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# AIRCRAFT MEASUREMENT OF RADIO FREQUENCY NOISE AT 121.5 MHz, 243 MHz AND 406 MHz

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# AIRCRAFT MEASUREMENT OF RADIO FREQUENCY NOISE AT 121.5 MHz, 243MHz AND 406MHz


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## Summary

An airborne survey measurement of terrestrial radio-frequency noise over U. S. metropolitan areas has been made at 121.5, 243 and 406 MHz with horizontal-polarization monopole antennas.

Flights were at 25,000 feet altitude during the period from December 30, 1976 to January 8, 1977.

Radio-noise measurements, expressed in equivalent antenna-noise temperature, indicate a steady-background noise temperature of 572,000 K, at 121.5 MHz, during daylight over New York City. This data is helpful in compiling radio-noise temperature maps; in turn useful for designing satellite-aided, emergency-distress search and rescue communication systems.


## Introduction

An airborne measurement of terrestrial radio-frequency (RF) noise at the emergency-distress, search and rescue (S&R) frequencies 121.5, 243 and 406 MHz was made over U. S. urban and suburban areas. The primary purpose of survey was to make in situ measurements of RF noise within the narrow S&R bands (121.5 MHz ± 25 kHz, 243.0 MHz ± 25 kHz, and 406.05 MHz ± 50 kHz) for compiling RF noise temperature maps, in turn helpful for designing satellite-aided S&R communication systems.

This is the second airborne flight survey of a series conducted by the National Aeronautics and Space Administration (NASA), the first Airborne Electromagnetic-Environment Survey (AEES-1) being conducted in 1975 (1). Although other airborne flights over both urban and suburban areas have been reported in the literature, e.g. (2)-(3), these reported measurements are for different frequencies and RF bandwidths than those associated with the S&R frequency bands.

Ploussios (2) measurements (1966) at 226.2, 305.5 and 369.2 MHz were for a 1.2 MHz receiver bandwidth, being much wider than the 15 kHz and 25 kHz bandwidth measurements at 121.5 and 243.0 MHz, respectively, for this survey. Skomal (3) indicates difficulty in scaling measurements from one bandwidth to other bandwidths because of uncertainties in the waveform periodicity of impulsive-type RF noise from urban and suburban areas.

## Aircraft Instrumentation

A Cessna 340-II aircraft was selected because of its capability for operation at an altitude of 25,000 feet.

A horizontal-polarization, quarter-wavelength, monopole whip antenna was used for each of the 121.5, 243 and 406 MHz frequency bands. The 121.5 MHz antenna was mounted horizontally on the starboard side of the aircraft fuselage, between the rudder and wing section, with the 243 MHz and 406 MHz antennas mounted on the opposite side of the fuselage spaced more than one wavelength apart at 243 MHz. No accurate information is available on the antenna radiation patterns; antenna-noise temperature values given are referenced to the antenna output terminal.

Electronics instrumentation was mounted in equipment racks housed within the pressurized passenger cabin. Instrumentation for RF noise recording (Figure 1) included low-noise 121.5 and 243 MHz receivers, two HP435A power meters, Techrite 444 stripchart recorder and an onboard clock that provided a local (EST) time reference. A third receiver for 406 MHz consisted of a low-noise preamplifier with spectrum analyzer and 35 mm, continuous-film scope camera.

All 3 receiver channels were calibrated, in flight, with an onboard, 0 to 20 dB range, reference-noise generator (Figure 1) with zero setting referenced to 290 degrees kelvin (K). A step attenuator with a range of 0 to 12 dB was inserted at the antenna output terminal (Figure 1) to extend the temperature measuring range of both 121.5 and 243 MHz channels.

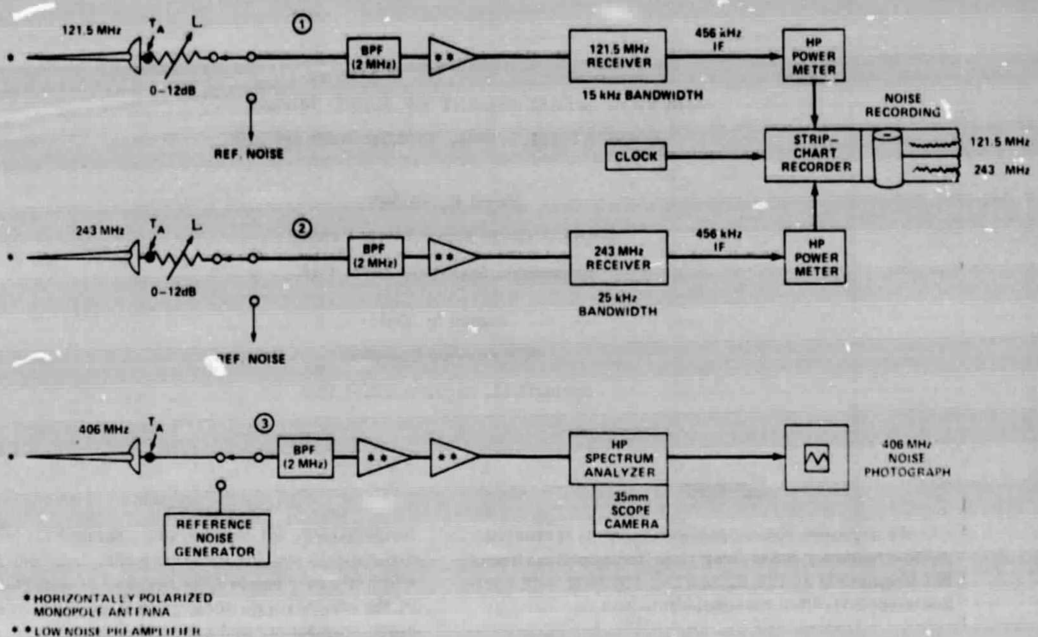


Figure 1. Block Diagram, Noise Recording Instrumentation On Aircraft

The 121.5 MHz receiver system noise figure was 5.0 dB, referenced to 290K, for zero dB attenuator setting, resulting in a noise-temperature measurement range capability of 290 to 1,400,000K. Similarly, the 243 MHz receiver noise figure was 9.0 dB, corresponding to a range of 290 to 3,600,000K.

## Aircraft Flight Profile

Flight Path 1 followed a 200-mile, straight-line course over the northeastern U.S.A. from Washington, D.C. to Westchester, New York (Figure 2). Both day and night flights were made. Flights began December 30, 1976 and were completed January 3, 1977.

Flight Path 2 over the mid-western U.S.A. began January 6, 1977 and was completed January 8, 1977.

## Aircraft Survey Data Measurements

Data presented herein consists of insitu RF noise measurements at 121.5 and 243.0 MHz, expressed in equivalent antenna-noise temperature (degs. K), referenced at the output terminal of a horizontally-polarized, monopole antenna. Flight data from 25,000-feet altitude over the cities of Baltimore, Maryland; Philadelphia, Pennsylvania; New Castle, Delaware; and New York City are included.

RF noise measurements at points 1-3, Figure 1, referenced to the onboard calibrated noise generator, are expressed by an absolute temperature equation from (4) as,

$$T = T_o \left[ F\left(\frac{N}{N_o} - 1\right) + 1 \right] \text{ degs. K} \quad (1)$$

where, F = Noise Figure of receiver, expressed as a power ratio

$\frac{N}{N_o}$ = Stripchart deflection, expressed as a power ratio, from reading $N_o$ corresponding to zero setting of 290K from noise generator

$T_o$ = 290K = Ambient temperature.

Using equation (3-70) from (5), the equivalent antenna-noise temperature at the antenna output terminal is

$$T_A = L\,T \text{ degs. K} \quad (2)$$

L = Attenuator loss, expressed in power, where $\infty > L \geq 1$.

combining equation (1) and (2),

$$T_A = L\,T_o \left[ F\left(\frac{N}{N_o} - 1\right) + 1 \right] \text{ degs. K.} \quad (3)$$

Equation (3) was used for computing values in Table 1.

The highest steady background temperature observed was 572,000K, at 121.5 MHz, during daylight hours over New York City, NYC (Table 1). Observations at 243 MHz were always less than corresponding values at 121.5 MHz, during daylight hours over the cities, generally in keeping with observations reported by Ploussios (2) and Skomal (3). Furthermore, the NYC observation is 6 dB greater,

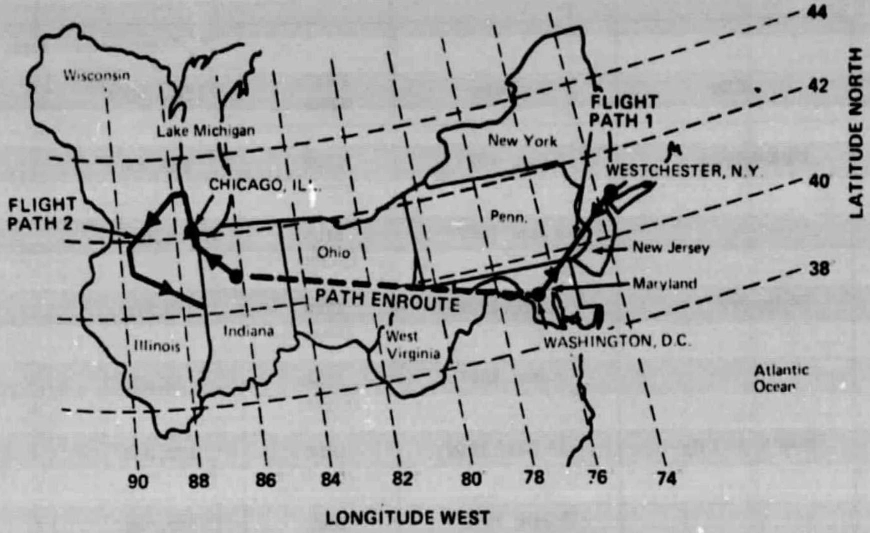


**Figure 2. Aircraft Flight Path**

at 121.5 MHz, than Baltimore or Philadelphia, during daylight, agreeing with Ploussios (2).

Nighttime observations were always less than daylight values by 6.3 to 10.6 dB, at 121.5 MHz, for NYC, Philadelphia and Baltimore. However, nighttime observations at 243 MHz show an unexpected 4.3 to 5.2 dB increase in temperature compared to 121.5 MHz nighttime observations for the same cities.

The data measurements exhibit good repeatability as evidenced by the same value of 572,000K being measured on two different days over NYC.

Observations over the New Castle, Delaware area indicate temperatures as low as 2600K and 1600K, respectively, for 121.5 and 243 MHz at night. These low values indicate the following:

1. Approximately 24 dB increase in steady-background, terrestrial, RF noise level comparing "noisy" daytime observations to "quiet" nighttime levels, for the worst case.

2. Low electromagnetic interference (EMI) environment onboard the test aircraft.

Higher levels of "discrete" RF noise were found to be present above the steady background level over the major cities, frequently saturating the noise-temperature measuring equipment at both 121.5 and 243 MHz.

Sufficient time has not been available to reduce and report data from Flight Path 2, nor 406 MHz data from Flight Path 1. These measurements should be the subject of a later paper.

## Conclusion

An airborne measurement survey has been reported for RF noise at 121.5 and 243 MHz for major, northeastern U.S.A. cities. Observations of steady-background, RF noise levels during daylight hours were always greater at 121.5 MHz than 243 MHz, in keeping with observations reported by Ploussios (2) and Skomal (3).

Data measurements exhibit good repeatability. Approximately a 24 dB increase in steady-background, RF noise level was observed comparing "noisy" daytime observations to "quiet" nighttime levels, for the worst case.


## Acknowledgment

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Table 1

Measured Antenna-Noise Temperature Over Eastern U.S. Cities (25,000 Feet Altitude)

| City | Date | EST* Time | $T_A$ Temperature-degs. Kelvin (K) | |
|---|---|---|---|---|
| | | | 121.5 MHz | 243 MHz |
| Philadelphia | 3 Jan. 1977 | 1525 (Day) | 139,000 | 70,800 |
| | 3 Jan. 1977 | 2158 (Night) | 21,000 | 55,800 |
| Baltimore | 3 Jan. 1977 | 1720 (Day) | 143,200 | 34,500 |
| | 3 Jan. 1977 | 2234 (Night) | 12,500 | 34,500 |
| New York City | 31 Dec. 1976 | 1051 (Day) | 572,000 | 358,500 |
| | 3 Jan. 1977 | 1605 (Day) | 572,000 | 283,500 |
| | 3 Jan. 1977 | 2125 (Night) | 135,300 | 453,000 |
| New Castle | 3 Jan. 1977 | 2204 | 8,500 | 12,500 |
| | 3 Jan. 1977 | 2215 (Night) | 2,600 | 1,600 |

*Eastern Standard Time (Hrs. — Mins.)


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