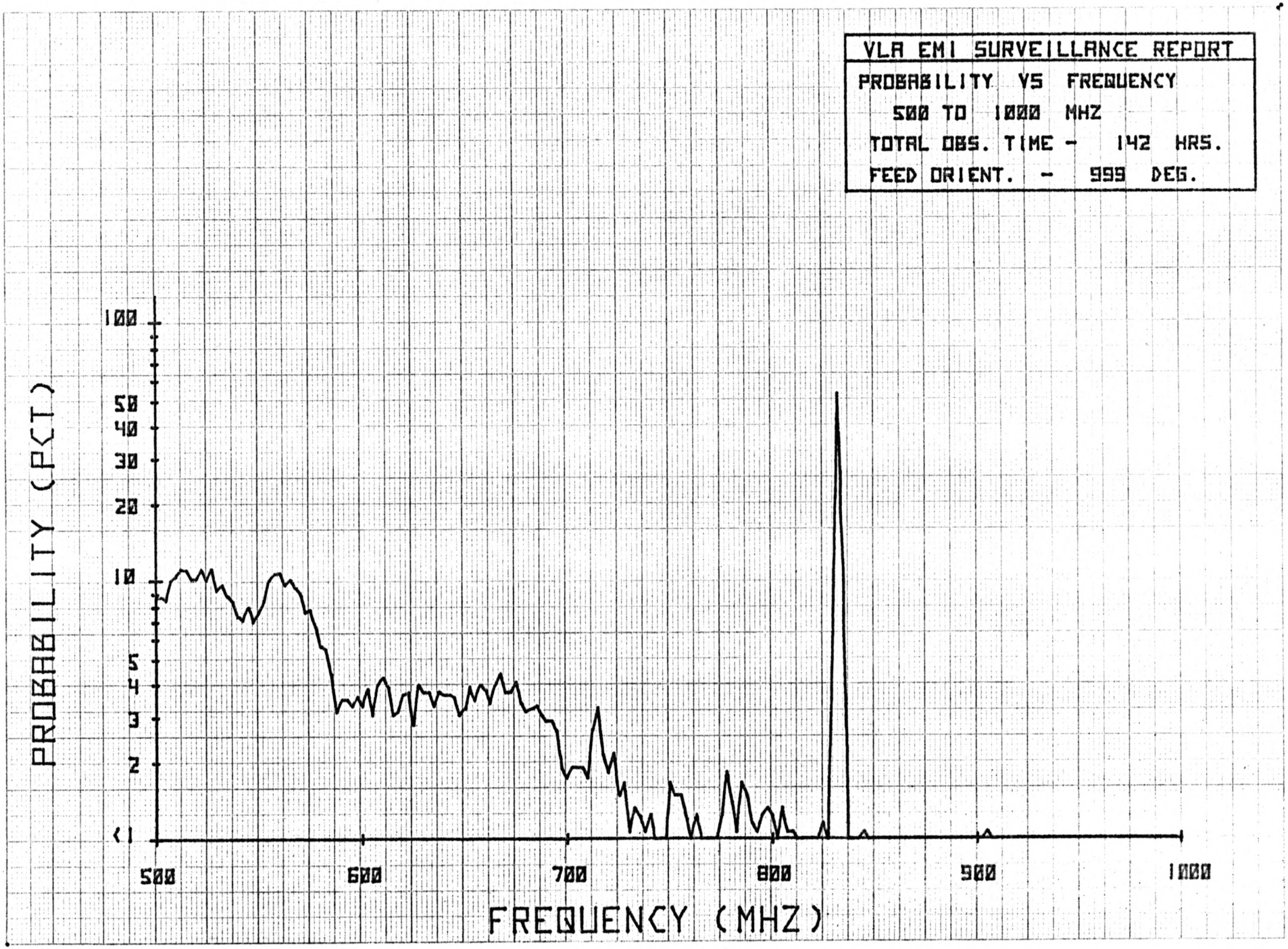

Figure 4

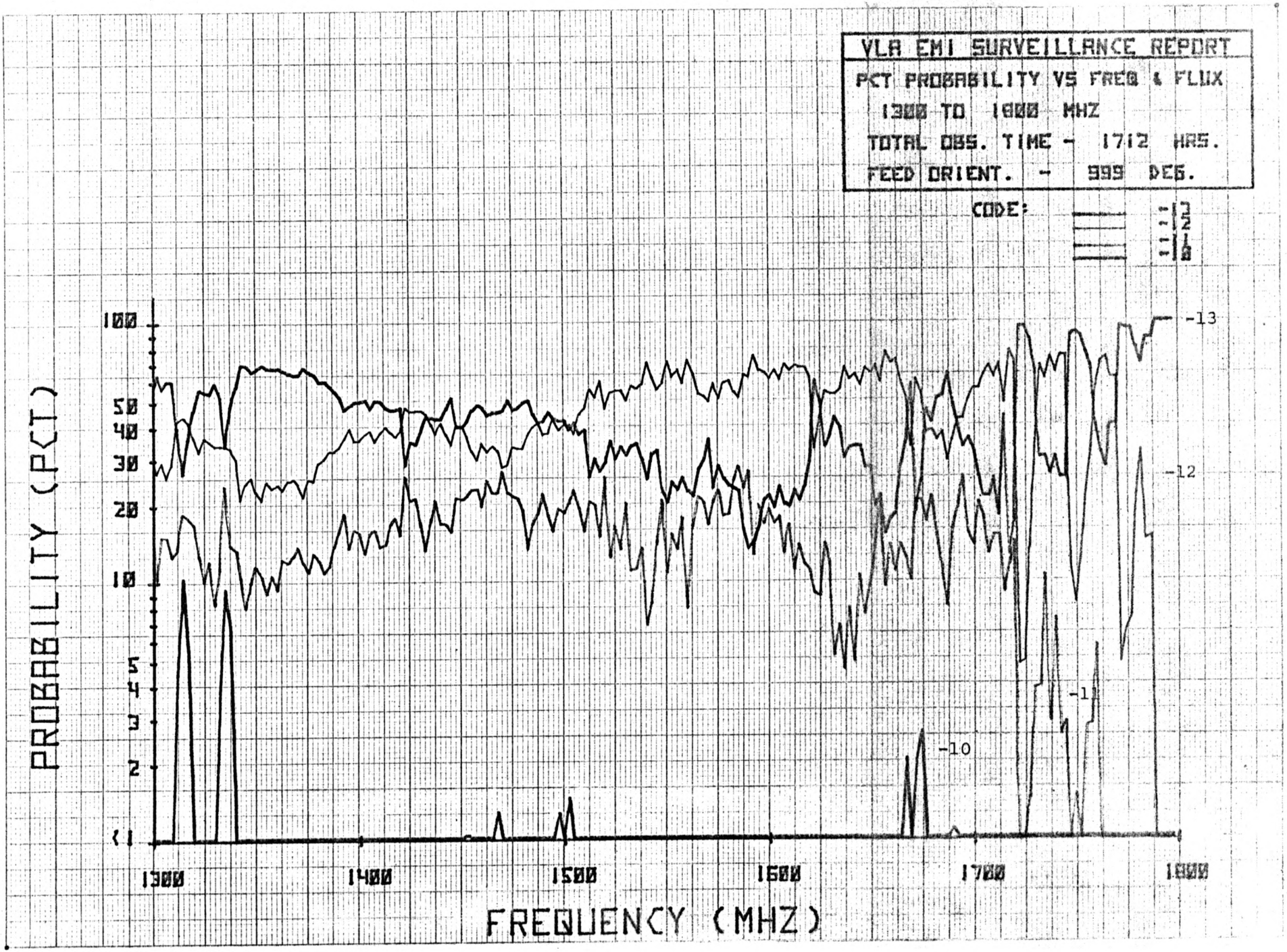
VLA EMI SURVEILLANCE REPORT
PCT PROBABILITY VS FREQ & FLUX
1300 TO 1800 MHZ
TOTAL OBS. TIME - 1712 HRS.
FEED ORIENT. - 999 DEG.
CODE:
PROBABILITY (PCT)
100
50
40
30
20
10
5
4
3
2
1
-13
-12
-11
-10
1300
1400
1500
1600
1700
1800
FREQUENCY (MHZ)

Figure 5

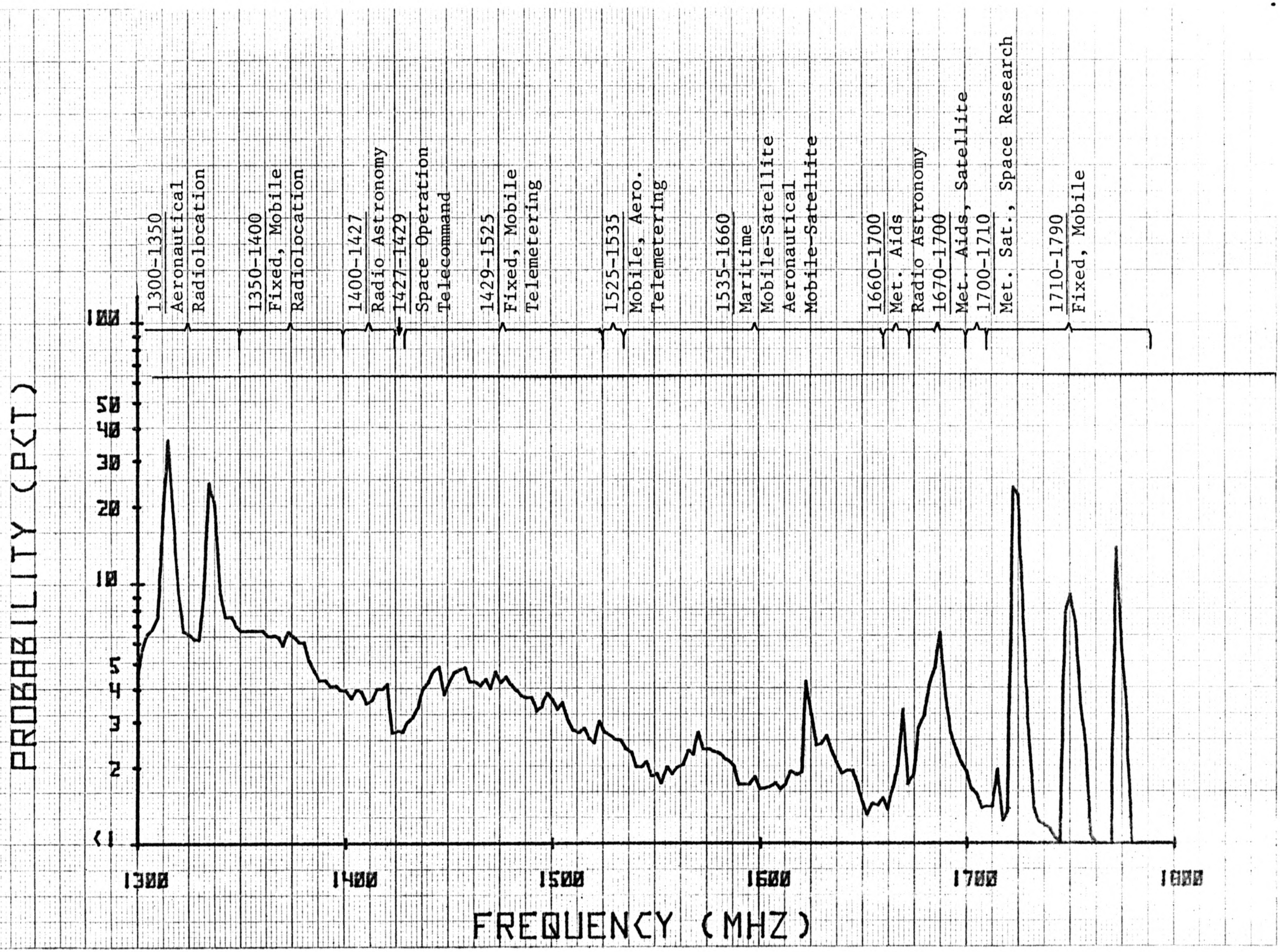

Figure 6

OFFICE OF TELECOMMUNICATIONS POLICY

FREQUENCY ALLOCATIONS

INTERNATIONAL			UNITED STATES			
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4
1300-1350 AERONAUTICAL RADIONAVIGATION 346 Radiolocation 347 348			1300-1350	G, NG 346	AERONAUTICAL RADIONAVIGATION Radiolocation G2	AERONAUTICAL RADIONAVIGATION
1350-1400 FIXED MOBILE RADIOLOCATION 349 349A	1350-1400 RADIOLOCATION 349 349A		1350-1400	G	RADIOLOCATION Fixed Mobile G2 G27	
1400-1427 RADIO ASTRONOMY			1400-1427	G, NG US74	RADIO ASTRONOMY G45	RADIO ASTRONOMY
1427-1429 FIXED MOBILE except aeronautical mobile SPACE OPERATION (Telecommand)			1427-1429	G, NG *US211	FIXED MOBILE except aeronautical mobile SPACE OPERATION (Telecommand) G30	SPACE OPERATION (Telecommand) Land Mobile (Telemetering and tele-command) Fixed (Telemetering)
1429-1525 FIXED MOBILE except aeronautical mobile	1429-1435 FIXED MOBILE	1429-1525 FIXED MOBILE	1429-1435	G, NG	FIXED MOBILE G30	Land Mobile (Telemetering and tele-command) Fixed (Telemetering)
	1435-1525 MOBILE Fixed		1435-1535	G, NG US78	MOBILE (Aeronautical telemetering)	MOBILE (Aeronautical telemetering)
1525-1535 FIXED 350B SPACE OPERATION (Telemetering) 350A Mobile except aeronautical mobile 350C Earth Exploration-Satellite	1525-1535 SPACE OPERATION (Telemetering) 350A Fixed Mobile 350D Earth Exploration-Satellite	1525-1535 FIXED 350B SPACE OPERATION (Telemetering) 350A Mobile Earth Exploration-Satellite				
1535-1542.5 MARITIME MOBILE-SATELLITE 352 352D 352E			1535-1542.5	G, NG 352E US39	MARITIME MOBILE-SATELLITE	MARITIME MOBILE-SATELLITE
1542.5-1543.5 AERONAUTICAL MOBILE-SATELLITE (R) MARITIME MOBILE-SATELLITE 352 352D 352F			1542.5-1543.5	G, NG 352F US39	AERONAUTICAL MOBILE-SATELLITE (R) MARITIME MOBILE-SATELLITE	AERONAUTICAL MOBILE-SATELLITE (R) MARITIME MOBILE-SATELLITE
1543.5-1558.5 AERONAUTICAL MOBILE-SATELLITE (R) 352 352D 352G			1543.5-1558.5	G, NG 352G US39	AERONAUTICAL MOBILE-SATELLITE (R)	AERONAUTICAL MOBILE-SATELLITE (R)
1558.5-1636.5 AERONAUTICAL RADIONAVIGATION 352 352A 352B 352D 352K			1558.5-1636.5	G, NG 352A 352B US39 US39A US208	AERONAUTICAL RADIONAVIGATION G54 G112	AERONAUTICAL RADIONAVIGATION
1636.5-1644 MARITIME MOBILE-SATELLITE 352 352D 352H			1636.5-1644	G, NG 352H US39	MARITIME MOBILE-SATELLITE	MARITIME MOBILE-SATELLITE
1644-1645 AERONAUTICAL MOBILE-SATELLITE (R) MARITIME MOBILE-SATELLITE 352 352D 352I			1644-1645	G, NG 352I US39	AERONAUTICAL MOBILE-SATELLITE (R) MARITIME MOBILE-SATELLITE	AERONAUTICAL MOBILE-SATELLITE (R) MARITIME MOBILE-SATELLITE
1645-1660 AERONAUTICAL MOBILE-SATELLITE (R) 352 352D 352J			1645-1660	G, NG 352J US39	AERONAUTICAL MOBILE-SATELLITE (R)	AERONAUTICAL MOBILE-SATELLITE (R)

Figure 7

INTERNATIONAL			UNITED STATES				
Region 1 MHz	Region 2 MHz	Region 3 MHz	Band MHz 1	National Provisions 2	Government Allocation 3	Non-Government Allocation 4	
1660-1670 METEOROLOGICAL AIDS RADIO ASTRONOMY 353A 354 354A 354B			1660-1670	G, NG US74 US99 US100	METEOROLOGICAL AIDS (Radiosonde) RADIO ASTRONOMY	METEOROLOGICAL AIDS (Radiosonde) RADIO ASTRONOMY	
1670-1690 METEOROLOGICAL AIDS FIXED METEOROLOGICAL-SATELLITE 324A (Space-to-Earth) MOBILE except aeronautical mobile 354			1670-1690	G, NG 324A	METEOROLOGICAL AIDS (Radiosonde) METEOROLOGICAL-SATELLITE (Space-to-Earth)	METEOROLOGICAL AIDS (Radiosonde) METEOROLOGICAL-SATELLITE (Space-to-Earth)	
1690-1700 METEOROLOGICAL AIDS METEOROLOGICAL-SATELLITE (Space-to-Earth) Fixed Mobile except aeronautical mobile 324B 354A	1690-1700 METEOROLOGICAL AIDS METEOROLOGICAL-SATELLITE (Space-to-Earth) 324B 354A 354C		1690-1700	G, NG 324B US100	METEOROLOGICAL AIDS (Radiosonde) METEOROLOGICAL-SATELLITE (Space-to-Earth)	METEOROLOGICAL AIDS (Radiosonde) METEOROLOGICAL-SATELLITE (Space-to-Earth)	
1700-1710 FIXED SPACE RESEARCH (Space-to-Earth) Mobile 354D	1700-1710 FIXED MOBILE SPACE RESEARCH (Space-to-Earth) 354D		1700-1710	G, NG	FIXED METEOROLOGICAL-SATELLITE (Space-to-Earth) MOBILE SPACE RESEARCH (Space-to-Earth)	METEOROLOGICAL-SATELLITE (Space-to-Earth) SPACE RESEARCH (Space-to-Earth)	

Figure 7A