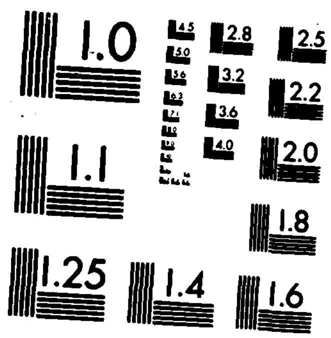
AD-A173 013 ICNIA (INTEGRATED COMMUNICATIONS NAVIGATION IDENTIFICATION AVIONICS) HF T..(U) ROME AIR DEVELOPMENT CENTER GRIFFISS AFB NY G A PFEIFFER JUL 86 1/1

UNCLASSIFIED RADC-TM-86-4 F/G 17/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

RADC-TM-86-4
In-House Report
July 1986

AD-A173 013

ICNIA HF TRANSMITTER SYSTEM PRELIMINARY STUDY

George A. Pfeiffer

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, NY 13441-5700

This report has been reviewed by the RADC Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

RADC-TM-86-4 has been reviewed and is approved for publication.

APPROVED:

LAURENCE W. DOUBLEDAY, Chief
Communications Transmission Branch
Communications Division

APPROVED:

BRUNO BEEK
Technical Director
Communications Division

FOR THE COMMANDER:

RICHARD W. POULIOT
Plans and Programs Division

AD-A173013

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS N/A
2a. SECURITY CLASSIFICATION AUTHORITY N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) RADC-TM-86-4	5. MONITORING ORGANIZATION REPORT NUMBER(S) N/A
6a. NAME OF PERFORMING ORGANIZATION Rome Air Development Center 6b. OFFICE SYMBOL (If applicable) DCCL	7a. NAME OF MONITORING ORGANIZATION N/A
6c. ADDRESS (City, State, and ZIP Code) Griffiss AFB NY 13441-5700	7b. ADDRESS (City, State, and ZIP Code) N/A
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Rome Air Development Center 8b. OFFICE SYMBOL (If applicable) DCCL	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N/A
8c. ADDRESS (City, State, and ZIP Code) Griffiss AFB NY 13441-5700	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 63109F; PROJECT NO. 2538; TASK NO. 04; WORK UNIT ACCESSION NO. TK

11. TITLE (Include Security Classification)
ICNIA HF TRANSMITTING SYSTEM PRELIMINARY STUDY

12. PERSONAL AUTHOR(S)
George A. Pfeiffer

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
In-House	FROM Apr 83 TO Dec 84	July 1986	36

16. SUPPLEMENTARY NOTATION
N/A

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Integrated Communications Navigation Idenfification Avionics (ICNIA), HF/VHF Transmitter, Wire Radiation and Scattering, CNI, Shunt Antenna, Method of Moments

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The ICNIA HF Transmitter System Preliminary Study describes an investigation to determine if it is feasible to develop and fabricate an airborne HF/VHF power amplifier, antenna coupler, and antenna for high speed, high performance aircraft having future application in integrated CNI avionics systems. A key objective was to investigate and validate an airborne antenna with low reactive components that could be fabricated into an aircraft frame. The study shows that it is feasible to design and fabricate HF/VHF equipment for small high speed, high performance aircraft that can be integrated into CNI avionics systems.

Keywords: included

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL George A. Pfeiffer	22b. TELEPHONE (Include Area Code) (315) 330-3077; 22c. OFFICE SYMBOL RADC (DCCL)

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1.0 Introduction:

Air Force Wright Aeronautical Laboratories, in the near future, is going to develop and demonstrate an advanced development model (ADM) airborne radio system in which all communications, navigation, and identification (CNI) functions in the 2-2,000 MHz spectrum are integrated into one software programmable, modular, and cost effective radio. The radio system is titled "Integrated Communications Navigation Identification Avionics" (ICNIA). This terminal will be used by both the Air Force and the Army in support of their air and ground mission. Each service has specific requirements, particularly in the HF/VHF frequency spectrum. The Air Force is interested in the frequency range of 5-88 MHz, whereas the Army is interested in the 2-30 MHz range.

2.0 Objective:

The primary objective of this preliminary study is to determine if it is feasible to develop, fabricate, test, and evaluate an airborne HF/VHF power amplifier, antenna coupler, and antenna for high speed and high performance aircraft. The study also provides schedules and milestone data to implement the development, fabrication, test, and evaluation of the transmitting system.

The secondary objective of this study is to determine if it is feasible to use one electrical design for the transmitting system for different types of aircraft and that fewer antennas are needed on aircraft than presently used.

3.0 AFWAL, Preliminary Specifications

The ICNIA ADM HF transmitting system will provide the functions of the AN/ARC-199(v) HF and the AN/ARC-186(v) VHF communications system. The module specification will be as follows:

3.1 Power Amplifier, Preliminary Specifications

Power Input: 1 watt normal
Power Output: 100 watts minimum (below 30 MHz)
Frequency Band: 5-88 MHz
Modulation: AM, SSB, FM
Input Impedance: 50 ohms
Output Impedance: 50 ohms
VSWR: 3 to 1, maximum

3.2 Antenna Coupler, Preliminary Specifications

Power Capacity: 200 watts (CW)
Frequency Band: 5-88 MHz
Timing Rate (tuning): 4 seconds, maximum
Tuning: Automatic
Transmit/Receive Switch

3.3 **Antenna, Preliminary Specifications:**

Antenna: 200 watts (CW)
Frequency Band: 5-88 MHz

The power amplifier and coupler are to weigh not more than 50 pounds combined nor will they occupy an area greater than 1,400 cubic inches.

4.0 **Aircraft Selection:**

Space limitations of a single-seat high speed, high performance tactical aircraft provide the driving criteria for the resultant equipment performance, size, and weight factors. The F-15 and F-16 fighter aircraft have been selected as the two prime Air Force aircraft that most fit this category. Early on, it was agreed that the main thrust would be placed on designing a transmitting system for the F-16 C and D model aircraft for the following reasons:

a. The F-16 is the smallest of the two aircraft.

b. There have been no efforts to equip the F-16 aircraft with small efficient, lightweight HF/VHF communications equipment.

c. The F-16 has the smallest area available to house a power amplifier, antenna coupler, and antenna.

d. The F-16 vertical stabilizer, rudder, and horizontal stabilizers are constructed of aluminum core and carbon-based composite materials.

5.0 **Antenna Selection**

A high frequency shunt antenna has been selected because of the flush mount characteristics. This shunt antenna is designed into the aircraft structure which eliminates vibration problems encountered by long wire and probe antennas. Long wire antennas on high speed, high performance aircraft create wind drag that is detrimental to aircraft speed. Vibration and temperature variations in flight also cause wire breakage. Probe antennas minimize wind drag, but because they protrude from the aircraft wing or vertical stabilizer, they are vulnerable to breakage by in-flight vibration and landings.

Both the long wire and probe antennas require heavy lightning arrestors for equipment protection. Shunt type antennas are physically short and grounded to the aircraft frame eliminating the need for heavy lightning arrestors.

6.0 **F-15 Aircraft**

Preliminary investigation has revealed that McDonnell Douglas Corporation, St. Louis MO, has fabricated a brassboard shunt type antenna (125 inches in length) into the left vertical stabilizer and has measured the antenna feedpoint characteristics (Appendix II and Data Sheet I) from 2 and 30 MHz. A production type vertical stabilizer will be produced by McDonnell Douglas starting in June, 1984. At this time, plans are to ask McDonnell Douglas to reverify the antenna feedpoint characteristics within the frequency spectrum of 2 to 30 MHz.

6.1 Antenna Analysis

A computer program (wire radiation and scattering), using methods of moments, was used to model the R and J components of the antenna at 21 frequencies (Data Sheet II). This data shows close correlation to the measured data obtained by McDonnell Douglas. Therefore, RADC is presently working with the F-15 SPO to have the antenna feedpoint characteristics measured from 30 to 156 MHz concurrent with the 2 to 30 MHz measurements in the June, 1984 time frame.

DATA SHEET I

F-15 HF Antenna Measurements

Frequency (MHz)	R Component	± J Component
2.0	0.8	31.4
2.5	1.0	39.2
3.0	0.9	47.2
3.5	1.2	55.2
4.0	0.9	63.5
4.5	1.3	72.0
5.0	1.0	80.5
5.5	1.3	89.6
6.0	1.0	99.2
6.5	1.5	108.0
7.0	2.3	119.0
7.5	2.9	129.0
8.0	2.4	139.0
8.5	2.6	151.0
9.0	2.8	163.0
9.5	3.4	176.0
10.0	4.3	191.0
10.5	5.8	206.0
11.0	8.6	224.0
11.5	13.7	244.6
12.0	23.0	263.0
12.5	36.3	283.7
13.0	46.5	300.4
13.5	63.5	326.9
14.0	115.7	341.9
14.5	125.3	273.7
15.0	70.8	288.4
15.5	56.3	329.2
16.0	55.9	369.8
16.5	59.9	410.7
17.0	70.0	457.7
17.5	89.2	511.3
18.0	121.5	576.3
18.5	181.6	646.0
19.0	272.7	703.0
19.5	389.4	726.2
20.0	513.3	693.7
20.5	583.1	610.2
21.0	586.8	551.1
21.5	579.6	550.0
22.0	590.4	576.2
22.5	626.6	628.0
23.0	700.6	708.0
23.5	842.4	782.8

DATA SHEET I (continued)

F-15 HF Antenna Measurements

Frequency (MHz)	R Component	± J Component
24.0	1055.1	842.2
24.5	1364.2	836.0
25.0	1792.5	659.5
25.5	2174.7	152.1
26.0	2114.8	-606.4
26.5	1620.4	-1084.8
27.0	1133.7	-1198.8
27.5	776.2	-1116.8
28.0	576.9	-983.3
28.5	469.5	-894.2
29.0	364.6	-830.5
29.5	231.9	-754.0
30.0	223.4	-683.4

DATA SHEET II

F-15 HF Antenna Characteristics/Computer Analysis

Frequency (MHz)	R Component	± J Component
5	0.842	76.0
8	2.58	140.0
10	5.12	173.3
11	127.6	271.2
12	162.0	399.8
13	172.1	179.0
14	100.0	261.7
15	111.8	375.7
16	192.2	547.6
17	528.8	822.3
18	1510.5	200.0
19	714.4	-453.4
20	471.0	-42.8
21	250.0	-345.0
23	139.8	-144.7
24	143.0	-72.9
25	172.0	-28.1
26	200.0	6.3
28	339.3	315.6
30	399.7	-161.7
60	169.8	75.7

7.0 **F-16 Aircraft**

The F-16 multi-role fighter aircraft, Models C and D, have been selected as the prime candidate for the ICNIA HF transmitting system. These models have large areas of carbon composite materials in the vertical stabilizer, rudder, and horizontal stabilizer (Figures 1 and 2). The dorsal areas of Models C and D (Figures 3a, 3b, 4, and 5) have been extended and enlarged for the installation of identification equipment. The forward area of the dorsal (Figures 3, 4, and 5) is the only space not utilized that is sufficient in area of house electronic equipments.

7.1 **Shunt Antenna**

A shunt type antenna, approximately 83 inches in length, has been selected for this aircraft to obtain maximum radiated powers and minimum tuning requirements.

7.1.1 **Mechanical Configurations**

The antenna can be constructed into the leading edge of the vertical stabilizer (Figure 3a). The front span of the vertical stabilizer (Figure

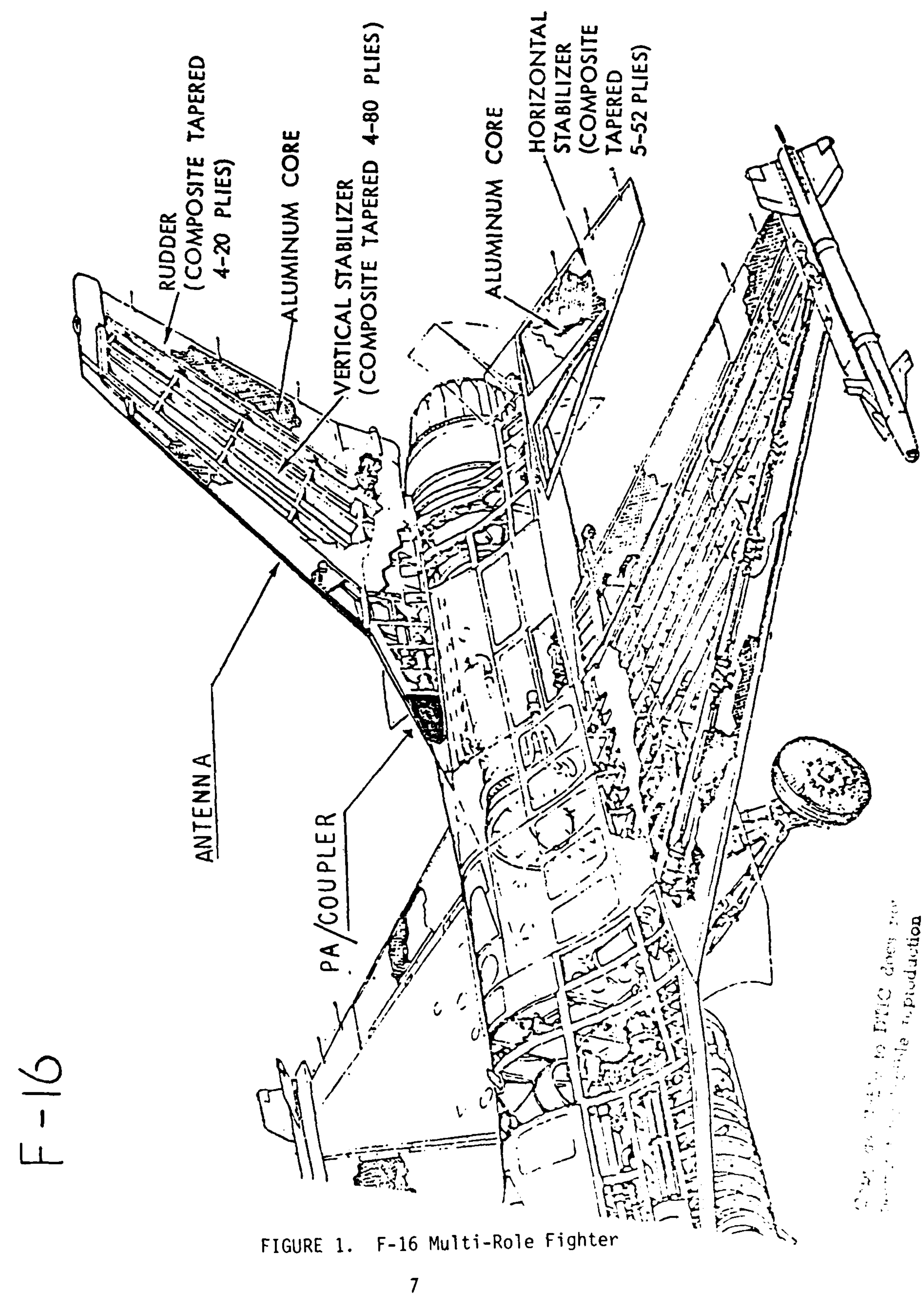


FIGURE 1. F-16 Multi-Role Fighter

- MATERIAL COMPOSITION
  - FIBER : T300 CARBON, 72% by WEIGHT
  - RESIN: 5208 EPOXY, 28% by WEIGHT
- WEIGHT DISTRIBUTION

PART	NO. OF PLIES	STRUCTURAL WEIGHT (lbs)	
		COMPOSITE	FIBERS
VERTICAL STABILIZER	4-80	100	72
FIXED LEADING EDGE	4-80	4.04	2.9
RUDDER	4-20	5.8	4.1
HORIZONTAL STABLIZER	5-52	66.3	47.7

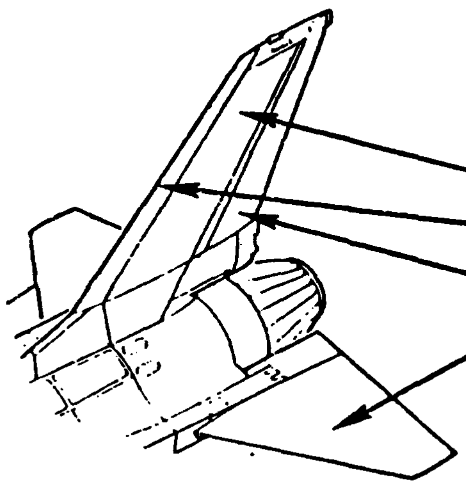


FIGURE 2. F-16 Composite Material Weight Summary

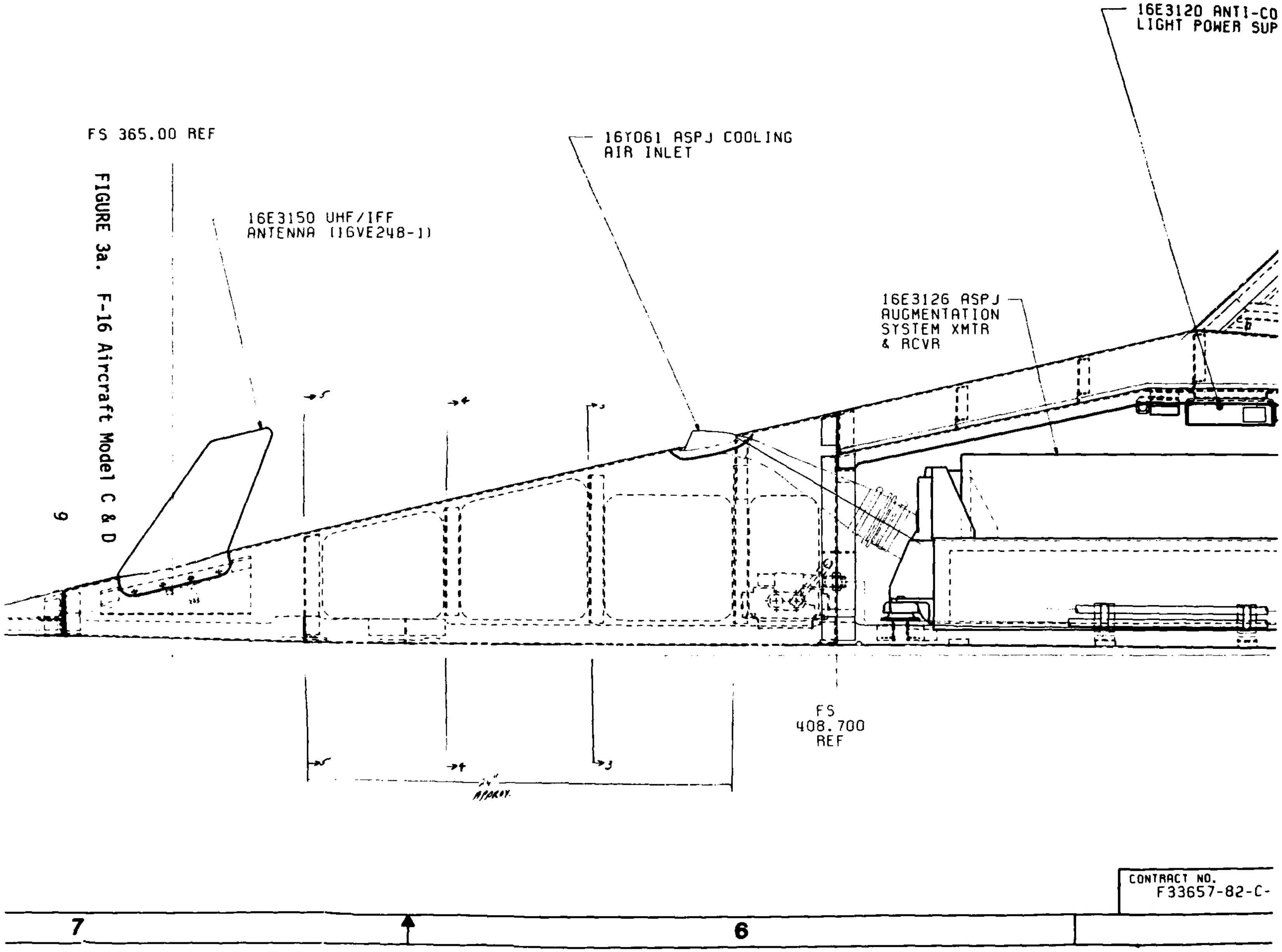
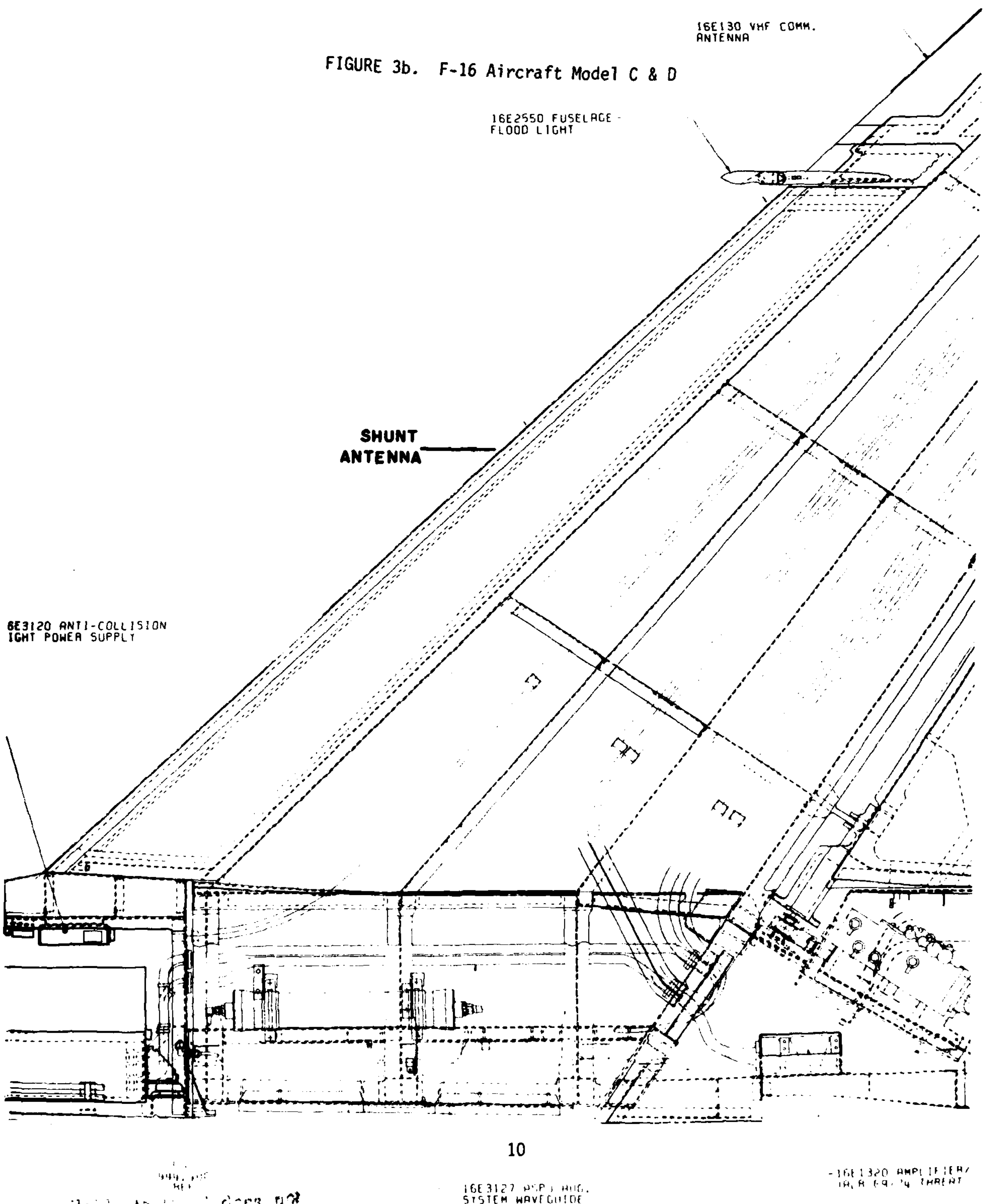


FIGURE 3a. F-16 Aircraft Model C & D

FIGURE 3b. F-16 Aircraft Model C & D



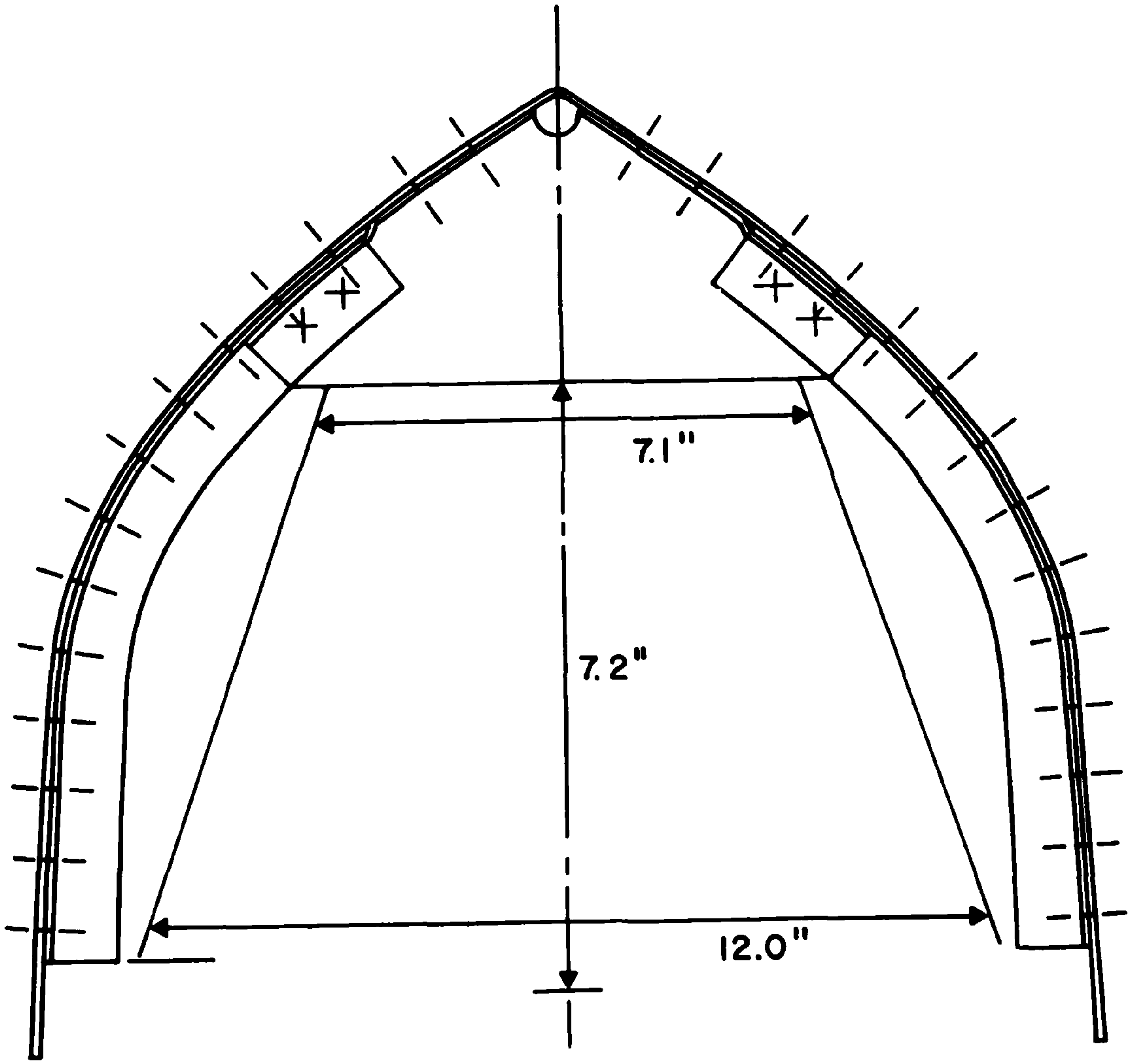


FIGURE 4. Dorsal Cross Section 3-3

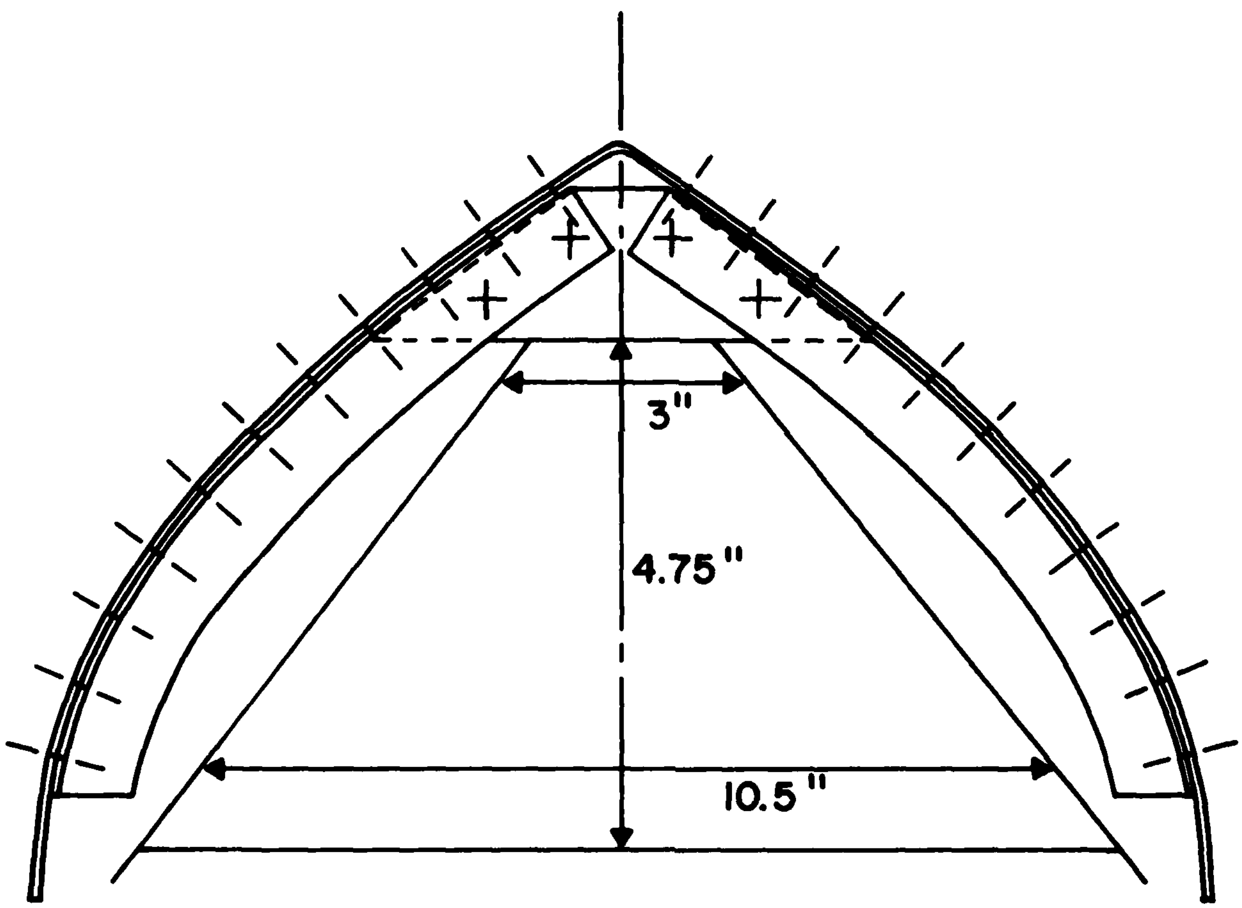


FIGURE 5. Dorsal Cross Section 5-5

6) is constructed of metal and can be designed as a portion of the antenna. The VHF communications antenna (16 E 130) will not have to be relocated.

7.1.2 Electrical

A computer program (Wire Radiation and Scattering) using the method of moments was used to model the R and J components of the antenna at six (6) frequencies (Data Sheet III). Horizontal and vertical radiation patterns were also analyzed at the same six frequencies (Figures 7, 8, 9, 10, 11, and 12). The preliminary data indicates that this antenna input impedance can be matched effectively from 5 to 88 MHz without reducing the input power due to high reactive components.

DATA SHEET III

F-16 HF Antenna Characteristics

Frequency (MHz)	R Component	± J Component
5	0.842	76.0
10	8.2	91.9
15	6.2	127.0
30	43.6	-53.8
60	10.6	-87.6
90	92.0	24.6

A preliminary analysis to determine what the radiated power will be for this type aircraft is impossible. The composite material used for the tail section and horizontal stabilizer is a carbon-based material (Figures 1 and 2). There is no available data on the amount of RF signal that will be absorbed by this material or how effective the RF coupling will be to the aluminum core and frame. Tests will be conducted to determine the amount of energy absorption due to the composite materials versus that of an aircraft with an all-aluminum horizontal stabilizer.

7.2 Power Amplifier/Antenna Coupler Specifications

7.2.1 Mechanical Specifications

Presently there are approximately 1,600 cubic inches of unused space in the forward dorsal area (Figures 3a, 3b, 4, and 5). Plans are to design a power amplifier/antenna coupler unit that will occupy no more than 1,400 cubic inches and weigh no more than 40 pounds.

7.2.2 Electrical Specifications

The electrical specifications are shown in Data Sheet IV for the frequency range of 5 to 88 MHz. There will also be a goal to extend the frequency

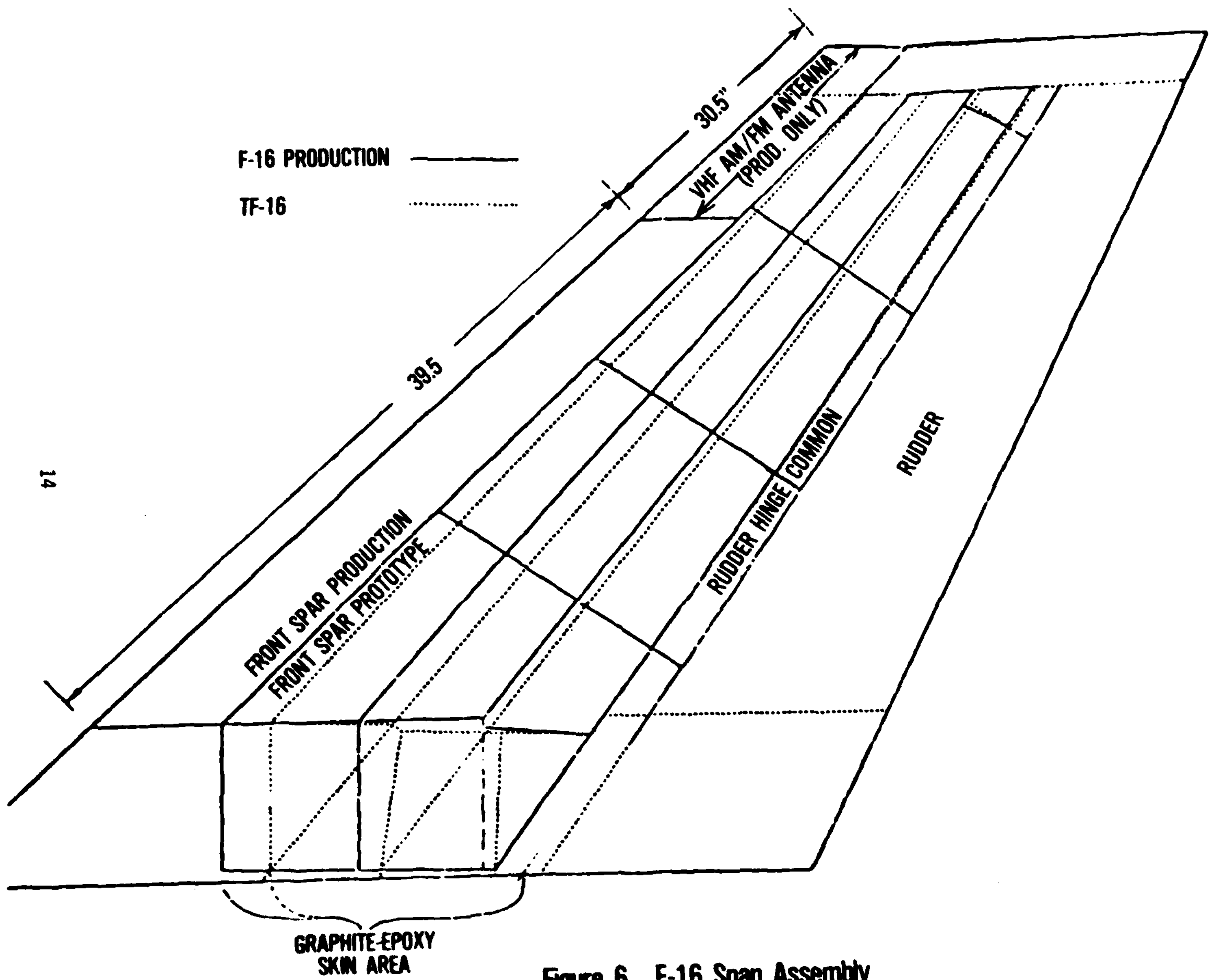


Figure 6. F-16 Span Assembly

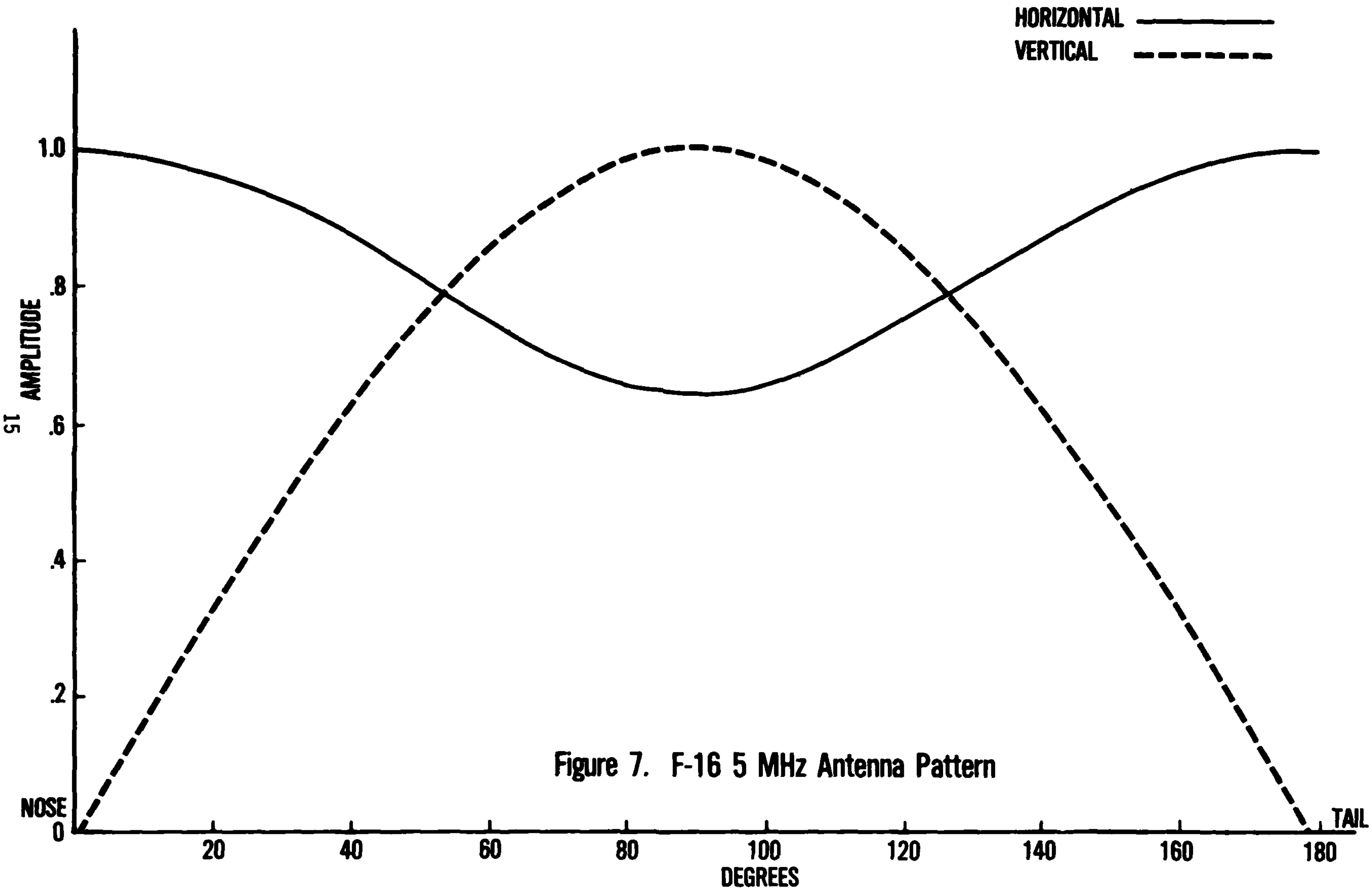


Figure 7. F-16 5 MHz Antenna Pattern

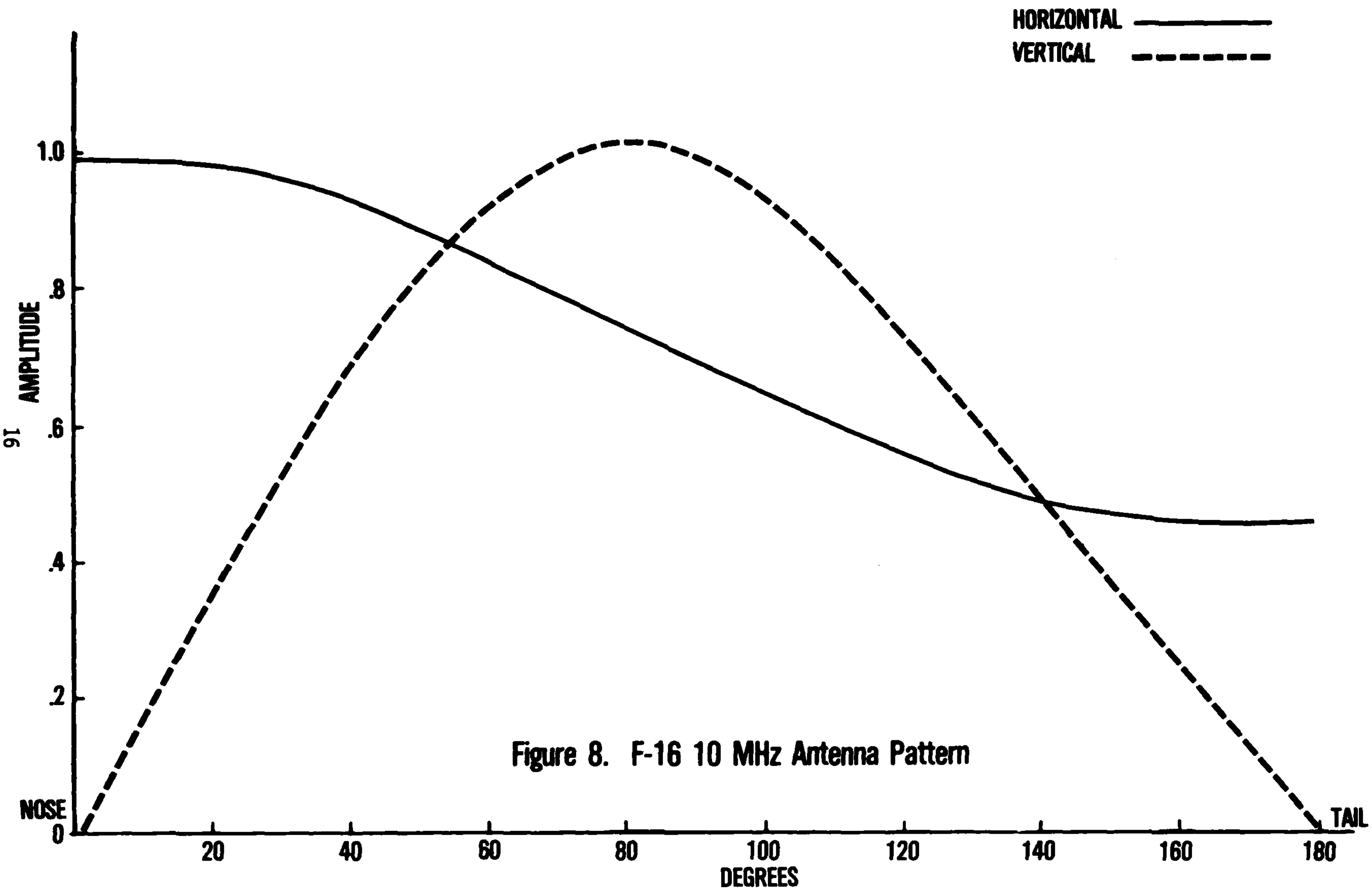


Figure 8. F-16 10 MHz Antenna Pattern

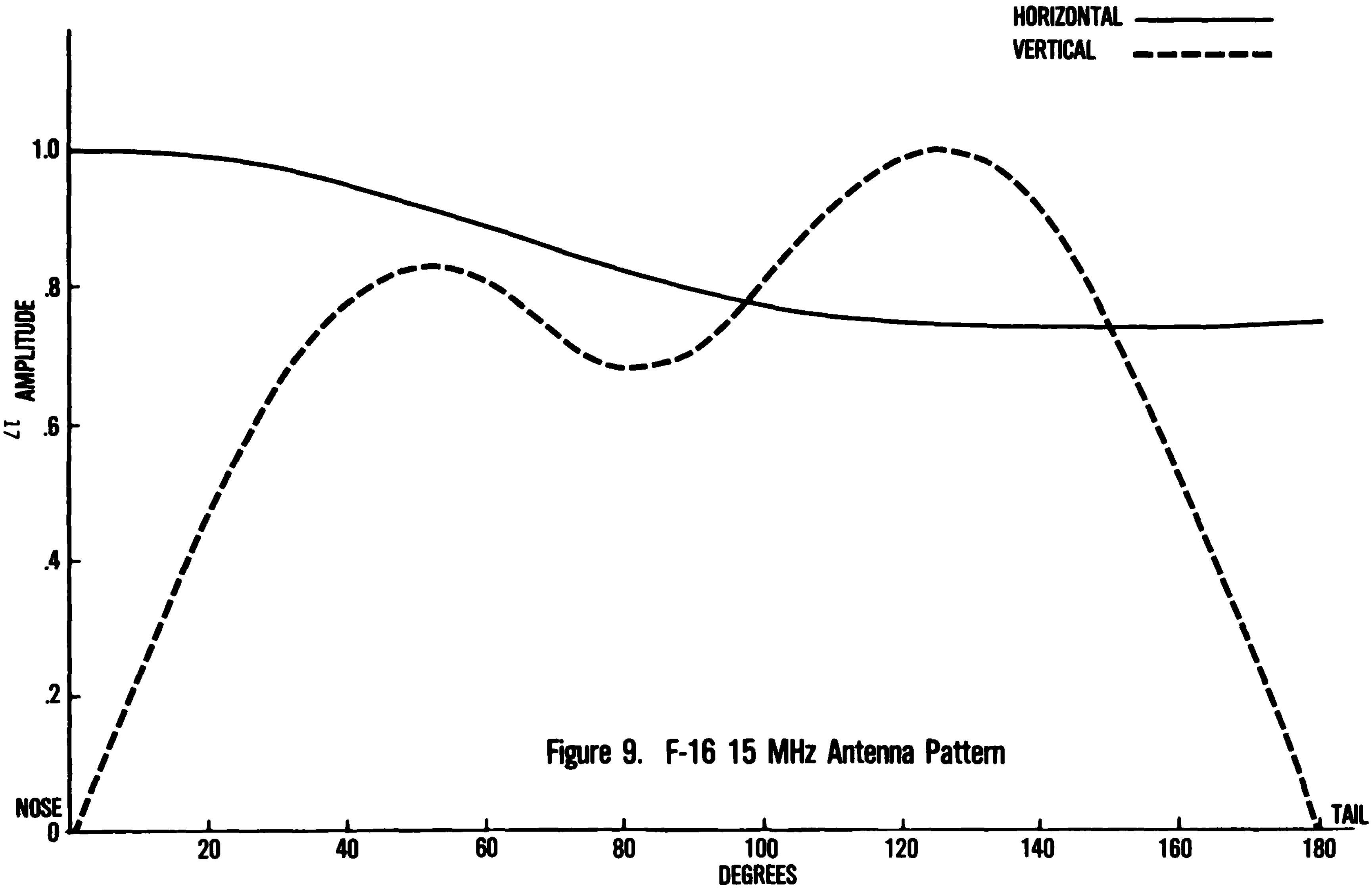


Figure 9. F-16 15 MHz Antenna Pattern

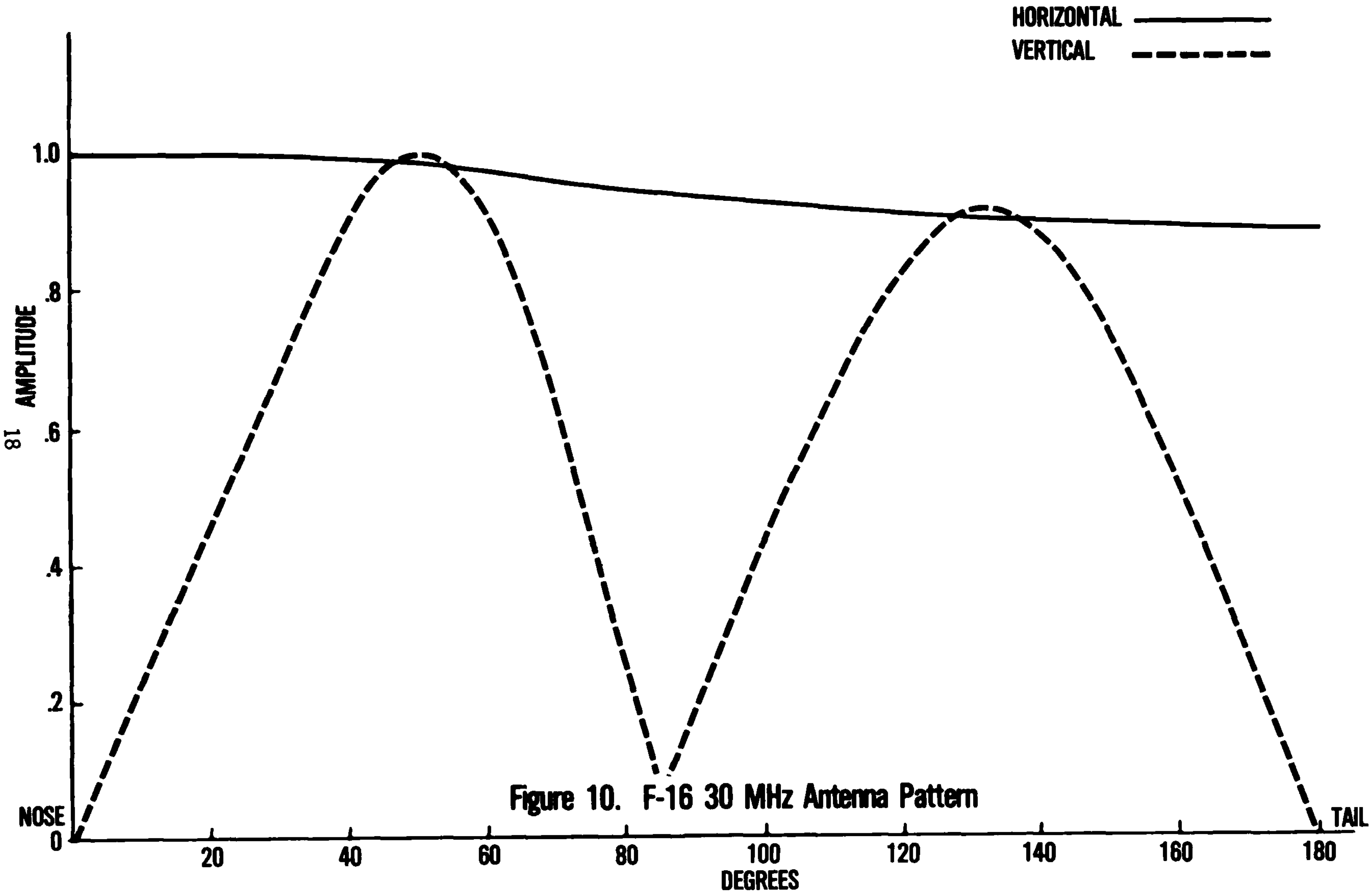


Figure 10. F-16 30 MHz Antenna Pattern

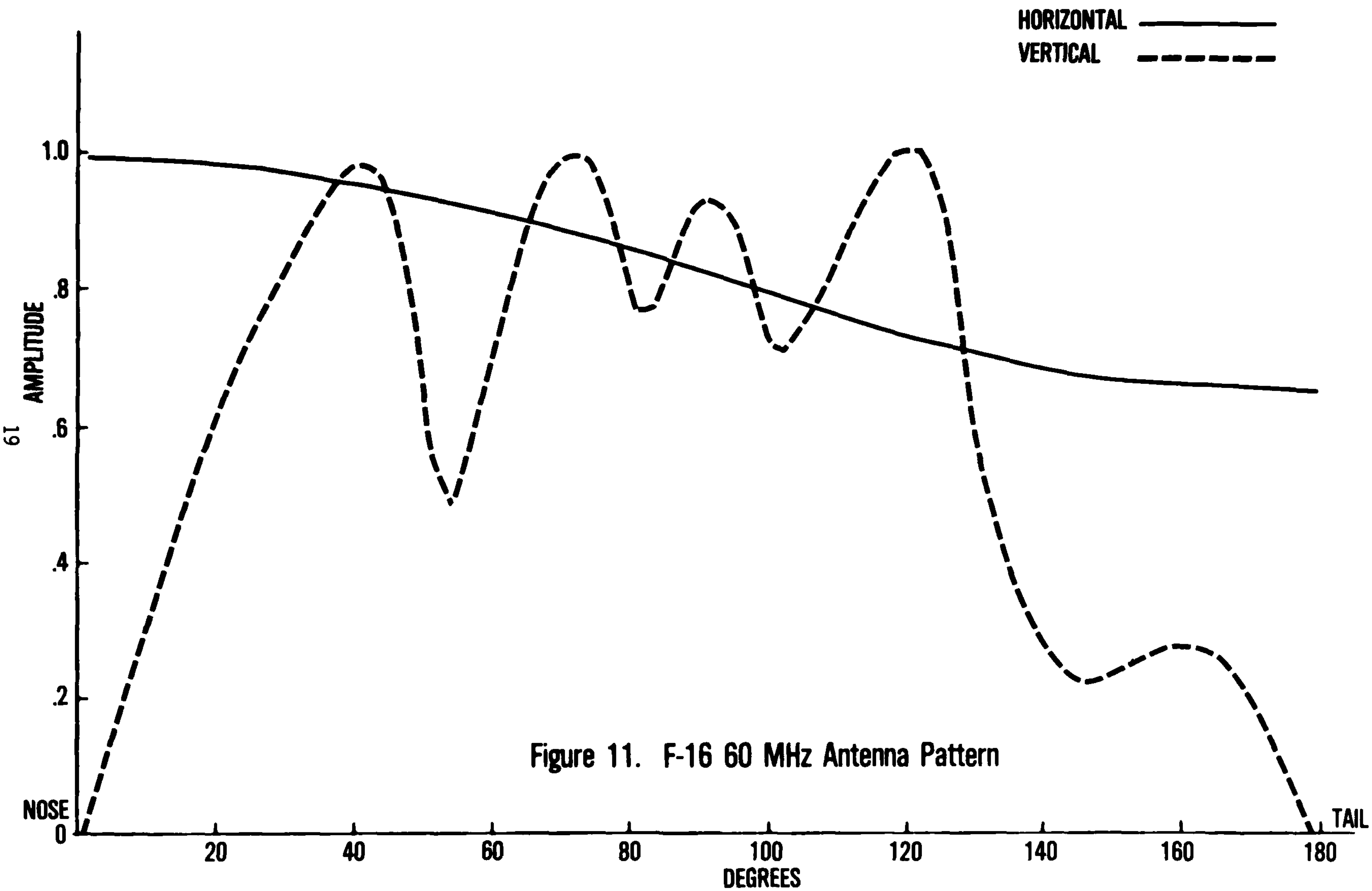


Figure 11. F-16 60 MHz Antenna Pattern

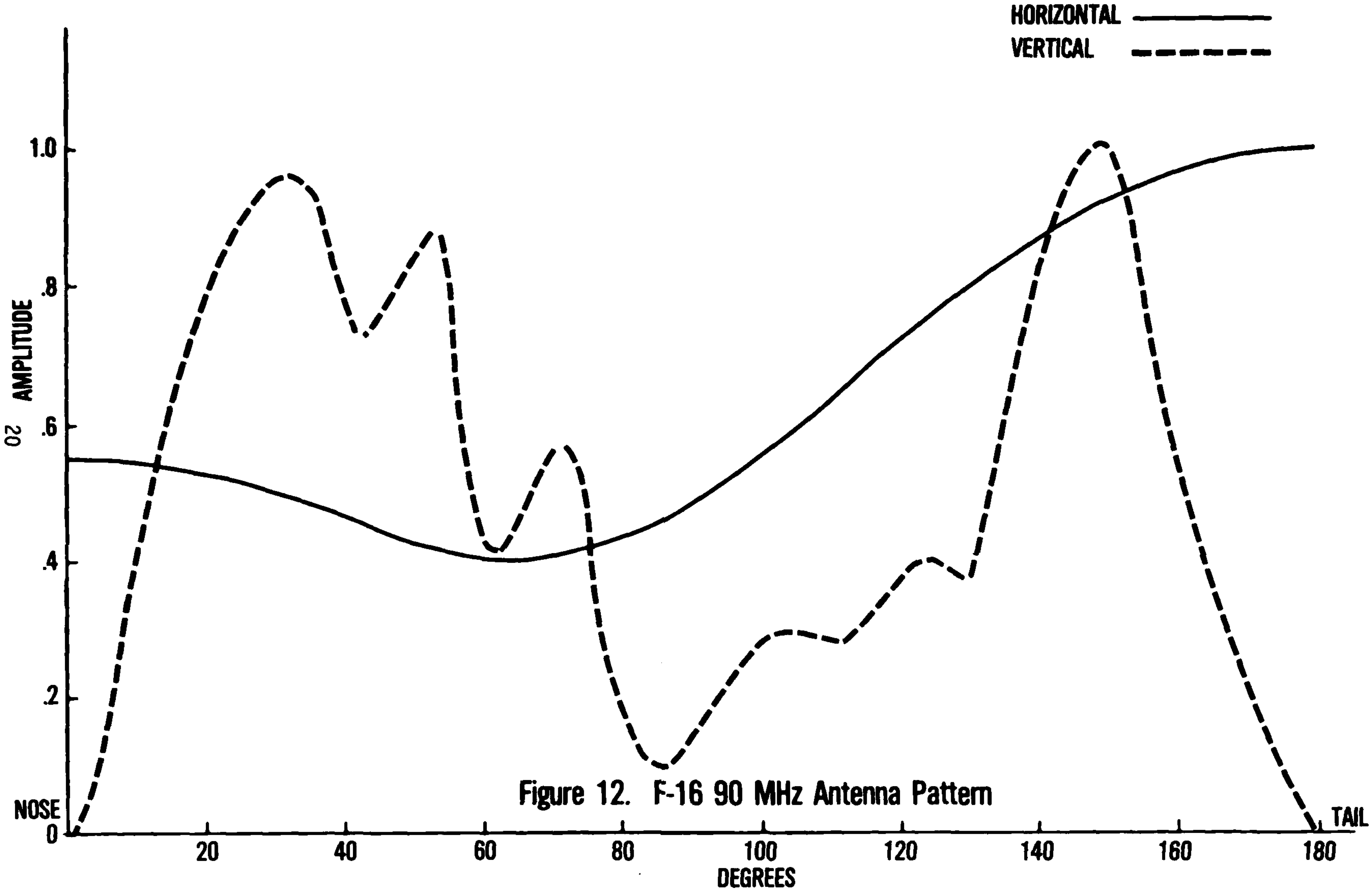


Figure 12. F-16 90 MHz Antenna Pattern

band to 156 MHz to eliminate a power amplifier and antenna coupler to cover the frequency band of 108 to 156 MHz. Presently, equipment such as the AN/ARC-186 and AN/ARC-108 each respectively cover the low VHF range (30 to 88 MHz) and high VHF (108 to 156 MHz) shown in Chart I. Covering the frequency range of 5 to 150 MHz would also eliminate the need for an antenna to cover the higher VHF range.

DATA SHEET IV

Electrical Specification

Power Input:	500 watts, 27.5 V DC
RF Power Input:	1 watt maximum, 50 ohms unbalanced
Tuning:	20 preset channels, automatic
Tuning Time:	50 msec preset channels, 4 sec maximum non-preset channels
Mode:	USB/LSB/AME/DATA/MCW
Secureability:	TSEC/KY-75 compatible
RF Power Output:	100 watt average, 200 watts pep (goal 200 watts average, 400 watts pep)
Antenna:	A/C shunt type (shorted)
Antenna Voltage:	5 KV maximum
Frequency Range:	5 to 88 MHz (Goal 2 to 156 MHz)

CHART I

Base Radio Functions

Frequency Spectrum	Type Communications	Modulation
HF (5 to 30 MHz)	Voice/Data	SSB, AMC
Low VHF (30 to 88 MHz)	Voice/Data (Close Air Support)	FM
High VHF (108 to 156 MHz)	Voice/Data (Air Traffic Control)	AM, FM

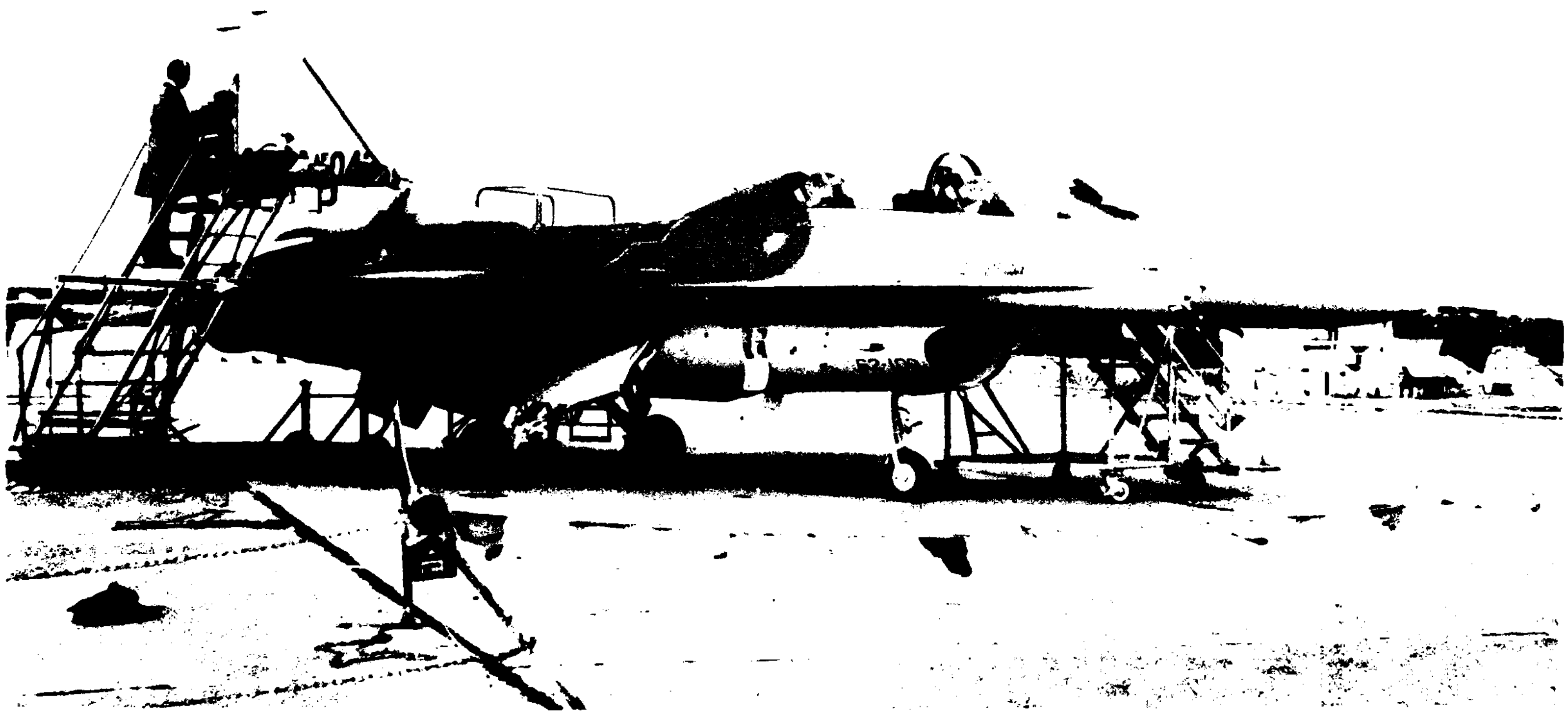
7.3 ADM Equipment Approach

7.3.1 Antenna Verification

RADC is presently working with General Dynamics to fabricate and install a prototype shunt antenna on a F-16 airframe (Picture 1). Antenna feedpoint characteristics, antenna patterns, and radiated efficiency will be measured. RADC is also working with the F-15 SPO to obtain the leading edge of a F-15 with a prototype shunt antenna installed. The antenna feedpoint characteristics for this antenna will be measured at the RADC Newport Test Site. After thorough analysis of these antennas a study will be conducted to determine if the weight and size of the HF/VHF transmitting system could be reduced.

8.0 Conclusion

The preliminary study shows that it is feasible to design and fabricate HF/VHF equipment for small high speed, high performance aircraft. The study also shows that it is feasible to use one electrical design for different types of aircraft. One coupler design can be used to tune HF/VHF equipment for the F-15, F-16, OH-58, and UH-1H Army helicopters (Data Sheets I, II, V, and VI). The Army built two (2) prototype shorted loop antennas and measured the antenna characteristics from 2 to 30 MHz as shown in Data Sheets V and VI.



PICTURE 1. F-16 Aircraft

DATA SHEET V

OH-58 Helicopter Antenna Measurements

Frequency (MHz)	R Component	X Component
2.0	0.451	51.5
3.0	0.80	80.0
4.0	1.60	113.0
5.0	2.65	152.0
6.0	3.54	203.0
7.0	4.78	274.0
8.0	21.0	391.0
9.0	125.0	584.0
10.0	363.0	628.0
11.0	727.0	930.0
12.0	1840.0	275.0
12.164	1900.0	0.0
13.0	1230.0	-1069.0
14.0	230.0	-803.0
15.0	115.0	-543.0
16.0	68.0	-384.0
17.0	54.0	-306.0
18.0	41.0	-259.0
19.0	26.0	-214.0
20.0	19.0	-176.0
21.0	14.0	-156.0
22.0	11.0	-122.0
23.0	8.3	-95.0
24.0	6.8	-78.0
25.0	5.14	-59.0
26.0	4.2	-40.0
27.0	3.8	-22.0
28.0	4.8	-2.9
28.3	4.9	0.0
29.0	4.7	16.0
30.0	6.3	36.0

DATA SHEET VI

UH-1H Helicopter Antenna Measurements

Frequency (MHz)	R Component	X Component
2.0	0.2	53.0
3.0	0.31	81.0
4.0	0.48	113.0
5.0	1.13	150.0
6.0	3.92	198.0
7.0	11.87	252.0
8.0	21.6	322.0
9.0	34.0	425.0
10.0	43.0	600.0
11.0	50.0	959.0
12.0	336.0	2124.0
12.813	10020.0	0.0
13.0	4684.0	-5202.0
14.0	262.0	-1233.0
15.0	138.0	-783.0
16.0	65.8	-536.0
17.0	31.0	-348.0
18.0	20.0	-308.0
19.0	14.0	-247.0
20.0	11.0	-200.0
21.0	9.3	-160.0
22.0	8.2	-125.0
23.0	7.0	-94.0
24.0	6.0	-65.0
25.0	5.3	-37.0
26.0	4.6	-9.0
26.3	4.5	0.0
27.0	5.5	86.0
28.0	9.3	53.0
29.0	15.5	86.0
30.0	21.0	132.0

END

12-86

DTIC