NASA CONTRACTOR REPORT

NASA CR-2640

TEST PLAN AND PRELIMINARY REPORT OF AIRBORNE ELECTROMAGNETIC ENVIRONMENT SURVEY OVER U.S.A. URBAN AREAS 0.4 TO 18.0 GHz

Ralph E. Taylor and James S. Hill

Prepared by
GOVERNMENT SERVICE OPERATION
Springfield, Va. 22151
for Goddard Space Flight Center

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • DECEMBER 1975

1. Report No. NASA CR-2640	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Test Plan and Preliminary Report of Airborne Electromagnetic Environment Survey Over U.S.A. Urban Areas 0.4 to 18.0 GHz		5. Report Date December 1975
		6. Performing Organization Code
7. Author(s) Ralph E. Taylor and James S. Hill		8. Performing Organization Report No.
9. Performing Organization Name and Address Government Service Operation RCA Service Company Springfield, VA 22151		10. Work Unit No.
		11. Contract or Grant No. NAS 5-24035
		13. Type of Report and Period Covered Contractor Report
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report describes an Airborne Electromagnetic Environment Survey (AEES) of five U.S. urban areas where terrestrially-generated radio-frequency interference (RFI) was measured over the frequency range from 0.4 to 18.0 GHz. A chartered Cessna 402 aircraft contained necessary measurement test equipment, including the receiving antennas mounted beneath the fuselage. U.S. urban areas including Washington, D.C.-Baltimore, MD; Philadelphia, PA; New York, NY; Chicago, ILL; and Palestine, TX were surveyed.

A flight test plan and preliminary test results for the 0.4 to 1.4 GHz frequency range, are included; a final test report describes more detailed results.

17. Key Words (Selected by Author(s)) Radio-frequency interference (RFI) Airborne RFI survey Terrestrially-generated RFI		18. Distribution Statement Unclassified-Unlimited Cat. 32	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 80	22. Price* $4.75

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE

LIST OF TABLES

TABLE

ACKNOWLEDGEMENTS

The authors wish to thank the Air Traffic Control Automation Division, AAT-500, Air Traffic Service Department of Transportation, Federal Aviation Administration, Washington, D. C. in particular, Mr. Nick Craddock and Mr. Leonard McHugh and other members of the ATC Automation Division for their invaluable assistance, advice and support in obtaining the necessary IFR and VFR air route clearance over heavily congested air route traffic zones over metropolitan areas.

We would also like to thank Mr. Fred Kissel, Westinghouse Electric Corporation for scheduling the operational support of the Application Technology Satellite-6 (ATS-6) that obtained data simultaneously while the aircraft was over New York City and Chicago, Illinois.

Thanks are also expressed to the Federal Airways Corporation and specifically Mr. James Flynn and Mr. Barry Smith for their excellent cooperation and support in arranging flight schedules and the various details of aircraft operation. Thanks are also due to Mr. L. C. Morgan of Page Airways Incorporated for mounting instrumentation and antennas on the aircraft.

SUMMARY

This report describes an Airborne Electromagnetic Environment Survey (AEES) of five U.S. urban areas where terrestrially-generated radio-frequency interference (RFI) was measured over the frequency range from 0.4 to 18.0 GHz. A chartered Cessna 402 aircraft contained necessary measurement test equipment, including receiving antennas mounted beneath the fuselage. U.S. urban areas including Washington, D. C.-Baltimore, MD; Philadelphia, PA; New York, NY; Chicago, Ill; and Palestine, TX were surveyed.

A flight test plan and preliminary test results for the 0.4 to 1.4 GHz frequency range, are included; a final test report describes more detailed results.

1.0 Introduction

The objective of this project is to make an Airborne Electromagnetic Environment Survey (AEES) of five U.S. urban areas to measure terrestrially-generated, radio-frequency spectrum occupancy statistics, including effective isotropic radiated power (EIRP), for use in specifying receiver-signal, design-performance parameters for the NASA Space Shuttle Electromagnetic Environment Experiment (EEE). The RCA Service Company of Springfield, Virginia provided personnel, facilities, and materials to make this aerial survey.

An attempt was made to locate a government-owned aircraft suitable for this type of survey. One of the aircraft which might have been used had an operating cost which could not be fitted into the budget. A second suitable aircraft was scheduled 100 percent for the next year. Cost and availability of charter aircraft were investigated and a Cessna 402 operated by Federal Airways Inc. was found to be available at a cost within budget limitations. A charter contract with Federal was drawn up which would allow modification of the aircraft to provide for installation of antennas and instrumentation. Arrangements were made with Continental Leasing Company to lease the antennas and instrumentation required for the survey. Continental agreed to purchase the antennas and a special band rejection filter so that it was not necessary to purchase any major items for the survey. This was another factor in meeting budgetary limitations.

The survey was run in the period of April 24th to May 7th, 1975 following a test plan which is included in this report. The test results have been reviewed and will be analyzed for inclusion in the final report. Some preliminary results are included in the report to illustrate the type of data which was collected on the survey.

2.0 Objective of Test Plan

The purpose of this test plan was to provide a test procedure for measurements in the 400 MHz to 18 GHz segment of the electromagnetic spectrum. The measurements were made with an instrumented aircraft operating over the following urban areas: Washington-Baltimore, Philadelphia, New York City, and Chicago. Measurements were made in Chicago to coordinate with an FCC survey of the 450 to 470 MHz UHF band land mobile band. Also, in Palestine, Texas additional measurements were made in the 450 MHz to 470 MHz band to study interference encountered by NASA to instrumentation in a high altitude balloon from land mobile emissions operating on carrier frequency of 468.825 MHz.

The data runs over the metropolitan areas were made in time periods selected to represent periods of major activity in the morning and afternoon with a contrasting period of lesser activity at night. The data runs were scheduled as follows:

Morning: - 0730 to 0930 hours

Afternoon: - 1430 to 1700 hours

Night: - 2230 to 2400 hours

The times given are local time in each case. An exception to this schedule occurred when the night measurements in New York City were moved to an earlier period, 2100 to 2230 hours, in order to coordinate with measurements being made by the ATS-6 satellite in the New York area.

The data were taken in the form of 35 mm photographs of the spectrum analyzer display and parallel magnetic tape recordings. Following the aerial survey, the photographs will be analyzed where maximum and minimum levels will be tabulated for discrete segments of the spectrum. This data will be presented in a final report.

3.0 Instrumentation

The instrumentation selected for this survey is listed below:

Quantity	Description
1 ea.	H-P Spectrum Analyzer, consisting of:
	1 ea. H-P 141T Display Section, Variable Persistence/Storage
	1 ea. H-P 8445B Automatic Preselector, DC-1.8 GHz Low-Pass Filter, 1.8-18 GHz Tracking Filter
	1 ea. H-P 8555A Tuning Section, 0.01-18 GHz (Internal Mixer), 12.4-40 GHz (External Mixer)
	1 ea. H-P 8552B 1F Section, 550 and 2050 MHz
1 ea.	H-P 3910B Magnetic Tape Recorder
1 ea.	H-P 8447B Preamplifier, 400 to 1400 MHz
1 ea.	Benrus 3625, 35 mm Scope Camera with 100 ft. Magazine
1 ea.	Topaz Model 500 GW Power Inverter, 500 watts
1 ea.	K&L 3TNF-392/808-5N Notch Filter, 392-808 MHz
1 ea.	S-A 12A-18 Horn Antenna, 18 to 26.5 GHZ
1 ea.	H-P 11519A Taper Waveguide Section 18 to 26.5 GHZ
1 ea.	H-P 11517A Mixer, 12.4 to 50 GHz
1 ea.	AEL ASN-115A Antenna, 0.4 to 2.0 GHz
2 ea.	AEL H-1498 Antenna, 2 to 18 GHz
1 ea.	RCA Camera Timer, Exposure and Interval Timer
1 ea.	Weston AC Voltmeter, 0-150 Volts

The instrumentation was connected as shown in the block diagram, Figure 1.

All items except the RCA Camera Timer are standard catalog item instruments. There has been a modification to the HP 8555A Spectrum Analyzer RF Section. The scan-width function switch has been rewired so that the predetection bandwidth is selectable in the "Full Band" position. Normally the bandwidth is fixed at 300 KHz in this function.

The RCA Camera Timer is a custom designed timer to control the shutter opening (exposure time) and interval between exposures. Shutter opening is variable from 0.1 to 150 seconds and triggering of the shutter can be done manually with a front panel push button or on a regular time interval, selectable from 0.1 to 100 seconds. An output from the timer can be used to trigger the spectrum analyzer sweep. A schematic diagram of the camera timer is shown in Figure 2.

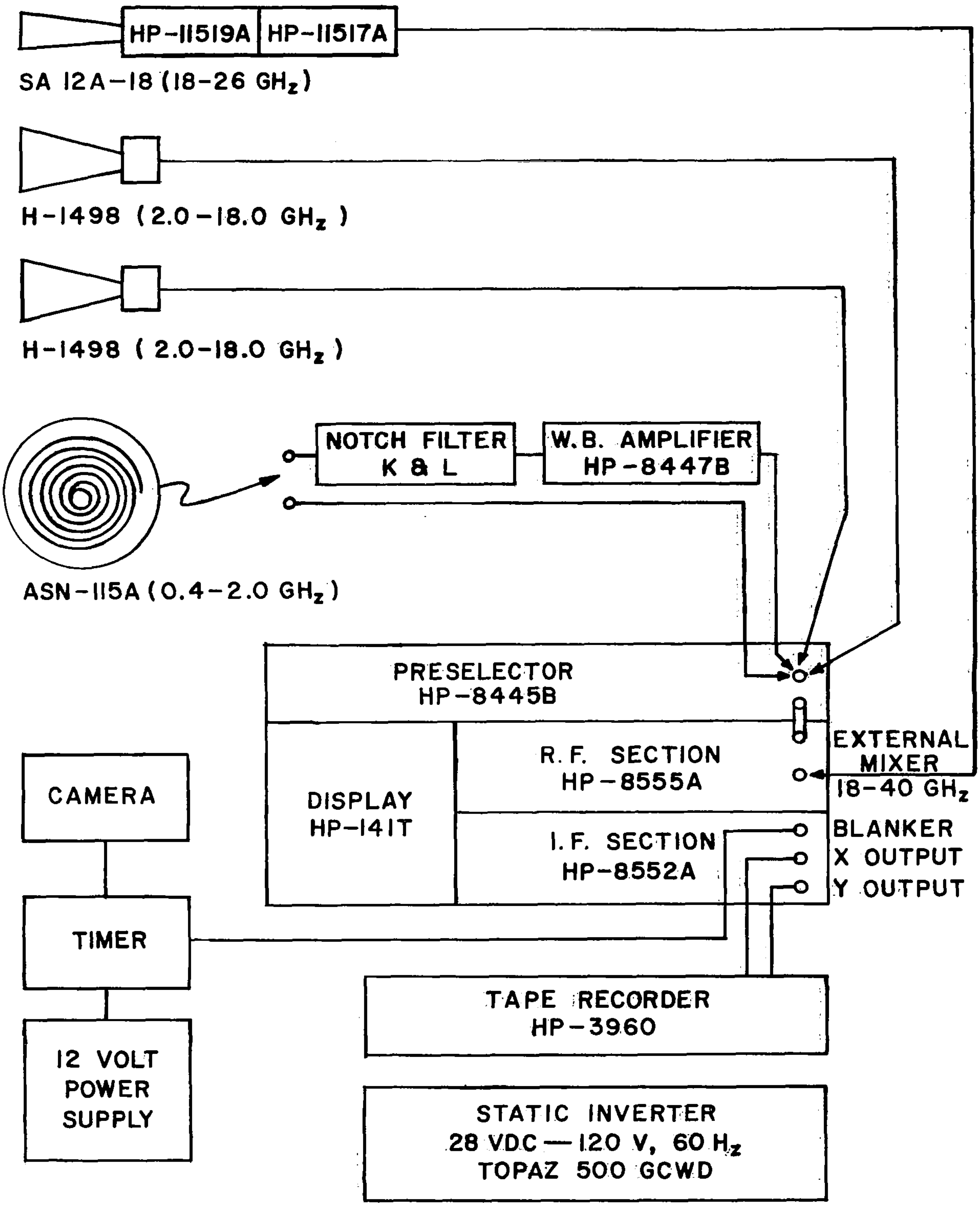
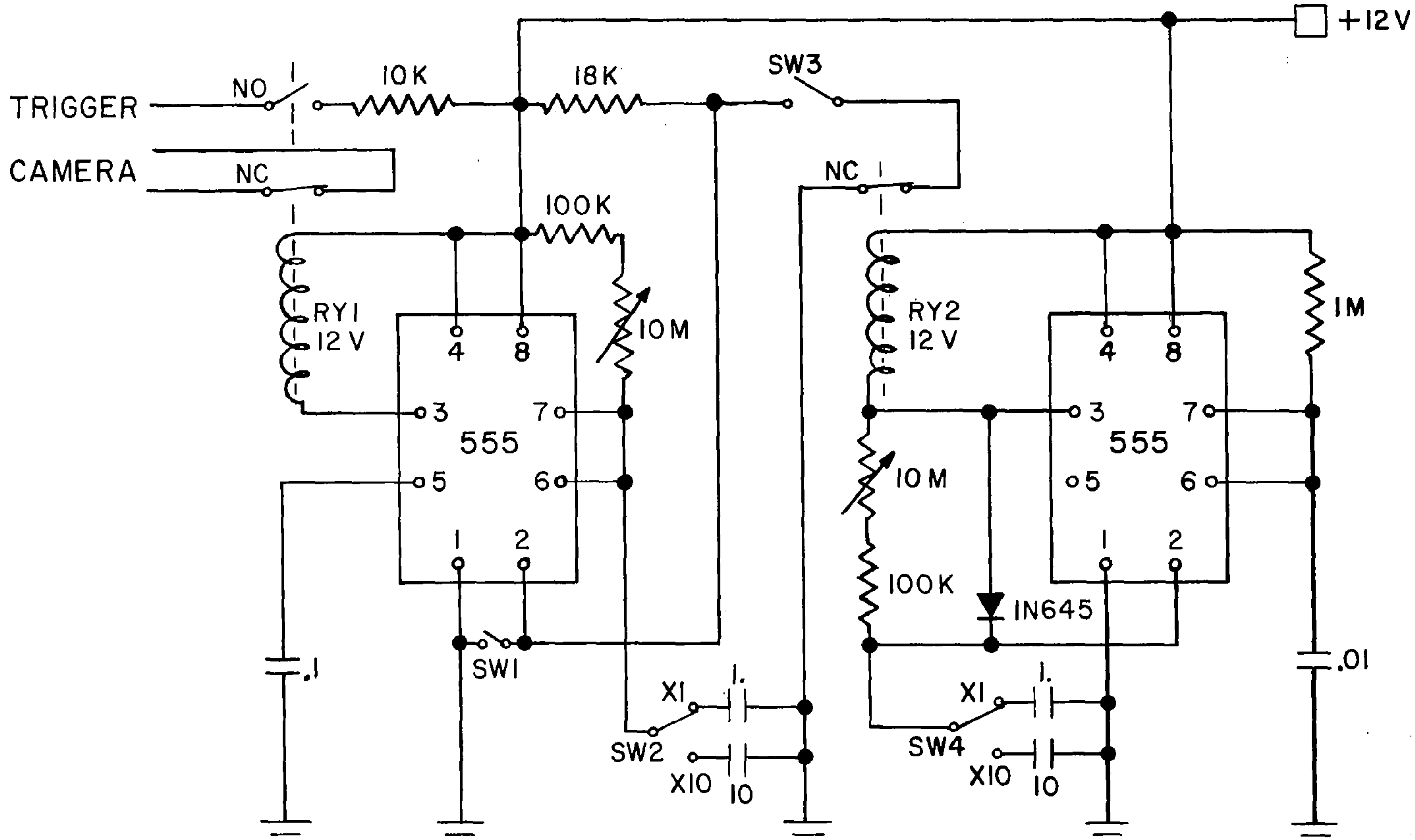


Figure 1 - INSTRUMENTATION INTERCONNECTION



DURATION TIME: 0.1 to 15 AND 1 TO 150 SEC.
INTERVAL TIME: 0.1 to 10 AND 1 TO 100 SEC.

Figure 2 - CAMERA TIMER SCHEMATIC CIRCUIT

4.0 Aircraft

The vehicle selected for this aerial survey was a Cessna 402, a twin engine plane with a cruising speed of 200 miles per hour. It accommodates a crew of two and has passenger cabin space with seating for six. The seats are adjustable in placement and may be removed if space is required for instruments or equipment. Three seats were removed so that the equipment rack could be mounted in the middle of the cabin floor. It was firmly fastened to the floor with the same type of clamps used for the seats. The 500 watt power inverter was fastened to the base of the equipment rack.

The antennas were mounted on the underside of the fuselage in the area below the equipment rack. This kept antenna to spectrum analyzer cables at a minimum length. Figure 3 shows the placement of the equipment rack; Figure 4 shows the locations of the antennas.

The AEL ASN-115A Antenna is right-hand circularly polarized and has two alternate mounting attachments. One mounting places the antenna in a nadir-looking position. The other is an horizon-looking mount which is tipped down so that the half-power beam edge is on the horizon. This latter horizon-looking mount was employed in the land mobile survey in Chicago and in the interference survey at Palestine, Texas.

The AEL H-1498 antennas were arranged so that one antenna is in a nadir-looking mount while the other is in an horizon-looking mount with the beam tipped down so that the half-power beam edge is on the horizon. Polarization of the antenna was horizontal. The nadir-looking antenna was used on the 50 mile run surveys while the horizon-looking antenna was used to sweep the

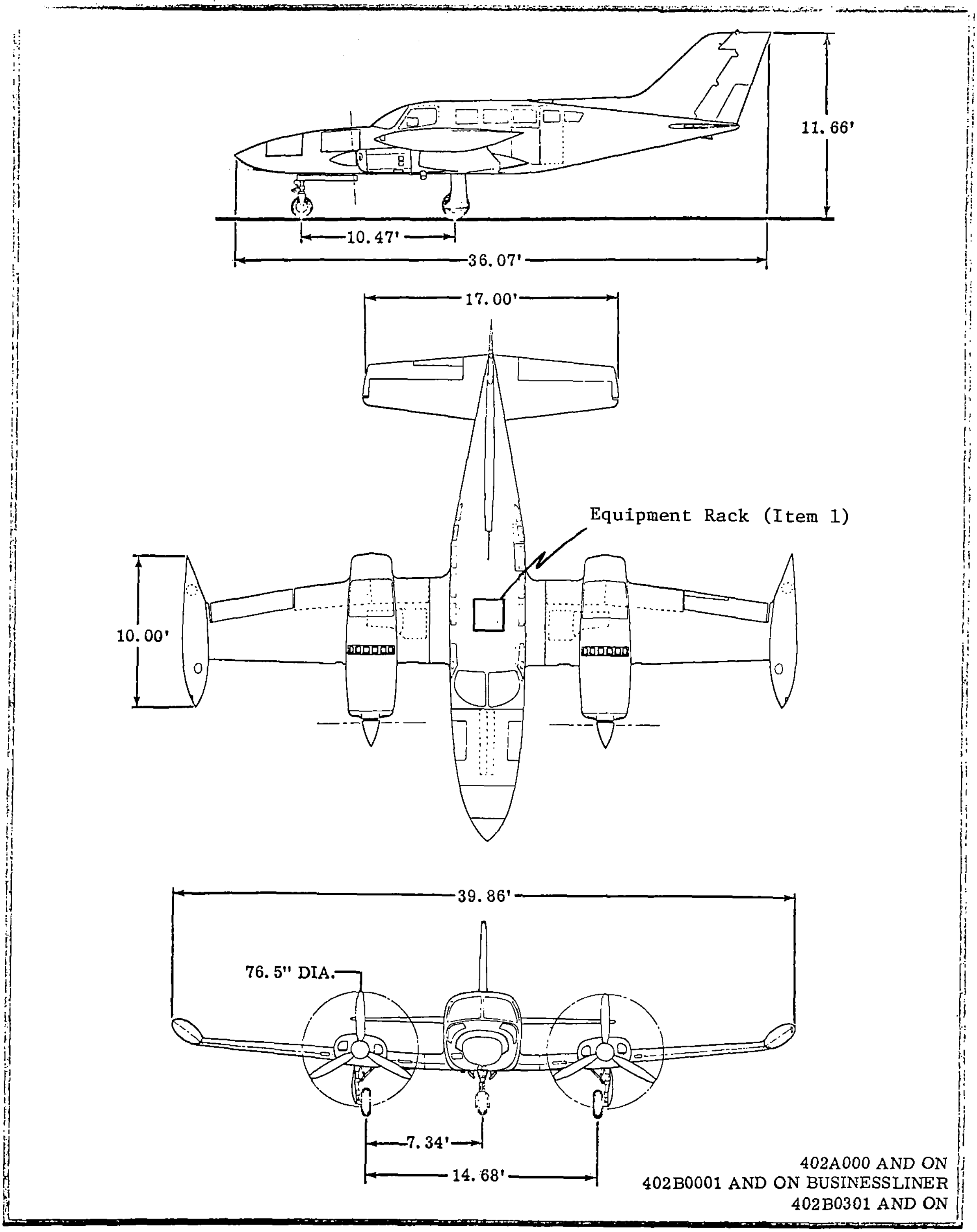


Figure 3 - LOCATION OF EQUIPMENT RACK ON CESSNA 402 AIRCRAFT

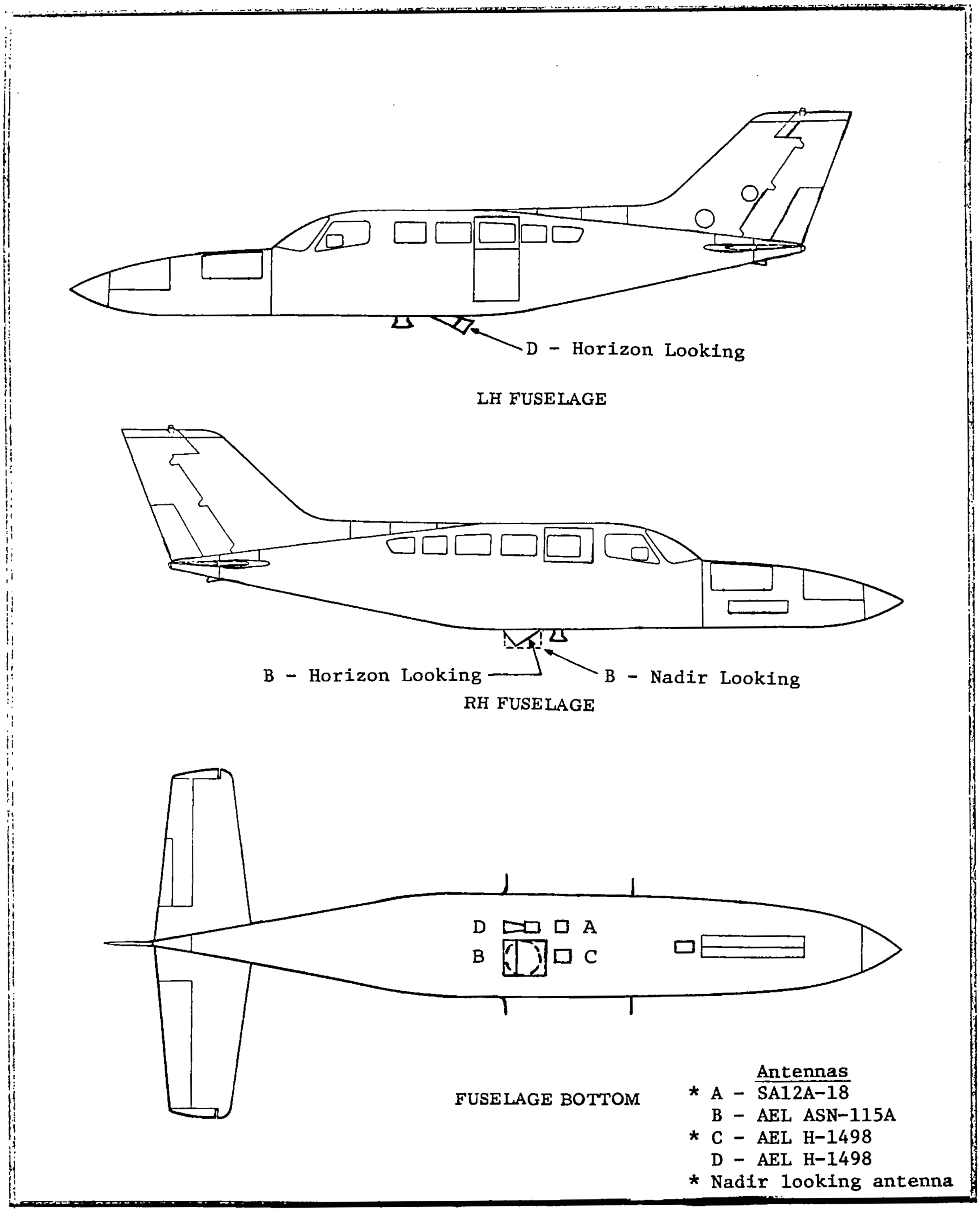


Figure 4 - LOCATION OF ANTENNAS ON AIRCRAFT

horizon while the aircraft was making the turnaround at the end of each 50 mile run.

The SA 12A-18 antenna was mounted so that it was flush with the bottom of the fuselage and looked through an aperature slightly larger than the mouth of the horn.

5.0 Installation of Instrumentation on Aircraft

In mounting equipment, such as the instrumentation required for this survey, weight, physical size and power requirements are important factors. Table 1 lists these factors for each equipment item. Items 2 through 10 in Table 1 are mounted in item 1, the Equipment Rack. The placement of the instrumentation in the rack is shown in Figure 5. The rack is located in the center of the passenger cabin. The Topaz power inverter is mounted on the base of the equipment rack.

The four antennas are mounted on the underside of the fuselage. The antenna for Bands 1 and 2, (see Table 5), a cavity backed spiral, American Electronics Laboratory Model ASN-115A antenna was mounted in a 6-inch-deep, 13-inch diameter aluminum can facing down. This mounting, shown in Figure 6, was used for all flights, except the spiral flights over Chicago and Palestine, Texas where the antenna mounting was changed to the mount shown in Figure 7. This mount placed the antenna in position so that it looked to the rear of the fuselage and at an angle 35 degrees below the horizon. There were two American Electronics Laboratory Model H-1498 horn antennas used on Bands 3, 4, and 5. One of these was mounted on the undersurface of the fuselage so that it looked down at nadir. The other antenna was mounted with the bracket shown in Figure 8 and 9 so that it looked to the rear of the fuselage and at an angle 25 degrees below the horizontal. The fourth antenna, a Scientific Atlanta Model 12A-18 was mounted so that it looked down to nadir through an opening in the fuselage skin. The taper waveguide section and mixer were mounted on the back of this antenna. When this antenna was used, it was connected directly to the external mixer input of the HP-8555A tuner section. The single coaxial cable connecting the mixer to the tuner carries the local oscillator signal to the mixer and the beat frequency signal back to the tuner of the spectrum analyzer.

TABLE 1

Equipment Size, Weight, and Power Load

	Item	Dimensions Inches W X H X D	Weight Lbs-Oz	Power Watts
1.	Equipment Rack	47-1/2x22/30	62-0	--
2.	HP-141T Display Section	16-3/4x8-3/4x16-3/8	40-0	225
3.	HP-8555A Tuner	8-7/8x4x13-1/2	14-15	
4.	HP-8552B I. F.	8-7/8x4x13-1/2	9-0	
5.	HP-8445B Preselector	16-3/4x3-15/32x18-3/8	19-8	
6.	HP-8447B Preamplifier	5-1/8x3-3/8x8-1/2	3-7	15
7.	HP-3910B Tape Recorder	16-3/4x15x7-3/8	50-0	130
8.	K&L 3TNF-392/808 5N Notch Filter	2-3/4x5-3/8x6-1/2	2-14	--
9.	Benrus 3625 Scope Camera	13-1/2x7-1/2x13-1/2	17-0	35
10.	RCA Timer/HP Power Supply	6x3-1/2x6 5-1/4x3-1/4x8	7-8	25
11.	Topaz Inverter	8-3/4x19x13-1/2	66-0	(500)
12.	AEL ASN-115A Antenna	12-1/8x4-5/8	3-3	
13.	AEL-H-1498 Antenna	3-3/16x4-7/8x3-7/8	-8	
14.	AEL-H-1498 Antenna	3-3/16x4-7/8x3-7/8	-8	
15.	SA-12A-18	10-5/8x4x3-5/16	2-0	
16.	HP-11519A Taper W. G.	3 Long	-2	
17.	HP-11517A Mixer	1-31/32x1/13/16x7/8	-9	
		Totals	299-2	430

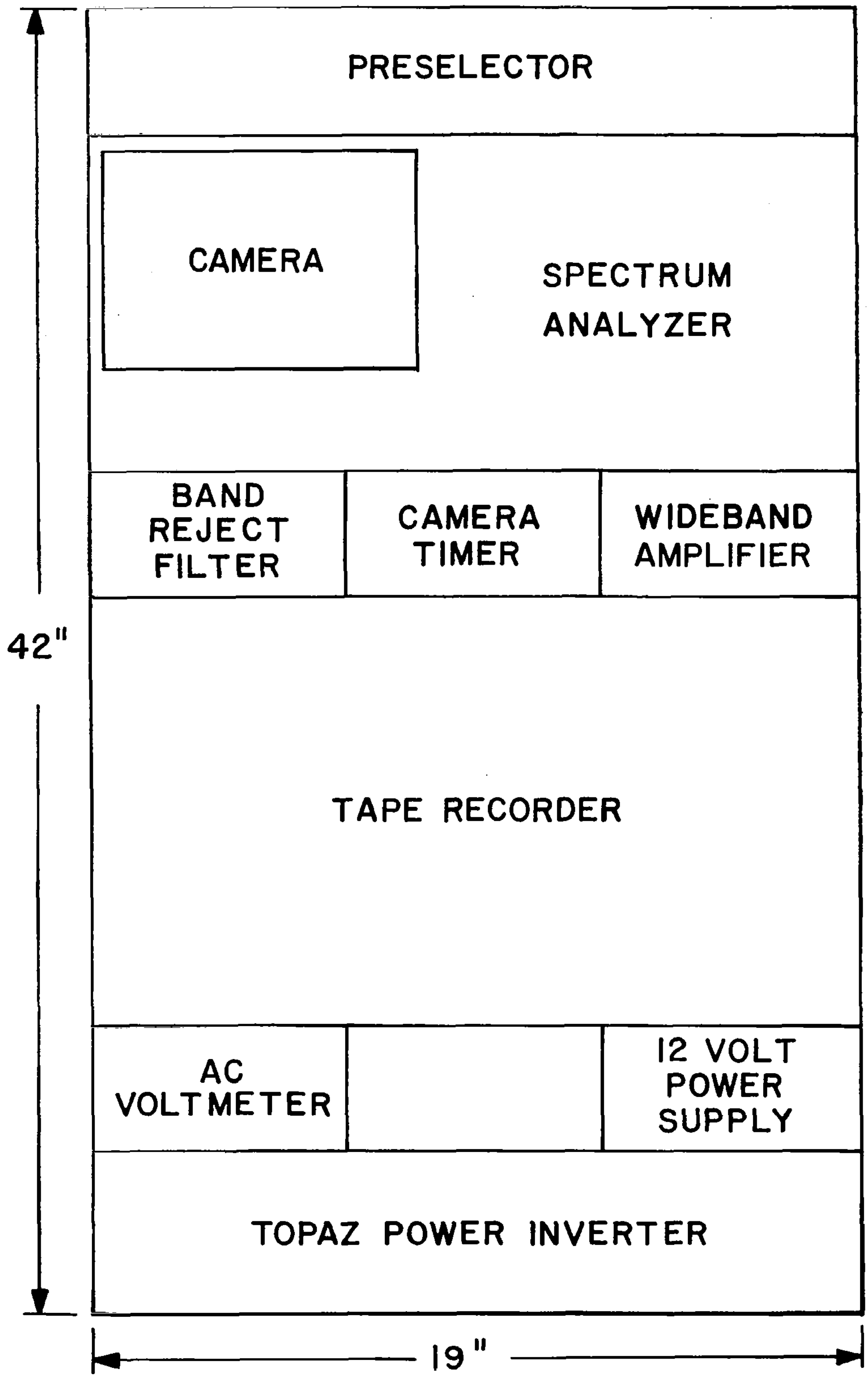


Figure 5 - INSTRUMENT PLACEMENT IN RACK

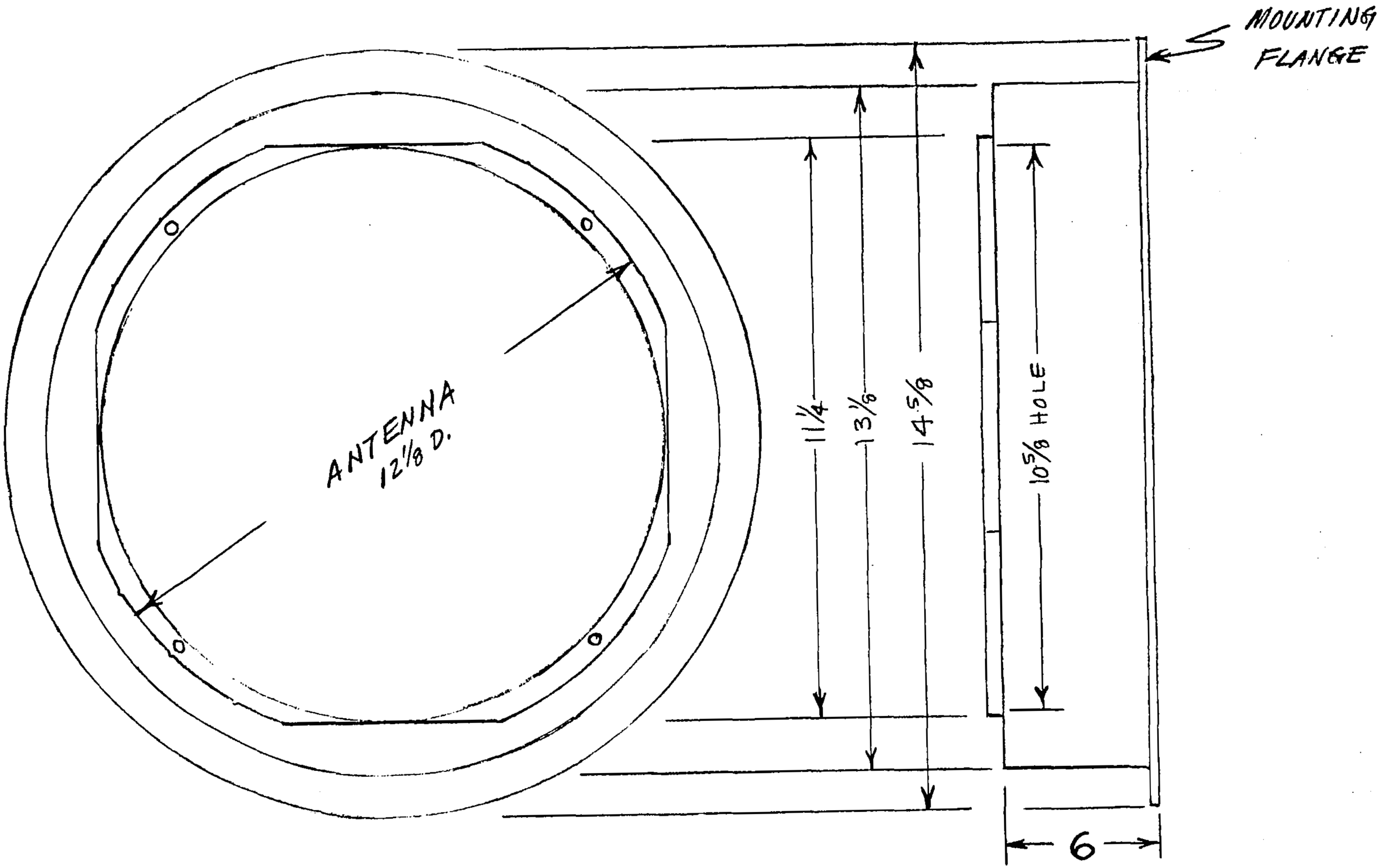


Figure 6 - MOUNTING FOR ASN-115A, ANTENNA, NADIR-LOOKING

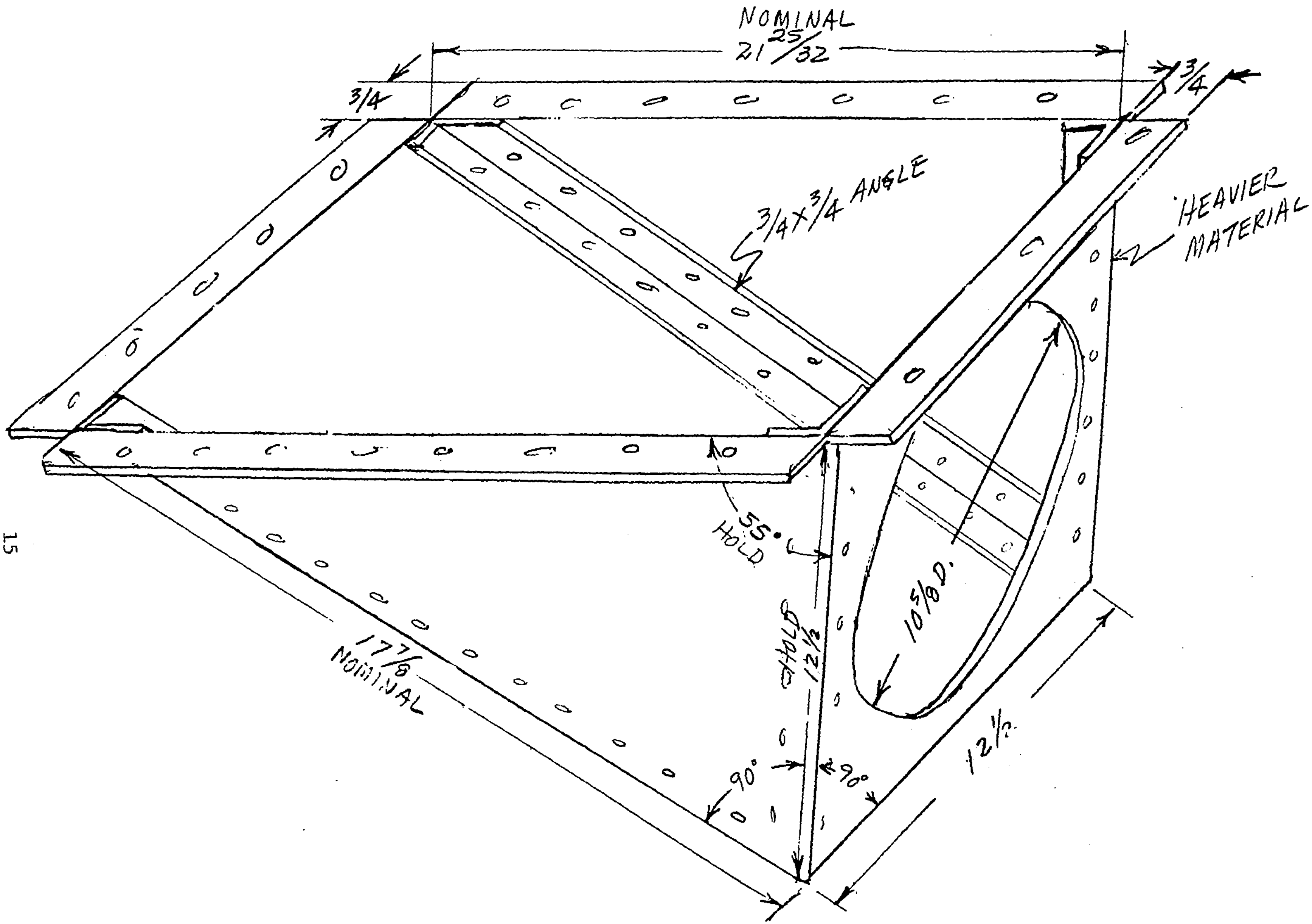


Figure 7 - MOUNTING FOR ASN-115A ANTENNA, HORIZON-LOOKING

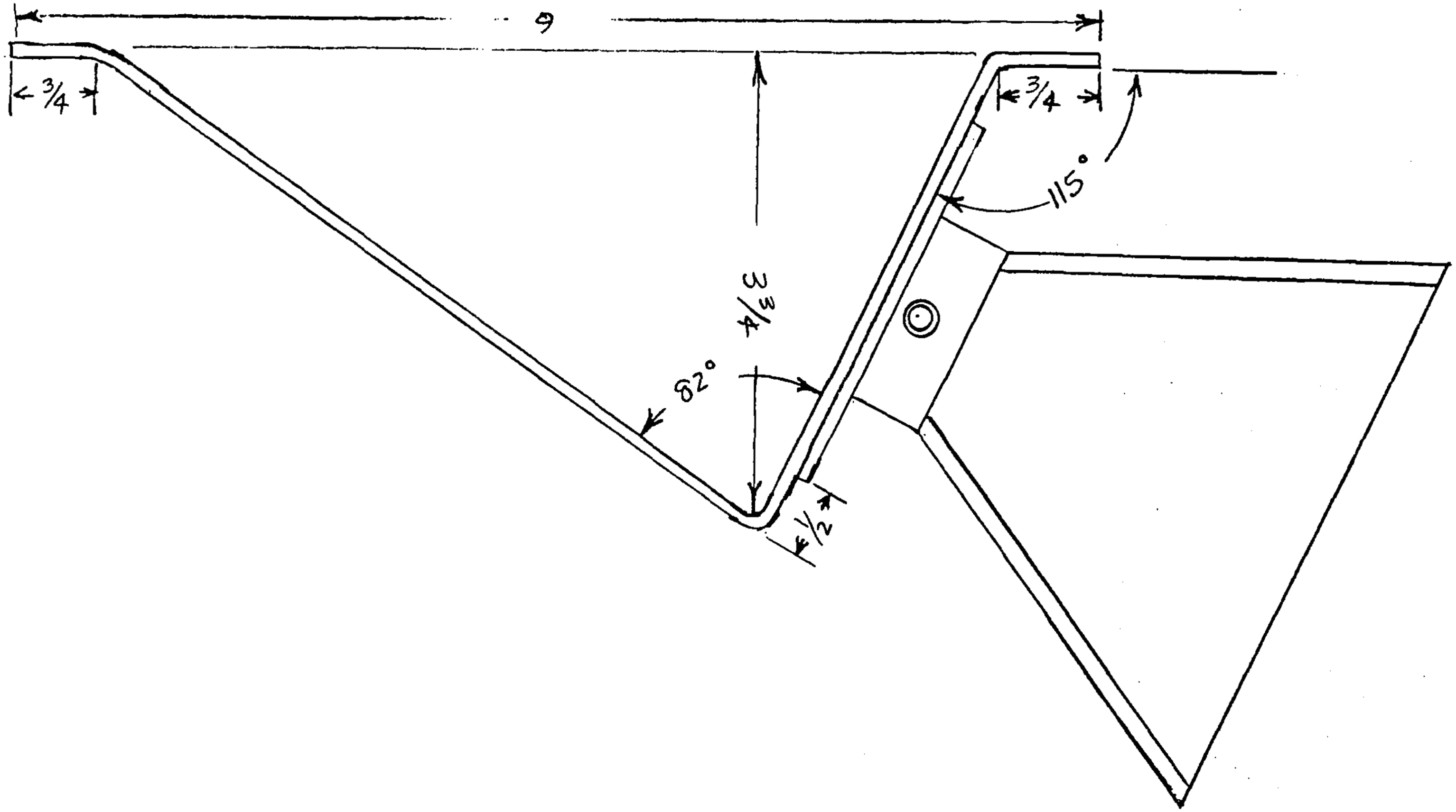


Figure 8 - MOUNTING FOR H-1498 ANTANNA, ELEVATION , HORIZON--LOOKING

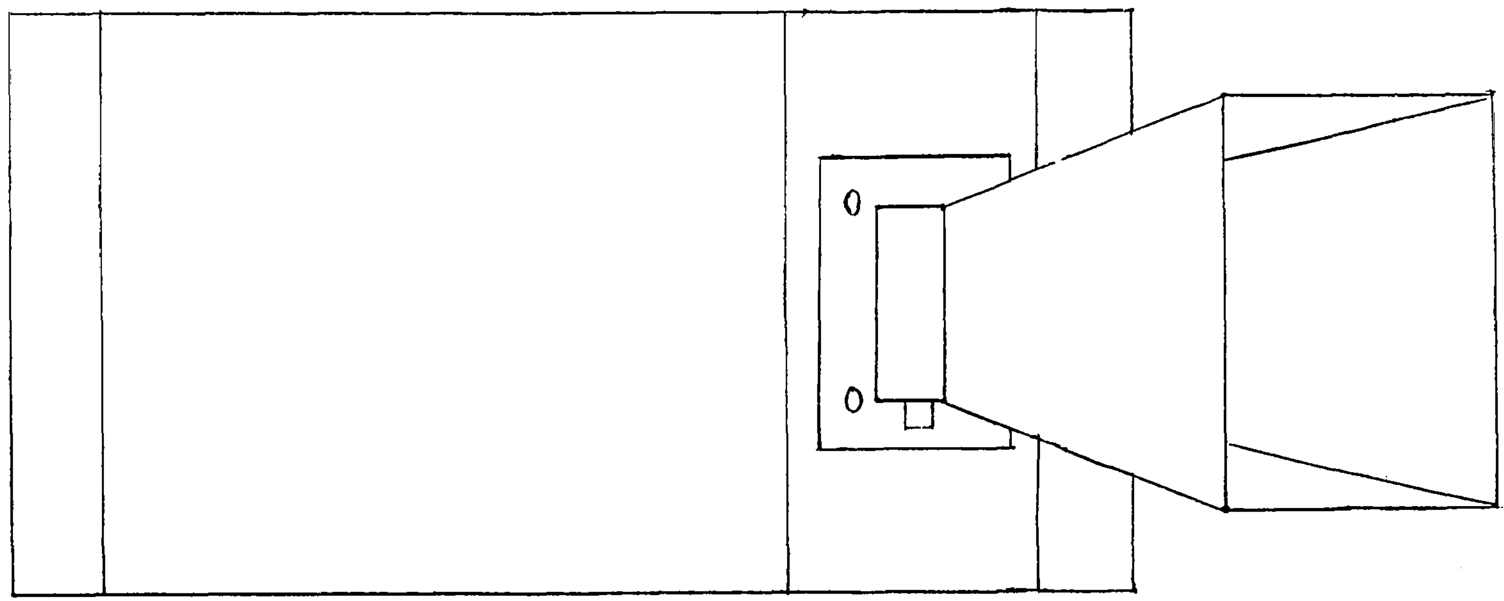


Figure 9 - MOUNTING FOR H-1498 ANTENNA, PLAN VIEW, HORIZON-LOOKING

6.0 Calibration

Following installation of the instrumentation and antennas in the aircraft a calibration run was scheduled. Antennas were set up on the ground at the RCA facility in Springfield, Virginia. An AIL Model 12A Power Oscillator was used to drive the ground antennas. With the ground antennas pointed at the zenith the aircraft was flown directly over the antennas while the instrumentation was in operation and both photographic and tape recorder records were made following the calibration schedule shown in Table 2. The calibration was made up to 2400 MHz, thus checking the ASN-115A cavity backed spiral and the H-1498 wide band horn antenna including the 0.01 to 2.05 and 2.07 to 6.15 GHz bands of the spectrum analyzer. Calibration of the upper bands of the spectrum analyzer were carried out on the ground with standard signal generators. It was assumed that the antenna gain varied according to the antenna gain curves furnished by the manufacturer, included here as Figures 10 through 13.

When no signals were observed on the 14.41 to 26.65 GHz band in the flights over Washington-Baltimore and Philadelphia, arrangements were made for Hewlett-Packard to check this band at the Teterboro, New Jersey Airport. It was found that the Model 11517A mixer was defective. A replacement mixer was not available immediately but one was located and shipped to Chicago in time to be used on the night-time measurements. It was also used briefly during the orbital measurements over Chicago and Palestine, Texas.

TABLE 2
CALIBRATION SCHEDULE

RUN	ALTITUDE FEET/GROUND	FREQUENCY MHz	TRANSMITTER OUTPUT POWER, WATTS	AIRCRAFT ANTENNAS	GROUND ANTENNAS
1	2,500	430	20	ASN-115A	Turnstile
2	2,500	1250	10	ASN-115A	SG Horn
3*	2,500	1250	10	ASN-115A	SG Horn
4	2,500	2400	5	H-1498	H-1498
5	5,000	430	20	ASN-115A	Turnstile
6	5,000	1250	10	ASN-115A	SG Horn
7*	5,000	1250	10	ASN-115A	SG Horn
8	5,000	2400	5	H-1498	H-1498
9	10,000	430	20	ASN-115A	Turnstile
10	10,000	1250	10	ASN-115A	SG Horn
11*	10,000	1250	10	ASN-115A	SG Horn
12	10,000	2400	5	H-1498A	H-1498

* These runs were made with the ASN-115A antenna connected directly to the HP-8445B Preselector instead of through the K&L Notch Filter and HP-8447 Wide-band Amplifier.

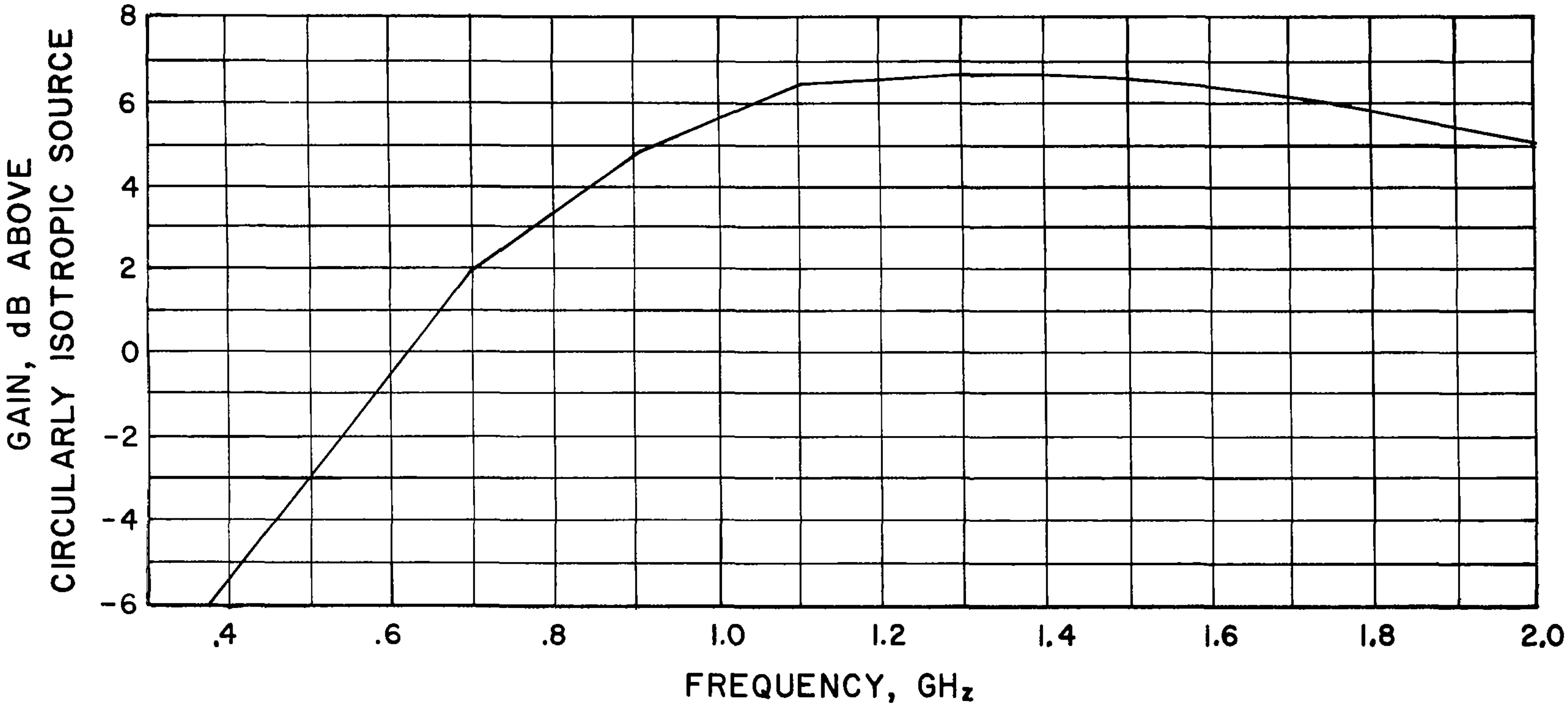


Figure 10 - GAIN VERSUS FREQUENCY, ASN-115A CAVITY BACKED SPRIAL ANTENNA

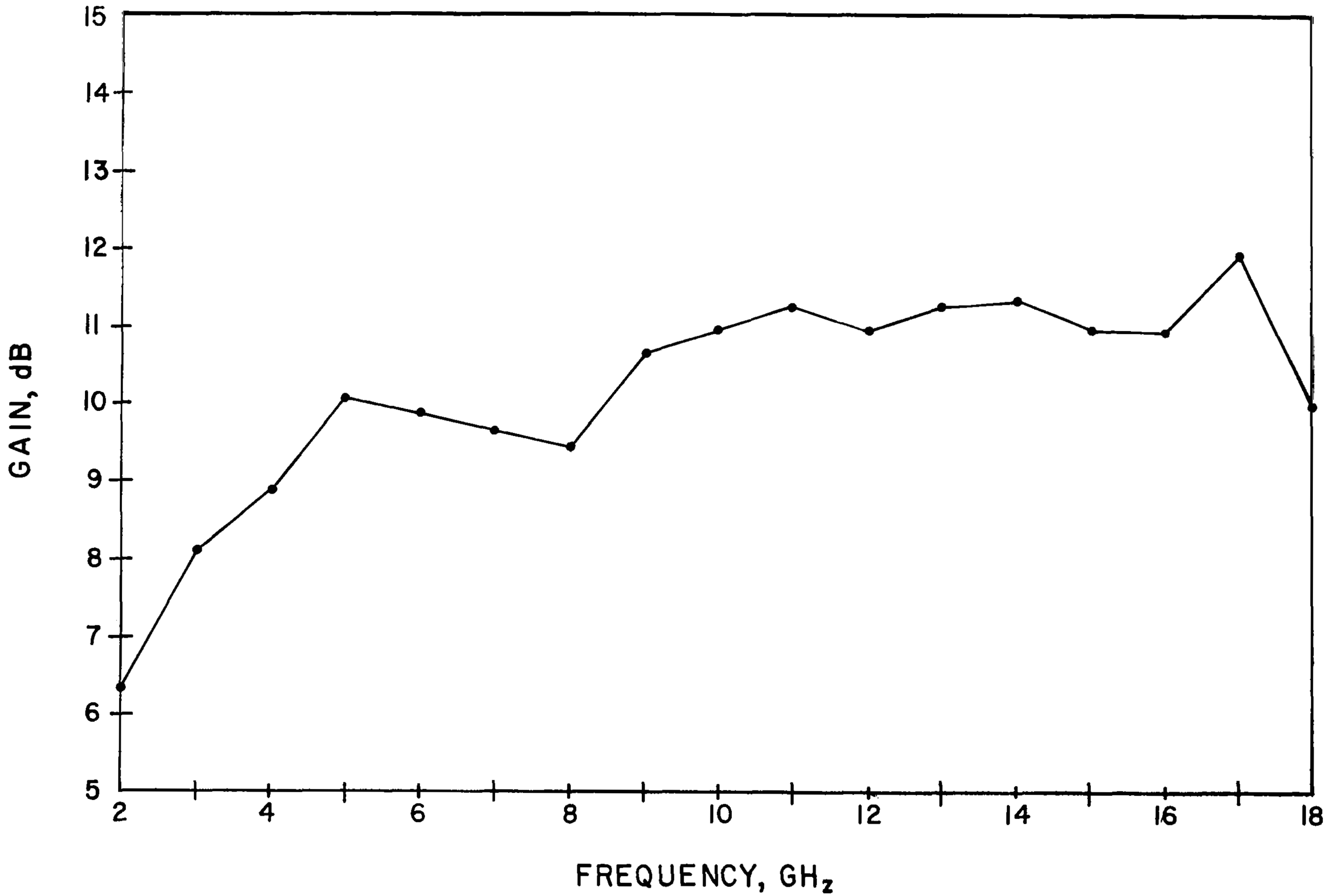


Figure 11 - GAIN VERSUS FREQUENCY, H-1498 ANTENNA, SER.NO. 103

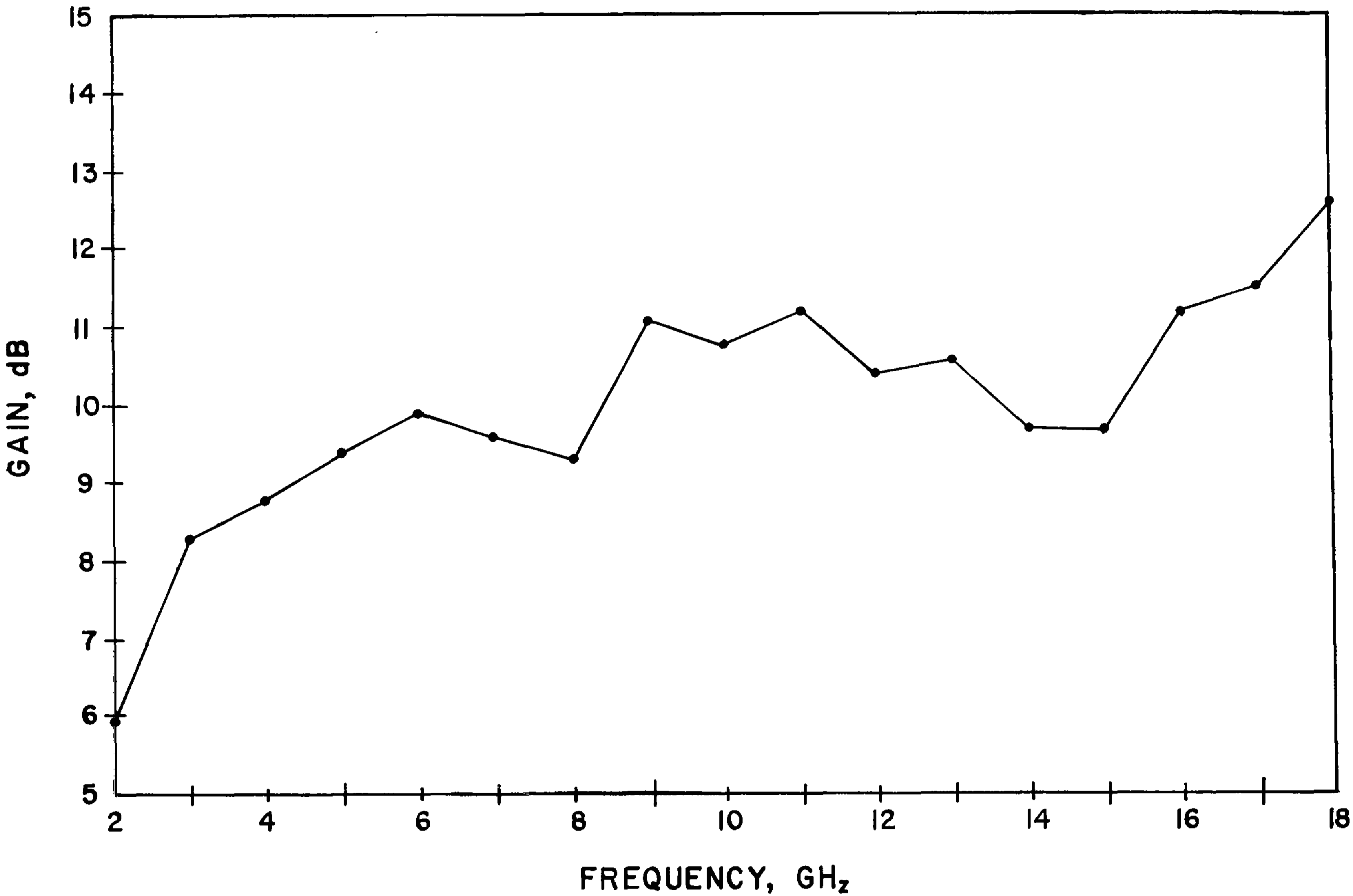


Figure 12 - GAIN VERSUS FREQUENCY, H-1498 ANTENNA, SER. NO. 105

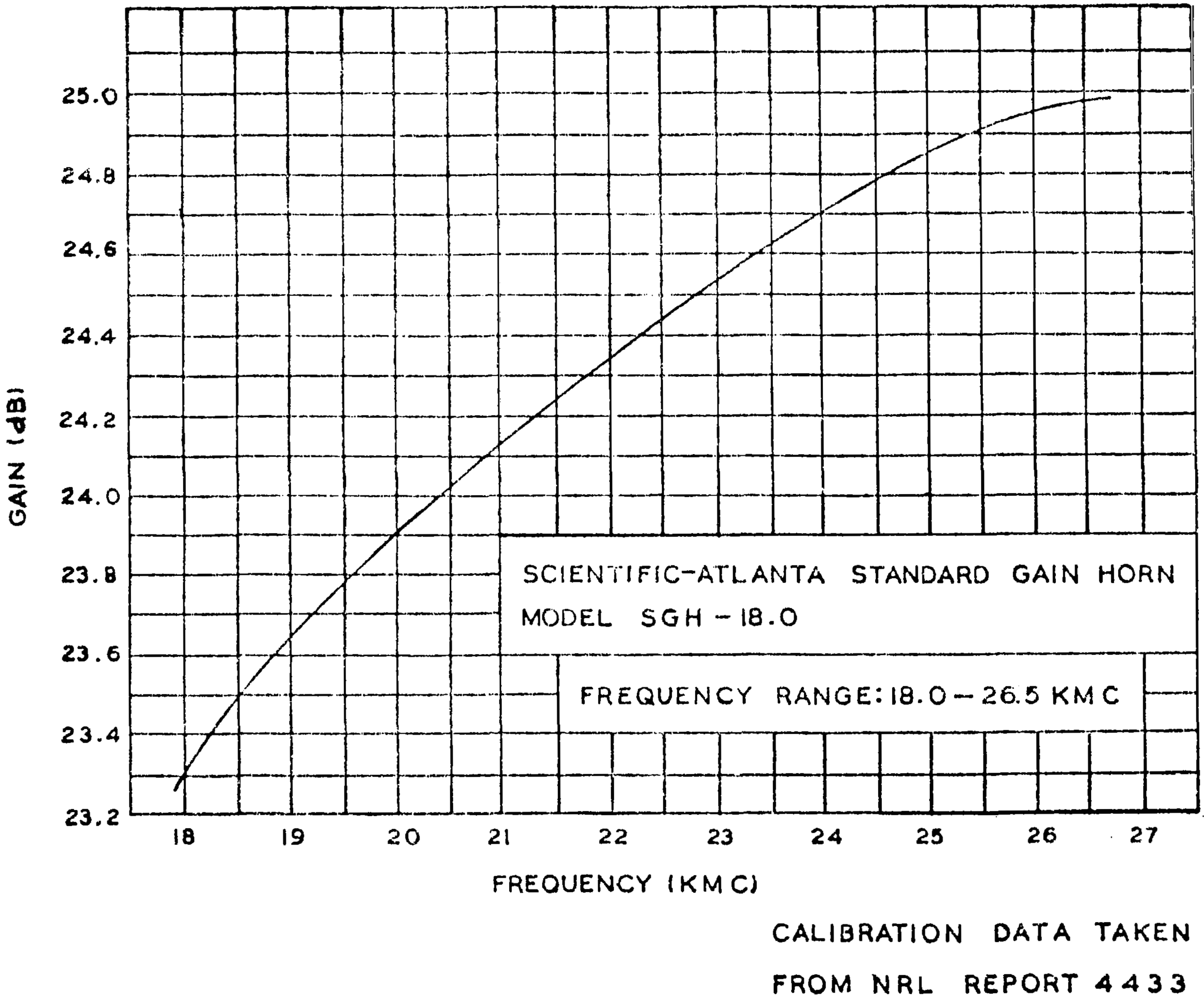


Figure 13 - GAIN VERSUS FREQUENCY, 12A-18 ANTENNA

7.0 Data Collection

The camera magazine holds 100 feet of 35 mm film. This allowed 1600 frames before reloading was necessary. At the rate of 120 frames per hour this meant 13 hours and 20 minutes maximum time per reel. With 4-1/2 hours scheduled for each metropolitan area, one reel was required for two metropolitan area surveys. Eastman Tri X panchromatic film was used.

The magnetic tape recorder was operated at a speed of 3-3/4 inches per second. The tape used, type 3M-207, is available in 1800 foot reels. This size reel ran for 1-1/2 hours and thus lasted through each 1-1/2 hour run. The HP-3960A Magnetic Tape Recorder has four channels. One channel recorded the horizontal scan voltage, another channel recorded the amplitude information and a third channel was used with a voice microphone to identify the tape as to location, band and other pertinent parameters, such as scan width, scan time, band width and reference level. This left a fourth channel available for recording a pocket-scanner receiver which was tuned to four selected channels (468.800, 468.825, 468.850, and 468.875 MHz) in the UHF band land mobile service.

8.0 Flight Profiles

Flight paths were scheduled over Washington-Baltimore, Philadelphia, New York City, and Chicago. The flight paths were laid out on the Aeronautical Charts shown as Figures 14 through 18. Only straight line flight paths were made except for the turnaround at each end. These paths were selected to traverse residential, industrial and commerical areas in suburban as well as urban inner-city regions. Each flight path was approximately 50 miles in length. At the end of each path there was a turnaround circle. While the aircraft was making its turnaround, the horizon-looking antenna was used to make a 360 degree survey of the horizon on bands 3, 4, and 5, (2.07 to 18.0 GHz). Figure 18 shows the cross-country route between the metropolitan areas enumerated above.

The Aeronautical Charts are marked with the locations of the UHF-TV transmitters which are near the flight paths. This information shown in Table 3, was used to adjust the notch filter to the video carrier of high power UHF-TV stations which might overload the preamplifier while Band 1 was being run.

A survey schedule is shown in Table 4. This shows a span of 13 days from the calibration and checkout run to and including the return to Washington. The schedule was based on favorable weather for the whole period. Delays in the schedule were anticipated because the weather had to be suitable for visual flight operation without turbulence.

The flight paths have also been laid out on ERTS photographs, Figures 14A through 17A, of each metropolitan area. The area swept on each flight can be judged by the circles showing the HPBW antenna footprint for the 70° cavity-backed spiral antenna and the 50° wide-band horn antenna.

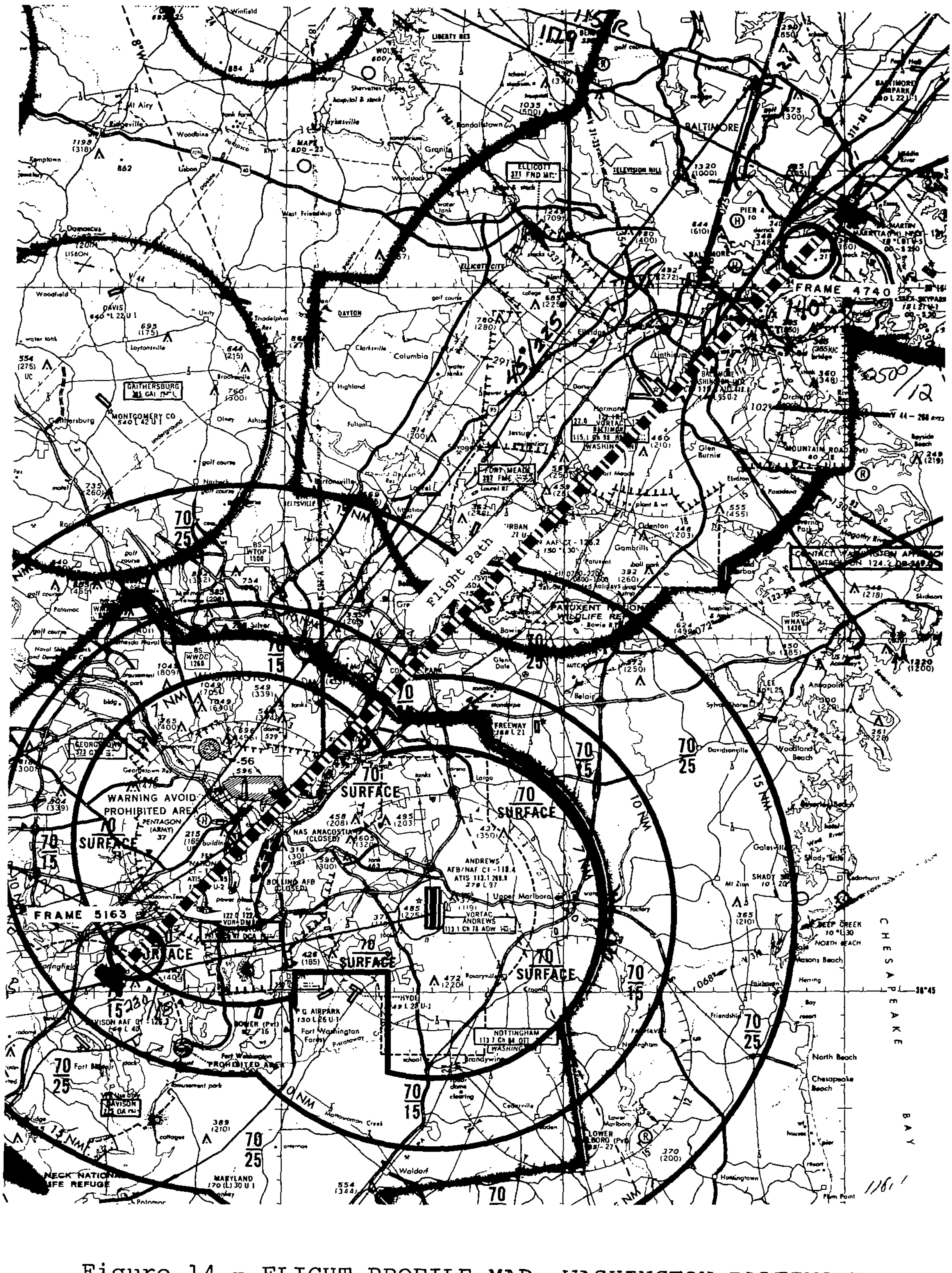


Figure 14 - FLIGHT PROFILE MAP, WASHINGTON-BALTIMORE

FIGURE 14A-ERTS FLIGHT PROFILE MAP,WASHINGTON-BALTIMORE

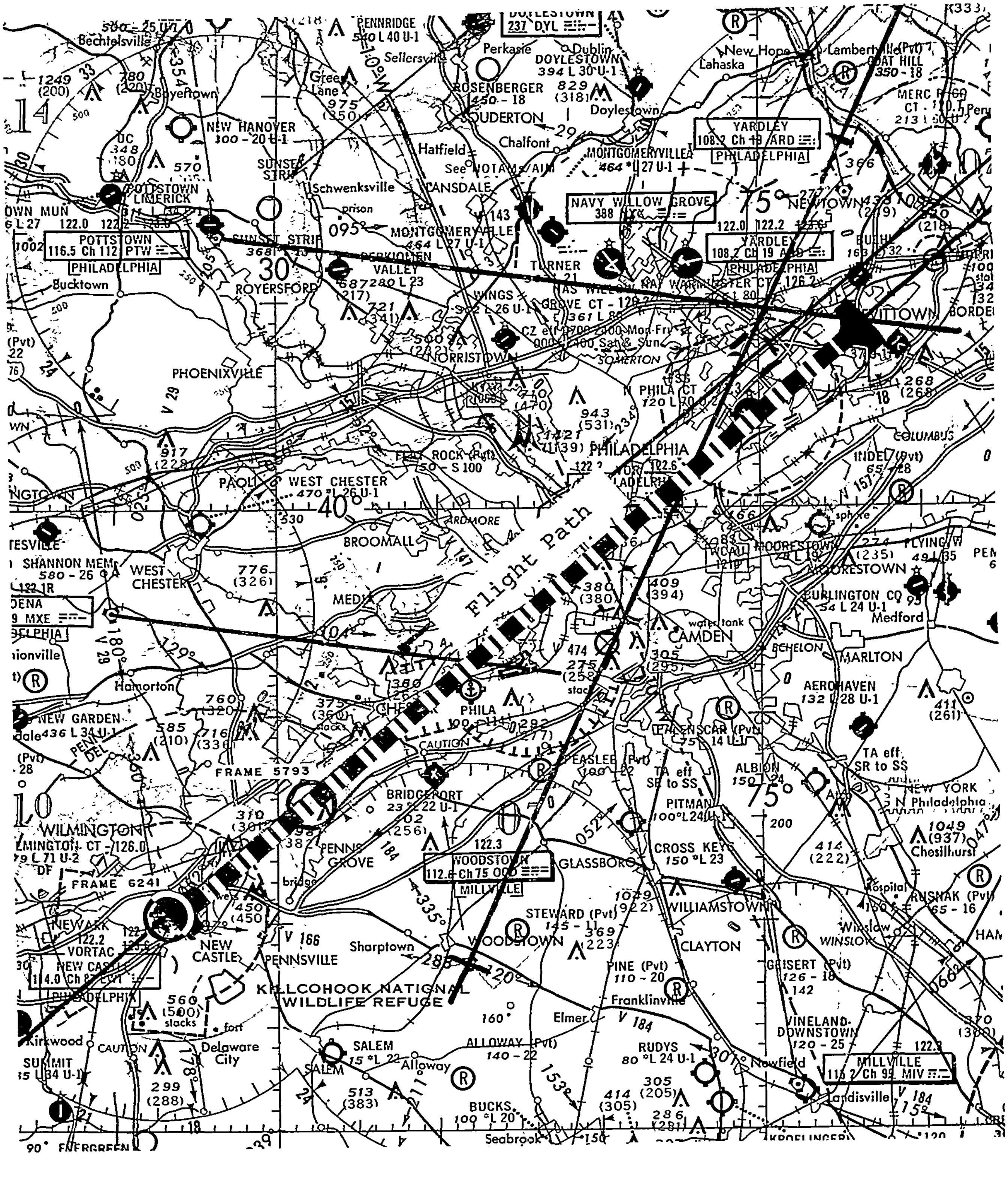


Figure 15 - FLIGHT PROFILE MAP, PHILADELPHIA

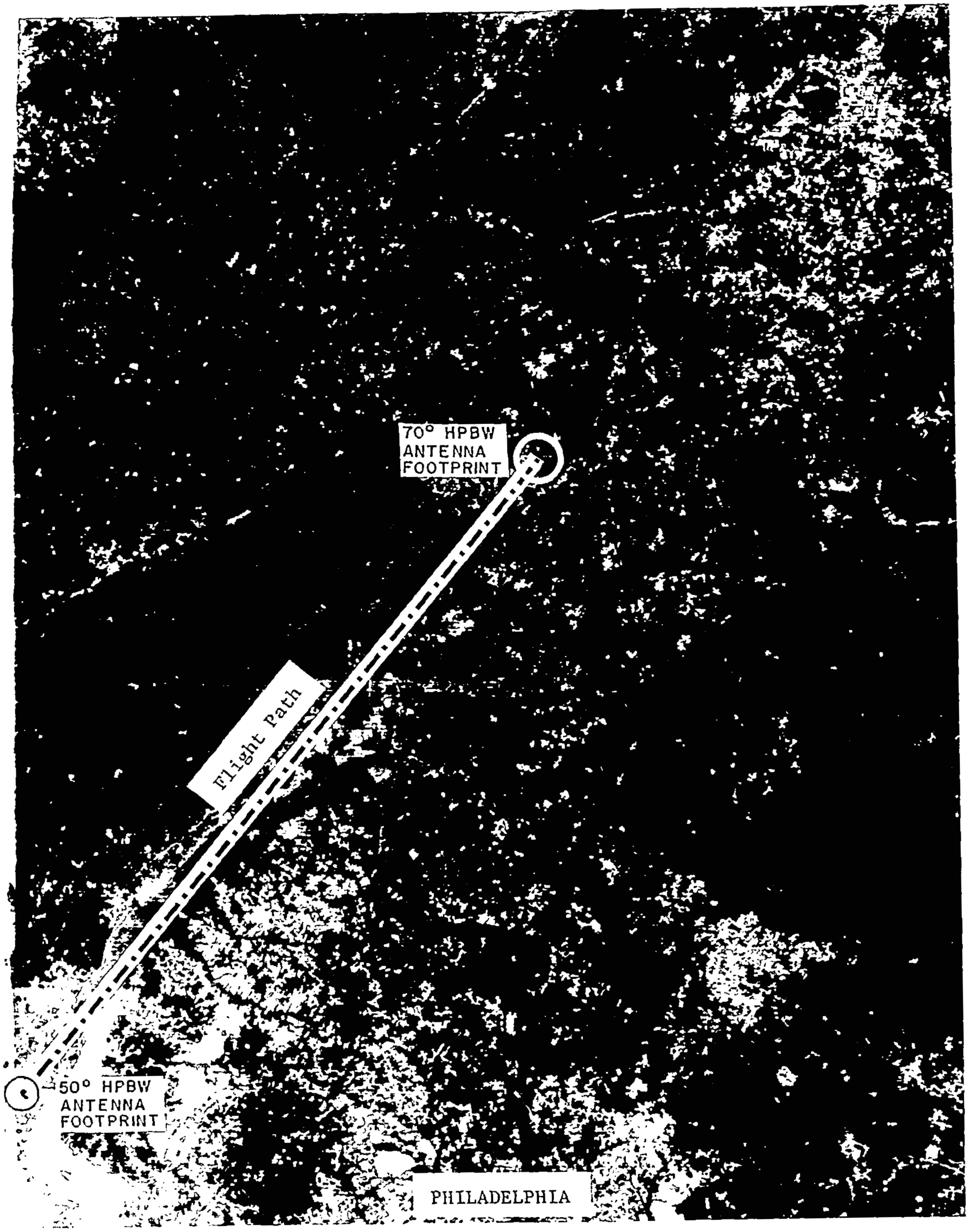


FIGURE 15A - ERTS FLIGHT PROFILE MAP, PHILADELPHIA

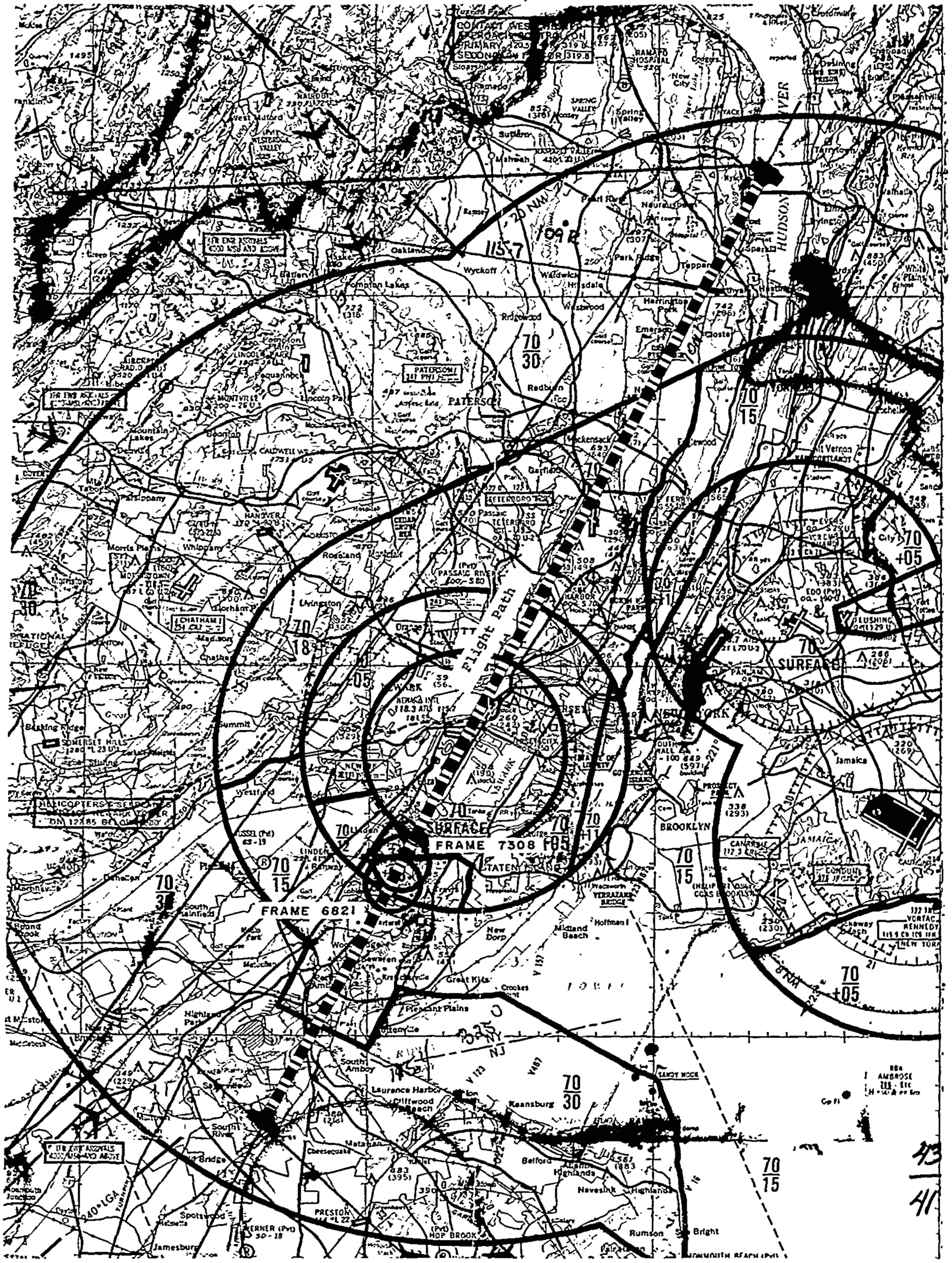


Figure 16 - FLIGHT PROFILE MAP, NEW YORK CITY

FIGURE 16A - ERTS FLIGHT PROFILE MAP, NEW YORK CITY

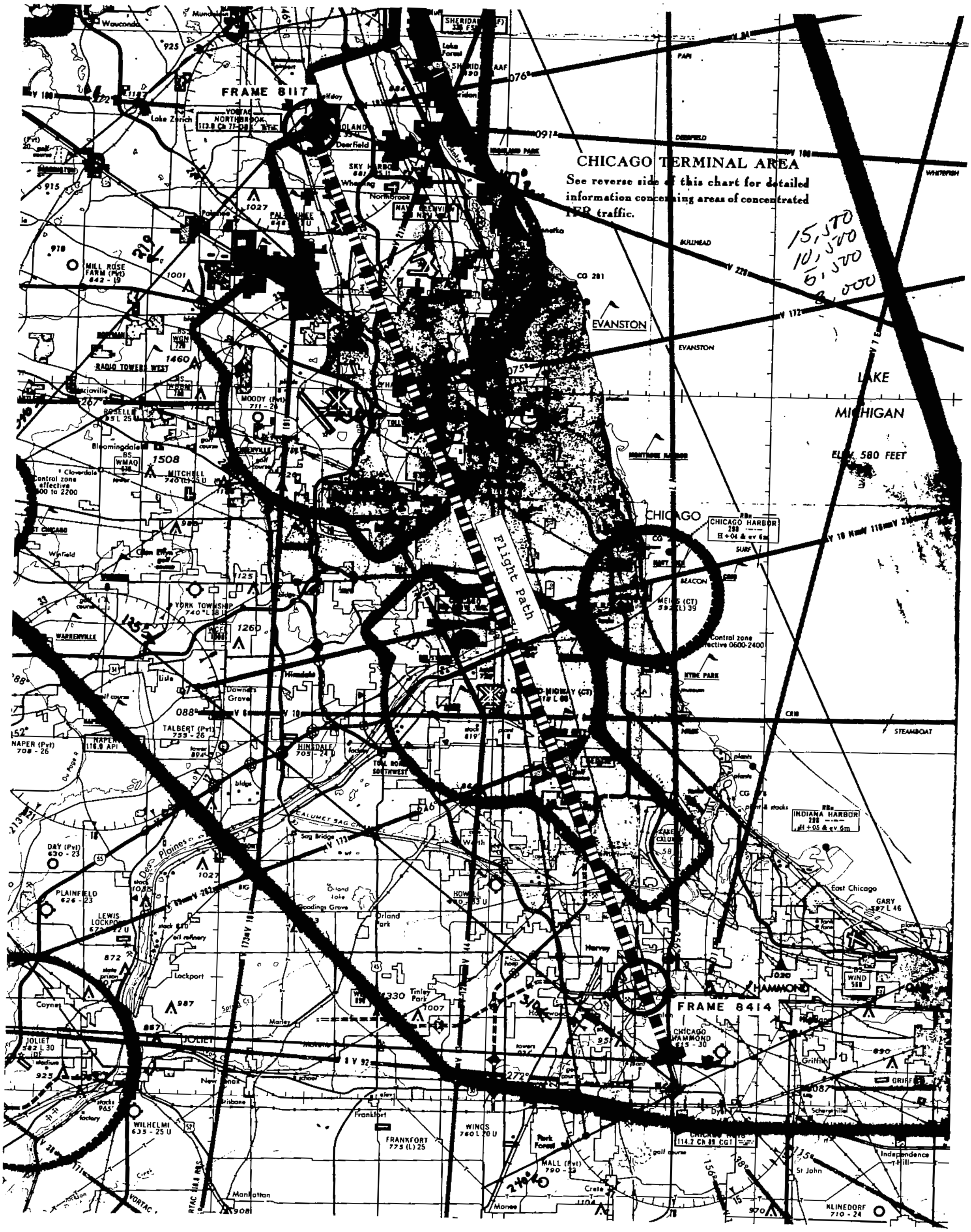


Figure 17 - FLIGHT PROFILE MAP, CHICAGO

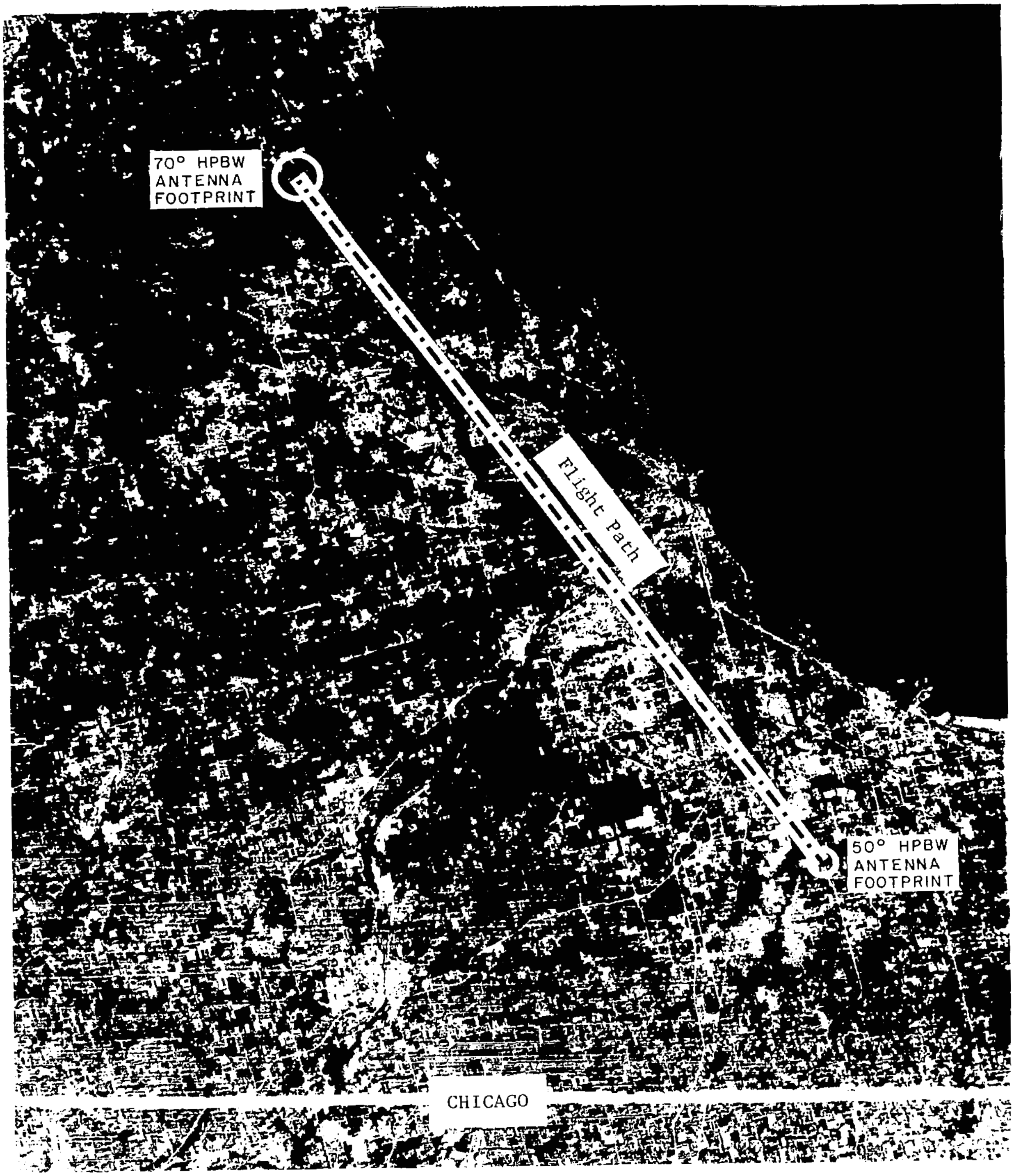


FIGURE 17A - ERTS FLIGHT PROFILE MAP, CHICAGO

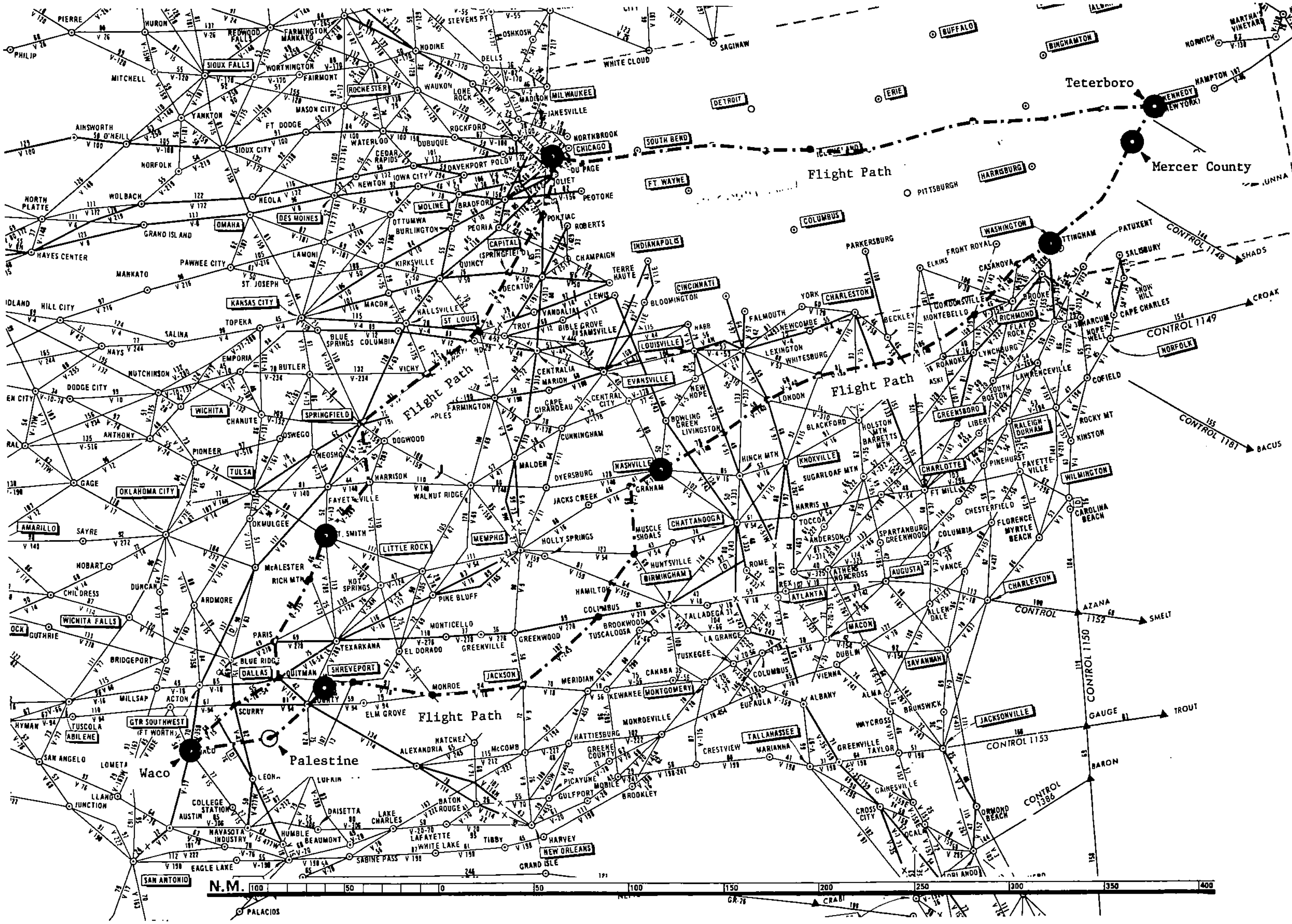


Figure 18 - CROSS-COUNTRY ROUTE MAP

TABLE 3
DATA ON UHF-TV STATIONS

LOCATION	CALL	CHANNEL	VIDEO ERP (KW) FREQUENCY (MHz)	LATITUDE LONGITUDE
Baltimore	WMPB	67	1000	39 27 Q0.1
			789.25	76 46 36.5
Baltimore	WBFF	45	1580	39 17 13
			657.25	76 45 16
Washington, D.C.	WDCA-TV	20	4000	38 57 49.4
			507.25	77 06 18.2
Washington, D.C.	WETA-TV	26	1100	38 57 49.4
			543.25	77 06 18.2
Philadelphia	WPHL	17	4300	40 02 30
			489.25	75 13 24
Philadelphia	WTAF-TV	29	5000	40 02 26
			561.25	75 14 20
Philadelphia	WUHY-TV	35	141	39 57 04
			597.25	75 10 08
Camden	WNJS	23	2323	39 43 41
			525.25	74 50 39
Philadelphia	WKBS-TV	48	2377	40 02 35.5
			675.25	75 14 32.5
Trenton	WNJT	52	1939	40 17 00
			699.25	74 41 20
Gordon City	WLIW	21	724	40 43 55
			513.25	73 36 12.4
Montclair	WNJM-TV	50	2094	40 51 53
			687.25	74 12 03

TABLE 3 (continued)
DATA ON UHF-TV STATIONS

LOCATION	CALL	CHANNEL	VIDEO ERP (KW) FREQUENCY (MHz)	LATITUDE LONGITUDE
Patterson	WXTV	41	2190	40 42 22
			633.25	74 00 28
Newark	WNJU-TV	47	380	40 44 54
			669.25	73 59 10
New York	WNYE-TV	25	658	40 41 21
			537.25	73 58 37
New York	WNYC-TV	31	890	40 44 54
			573.25	73 59 10
Bridgeport	WEDW	49	617	41 16 46
			681.25	73 11 09
Patchogue	WSNL	67	1280	40 48 27
			789.25	73 10 48
New Brunswick	WNJB	58	1321	40 37 17
			735.25	74 30 15
Chicago	WCIU-TV	26	1162	41 52 39
			543.25	87 38 02
Chicago	WFLD-TV	32	2500	41 53 55.5
			579.25	87 37 23
Chicago	WSNS-TV	44	2500	41 53 55.5
			652.25	87 37 23
Chicago	WXXW	20	457	41 54 01
			507.25	87 37 28
Gary	WCAE	50	12	41 28 01
			687.25	87 28 25

TABLE 4 - SURVEY TIME SCHEDULE

DAY	OPERATION	SURVEY FLIGHT HOURS	IN-ROUTE HOURS
1	Calibration and check out	2.0	
2	Review on ground		
3	Washington-Baltimore survey	4.5	
4	Travel to Mercer County, N. J. Airport		1.0
5	Philadelphia survey	4.5	
6	Rest		
7	New York City survey	4.5	
8	Travel to St. Charles, Illinois		4.5
9	Chicago	4.5	
10	Chicago Land Mobile survey	4.0	
11	Travel to Palestine, Texas		5
12	Palestine interference survey	4.0	
13	Travel to Washington		6.5
	Total	28.0	17.0

9.0 Survey Operational Procedure

When calibration and checkout of the instrumentation had been completed the aircraft was scheduled to start the aerial survey. The survey was run with an aircraft speed of 200 miles per hour. The halfpower beamwidth (HPBW) of the ASN-115A antenna is 70 degrees, the H-1498 horn antenna is 50 degrees, and the SA 12-18 antenna is 11 degrees. With the aircraft at an altitude of 8000, 10,000 and 12,000 feet above level terrain, the halfpower footprint diameter (mi.) of the antennas looking at nadir is given in Table 4A.

TABLE 4A - HPBW FOOTPRINT OF ANTENNAS LOOKING AT NADIR

(DIAMETER IN MILES)

HPBW (Degrees)	8000'	AIRCRAFT ALTITUDE 10,000'	12,000'
11^{o}	0.29	0.36	0.44
50^{o}	1.41	1.77	2.12
70^{o}	2.12	2.65	3.18

This can be compared with the footprint of a satellite antenna with a 1^{o} HPBW. At an altitude of 400 km (248.6 miles) its HPBW antenna footptint is 4.34 miles, compared with 2.65 miles for the 70^{o} cavity-backed spiral antenna at an altitude of 10,000 feet.

Since the survey was run at 10,000 feet where possible, the time interval between exposures of the spectrum analyzer was based on data for this altitude. The number of 35 mm frames per hour required to get adjacent coverage without overlap is 200 divided by the diameter of the footprint for an aircraft speed of 200 miles per hour. For the 70 degree HPBW antenna, this is 75 frames per hour or a time interval of 48 seconds. For the 50 degree beamwidth antenna this is 113 pictures per hour or a time interval of 32 seconds. For the 11 degree beamwidth antenna this is 555 frames per hour or a time interval of 6.5 seconds. The scan time of the spectrum analyzer can be varied in discrete steps from 1 millisecond to 100 seconds in a 1, 2, 5 sequence. Thus, the scan time of 20 seconds was selected for the bands using the 70 degree and 50 degree HPBW antennas. The interval between start of scans was selected as 30 seconds, giving some overlap. On band 6, using the 11 degree HPBW antenna, a scan time of 10 seconds and an interval time of 30 seconds was used to give a regular sampling of the path instead of continous coverage which would have required a greater bandwidth.

Figure 18A shows the footprint patterns for the cavity-backed spiral antenna having a HPBW of 70^{o} and for the wide-band horn antenna having a HPBW of 50^{o}. The cavity-backed spiral antenna was used in the frequency range of 400 to 2000 MHz and the wide-band horn antenna from 2 to 18 GHz. The pattern shows the overlap of the footprints for scan durations of 10 and 20 seconds and a period of 30 seconds. As this type of pattern is extended along the 50 mile flight path, there are areas which are overlapped from one frequency scan to the following scan. Referring to Figure 18A, in position 1 of the footprint, the frequency scan is at the high end of the band. For position 2 the frequency scan is at the low end of the band. Thus the overlapped area has been scanned at the low and the high end of the frequency band.

The bandwidth of the spectrum analyzer can be adjusted from 0.10 to 300 kHz in a 1, 3 sequence. To maintain accuracy of the spectrum analyzer the relationship of bandwidth, (BW); scan width, (SW); η=constant, and scan time (ST), must meet the critera:

$$(BW)^2 \geq \eta\frac{(SW)}{(ST)}$$

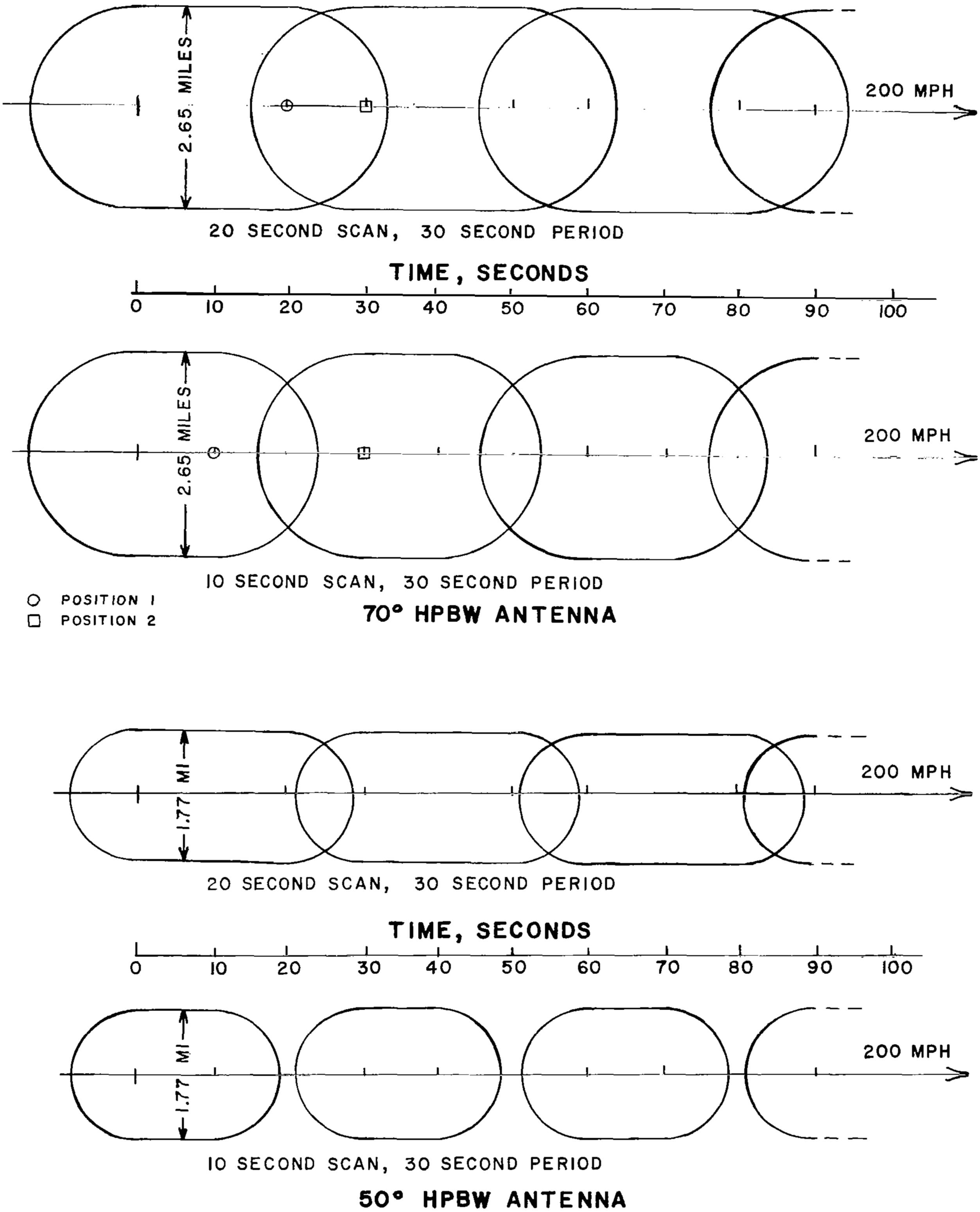


FIGURE 18A – ANTENNA FOOTPRINT PATTERNS

The constant η has a value of 1 for CW signal and may have a value up to 70 for a radar signal. Values of 1 and 10 have been selected for this survey as shown on Figure 19.

Table 5 shows this relationship within the range of control adjustments with scan time selected as 20 seconds and the scan widths selected for full bands of the spectrum analyzer, the minimum bandwidth being given in Table 5. Table 5 also shows the bandwidths selected for the survey. These bandwidths were greater than the minimum required so as to give suitable response to impulsive type signals. Table 5 also gives operational parameters for the 450 to 470 MHz land mobile survey using a scan time of 1 second. The above equation relating scan time, and frequency scan width in terms of the constant η and predetection bandwidth for the spectrum analyzer are plotted in Figure 19.

In scheduling the bands of frequencies which were used in traversing the flight paths special attention was given to the frequency bands of interest to NASA as shown in Figure 19A. Table 6 shows the bands covered and the way in which some of them were expanded for more detailed data. For example the 2.2 to 2.3 GHz band was expanded to look at 2.24 to 2.26 GHz and the 5.9 to 6.4 GHz band was expanded to look at 6.1 to 6.2 GHz in detail.

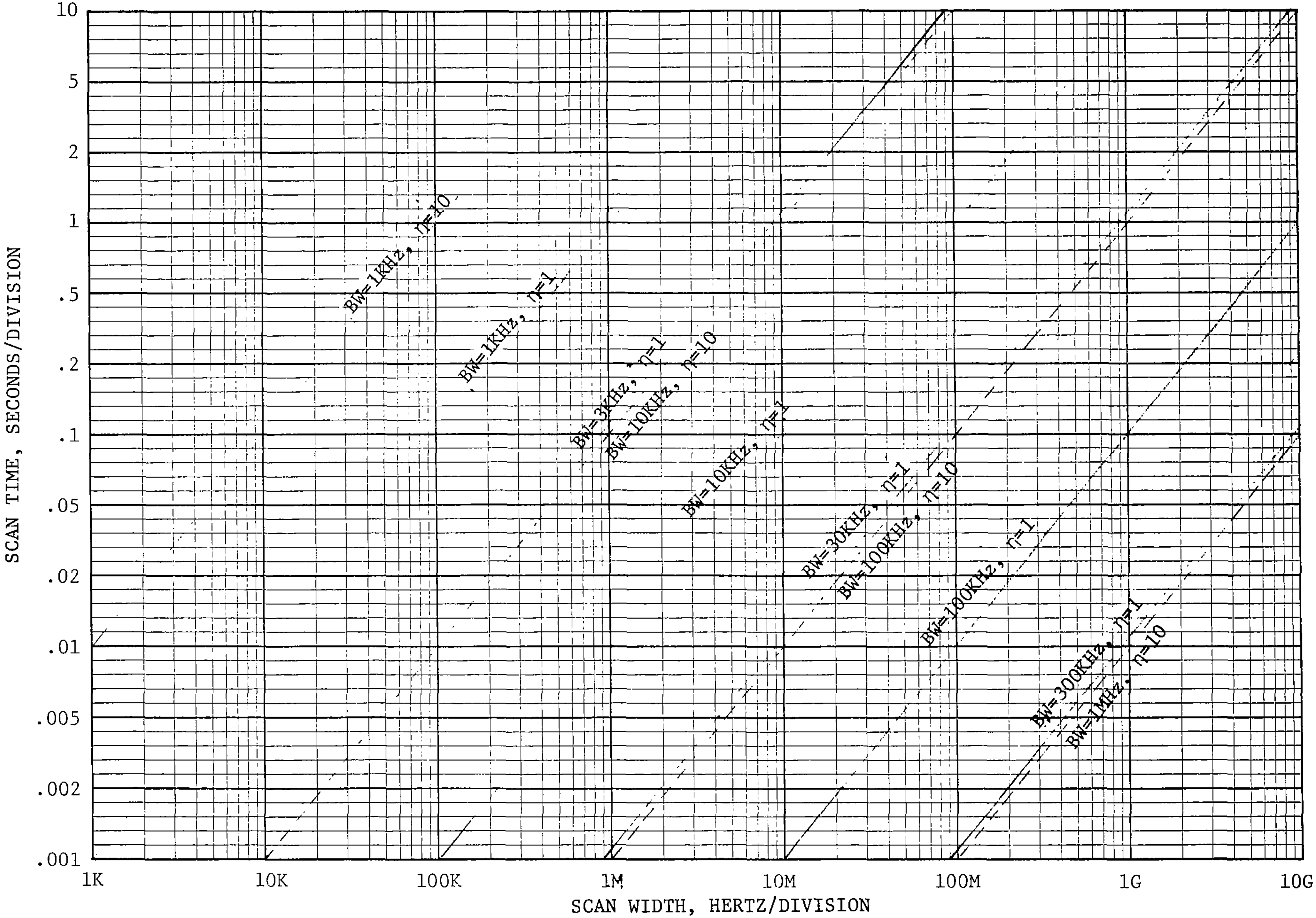


Figure 19 - RELATIONSHIP OF SPECTRUM ANALYZER BANDWIDTH, SCAN WIDTH, AND SCAN TIME

TABLE 5 - SELECTION OF SPECTRUM ANALYZER BANDWIDTH

FOR SCAN TIME OF 20 SECONDS, CAMERA EXPOSURE TIME OF 20 SECONDS

BAND	FREQUENCY (GHz)	FREQUENCY SCAN WIDTH (GHz)	$\eta=1$ MIN. BW (KHz)	SURVEY BW (KHz)
1	0.4-1.4	1.0	7.071	30
1A	0.400-0.420	0.02	1.000	10
1B	0.400-0.405	0.005	0.500	10
1C	0.450-0.470	0.02	1.000	10
1D	0.468-0.470	0.002	0.316	10
1C*	0.450-0.470	0.02	4.472	10
2	1-2	1.0	7.071	30
2A	1.525-1.575	0.050	1.581	30
2B	1.625-1.675	0.050	1.581	30
3	2.07-6.15	4.08	14.282	30
3A	2.2-2.3	0.10	2.236	30
3B	2.24-2.26	0.020	1.000	30
4	4.13-10.25	6.12	17.492	100
4A	5.9-6.4	0.5	5.000	100
4B	6.1-6.2	0.1	2.236	100
5	10.29-18.00	7.71	19.634	100
6	14.41-26.65	12.24	24.738	100

* Bandwidth corresponding to scan time of 1 sec'nd (exposure time of 1 second), an alternate routine.

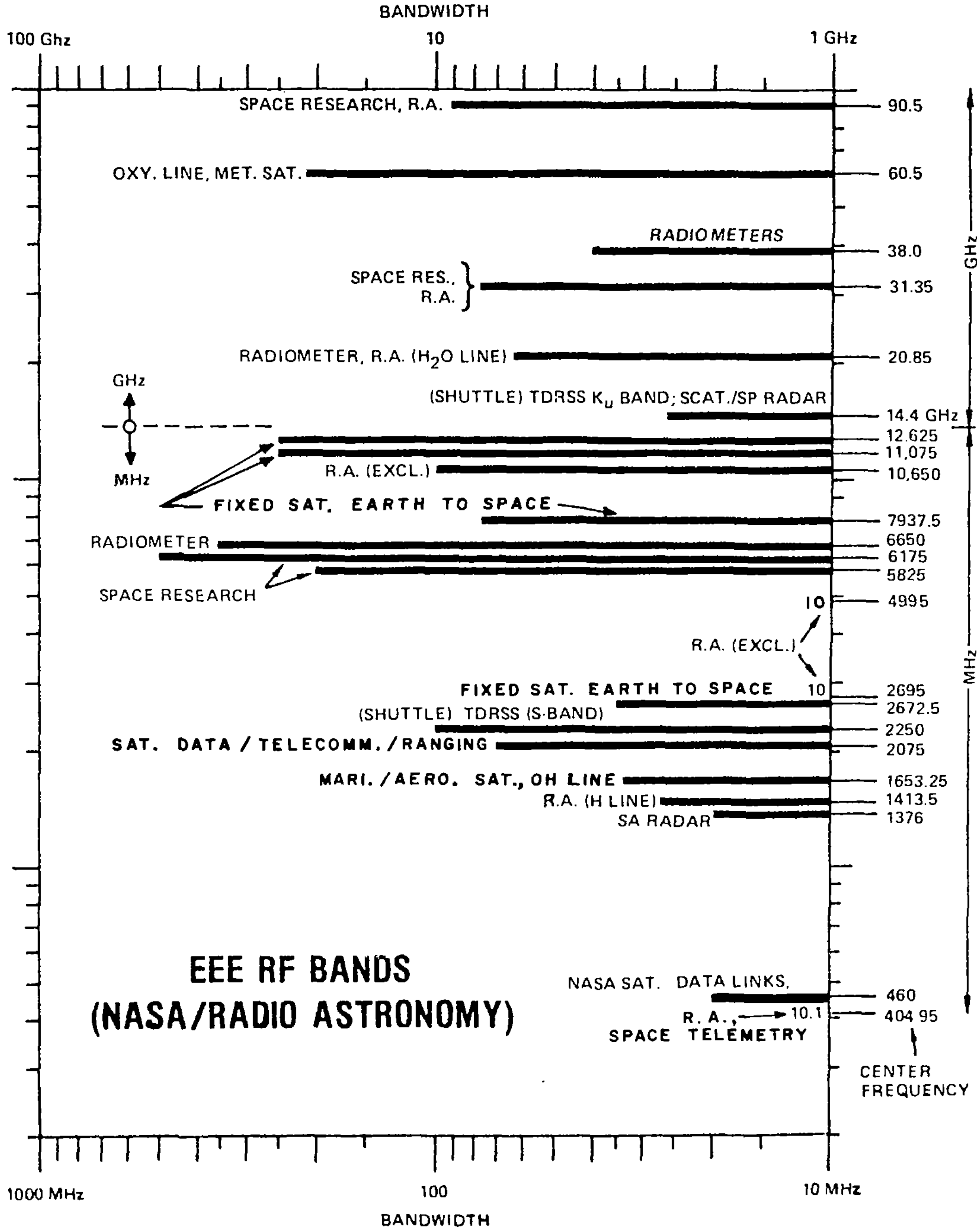


FIGURE 19A - TYPICAL FREQUENCY BANDS OF INTEREST TO NASA

TABLE 6

FLIGHT REQUIREMENTS SUMMARY

RUN	* ANT	FREQ. (GHz)	BW (Hz)	SCAN WIDTH/DV	SCAN TIME/DV	TIMER EXP/INTVL	TIME (MIN.)
1	NS	0.4-1.4	30K	100MHz	1s	10/30	12
1 tn	HC	2.07-6.15	30K	full	1s	10/30	3
2A	NS	.45-.47	10K	2MHz	50ms	1/10	4
2B	NS	.468-.47	10K	.2MHz	50ms	1/10	4
2C	NS	1.0-3.0	30K	100M	1s	10/30	4
2 tn	HC	2.07-6.15	30K	full	1s	10/30	3
3A	NS	.45-.47	10K	2MHz	50ms	1/10	4
3B	NS	.468-.47	10K	.2MHz	50ms	1/10	4
3C	NC	2.07-6.15	30K	full	1s	10/30	4
3 tn	HC	4.13-10.25	100K	full	1s	10/30	3
4A	NC	2.2-2.3	30K	10MHz	50ms	1/10	4
4B	NC	2.24-2.26	30K	2MHz	50ms	1/10	4
4C	NC	4.13-10.25	100K	full	1s	10/30	4
4 tn	HC	10.29-18	100K	full	1s	10/30	3
5A	NC	5.9-6.4	100K	50MHz	50ms	1/10	4
5B	NC	6.1-6.2	100K	10MHz	50ms	1/10	4
5C	NC	10.29-18	100K	full	1s	10/30	4
5 tn	HC	10.29-18	100K	full	1s	10/30	3
6A	HSA	14.41-26.65	100K	full	1s	10/30	3
6B	NS	.400-.405	10K	.5MHz	50ms	1/10	3
6C	NS	.400-.420	10K	2MHz	50ms	1/10	3

TABLE 6 (Continued)

FLIGHT REQUIREMENTS SUMMARY

RUN	* ANT	FREQ (GHz)	BW (Hz)	SCAN WIDTH/DV	SCAN TIME/DV	TIMER EXP/INTVL	TIME (MIN.)
6D	NS	.450-.470	10K	2MHz	50ms	1/10	3
6E	NS	.468-.470	10K	.2MHz	50ms	1/10	3
6F	NS	1.525-1.575	30K	5MHz	.1s	2/10	3
6G	NS	1.625-1.675	30K	5MHz	.1s	2/10	3
6 tn	HSA	14.41-26.65	100K	full	1s	10/30	3

tn = turn, EXP = exposure time (sec), INTVL = exposure interval (sec)
* Antennas: N = nadir looking, H = horizon looking, S = cavity backed spiral, C = horn, SA = Scientific Atlanta Horn

The Flight Operational Precedure

1. Set spectrum analyzer controls as described in preceeding discussion. Insert proper card in camera data unit.
2. Adjust spectrum analyzer tuning to band 1, 0.9 GHz with 0.1 GHz per division scan width and 30 kHz bandwidth.
3. Connect nadir-looking ASN-115A antenna through notch filter and HP-8447B amplifier to HP-8445B preselector input. Adjust notch filter to UHF-TV channel as required, for rejection of UHF-TV signal.
4. Make identification of band and spectrum analyzer parameters in tape recorder microphone.
5. Check clock and frame counter in camera data unit.
6. Start flight at marker at one end of 50 mile run.
7. Proceed toward far end of 50 mile run.
8. Turn around at end of run and prepare to make run in reverse direction.
9. Connect nadir-looking ASN-115A antenna directly to input of HP-8445B preselector.
10. Tune spectrum analyzer to Band 2 for 1.5 GHz with 0.1 GHz per division scan width.
11. Make identification of band and spectrum analyzer parameters in tape recorder microphone.
12. Start reverse run for 50 miles. Readjust spectrum analyzer to examine smaller frequency regions (see Table 6).
13. At end of run prepare for wide sweep turnaround.
14. Connect horizon-looking H-1498 antenna to HP-8445B preselector input.
15. Adjust spectrum analyzer to band 3, 2.0 to 6.15 GHz.
16. Switch camera timer to manual and make one exposure for each 45 degrees of arc of the aircraft turnaround maneuver.

17. At completion of turnaround change from horizon-looking H-1498 antenna to nadir-looking H-1498 antenna and switch camera timer to automatic.
18. Make identification of band and spectrum analyzer parameters on tape recorder microphone.
19. Start run on 50 mile path. Readjust spectrum analyzer to examine smaller frequency regions (see Table 6).
20. At end of run prepare for turnaround operation.
21. Connect horizon-looking H-1498 antenna to HP-8445B preselector input.
22. Adjust spectrum analyzer to band 4, 4.13 to 10.25 GHz and adjust bandwidth to 100 KHz.
23. Switch camera timer to manual and make one exposure for each 45 degree arc of the turnaround maneuver.
24. Upon completion of turnaround change from horizon-looking to nadir-looking H-1498 antenna and switch camera timer to automatic.
25. Make identification on tape recorder microphone.
26. Start run reverse on 50 mile path. Readjust spectrum analyzer to examine smaller frequency regions (see Table 6).
27. At end of tun prepare for turnaround operation.
28. Connect horizon-looking H-1498 antenna to HP-8445B preselector input.
29. Adjust spectrum analyzer to band 5, 10.29 to 18 GHz.
30. Switch camera timer to manual and make one exposure for each 45 degree arc of the turnaround maneuver.
31. Upon completion of turnaround change from horizon-looking to nadir-looking H-1498 antenna and switch camera timer to automatic.
32. Make identification on tape recorder microphone.
33. Start run on 50 mile path. Readjust spectrum analyzer to examine smaller frequency regions (see Table 6).

34. At end of run make minimum radius turnaround.

35. Connect SA-12A-18 antenna-waveguide adapter-mixer to the "External Mixer, 18-40 GHz" jack on the RF unit panel.

36. Adjust spectrum analyzer to band 6, 14.41 to 26.65 GHz.

37. Make identification on tape recorder microphone.

38. Start reverse run on 50 mile path. Readjust spectrum analyzer to examine smaller frequency regions (see Table 6).

39. At end of run make closing identification on tape recorder microphone and operate internal calibrator of spectrum analyzer.

40. Remove card from camera data unit.

41. Return to base.

This operating procedure will be repeated for the morning, afternoon and evening schedule over each metropolitan area. Table 6 shows the Flight Requirements Summary which will apply.

10.0 Palestine, Texas Interference Survey

NASA has been experiencing interference to a high altitude balloon experiment in Palestine, Texas operating at 468.825 MHz. The interference is in the UHF band land mobile band from 450-470 MHz, a frequency band allocated to fixed and land mobile users. The aircraft surveyed the 450 to 470 MHz segment of the radio frequency spectrum with an horizon-looking antenna for maximum coverage geographically. The ASN-115A antenna was removed from its nadir-looking mount and installed in a mount on the underside of the fuselage which looked toward the aircraft's tail section and at a depression angle of 35 degrees below the horizon so that the half power (3dB) point of the beam was along the horizon. The aircraft was flown in an 8 mile diameter circle at altitudes of 2,500, 5,000, 10,000, and 15,000 feet. At each altitude the spectrum analyzer was used to take a series of 1 second exposures as the aircraft circled in flight. The bandwidth of the spectrum analyzer was set at 10 kHz.

Table 7 gives the relationship between altitude, h, in statute miles, and slant range, S, to the radio horizon, in statute miles, as given by

$$S = 102.76 \sqrt{h} \quad \text{St. Mi.}$$

TABLE 7 - SLANT RANGE TO RADIO HORIZON VERSUS ALTITUDE

h		S	Θ
Feet	St. Miles	Statute Miles	Degrees
1000	.189	44.7	89.4
2500	.473	70.7	89.1
5000	.945	99.8	88.7
10,000	1.894	141.4	88.2
12,000	2.273	154.9	88.0
15,000	2.841	173.2	87.8

In Table 7 the value of Θ, the angle from nadir to the visible horizon, is derived from the equation.

$$\Theta = \sin^{-1} \left(\frac{R}{R+h}\right)$$

where R is the earth's radius (3960 miles)

and h is the altitude in statute miles.

11. Preliminary Data

The test flights were run over the metropolitan areas of Washington-Baltimore, Philadelphia, New York City, and Chicago in the period of April 24 through May 2, 1975 and the spiral flights over Chicago were made on May 2 and over Palestine, Texas on May 5 and 6, 1975. About 5750 frames of 35 mm film were taken on these flights and on the calibration flights before and after the test runs. An analysis will be made of selected samples of the 5750 frames.

The 5750 35 mm frames will be arranged in sequence with 70 on a page and will be included in the Final Report. Arranged in this way they can readily be scanned by eye in about one minute per page. A catalog of all of the 5750 frames is in preparation. It will identify each frame as to the location, day, time of day, frequency band, altitude, and spectrum analyzer parameters. This will in effect serve to identify the large data file represented by the five reels of 35 mm film. In addition, 9 hours of the sound record of the output of the pocket scanner has been transferred from channel 3 of the data magnetic tape to cassette form. This will provide much easier access to this data by the use of a conventional cassette tape player.

Figures 20 through 31 are 8x10 inch enlargements of sample frames of the data. Two frequency bands were selected for sampling, 450 to 470 MHz and 400 to 1400 MHz. A sample frame of each of these frequency bands is included from each of the four metropolitan areas, Washington-Baltimore, Philadelphia, New York City, and Chicago. The locations at which these sample measurements were made are marked on the maps corresponding to the metropolitan areas, Figures 14 through 17. In addition Palestine, Texas data is included and represented by sample frames of the data taken at the 10,000 foot altitude for the 450 to 470 MHz and the 465 to 470 MHz bands.

The clock in each frame shows the time of day, local time. The data is marked on the photograph in day, month and year. For example 010575 is May 1, 1975. Please notice that some of the spectrum analyzer displays are reversed from left to right. Therefore, the lowest frequency of each band appears at the right side of the display and the highest frequency at the left side. This is due to the fact that the spectrum analyzer display is photographed as a reflection from a mirror.

Signal strength is indicated on the vertical scale which is a logarithmic scale with each major division indicating 10 decibels. A reference level is marked at the top of each grid. This level is referenced to the EIRP of an emitter in the peak of the antenna beam at an altitude of 10,000 feet. The reference level varies with frequency because the parameters; space loss, antenna gain, coaxial cable loss, amplifier gain, filter insertion loss, and preselector insertion loss, are each a function of frequency. Consequently the reference level shown on each frame is an average level for the frequency range shown.

For the 400 to 1400 MHz range the variation from the average level is 6 dB. The largest part of this being the change is space attenuation with frequency. Consequently Figures 24 through 27 each have the frequency range broken into three sub-bands; 400 to 1000, 1000 to 1200, and 1200 to 1400 MHz. A reference level has been provided for each of these sub-bands so that the variation the average level shown is not greater than 2 dB. A scale is marked for each sub-band with EIRP levels as indicated with the major grid lines spaced 10 dB. These are levels for emitters in the peak gain point of the antenna pattern. Emitters at the edge of the footprint represented by the half-power beamwidth of the antenna would have an EIRP 3 dB above the level indicated on the grid. Thus the variation from the average EIRP scale is 2 dB

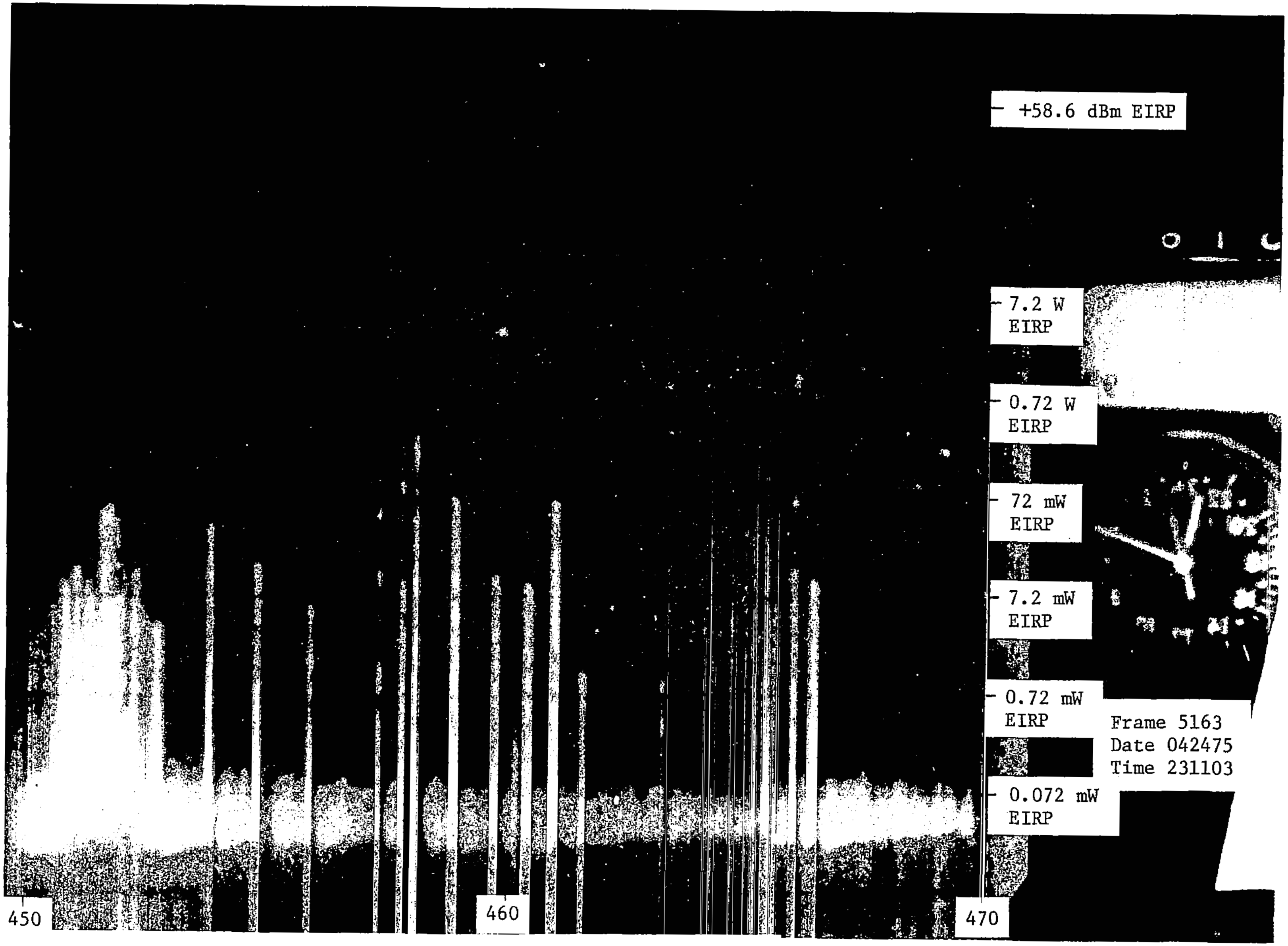


Figure 20 - Washington-Baltimore Run Sample Frame,
450-470 MHz

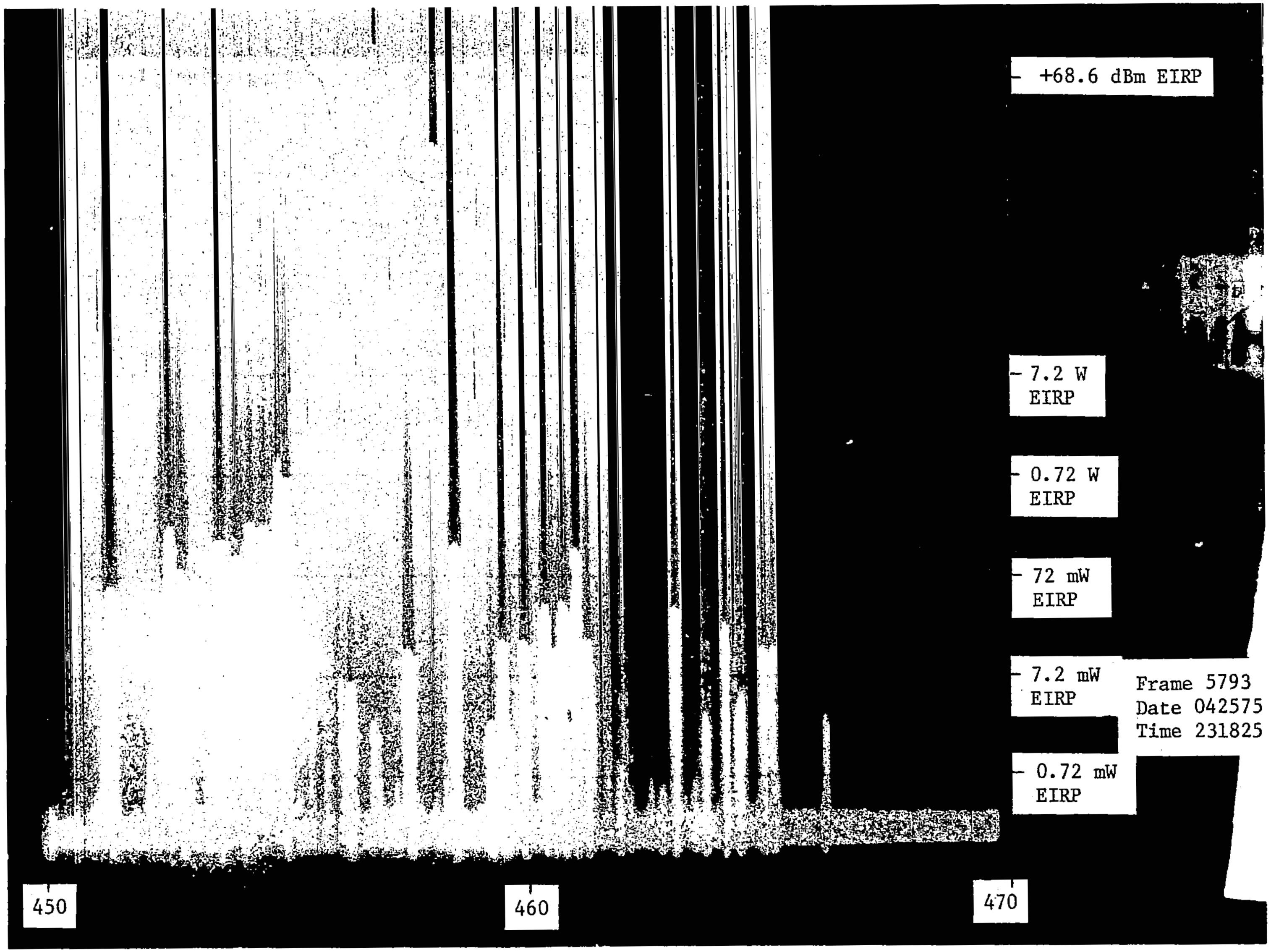


Figure 21 - Philadelphia Run Sample Frame, 450-470 MHz

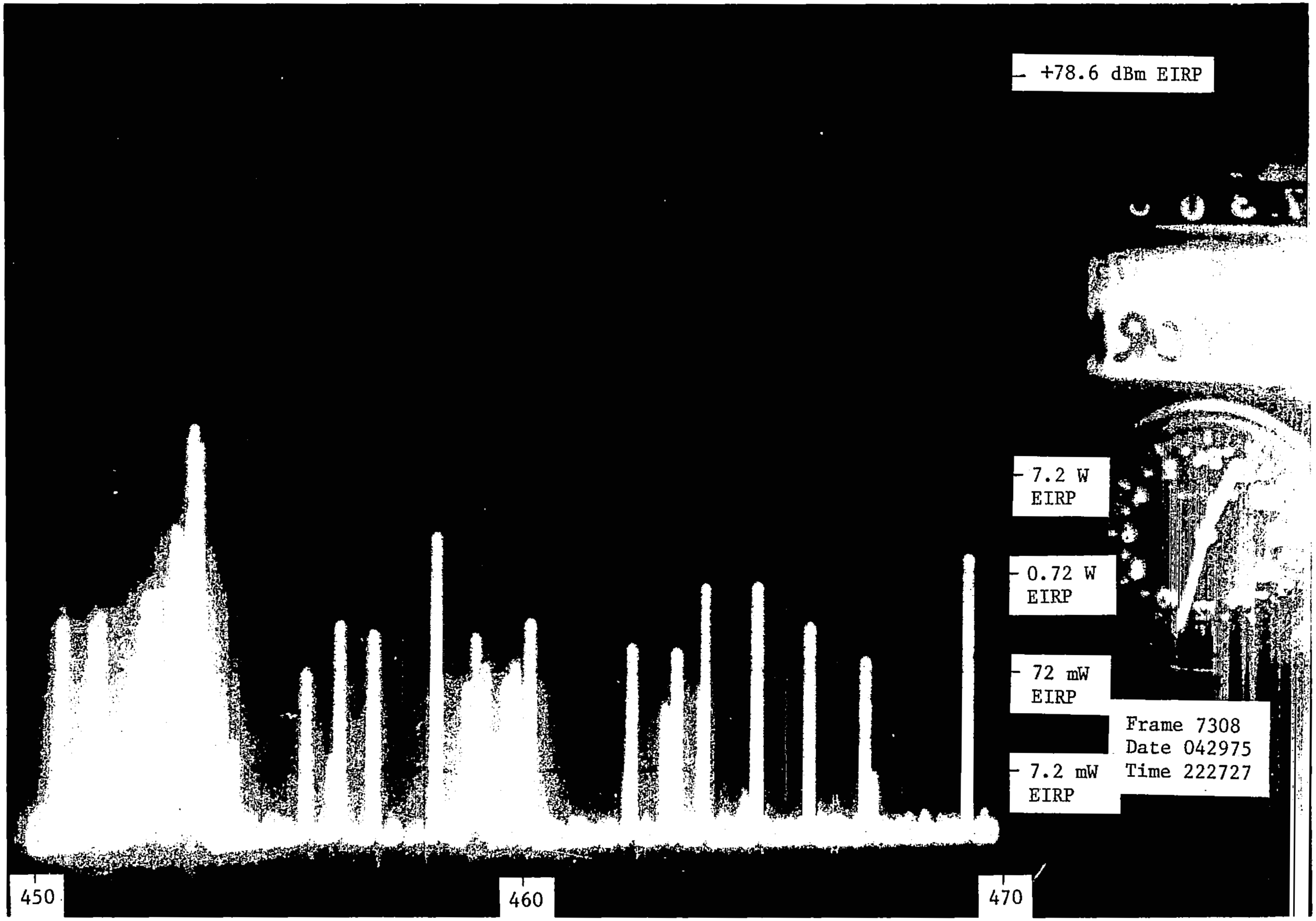


Figure 22 - New York City Run Sample Frame, 450-470 MHz

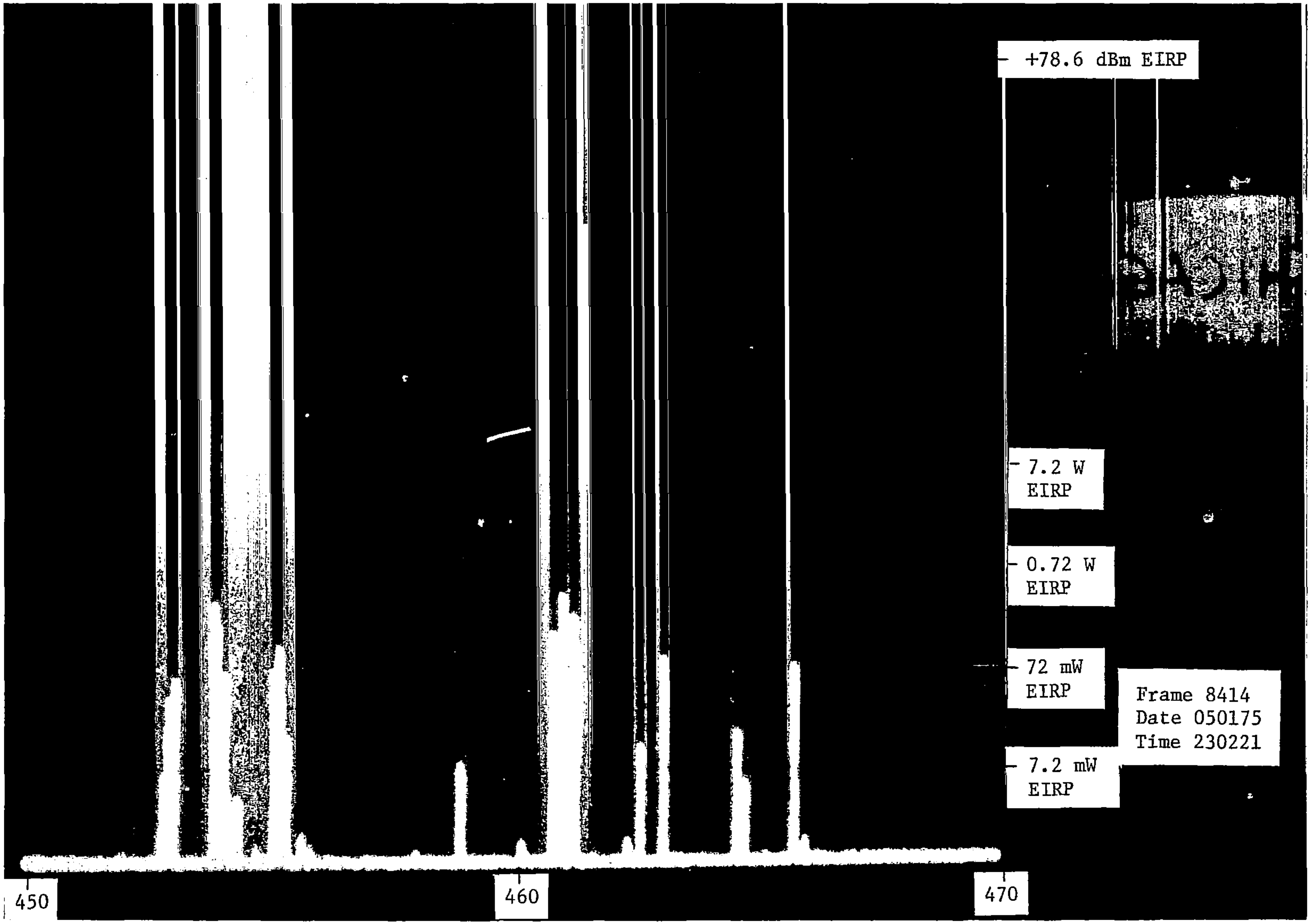


Figure 23 - Chicago Run Sample Frame, 450-470 MHz

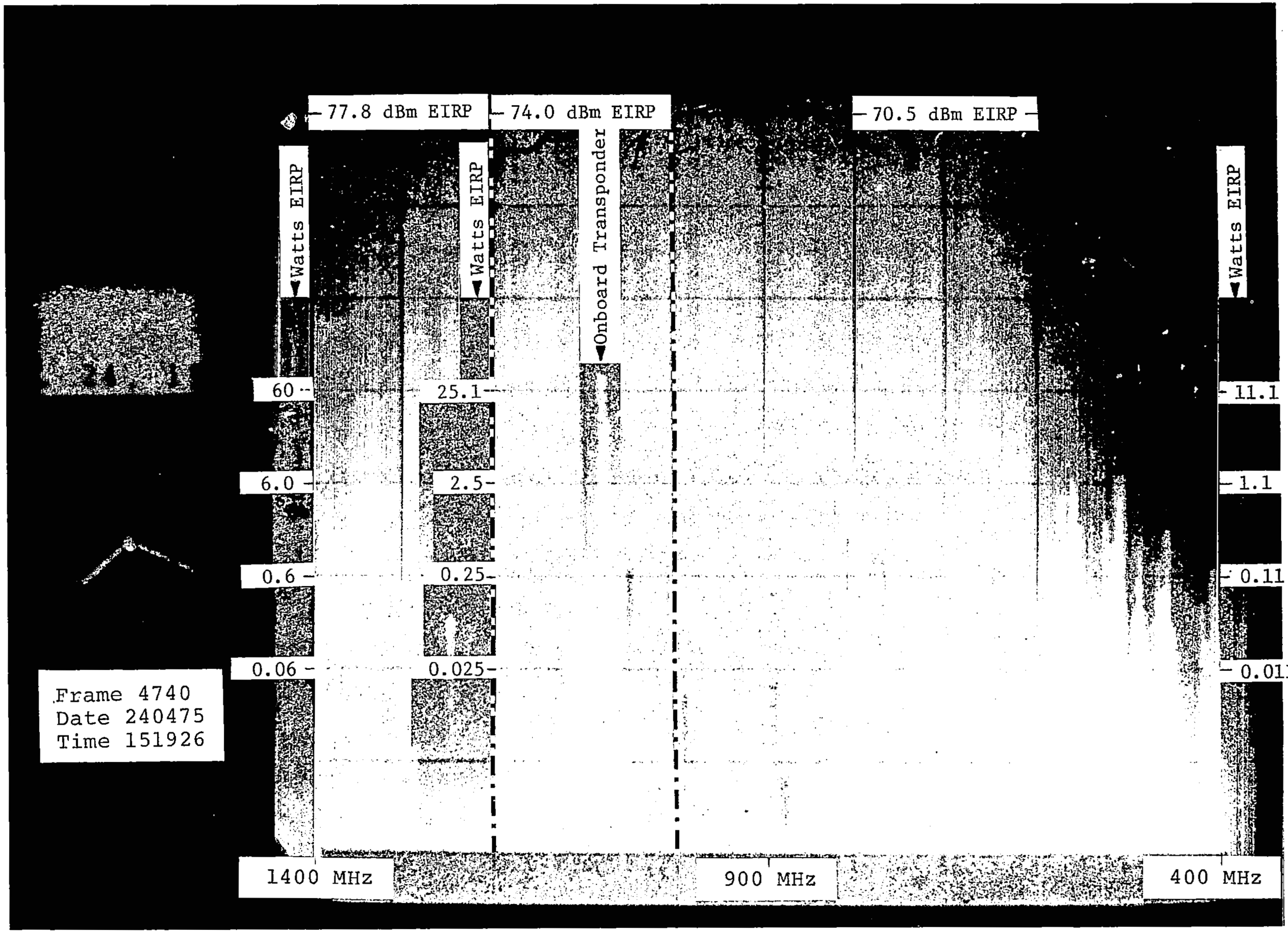


Figure 24 - WASHINGTON-BALTIMORE RUN SAMPLE FRAME, 400-1400 MHz

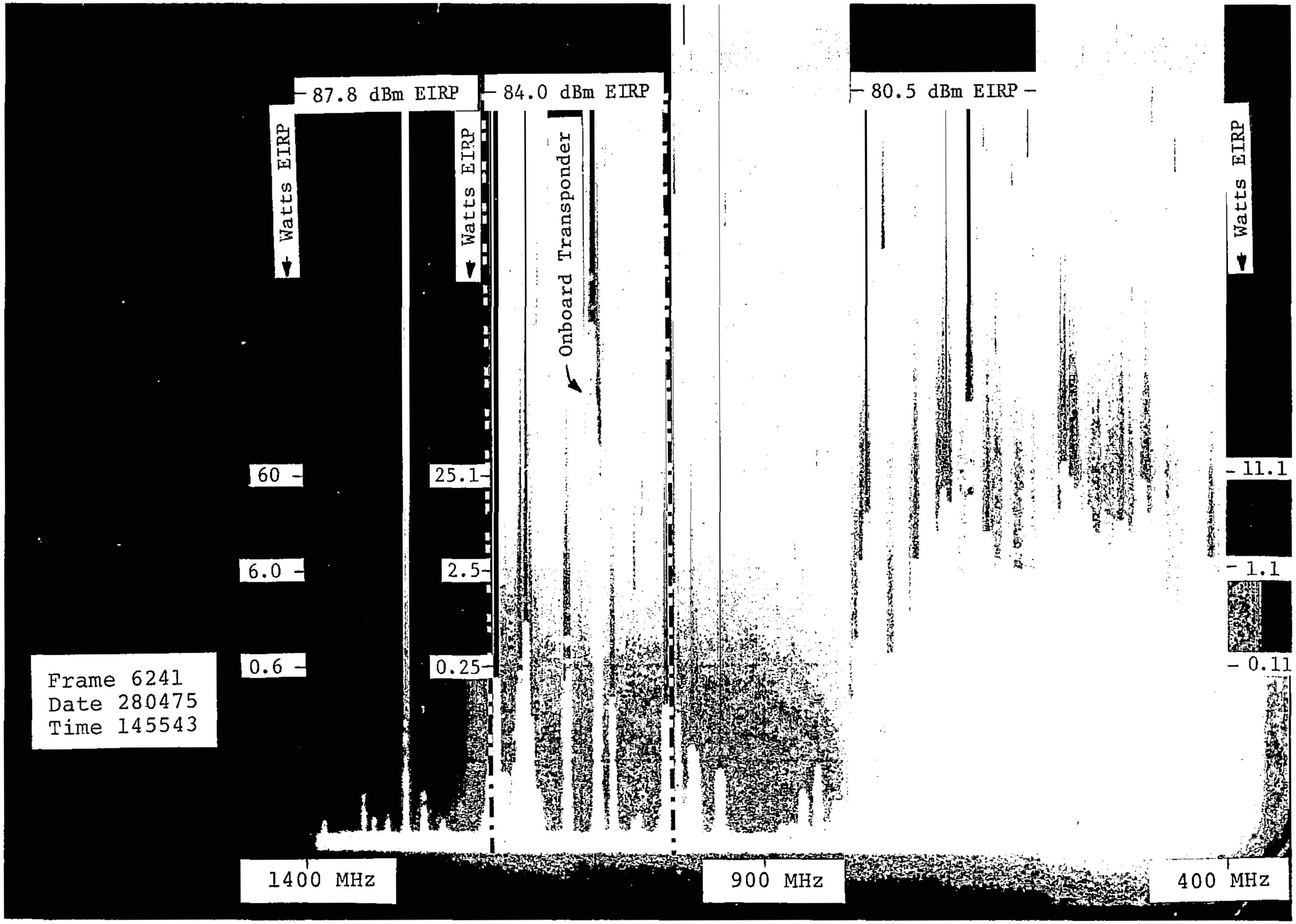


Figure 25 - PHILADELPHIA RUN SAMPLE FRAME, 400-1400 MHz

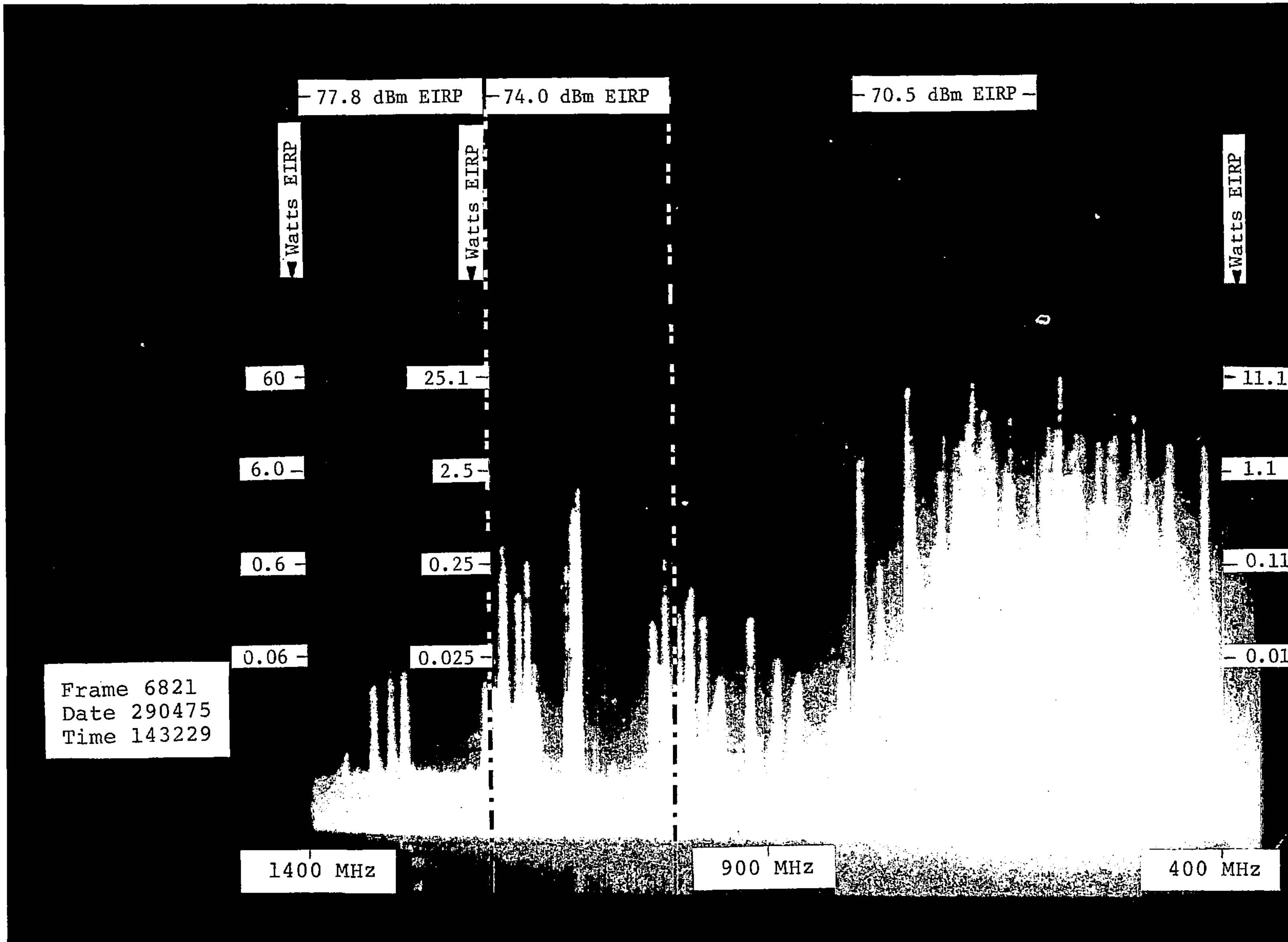


Figure 26 - NEW YORK CITY RUN SAMPLE FRAME, 400-1400 MHz

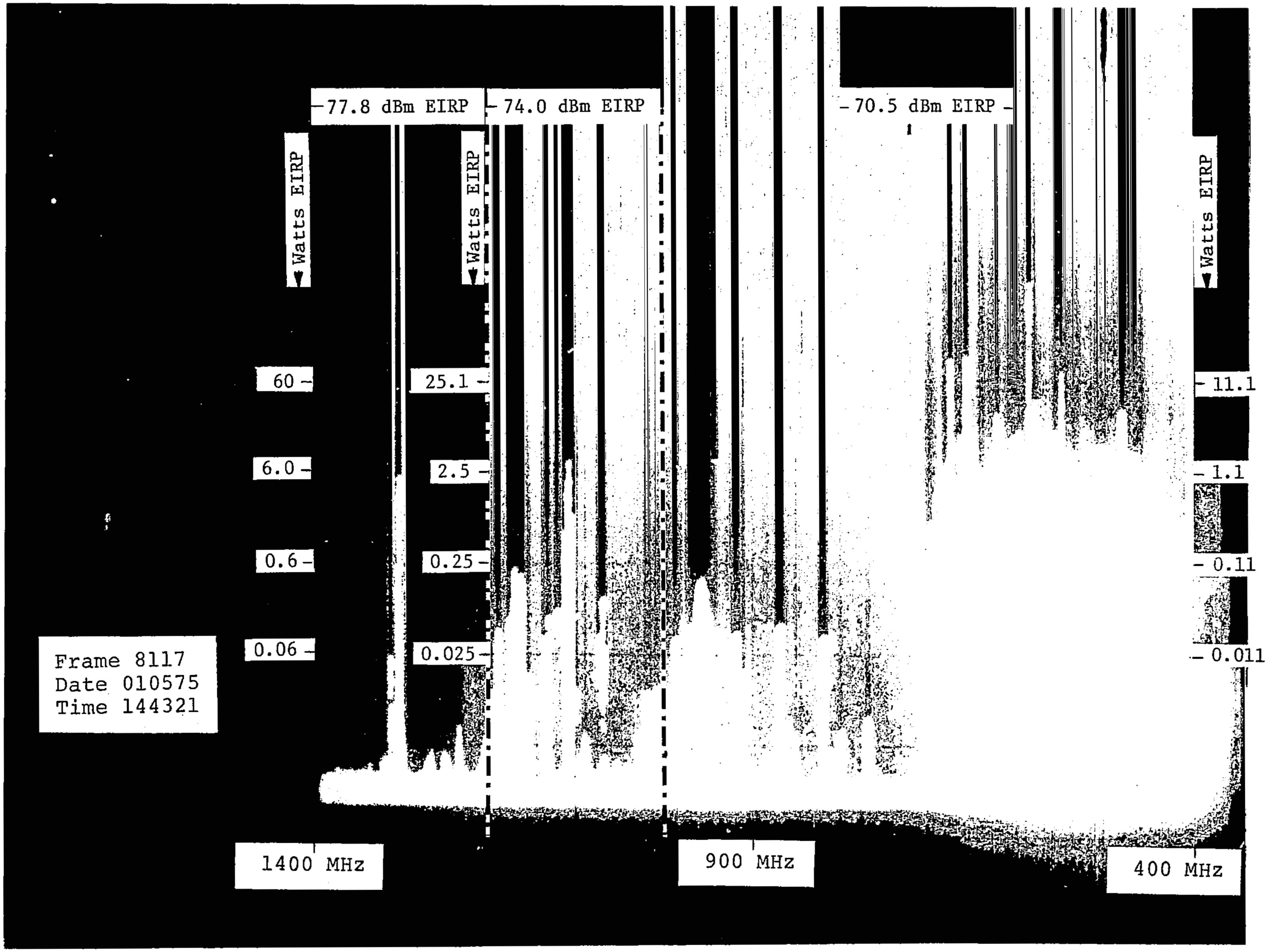


Figure 27 - CHICAGO RUN SAMPLE FRAME, 400-1400 MHz

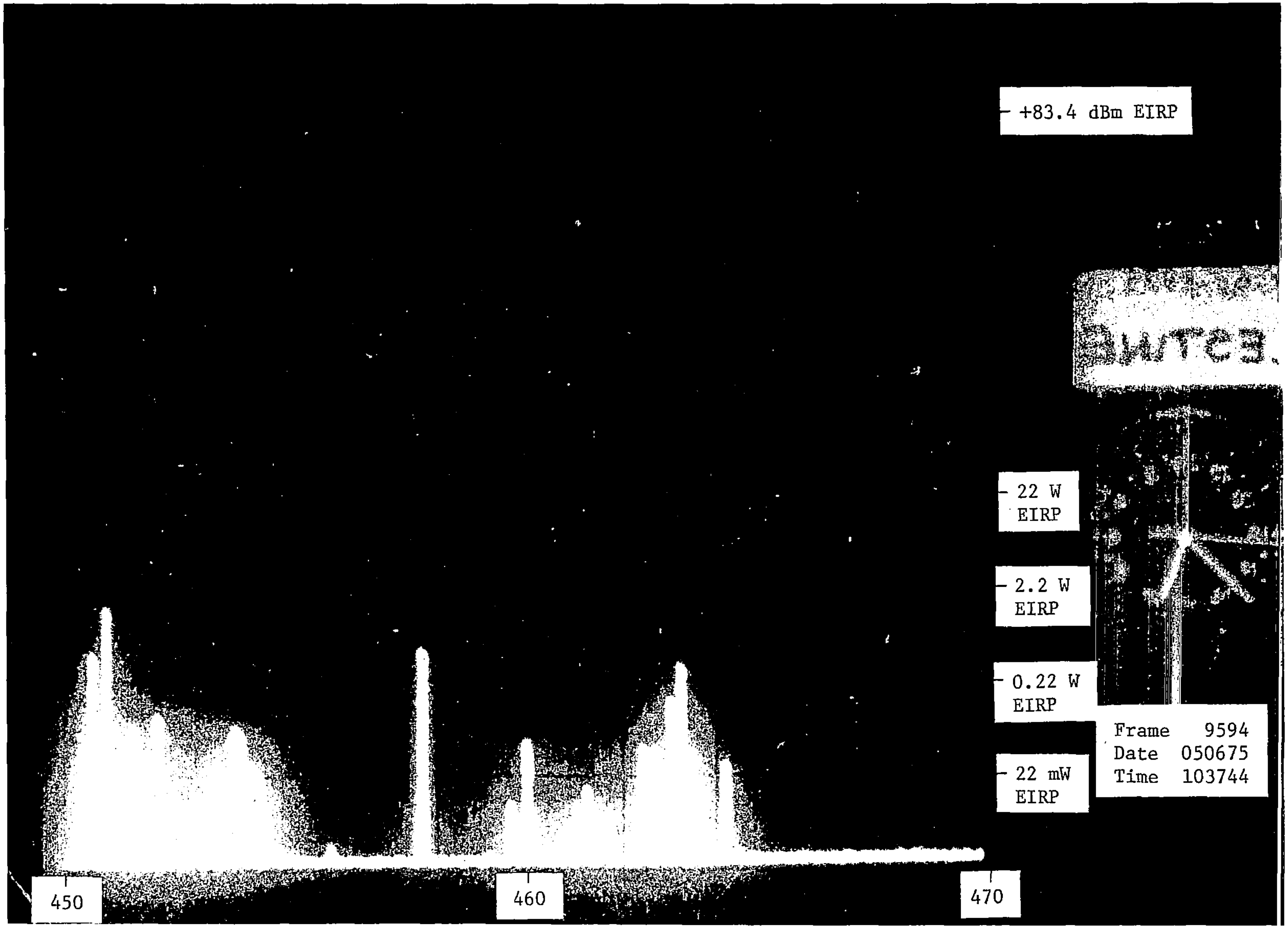


Figure 28 - Palestine, Texas, Morning Run Sample Frame, 5,000' Altitude, 450-470 MHz

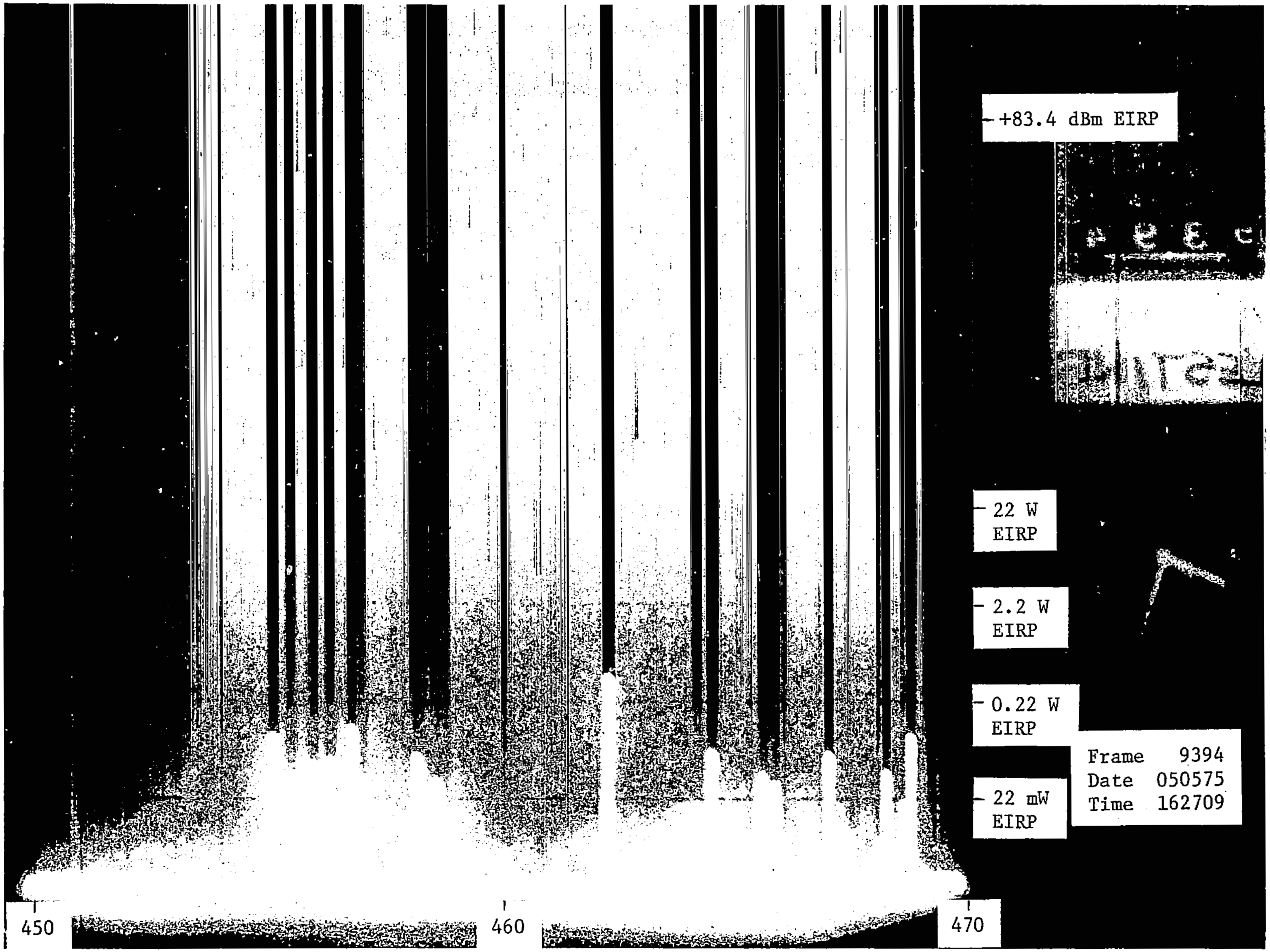


Figure 29 - Palestine, Texas, Afternoon Run Sample Frame, 15,000' Altitude, 450-470 MHz

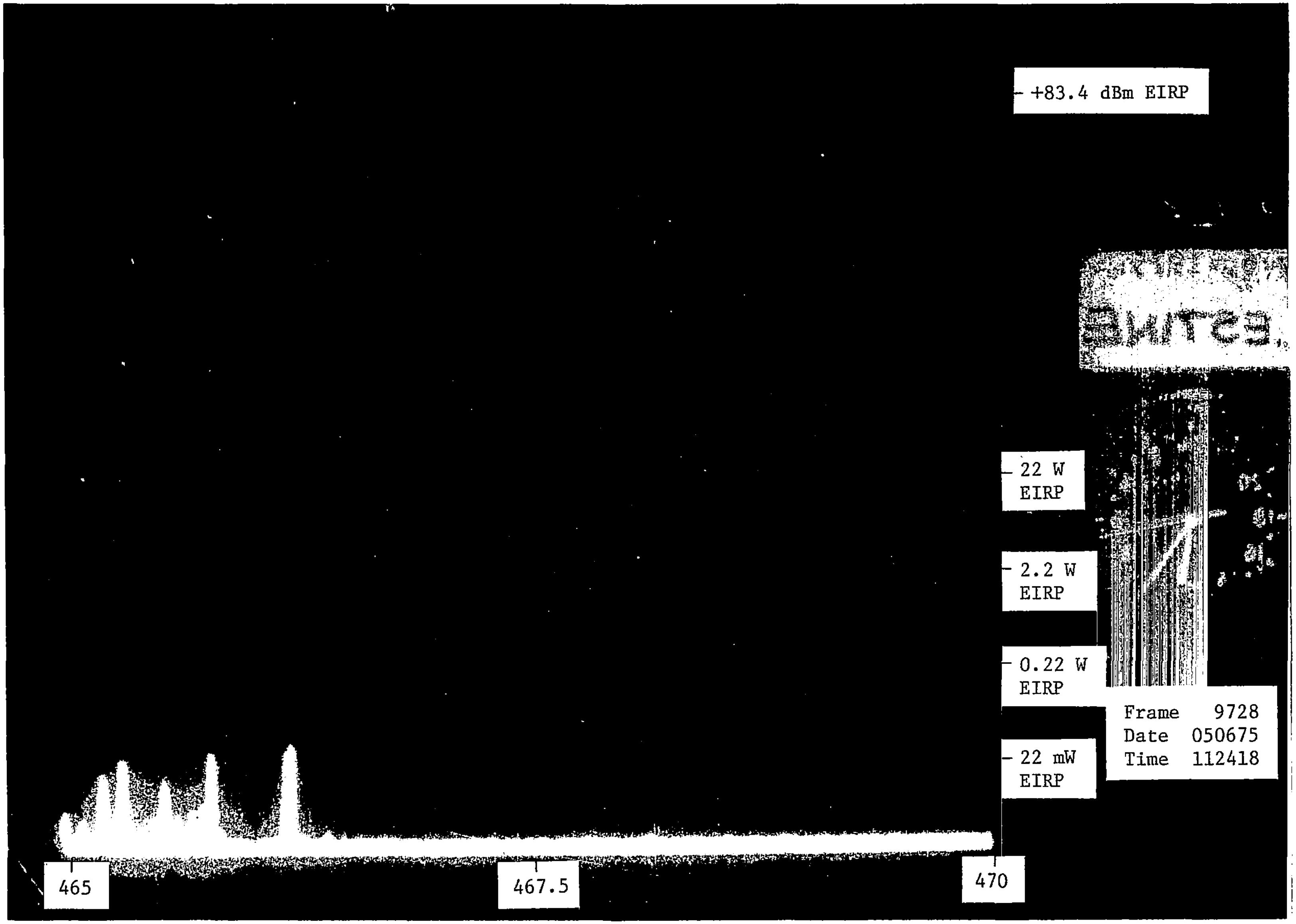


Figure 30 - Palestine, Texas, Morning Run Sample Frame,
15,000' Altitude, 465-470 MHz

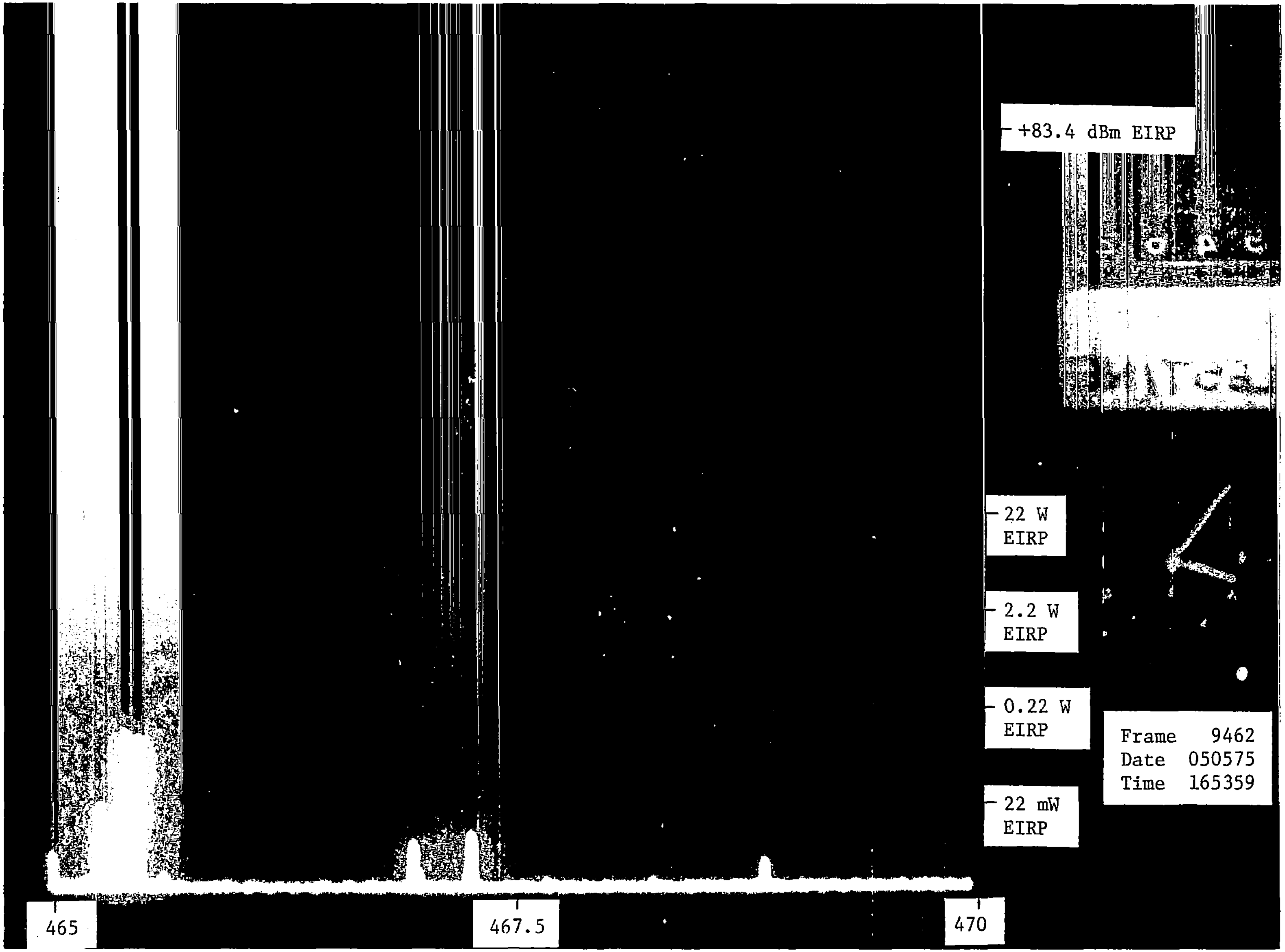


Figure 31 - Palestine, Texas, Afternoon Run Sample Frame,
10,000' Altitude, 465-470 MHz

for the frequency effect on the parameters enumerated above, plus 3 dB for the effect of position of the emitter within the antenna footprint pattern.

Figures 24, 25, 26 and 27 have marked similarity of characteristics. In each there is a solid band of signals from 400 MHz to 700 MHz. This part of the spectrum is allocated as follows:

Frequency MHz	Service
400-406	Gov't. and Non-Gov't. Meteorological Aids
406-410	Gov't. and Non-Gov't. Satellite, Radio Astronomy
410-420	Government
420-450	Amateur
450-470	Land Mobile, NASA Meteor Satellite Data Collection, Radio Astronomy
470-512	TV Broadcast and Assigned Land Mobile
512-806	TV Broadcast, Channel 21 to 69

Figure 32 and 33 show frequency allocations and power levels taken from Table 3. These figures can be used to identify signals shown in the spectrum analyzer displays of Figures 24,25,26 and 27. The frequency scales are matched between the two sets of figures. However, there are many more signals that have not been identified. FCC Docket 18261 made TV channels 14 through 20 (470 to 512 MHz) available for the land mobile service on an assigned basis in large urbanized areas. The assignments in areas covered by the aerial survey are as follows:

Washington,	Channels 17 and 18 (488-500 MHz)
Philadelphia,	Channels 19 and 20 (500-512 MHz)
New York City,	Channels 14 and 15 (470-482 MHz)
Chicago,	Channels 14 and 15 (470-482 MHz)

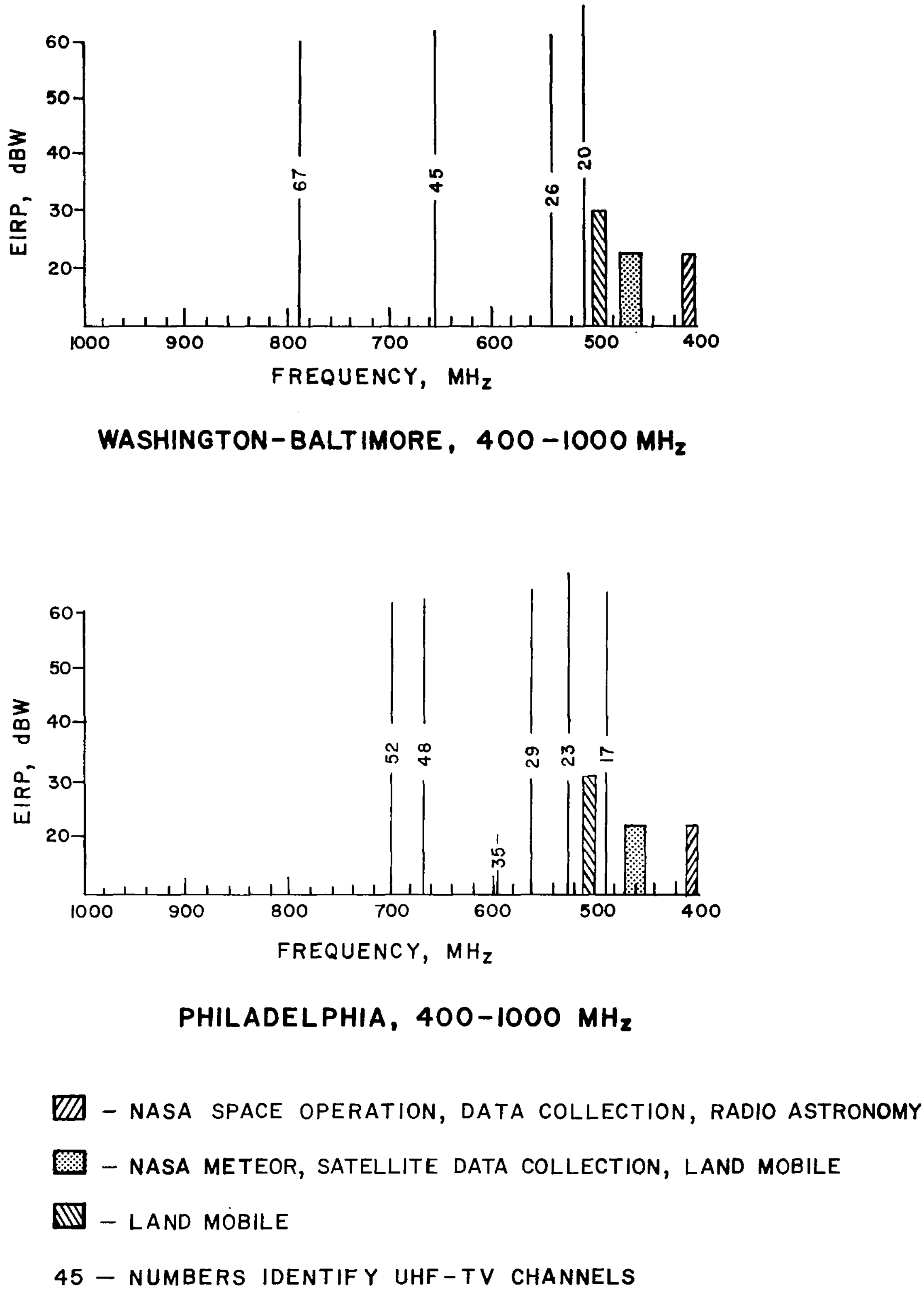
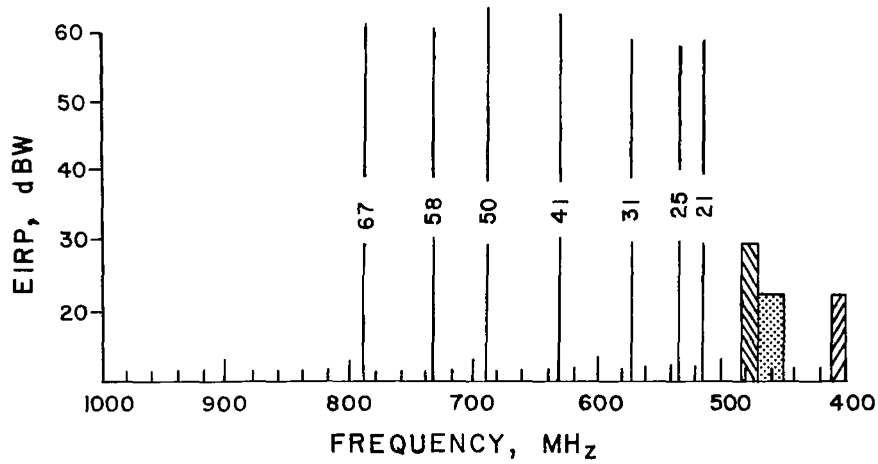
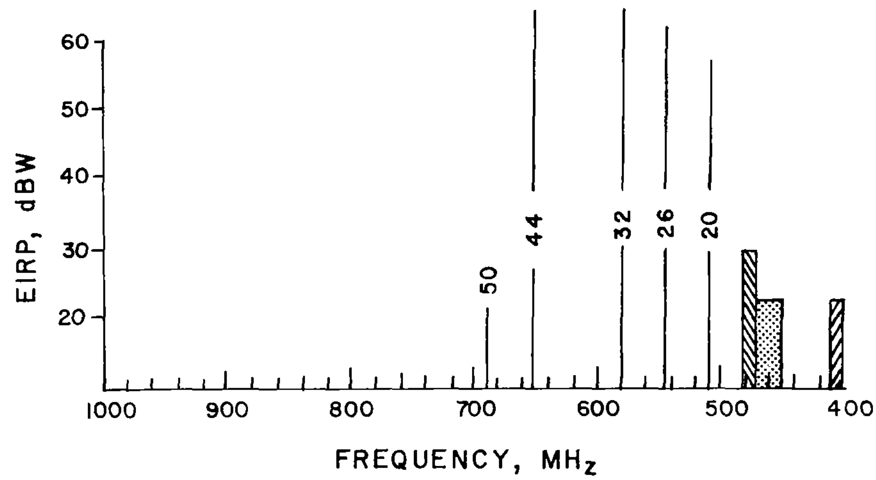


Figure 32 - 400-1000 MHz Frequency Allocations, Washington-Baltimore and Philadelphia



NEW YORK CITY, 400 – 1000 MHz



CHICAGO, 400 – 1000 MHz

▨ – NASA SPACE OPERATION, DATA COLLECTION, RADIO ASTRONOMY

▩ – NASA METEOR, SATELLITE DATA COLLECTION, LAND MOBILE

▧ – LAND MOBILE

45 – NUMBERS IDENTIFY UHF-TV CHANNELS

Figure 33 - 400-1000 MHz Frequency Allocations, New York City and Chicago

On Figures 24 and 25 the strong signal at 1080 MHz is due to the onboard aircraft transponder as indicated on the figure. Due to the intermittent operation of the transponder, it does not appear in Figures 26 and 27. The other signals in the range of 800 to 1400 MHz may in part be harmonics of powerful broadcast stations. An effort will be made to identify these signals for the Final Report. Figures 28, 29, 30 and 31 show sample data for Palestine, Texas in the 450 to 470 MHz band and the 465-470 MHz band for both morning and afternoon runs. There is a marked difference in the number of signals which appear in this location compared with the larger metropolitan areas. The Palestine data was taken with an horizon-looking antenna which looked at a much larger geographical area than the nadir-looking antenna.

A trial run analysis task was performed on selected portions of the data. All of the data in the land-mobile band (450-470 MHz) over Palestine, Texas was analyzed as to signal strength distribution. A count was made of the number of signals exceeding each spectrum analyzer input level from -40 dBm to -80 dBm. The counts then were expressed as a percentage of the total number of signals visible on the display. This data is tabulated in Table 8. For comparison, the New York City and Philadelphia afternoon runs were also analyzed and appear in Table 8.

A comparison can be made between morning and afternoon runs in Palestine, Texas as well as between the four altitudes at which the flights were made. Also the afternoon runs at 10,000 feet altitude can be compared between Palestine, Texas and New York City and Philadelphia. It is planned to expand this type of analysis in the final report.

TABLE 8 - SIGNAL DISTRIBUTION IN LAND MOBILE BAND, 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.	Sigs. per Frame Observed
Palestine	A	2.5	0	0	7.6	35.0	100	340	17	20.0
Palestine	A	5.0	0	0	5.5	31.2	100	631	23	27.4
Palestine	A	10.0	0	0.1	4.3	27.0	100	786	25	31.4
Palestine	A	15.0	0	0	4.1	23.4	100	657	22	29.9
Palestine	B	2.5	0	0	2.8	15.0	100	140	9	15.6
Palestine	B	5.0	0	0	2.4	23.6	100	292	13	22.5
Palestine	B	10.0	0	0	1.9	29.7	100	681	24	28.4
Palestine	B	15.0	0	0	1.9	25.3	100	691	22	31.4
New York	A	10.0	0	2.8	25.5	67.0	100	2158	45	48.0
New York	B	10.0	0	2.7	27.3	68.7	100	1445	22	65.7
New York	C	10.0	0	4.2	22.1	58.9	100	914	28	32.6
Philadelphia	A	10.0	0.5	6.9	36.9	76.0	100	2122	39	54.4
Philadelphia	B	10.0	0.1	4.7	23.1	60.9	100	2857	38	75.2
Philadelphia	C	10.0	0	7.9	32.5	60.5	100	483	14	34.5
Chicago	A	3.0	0.1	3.5	21.7	51.4	100	765	19	40.3
Chicago	A	5.0	0.3	8,6	37.4	62.3	100	872	19	45.9
Chicago	A	10.0	0.4	5.9	29.5	56.4	100	823	18	45.7
Chicago	A	15.0	0	6.5	38.0	72.5	100	1232	30	41.1
Chicago	B	2.5	0.4	3.5	24.2	59.3	100	942	20	47.1
Chicago	B	6.5	0.4	7.5	39.9	70.6	100	1052	17	61.9
Chicago	B	10.0	0	3.9	47.8	70.1	100	692	11	62.9
Chicago	B	15.0	0.1	4.6	31.2	71.3	100	1235	21	58.8

Time Block Code: A-Morning, B-Afternoon, C-Night

It was also observed that activity in the UHF land mobile band, 450 to 470 MHz, was greatest during the afternoon hours and was reduced by roughly 50% in the evening period. This was in agreement with information received from the FCC and from Skomal of the Aerospace Corporation. The right hand column of Table 8, "signals per frame observed", is a comparative indication of band usage.

The data taken with the horizon-looking antenna has somewhat more ambiguity than that taken with the nadir-looking antenna because the horizon-looking antenna sees a more extensive geographical area. With the aircraft at an altitude of 10,000 feet, the slant range to the horizon is 141.4 miles. From a practical standpoint the area to be considered is the antenna footprint described by the 3 dB half-power points of the antennas, but restricted to angles lower than 5 degrees below the horizon. On this basis the difference in path loss between the shortest and longest paths is 18.0 dB for the 70° wide cavity-backed spiral antenna and 16.4 dB for the 50° wide wide-band horn antenna. This results in somewhat lesser measurement accuracy with the horizon-looking antennas. However, there is sufficient indication of the type of signals present in the geographical region. Thus while the antenna is looking at a large geographical area, it is receiving signals from emitters that are as far as 16.34 miles or as close as 2.02 miles for the cavity-backed spiral antenna or 2.47 miles for the wide-band horn antenna. The signal received by the spectrum analyzer may represent a strong emitter at the far range or it may be a weaker emitter close to the aircraft.

The data taken with the nadir-looking antennas will be reduced to EIRP levels for emitters within the relatively small geographical area seen by the antenna.

The EIRP accuracy at the antenna 3 dB points, at nadir, is within 3.6 dB in the 450 to 470 MHz band and 5 dB in the 400 to 1400 MHz band.

The Final Report will include the necessary calibration correction curves to more accurately determine the EIRP level for an earth-based emitter.

12.0 Final Report

The Final Report will contain the data acquired in the aerial survey. It is planned to include contact photographic prints showing the display of the spectrum analyzer. There are approximately 5750 frames of this 35 mm film which will be mounted with 70 on a page. Presenting them in this way will allow the reader of the report to quickly compare frame-to-frame and see the dynamics of spectrum usage. A catalog is being prepared which will identify and describe each of these frames.

Some analysis has already been done on the 450 to 470 MHz UHF band land mobile band as presented in the preliminary data of the previous section. This will be completed on all the data for this band. In addition the 400 to 420 MHz band will be analyzed in the same way. A signal count will be made in some of the other expanded bands as time permits.

In Chicago, a great deal of data in the 450 to 470 MHz band was taken at altitudes of 3,000, 5,000, 10,000, and 15,000 feet with the antenna looking at the horizon. This data will be analyzed and compared with the Federal Communications Commission (FCC) land mobile survey conducted at ground level. This should add a new dimension to the land based data acquisition of the FCC survey.

In Palestine, Texas the data was taken at four different altitudes, as in the Chicago survey. A study will be made of this data to resolve the interference problem encountered in the high altitude balloon experiments conducted there by NASA using 468.825 MHz.