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0.4 TO 10 GHz AIRBORNE ELECTROMAGNETIC ENVIRONMENT SURVEY OF U.S.A. URBAN AREAS

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MAY 1976

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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0.4- TO 10-GHz AIRBORNE ELECTROMAGNETIC-ENVIRONMENT SURVEY OF UNITED STATES URBAN AREAS

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Summary

An Airborne Electromagnetic-Environment Survey (AEES) of some U.S. metropolitan areas measured terrestrial emissions within the broad-frequency spectrum from 0.4 to 10 GHz. A Cessna 402 commercial aircraft was fitted with both nadir-viewing and horizon-viewing antennas and instrumentation, including a spectrum analyzer, a 35-mm continuous-film camera, and a magnetic-tape recorder. Most of the flights were made at a nominal altitude of 10,000 feet, and Washington, D.C., Baltimore, Philadelphia, New York, and Chicago were surveyed.

The 450-to 470-MHz land-mobile UHF band is especially crowded, and the 400-to 406-MHz space bands are less active. This paper discusses test measurements obtained up to 10 GHz. Sample spectrum-analyzer photographs were selected from a total of 5750 frames representing 38 hours of data.

Introduction

An airborne-measurement survey was made over U.S. urban areas, continuously covering the frequency range from 0.4 to 10 GHz to obtain electromagnetic-environment data in the space bands of interest to the National Aeronautics and Space Administration (NASA).

Although previous aircraft flights over both urban and surburan areas have been reported in the literature,[1-13] their measurements cover only portions of the frequency spectrum of interest to NASA.

The airborne measurements were made during a 13-day period from April 24 to May 6, 1975, with an instrumented commercial Cessna 402 aircraft over Washington, D.C.; Baltimore, Maryland; Philadelphia, Pennsylvania; New York, New York; and Chicago, Illinois. The Palestine, Texas, area was also measured in the 450- to 470-MHz band to determine the magnitude of interference from UHF-band fixed/land-mobile emissions to NASA's experimental high-altitude meteorological balloons launched in the Palestine area. In addition, the 450- to 470-MHz band was measured between New York and Chicago; between Chicago and Waco, Texas; and between Longview, Texas, and Washington, D.C.

Aircraft Instrumentation

A Cessna 402 aircraft (Fig. 1) was selected for the test because both antennas and instrumentation could be mounted readily without major modifications to the aircraft and because low-cost operation was a primary consideration. A combination of nadir- and horizon-viewing antennas were mounted on the bottom of the fuselage for maximum geographical coverage; a standard equipment rack mounted inside the passenger cabin housed the instrumentation electronics.

Figure 1. Cessna 402 Aircraft for NASA AEES Flight Tests

The spectrum analyzer consisted of a Hewlett Packard HP-8555A RF section, an HP-141T (long persistence) display unit, an HP-8552A IF section, and an HP-8445B preselector (Fig. 2).

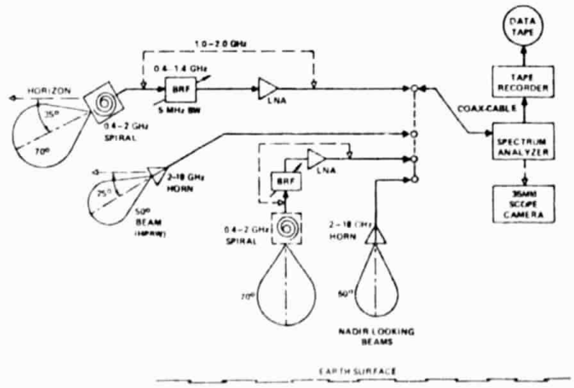


Figure 2. AEES Antenna and Instrumentation Measurement System

To record the data, a Benrus 3625, 35-mm scope camera with a 100-foot magazine took photographs of the display unit in the spectrum analyzer with Eastman Tri-X panchromatic film. A special camera timer controlled the shutter opening (exposure time) and the intervals between exposures. The shutter opening was variable from 0.1 to 150 seconds, and could be triggered either manually or automatically. The selected scan time was 20 seconds per frame with a 30-second interval between frames.

An HP-3960B magnetic-tape unit (Fig. 2) recorded the horizontal and vertical outputs of the spectrum analyzer in a backup mode. A Realist PRO-5 UHF (pocket) scanner monitored uplink voice transmissions from 468.8 to 468.875 MHz.

Several passenger seats were removed to accommodate the electronics and equipment rack. The 300-pound rack was bolted directly to the floor-support cross members (Fig. 3). A Topaz 500 GCWD static inverter provided the prime 120-volt, 60-Hz power from the aircraft's 28-vdc supply. All antennas were mounted on the underside of the fuselage (Fig. 4). The horizon antennas were tilted so that the upper edge of the half-power beamwidth (HPBW) point on the radiation pattern was along the horizon for maximum geographical coverage.

Figure 3. Aircraft AEES Electronic System

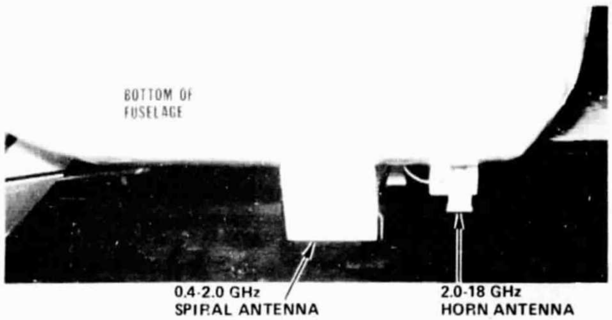


Figure 4. Aircraft Antenna Installation
(Horizon Looking Antennas)

A cavity-backed, constant-beamwidth, circularly polarized, spiral antenna (AEL Model ASN-115A) with an HPBW of 70 degrees covered the 0.4- to 2.0-GHz range. A constant-beamwidth, broadband, linearly polarized horn antenna (AEL Model H-1498) covered the 2.0- to 10-GHz range. For increased sensitivity, an HP-8447 low-noise preamplifier (LNA) with a measured noise figure of 9 ± 3 dB and 22-dB gain covered the 0.4- to 1.4-GHz portion of the range. To prevent signal overload, a tunable low-loss band-reject filter (0.5-dB insertion loss and 45-dB notch depth with 3-dB bandwidth of 5 MHz) was tuned to reject local high-power UHF-TV broadcast signals. For 1.0- to 2.0-GHz operations, the LNA and band-reject filter could be bypassed with a coaxial cable (Fig. 2).

In terms of effective isotropic radiated power (EIRP) at the Earth's surface relative to the peak-gain point on the radiation pattern, the threshold sensitivity of the nadir system varies from 0.007 to 0.098 watts (7 to 98 milliwatts) over 0.4 to 1.4 GHz (Table 1). The nadir system is less sensitive from 2.0 to 10 GHz, where the threshold EIRP varies from 11 to 110 watts, respectively. The horizon-viewing system is even less sensitive over the 2.0- to 10-GHz range, but sensitivity is sufficient for detecting high-power continuous-wave transmitters or radar.

Table 1
AEES Receiving System Sensitivity at an Altitude of 10,000 Feet

Frequency (GHz)	Overall System Noise Figure (db)	Threshold EIRP*	
		Nadir-Viewing Antenna (Watts)	Horizon-Viewing Antenna (Watts)
0.4	9.5	0.007	0.021
0.8	11.4	0.009	0.028
1.4	16.5	0.098	0.295
2.0	38.3	11	46
4.0	38.3	18	102
10.0	38.3	110	646

*Corresponds to -70-db deflection on spectrum analyzer for 0-db attenuator setting.

Aircraft Flight Profile and Schedule

The flight survey began in the Washington/Baltimore area and continued to Philadelphia, New York, and Chicago. A cross-country flight was made from Chicago to Palestine, Texas (Fig. 5), with a return path to Washington. [14] The flight paths over these cities were planned on aeronautical charts as straight-line courses approximately 50 statute miles long. Flight paths were selected to transverse the central (urban) city, as well as industrial, residential, and rural areas. The altitude was a nominal 10,000 feet, except for Chicago and Palestine, where additional tests were conducted from an altitude of 2500 to 15,000 feet.

Figure 5. USA Cross-Country Aircraft Flight Path

The flight path over each city has been projected on a Landsat photograph for that area, relating geographical area with test measurements (Figs. 6 through 9). These figures also show nadir footprints of the 70°- and 50°-HPBW -antenna radiation patterns. At 10,000 feet, the 70°-HPBW ground footprint of the nadir antenna is approximately 2.7 miles in diameter. The horizon 70°-HPBW antenna footprint increases to about 13 miles in diameter at 5 degrees below the horizon. Because the aircraft's ground speed averaged 200 miles per hour and a 35-mm photographic frame was taken every 30 seconds, the antenna footprints overlapped significantly between adjacent frames.

To fully scan the frequency spectrum from 0.4 to 10 GHz, six separate runs along the nominal 50-mile flight path across each city were necessary. Each set of six runs provided an average of 100 minutes (1-2/3 hours) of data. In general, a major frequency band was covered during each run.

Flights across each city were made in three time blocks (local time): morning (0730 to 0930 hours), afternoon (1430 to 1700 hours), and night (2230 to 2400 hours). The morning and afternoon runs covered periods of major activity, and the nighttime runs represent periods of less activity.

The instrumentation system was operationally calibrated during a flyover test of ground-based radiations of known power output at the amateur-band frequencies of 430, 1250, and 2430 MHz for altitudes of 2500, 5000, and 10,000 feet. The measured values of the calibration signals were within 1 to 2 dB of the theoretical value at 10,000 feet.

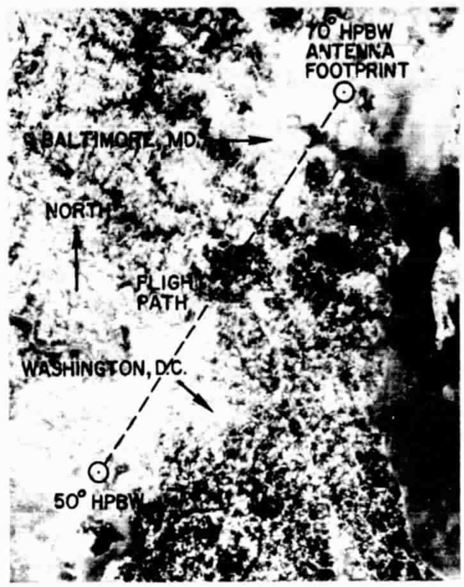


Figure 6. Aircraft Flight Profile, Washington, DC - Baltimore, MD.

Figure 7. Aircraft Flight Profile, Philadelphia, Penn.

Aircraft Survey Data Measurements

Aircraft survey electromagnetic-environment measurements presented here cover the following ranges: 400-420, 450-470 MHz and 0.4-1.4, 1.525-1.575, 1.625-1.675, 2.2-2.3, 2.24-2.26, 2.07-6.15, and 6.1-6.2 GHz. Figures 10 through 15 are sample photographs for these frequency ranges referenced to the Earth's surface.

These photographs were selected from 5750 frames representing 38 hours of test data.[15] The following comments apply generally for data obtained in the foregoing frequency bands:

1. **0.4- to 1.4-GHz frequency range using nadir antenna (Figs. 10 and 11):**
   a. **410 to 800 MHz:**
      (1) **Solid band of emissions is attributable to UHF-TV channels 14 to 69, land-mobile systems, etc.**
      (2) **Frequency spectrum is remarkably similar along the 50-mile flight path and from city to city.**
      (3) **Peak EIRP values range from 10 to 200 watts over the 410- to 800-MHz range.**
      (4) **Because the radio horizon distance is about 141 miles for a 10,000-foot altitude, there is indication that high-power UHF-TV transmissions (e.g., several megawatts EIRP) are present from a distant city that appears in the antenna.**
      (5) **The 420- to 450-MHz amateur band is relatively quiet and free of emissions.**

   b. 450 to 470 MHz (Figs. 11, 12, and 13): The fixed/land-mobile UHF band is densely populated, especially during the morning and afternoon. Emissions present in the 460- to 470-MHz band shared by meteorological satellites can interfere with space operations during daylight hours.

   c. 400 to 420 MHz (Figs. 13 and 14): Philadelphia, New York, and Chicago data indicate that the 400- to 403-MHz space bands are relatively free of terrestrial emissions that might interfere with space missions.

   d. 1090 MHz (Figs. 10 and 11): Multiple aircraft air-traffic control radar beacon transponder emissions (called "fruit,"[16-18] are evidenced at 1090 MHz. Transponder emissions from the test aircraft are sometimes present.

2. 1.525 to 1.575 GHz (Fig. 15): The 1.525- to 1.5585-GHz maritime/aeronautical mobile-satellite bands are relatively free of emissions from the Chicago area.

3. 1.625 to 1.675 GHz (Fig. 15): The 1.6365- to 1.6600-GHz maritime/aeronautical satellite bands contain emissions equal to 2 watts EIRP in the Chicago area.

4. 2.2 to 2.3 GHz (Figs. 14 and 15): The Earth-to-space satellite data-relay band contains single emitters with ERIP's of about 5 watts in the New York and Chicago areas. The expanded portion of this range is 2.24 to 2.26 GHz. Fig. 14 shows a single 800-watt emitter in Chicago.

5. 2.07 to 6.15 GHz (Fig. 15): In the Chicago area, this band contains single, 65-watt emission at 2.1 GHz and single, 50-watt emission at 6.11 GHz.

6. 4 to 10 GHz: This frequency range is typically occupied by multikilowatt EIRP emissions, including commercial aircraft radar.

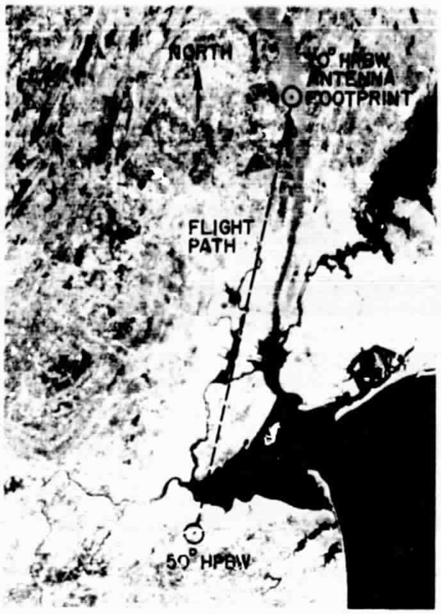
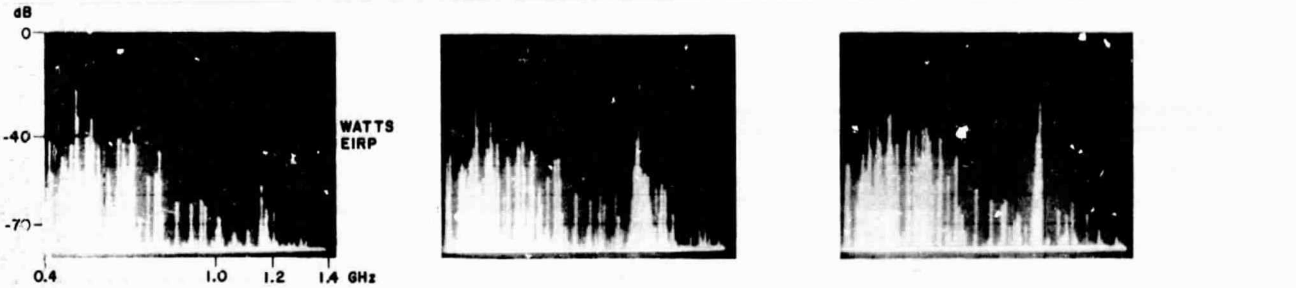


Figure 8. Aircraft Flight Profile, New York City, NY

Figure 9. Aircraft Flight Profile Chicago, Ill.

Signal Distribution Analysis of Fixed/Land-Mobile UHF-Band System

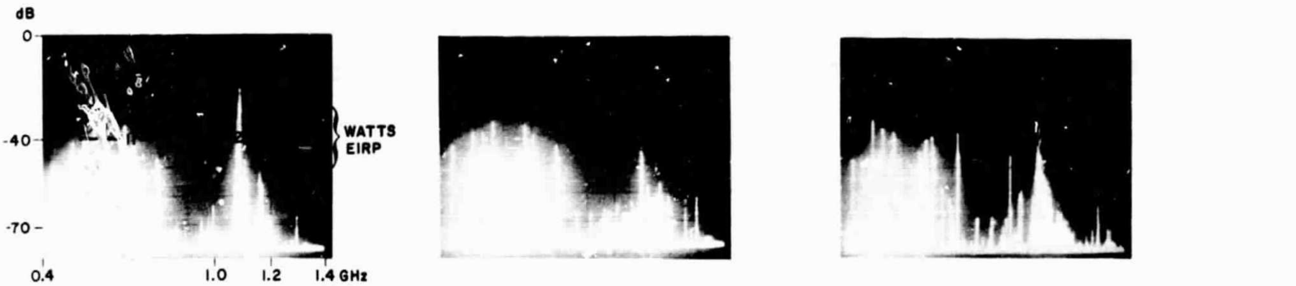
Table 2 lists 450- to 470-MHz observations obtained 2500 to 15,000 feet over Chicago and Palestine, Texas, by spiral aircraft flights with the horizon antenna. Observations obtained 10,000 feet over New York and Philadelphia with the nadir antenna have been included for comparison. Except for Palestine, the cities surveyed had similar activity during the morning, afternoon, and nighttime periods at an altitude of 10,000 feet. This was evidenced by the number of signals per frame observed.



(a) Washington-Baltimore, Afternoon
April 24, 1975
Time: 150610 (Start Run)

(b) Washington-Baltimore, Afternoon
April 24, 1975*
Time: 151343 (Run Midpoint)

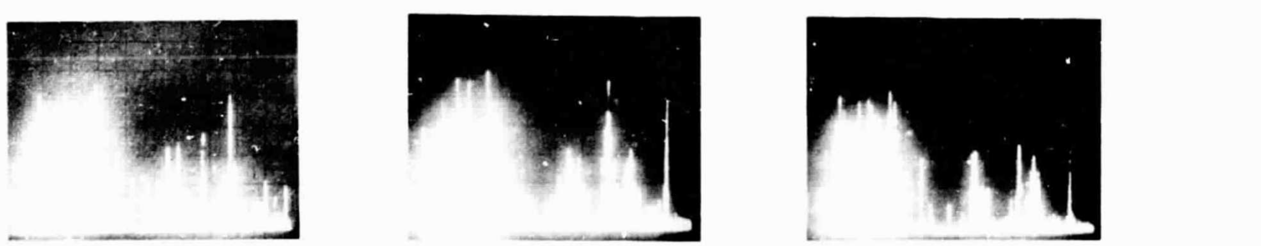
(c) Washington-Baltimore, Afternoon
April 24, 1975*
Time: 152007 (End of Run)



(d) Phil[illegible]lphia, Afternoon,
April 28, 1975
Time: 145617

(e) Philadelphia, Afternoon,
April 28, 1975**
Time: 145724 (4-Mile Point)

(f) Philadelphia, Afternoon,
April 28, 1975**
Time: 150[illegible]1 (30-Mile Point)



(g) Chicago Afternoon,
May 1, 1975*
Time: 143020 (Start Run)

(h) Chicago, Afternoon,
May 1, 1975*
143650 (Run Midpoint)

(i) Chicago Afternoon,
May 1, 1975*
Time: 144250 (42-Mile Point)

(j) New York City, Afternoon,
April 29, 1975*
Time: 14300 (Start Run)

(k) New York City, Afternoon,
April 29, 1975*
Time: 143458 (17-Mile Point)

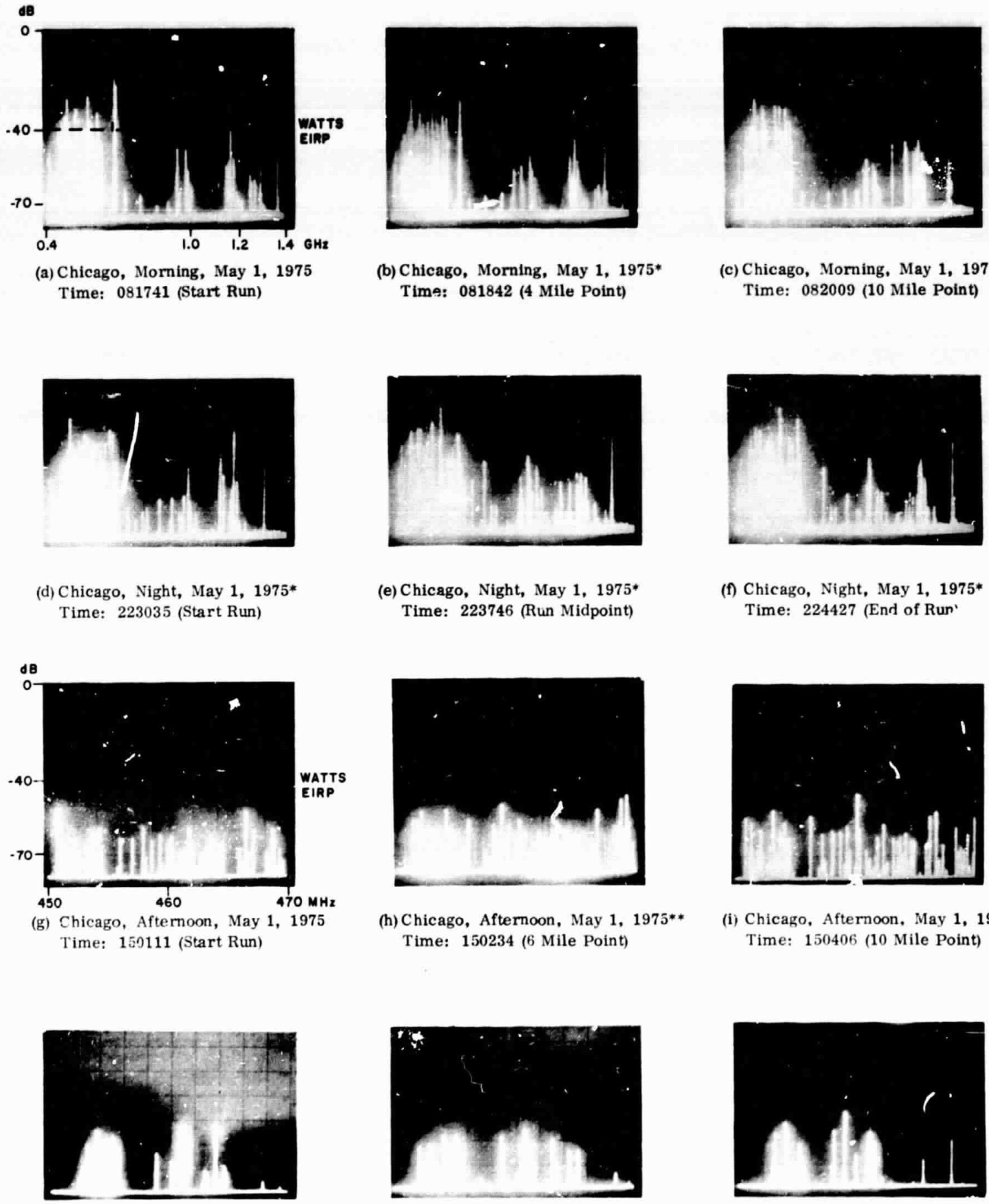
(l) New York City, Afternoon,
April 29, 1975*
Time: 143955 (33-Mile Point)

Figure 10. Washington-Baltimore, Philadelphia, Chicago, and New York City (Afternoon) -0.4 to 1.4 GHz

Scale: * Same as (a)
** Same as (d)

Altitude: 10,000 Feet
Aircraft Heading: North

Analyzer Bandwidth: 30kHz
Antenna: NADIR



(a) Chicago, Morning, May 1, 1975
Time: 081741 (Start Run)

(b) Chicago, Morning, May 1, 1975*
Time: 081842 (4 Mile Point)

(c) Chicago, Morning, May 1, 1975*
Time: 082009 (10 Mile Point)

(d) Chicago, Night, May 1, 1975*
Time: 223035 (Start Run)

(e) Chicago, Night, May 1, 1975*
Time: 223746 (Run Midpoint)

(f) Chicago, Night, May 1, 1975*
Time: 224427 (End of Run)

(g) Chicago, Afternoon, May 1, 1975
Time: 150111 (Start Run)

(h) Chicago, Afternoon, May 1, 1975**
Time: 150234 (6 Mile Point)

(i) Chicago, Afternoon, May 1, 1975**
Time: 150406 (10 Mile Point)

(j) Chicago, Night, May 1, 1975**
Time: 230120 (Start Run)

(k) Chicago, Night, May 1, 1975**
Time: 230251 (5 Mile Point)

(l) Chicago, Night, May 1, 1975**
Time: 230422 (10 Mile Point)

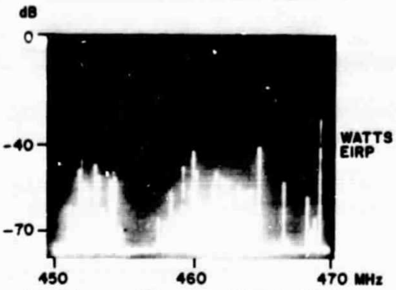
Figure 11. Chicago (Morning-Nighttime) -0.4 to 1.4 GHz and 450 to 470 MHz

Scale: *Same as (a)
**Same as (g)

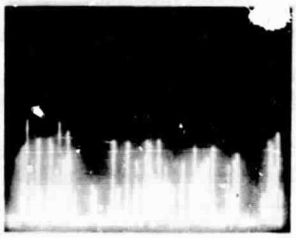
Altitude: 10,500 ft
Aircraft Heading: North

Analyzer Bandwidth:
Fig. 11a to 11f -30kHz
Fig. 11g to 11l -10kHz

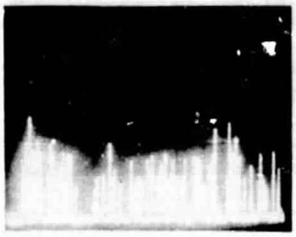
Antenna: NADIR



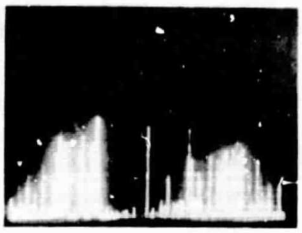
(a) Chicago, Morning, May 1, 1975
Time: 084932 (Start Run)



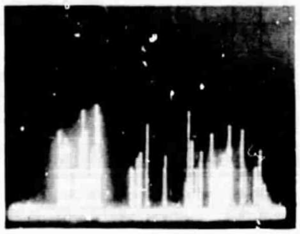
(b) Chicago, Morning, May 1, 1975*
Time: 085118 (7-Mile Point)



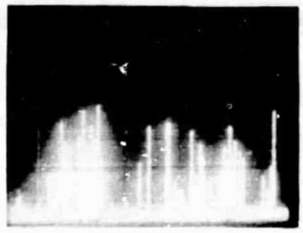
(c) Chicago, Morning, May 1, 1975*
Time: 085304 (12-Mile Point)



(d) New York City, Morning,
April 30, 1975*
Time: 075655 (Start Run)



(e) New York City, Morning,
April 30, 1975*
Time: 075959 (10-Mile Point)

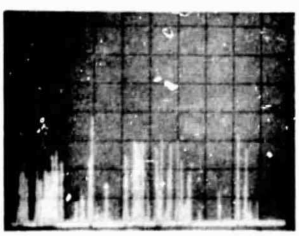


(f) New York City, Morning,
April 30, 1975*
Time: 080304 (20-Mile Point)

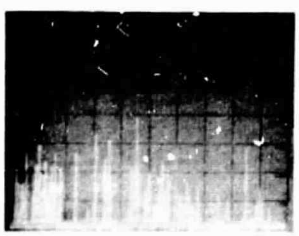
(g) Philadelphia, Morning,
April 28, 1975*
Time: 075849 (3-Mile Point)

(h) Philadelphia, Morning,
April 28, 1975*
Time: 080002 (7-Mile Point)

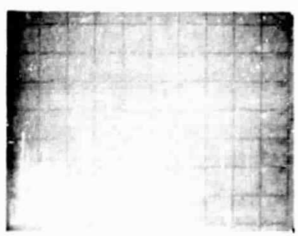
(i) Philadelphia, Morning,
April 28, 1975*
Time: 080105 (10-Mile Point)



(j) Washington-Baltimore, Morning,
April 25, 1975*
Time: 080904 (Start Run)



(k) Washington-Baltimore, Morning,
April 25, 1975*
Time: 081006 (4-Mile Point)



(l) Washington-Baltimore, Morning,
April 25, 1975*
Time: 081108 (7-Mile Point)

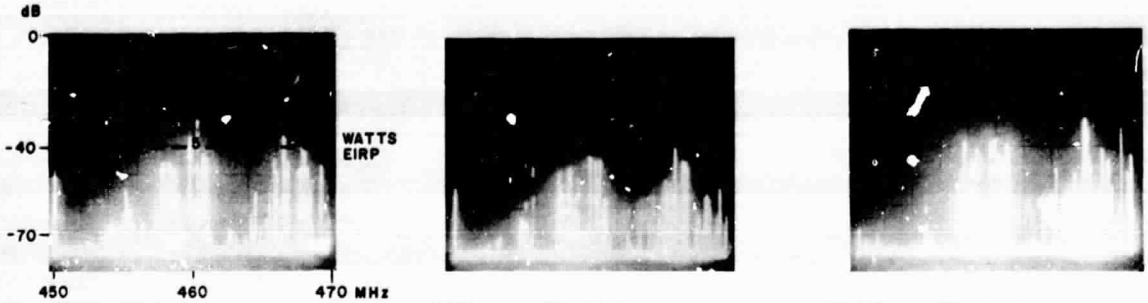
Figure 12. Washington-Baltimore, Philadelphia, New York City, and Chicago (Morning)-450 to 470 MHz

Scale: *Same as (a)

Altitude:
Figures 12a-12f -10,500 Feet
Figures 12g-12l -10,000 Feet

Analyzer Bandwidth:
Figures 12a-12f -10kHz
Figures 12g-12l -30kHz

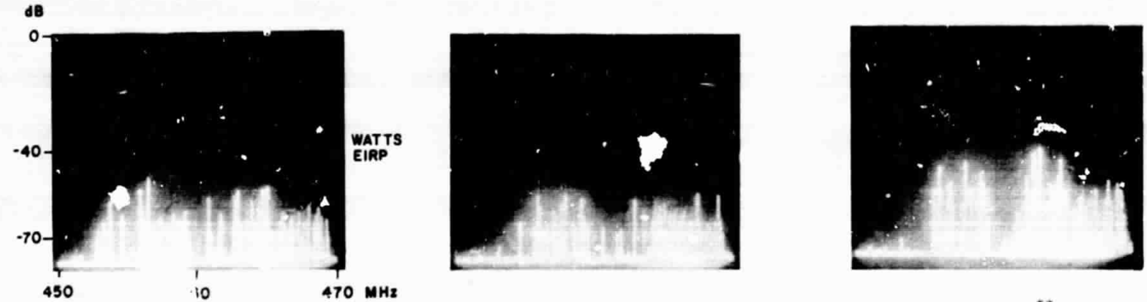
Aircraft Heading: North
Antenna: NADIR



(a) Chicago, Morning
May 2, 1975
Time: 092655 Heading: 90° East

(b) Chicago, Morning*
May 2, 1975
Time 093010 Heading: 180° South

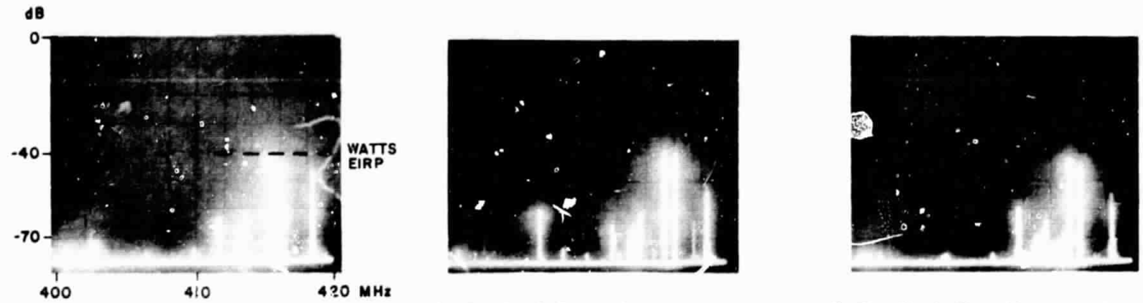
(c) Chicago, Morning*
May 2, 1975
Time: 093305 Heading: 270° West



(d) Chicago, Afternoon
May 2, 1975
Time: 143044 Heading: 90° East

(e) Chicago, Afternoon**
May 2, 1975
Time: 143223 Heading: 180° South

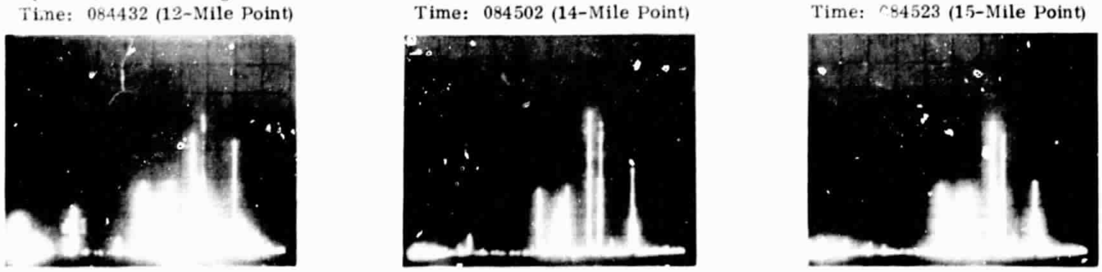
(f) Chicago, Afternoon**
May 2, 1975
Time: 142746 Heading: 270° West



(g) New York City, Morning
April 30, 1975 Heading: South
Time: 084432 (12-Mile Point)

(h) New York City, Morning***
April 30, 1975 Heading: South
Time: 084502 (14-Mile Point)

(i) New York City, Morning***
April 30, 1975 Heading: South
Time: 084523 (15-Mile Point)



(j) New York City, Night***
April 29, 1975 Heading: South
Time: 222336 (10-Mile Point)

(k) New York City, Night***
April 29, 1975 Heading: South
Time: 222439 (13-Mile Point)

(l) New York City, Night***
April 29, 1975 Heading: South
Time: 222532 (20-Mile Point)

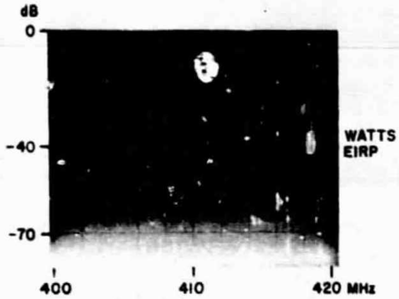
Figure 13. Chicago(Morning and Afternoon) 450 to 470 MHz; New York City (Morning and Nighttime) 400 to 420 MHz

Scale: *Same as (a)
**Same as (d)
***Same as (g)

Altitude:
Figs 13a to 13f - 15,000 Feet
Figs 13g to 13l - 10,500 Feet

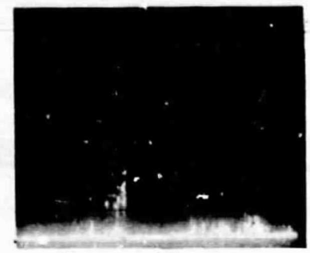
Antenna:
Figs. 13a to 13f - Horizon
Figs. 13g to 13l - NADIR

Analyzer Bandwidth: 10 kHz



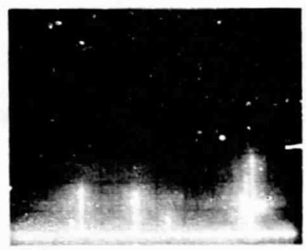
(a) Philadelphia, Afternoon
April 28, 1975. Altitude: 10,000 ft
Time: 161441 (12-Mile Point)

(b) Philadelphia, Afternoon*
April 28, 1975. Altitude: 10,000 ft
Time: 161512 (13-Mile Point)

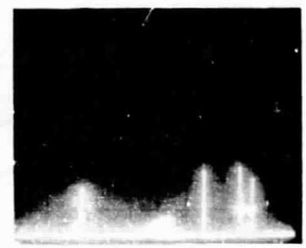


(c) Philadelphia, Afternoon*
April 28, 1975. Altitude: 10,000 ft
Time: 161603 (17-Mile Point)

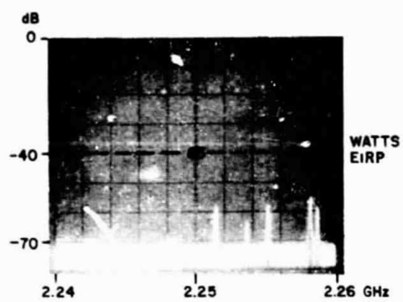
(d) Chicago, Afternoon*
May 1, 1975. Altitude: 9,500 ft
Time: 154905 (10-Mile Point)



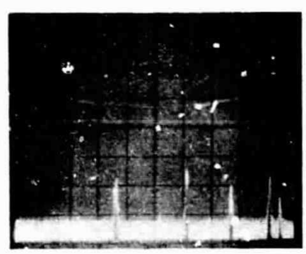
(e) Chicago, Afternoon*
May 1, 1975. Altitude: 9,500 ft
Time: 154946 (12-Mile Point)



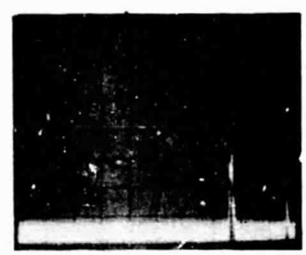
(f) Chicago, Afternoon*
May 1, 1975. Altitude: 9,500 ft
Time: 155017 (14-Mile Point)



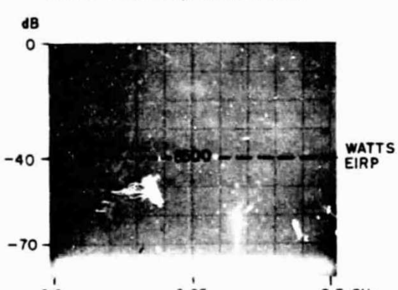
(g) Washington-Baltimore Afternoon
April 24, 1975. Altitude 10,000 ft
Time: 161032 (7-Mile Point)



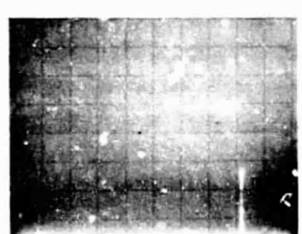
(h) Washington-Baltimore Afternoon**
April 24, 1975. Altitude: 10,000 ft
Time: 161122 (10-Mile Point)



(i) Washington-Baltimore Afternoon**
April 24, 1975. Altitude: 10,000 ft
Time: 161212 (12-Mile Point)



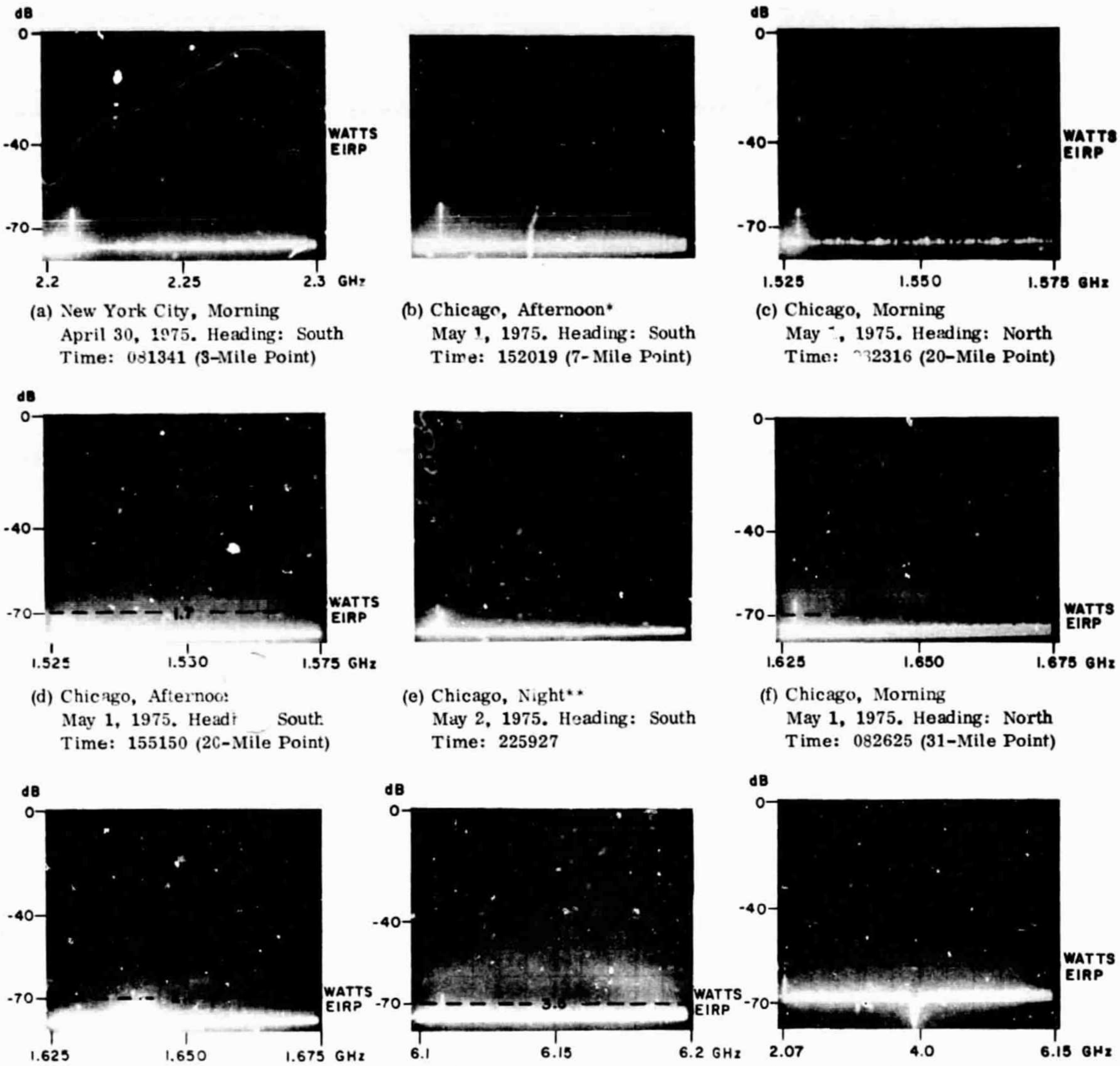
(j) Chicago, Night
May 2, 1975. Altitude: 9,500 ft
Time: 222538 (Start Run)



(k) Chicago, Night***
May 2, 1975. Altitude: 9,500 ft
Time: 222548 (0.5-Mile Point)

(l) Chicago, Night***
May 2, 1975. Altitude: 9,500 ft
Time: 222558 (1-Mile Point)

Figure 14. Philadelphia and Chicago (Afternoon) -400 to 420 MHz; Washington-Baltimore (Afternoon) -2.24 to 2.26 GHz; Chicago (Night) -2.2 to 2.3 GHz. Analyzer Bandwidth: Aircraft Heading: South
Scale: *Same as (a) Figs. 14a to 14f -10 kHz Antenna: NADIR
**Same as (g) Figs. 14a to 14e -30 kHz
***Same as (j)



(a) New York City, Morning
April 30, 1975. Heading: South
Time: 081341 (3-Mile Point)

(b) Chicago, Afternoon*
May 1, 1975. Heading: South
Time: 152019 (7-Mile Point)

(c) Chicago, Morning
May 1, 1975. Heading: North
Time: 082316 (20-Mile Point)

(d) Chicago, Afternoon
May 1, 1975. Heading: South
Time: 155150 (20-Mile Point)

(e) Chicago, Night**
May 2, 1975. Heading: South
Time: 225927

(f) Chicago, Morning
May 1, 1975. Heading: North
Time: 082625 (31-Mile Point)

(g) Chicago, Night
May 2, 1975. Heading: South
Time: 230154 (26-Mile Point)

(h) Chicago, Afternoon
May 1, 1975. Heading: North
Time 153253 (10-Mile Point)

(i) Chicago, Afternoon
May 1, 1975. Heading: North
Time: 144521

Figure 15. New York City (Morning) - 2.2 to 2.3 GHz, Chicago 1.525 to 6.15 GHz

Scale: *Same as (a)
**Same as (d)

Antenna: NADIR

Altitude: Figs. 15a to 15c-10,500 feet
Figs 15d to 15e-9,500 feet
Figs. 15f -10,500 feet
Fig. 15g -9,500 feet
Figs. 15h-15i -10,500 feet

Analyzer bandwidth:
Figs. 15a to 15g - 30 kHz
Figs. 15h to 15i - 100 kHz

Table 2
Signal Distribution in the Fixed/Land Mobile UHF-Band, System 450-470 MHz

Location	Time* Block	Altitude K ft	% Signals Above Indicated Level at Input to Spectrum Analyzer -40 dbm	-50 dbm	-60 dbm	-70 dbm	-80 dbm	Total Signals	No. Frames Obsvd.	Signals per Frame** Observed
Palestine, Texas	A	2.5	0	0	7.8	35.0	100	340	17	20
	A	5.0	0	0	5.5	31.2	100	631	23	27
	A	10.0	0	0.1	4.3	27.0	100	786	25	31
	A	15.0	0	0	4.1	23.4	100	657	22	30
	B	2.5	0	0	2.8	15.0	100	140	9	16
	B	5.0	0	0	2.4	23.6	100	292	13	23
	B	10.0	0	0	1.9	29.7	100	681	24	28
	B	15.0	0	0	1.9	25.3	100	691	22	31
New York, New York	A	10.0	0	2.8	25.5	67.0	100	2158	45	48
	B	10.0	0	2.7	27.3	68.7	100	1445	22	65
	C	10.0	0	4.2	22.1	58.9	100	914	28	33
Philadelphia, Pennsylvania	A	10.0	0.5	6.9	36.9	76.0	100	2122	39	54
	B	10.0	0.1	4.7	23.1	60.9	100	2857	38	75
	C	10.0	0	7.9	32.5	60.5	100	483	14	35
Chicago, Illinois	A	3.0	0.1	3.5	21.7	51.4	100	765	19	40
	A	5.0	0.3	8.6	37.4	62.3	100	872	19	46
	A	10.0	0.4	5.9	29.5	56.4	100	823	18	46
	A	15.0	0	6.5	38.0	72.5	100	1232	30	[illegible]
	B	2.5	0.4	3.5	24.2	59.3	100	942	20	47
	B	6.5	0.4	7.5	39.9	70.6	100	1052	17	62
	B	10.0	0	3.9	47.8	70.1	100	692	11	63
	B	15.0	0.1	4.6	31.2	71.3	100	1235	21	59

*A-morning, B-afternoon, C-night
**20-second scan time per frame; 30-seconds time internal between frames.

The greatest activity occurred during the afternoon, with less acitvity at nighttime. At Palestine, morning and afternoon activity was similar to nighttime activity in the major cities.

Analysis of the percentage of signals above the -60dBm input power level to the spectrum analyzer indicates that (Table 2):

(1) Chicago activity is greater than Palestine activity at all altitudes during the morning and afternoon periods;

(2) Palestine activity is greater at 5000 or less feet in the morning and afternoon, and morning activity is greater than afternoon activity; and

(3) Chicago activity increases with altitude, and there is generally more activity in the afternoon than in the morning.

Data obtained between cities[15] with the horizon antenna shows little activity in the 450- to 470-MHz UHF band for the fixed/land-mobile system, and signals in rural areas are relatively few. As the test aircraft approached metropolitian areas, activity increased in relation to population density.

Conclusions

In general, RF activity is greater below 1.5 GHz, a region containing allocated UHF-TV transmissions, fixed/land-mobile and air-traffic control radar beacon systems, etc. The region from 1.5 to 10 GHz contains fewer, but more high-powered emitters. However, a more extensive flight survey should reveal an even greater number of emitters in this frequency range.

The 450- to 470-MHz fixed/land-mobile UHF band is especially active. Meteorological satellite missions operating within the overlapping 460- to 470-MHz band can experience RF interference from terrestrial emissions, particularly during daylight hours when the populace is active.

Acknowledgments

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