CCR Number: 0004R1 **CRITICALITY: ROUTINE** **DUE:03/13/98**

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NEW MILLENNIUM PROJECT CONFIGURATION CHANGE REQUEST

PROGRAM EO-1	**TITLE** BASELINE EO-1 X-BAND PHASED ARRAY ANTENNA SYSTEM
CCR NO. 0004R1	ORIGINATOR Boeina Aerospace
DATE INITIATED 02/20/98	ORIGINATOR'S CHG. NO. ICD-047
DUE DATE	SPONSOR/CODE K Perko/NMP-XPAA Lead PHONE x6375

EFFECTIVITY	CHANGE CLASS	TYPE OF CHANGE
ITEM: ~~XPAA~~ S/N	I II PRELIMINARY ☐ ☐ FORMAL ☐ ☐	MILESTONE ☐ INTERFACE ☐ SOFTWARE ☐ DOCUMENT ☒ POWER ☐ OTHER ☐ COST ---- 0 WEIGHT ☐ ☐
ITEM: S/N	**DOCUMENTS OR SOFTWARE AFFECTED**	
ITEM: S/N	EO-1 ICD-047	

PROBLEM

The attached revised draft version of **EO1-ICD-047,** Earth Orbiter -1 (EO-1) X-Band Phased Array Antenna (XPAA) Interface Control Document (ICD) requires baselining. The document defines the functional, physical and electrical characteristics of the XPAA that impacts the EO-1 spacecraft on which it will be installed.

This CCR (No **0004R1)** supercedes CCR 0004 as there were numerous changes made as a result of input from reviewers. The changes were significant enough to warrant a **completly** new CCR with a revised draft for review and subsequent baselining.

PROPOSED SOLUTION

Approve the attached revised draft version of EO-1 ICD-047, XPAA ICD, by the EO-1 Level II Configuration Control Board (CCB). This draft issue will be formally released after CCB approval. Future changes will be initiated by submittal of Configuration Change Requests **(CCRs)** and Preliminary Interface Revision Notices (PIRNs) for CCB approval. This document is maintained by the EO-1 Configuration Management Office (CMO).

BOARD ACTION	APPROVAL LEVEL REQUIRED	CRITICALITY LEVEL	PROCUREMENT CHANGE ORDER CLASSIFICATION		
APPROVE ☑	LEVEL I HQS ☐	EMERGENCY ☐	ROUTINE	URGENT	EMERGENCY ☐
APPROVE WITH CHANGE ☐	LEVEL II GSFC ☐	URGENT ☐	OPTION 1 ☐	OPTION 1 ☐	
DISAPPROVE ☐	LEVEL III ☐	ROUTINE ☒	OPTION 2 ☐	OPTION 2 ☐	
WITHDRAW ☐					

COMMENTS

CHAIRPERSON [signature] 10 Apr DATE 98

3/28/96

EO-1 ICD-47
Revised Draft Issue
February 20, 1998

EO-1
X-BAND PHASED ARRAY ANTENNA SYSTEM
INTERFACE CONTROL DOCUMENT (ICD)

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

EO-1 ICD-047
Revised Draft Issue
February 20, 1998

Interface Control Document

(XPAA-092)

for

X-Band phased Array Antenna/Earth Observer-1 Spacecraft

New Millennium Project

NASA Goddard Space Flight Center

ABSTRACT

The Interface Control Document for the New Millennium Project X-band Phased Array Antenna (XPAA) provides a definition of all functional, physical and electrical characteristics of the XPAA that impact the Earth Orbiter-1 (EO-1) spacecraft on which it will be installed. The interface definition in the ICD is designed to ensure that equipment and software delivered by The Boeing Company will operate properly when installed on the EO-1 spacecraft, will meet the requirements for which it was designed and will not adversely affect any aspect of the EO-1 spacecraft operations.

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ACRONYMS AND ABREVIATIONS

ASIC	Application Specific Integrated Circuit
CMOS	Complementary Metal Oxide Semiconductor
DC	Direct Current
D&SG	Defense & Space Group (Boeing)
COTS	Commercial Off-The-Shelf
EO-1 S/C	Earth Orbiter-1 Spacecraft
EIRP	Effective Isotropically Radiated Power
ESN	Essential Services Node
FPGA	Field Programmable Gate Array
ICD	Interface Control Document
LVPC	Low Voltage Power Supply
MCM	Multi-Chip Module
MMIC	Monolithic Microwave Integrated Circuit
NASA	National Aeronautics and Space Administration
NMP	New Millennium Project
PSE	Power System Electronics
RF	Radio Frequency
RFI	Radio Frequency Interference
RSN	Remote Services Node
SOW	Statement of Work
SSO	Space Systems Operation (Litton Amecom)
TTL	Transistor-Transistor Logic
UART	Universal Asynchronous Receiver-Transmitter
V	Volts
XPAA	X-Band Phased Array Antenna
WARP	Wideband Advanced Recorder Processor

1. GENERAL

This ICD contains data and drawings required to define the interface characteristics of the X-Band Phased Array Antenna System (referred herein as the “antenna” or “XPAA”) that will be mechanically, functionally and electrically integrated with the Earth Orbiter-1 Spacecraft.

1.1. Scope and Purpose

The ICD will contain all software, hardware (mechanical), thermal, electrical power, RF signal, logic or control signal, telemetry signal, data signal and operational interfaces of the XPAA with the EO-1 spacecraft. Included are the ESN and RSN components.

1.2. Antenna Subsystem Overview

The X-Band phased array antenna comprises 64 active radiating elements each with an independent phase controller and power amplifier allowing electronic steering of the antenna beam. Element phases are calculated to point the beam at the commanded elevation and azimuth by an RSN provided by Litton Amecom. Telemetry and commands are transmitted to the antenna over a dual MIL-STD 1773 fiber optic data bus. A 8.225 GHz RF excitation is supplied by the WARP via a coaxial cable, and consists of a QPSK modulated signal at a data rate of 105 Mbps.

One advantage of an electronically steered antenna for small satellite applications, where platform stability is important, is that no reaction torque compensation is needed during a communications pass allowing the simultaneous acquisition of precision optical data. The phased array is also smaller than a comparable mechanically steered gimbaled system while maintaining high data rate communications capabilities.

1.3. Applicable Documents

a. **NASA Document 737-EO1-RSD-XPAA**, “Performance Specification and Design Requirements for the New Millennium Program Earth Orbiter-1, X-Band Phased Array Antenna”, released April 1, 1997

b. **NASA Document 737-EO1-SOW-XPAA**, “Statement of Work for the New Millennium Program Earth Orbiter-1, X-Band Phased Array Antenna”, released April 4, 1997

c. **SAI-SPEC-158,** “EO-1 Verification Plan and Environmental Specification”, dated July 31, 1997.

d. **MIL-STD-461C,** Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference (Notice 1)

e. **MIL-STD-462,** Measurement of Electromagnetic Interference Characteristics

f. **MIL-STD-1773B,** Fiber Optics Mechanization of an Aircraft Internal Time-Division Command/Response Multiplex Data Bus

g. **NASA Document ICD-735-2827**, “Essential Services Node hardware Specification (Revision 2.0)”

h. **Litton Drawing No. 184622,** “Chassis Assembly, LWH-14-.050”

i. **Litton Document ICD-TBD**, “X-Band Exciter to Memory Interface Control Card”

j. **AM-149-0020(155),** “System Level Electrical Requirements, EO-1”

k. **AM149-0050(155),** “1773 ICD”

l. **Boeing XPAA-093,** “X-Band Phased Array Antenna (XPAA) Remote Services Node (RSN) Software Specification”

2. SYSTEM INTERFACE DIAGRAM

2.1. General

An interconnect diagram is provided to show the system level interconnects for RF excitation, fiber optic control and telemetry signals, and DC power. A service connector for software loading, and a test connector for testing during integration are also shown. Electrical and signal characteristics, and cabling are further defined in Section 5.

Figure 2.1-1 shows the system interface connections between the antenna and the WARP, the fiber optic star coupler, and the 28 V power supply.

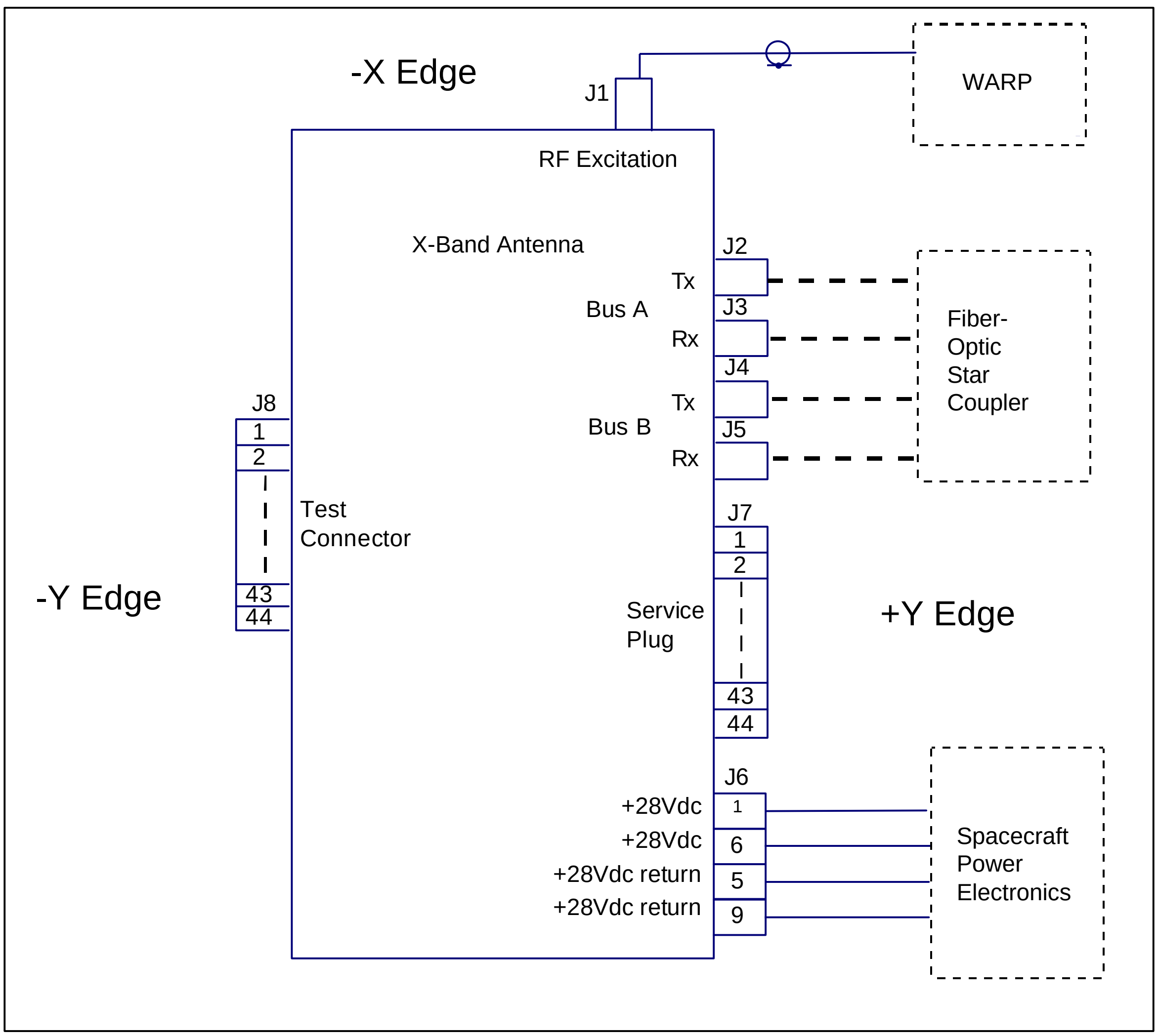


Figure 2.1-1. System Interface Diagram

3. MECHANICAL INTERFACE

3.1. General

The antenna enclosure is a two level structure. The 64 radiating elements and the high wattage dc to dc converters for the antenna 5V power are located on the upper level, and an RSN controller board is located on the lower level. The lower level of the enclosure is geometrically identical to one slot of the Litton Chassis (Litton drawing No. 184622) permitting the generic RSN board to be accommodated without any mechanical change to the basic RSN.

3.2. Antenna Envelope

Figure 8.1-1 shows the physical envelope of the antenna. The RF excitation input is located on the -X direction face of the antenna. The service connector and the fiber optic connectors are located on the positive Y direction face. The test connector is located on the negative Y direction face.

3.3. Antenna Footprint and Fastener Requirements

Figure 8.1-2 shows the mechanical footprint of the antenna. The antenna is secured to the mounting plate by 8 NES 1578 ¼-28 threaded fasteners.

3.4. Antenna Mounting Requirements

A gasket of Chomerics Cho-Therm 1671 will be placed between the antenna flange and the mounting plate, and the ¼-28 fasteners torqued to 91 ins-lbs.

3.5. Antenna Mass and Center of Mass

The antenna shall weigh not more than 5.5 kg. The center of mass shall be determined to an accuracy of +/- 2.5 mm in three dimensions.

4. THERMAL INTERFACE

4.1. General

The antenna shall be thermally coupled to the spacecraft interface plate. The nadir facing metal surface of the antenna shall be painted white. The nadir radiating surface shall consist of white Tefzel (DuPont 500 CLZ WTHP.) The spacecraft shall supply MLI and heaters necessary to maintain the interface plate temperature within the limits described in Table 4.1-1. Figure 4.1-2 shows the various elements contributing to the thermal design.

Limits	Operating	Non-Operating
Minimum Temperature	0	-10
Maximum Temperature	40	50

Table 4.1-1 XPAA Temperature Limits, Degrees C.

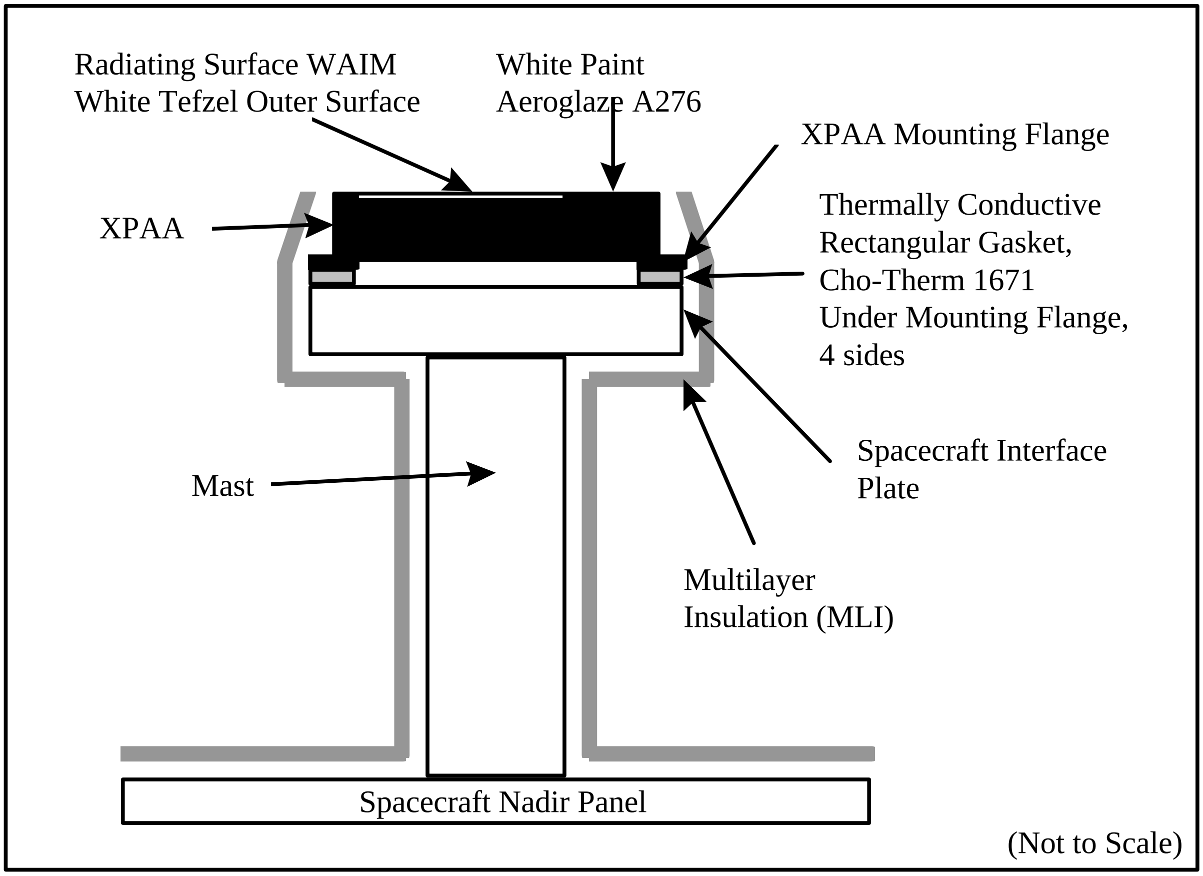


Figure 4.1-2. XPAA Thermal Interfaces

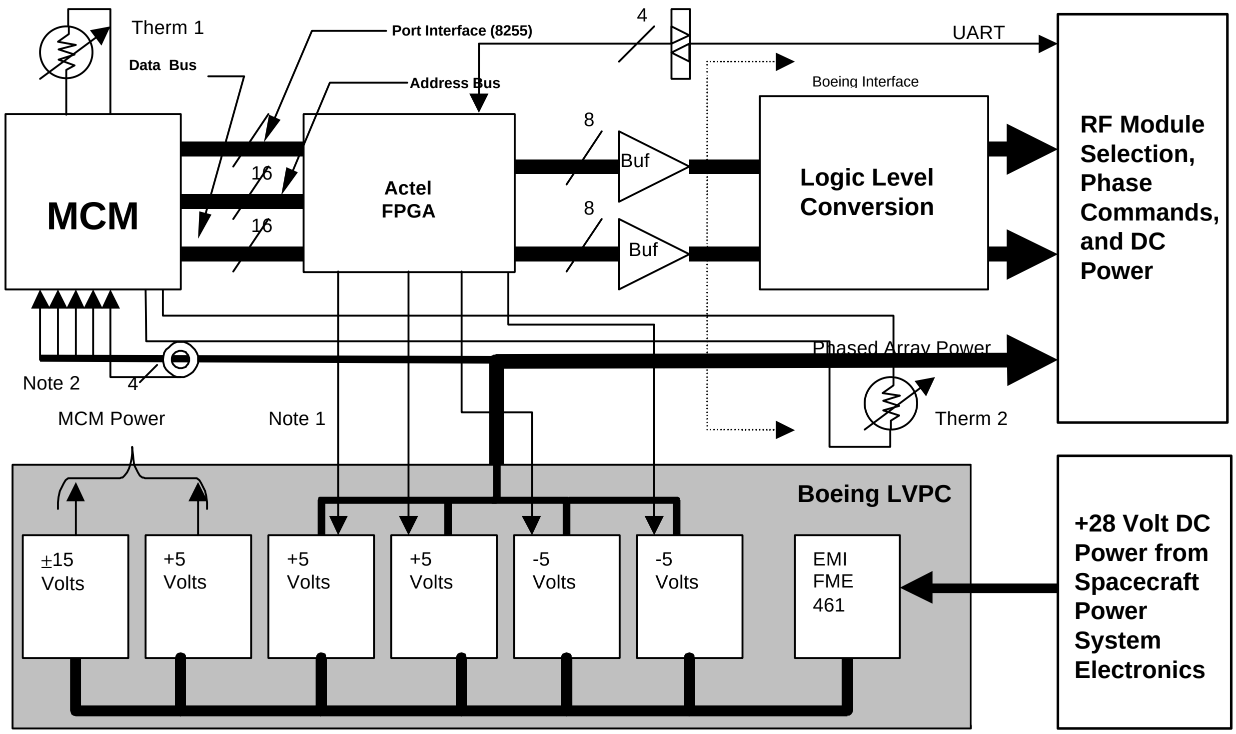
5. ELECTRICAL INTERFACE

5.1. General

The antenna comprises a 64 element array, and an RSN board. With the exception of the antenna modules, all electrical and electronic components are mounted on the RSN board.

5.2. Electrical Block Diagrams

Figure 5.2-1 shows the RSN electrical block diagram and external interfaces.



Note 1: Discrete provides TTL compatible power supply turn on/off
Note 2: Voltages and current shall be monitored in a "standard fashion"

Figure 5.2-1. RSN Electrical Block Diagram

Support electronic components, a FPGA, level translation (TTL to -5 to 0V) integrated circuits, and six dc-to-dc power converters are located on the RSN board. Four low power converters and an RFI filter are located on the "A" side of the RSN board, and two 30 W converters are located on the "B" side of the board.

Figure 5.2-2 shows the RF module array diagram. The array is divided into two sections fed by separate low voltage power supplies for improved reliability .

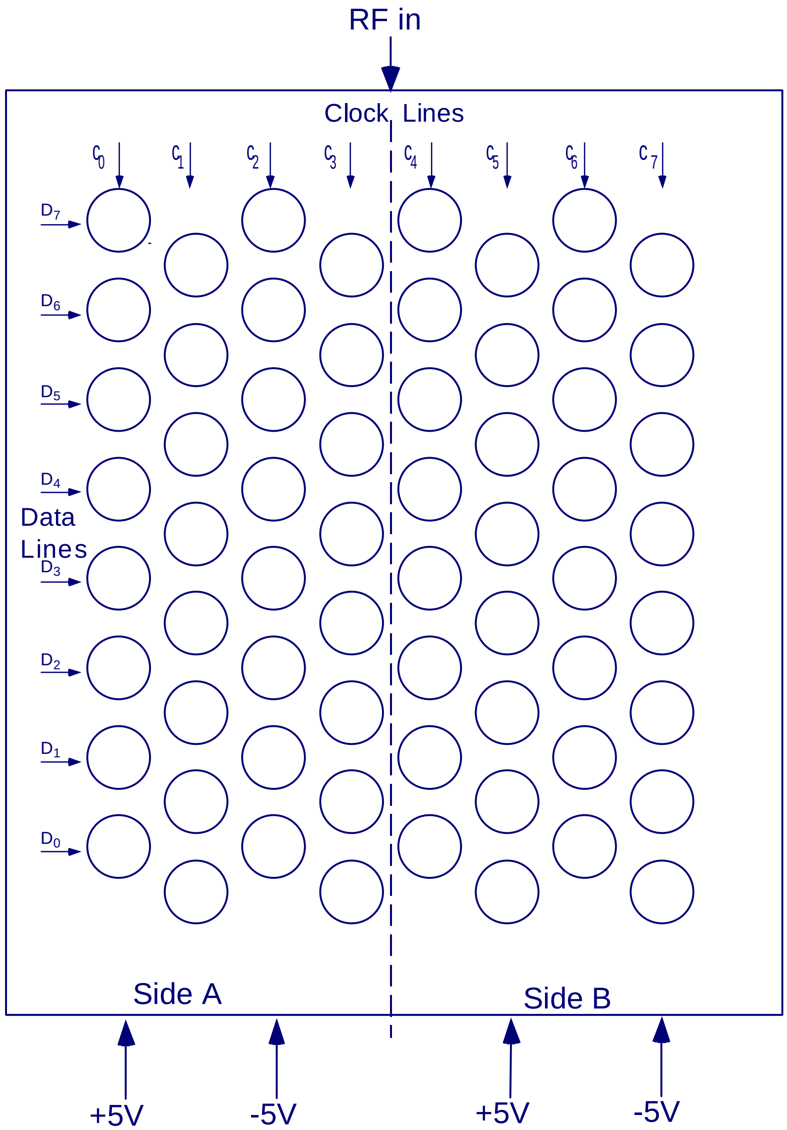


Figure 5.2-2. RF Module Array Diagram

5.3. RF Interface

Figure 5.3-1 shows the system RF allocations. The excitation is described in the Litton Exciter Specification, document number TBD. The input interface connector is a female SMA connector mounted at the center of the +Y face of the enclosure. The connector should be tightened to 6 ins-lbs.

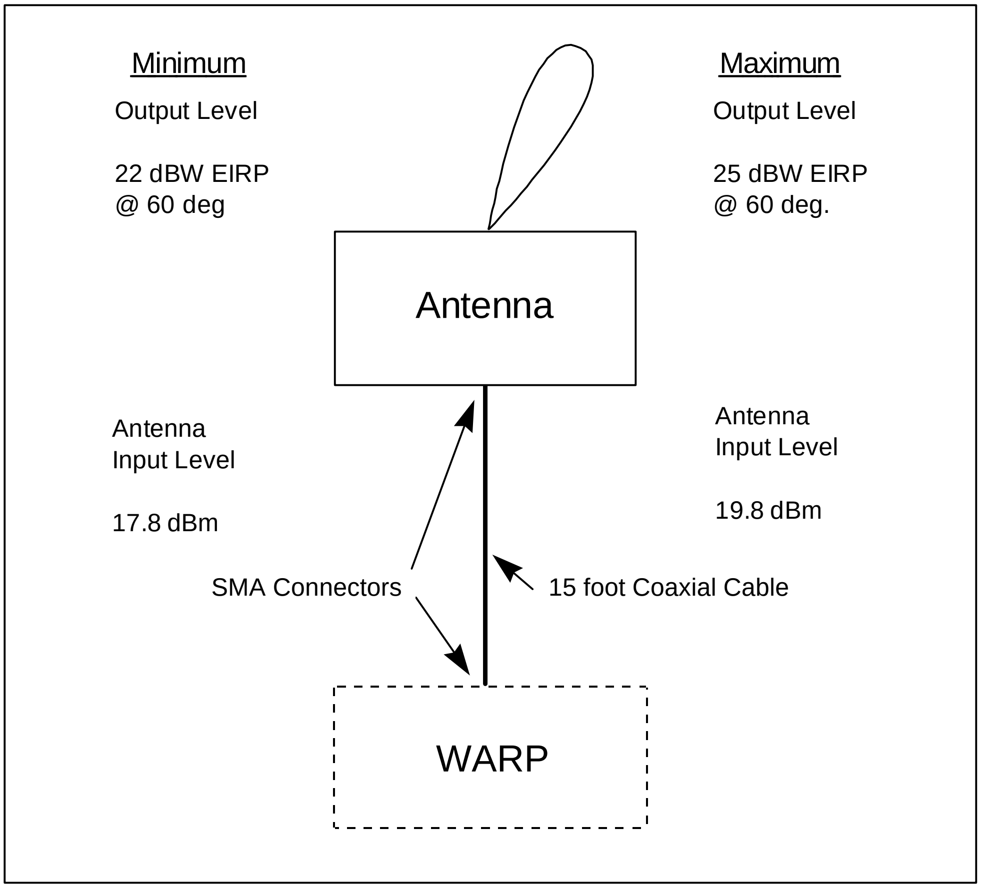


Figure 5.3-1. RF Allocations

5.4. Maximum RF Power into the Antenna

RF excitation power applied to the RF input connector (J1) must not exceed 500 mW or 27 dBm.

5.5. DC Power Requirements

The nominal dc power requirement is 44 W with a worst case of 60 W while transmitting. The antenna will operate over an input voltage range of 21 to 35 V with source impedance, transients, and ripple in accordance with the statement of work. The interface connector is J6, type 311P 409-1P and the pin assignment is shown in Table 5.9-2. When not transmitting, the ESN and 1773 interface draw approximately 3 watts.

5.6. Communications Interface

Command, pointing, and telemetry information is transmitted over a dual 1773 bus. The protocols are described in RSN ICD Document No. AM149-0050(155). The Output Optical Power for the 1773 Transceivers is -11 dBm (min) and -6 dBm (max). There is an insertion loss of 0.15 dBm (max.) associated with the fiber-optic coupler which needs to be subtracted from the output power.

5.7. Cabling Interface

The antenna cabling interface is described in the cable harness ICD Swales document No. TBD.

5.8. EMI/RFI

The antenna will satisfy conducted and radiated emission and conducted and radiated susceptibility requirements as specified in 737-EO1-SOW-XPAA.

5.9. List of Connectors

The antenna external interfaces are implemented with the connectors listed in Table 5.9-1. Connector pin outs are listed in Tables 5.9-2 - 5.9-4.

Connector Number	Connector Type	Pins Used	Description
J1	SMA	-	RF Excitation Input
J2	FC	Fiber	1773 Bus A Input
J3	FC	Fiber	1773 Bus A Output
J4	FC	Fiber	1773 Bus B Input
J5	FC	Fiber	1773 Bus B Output
J6	311-P409-1PB-15 9-Pin D-Type Male	1,5,6,9	28V Input Power
J7	311-P407-3S-B-15 44-Pin D-Type Female	TBD	Service Connector
J8	311-P407-3S-B-15 44-Pin D-Type Female	All	Test Connector

Table 5.9-1 Antenna Connectors

Pin Number	Signal	Description
1	28V in A	Switched +28 V Power from S/C
5	28V Return A	28 V Power Return
6	28V in B	Switched +28 V Power from S/C
9	28V Return B	28 V Power Return

Table 5.9-2 Connector J6 Pin-Outs

	TBD	

Table 5.9-3 Connector J7 Pin-Outs

Pin Number	Function	Description
1	CLK_0	Clock line 0
2	CLK_1	Clock line 1
3	CLK_2	Clock line 2
4	CLK_3	Clock line 3
5	CLK_4	Clock line 4
6	CLK_5	Clock line 5
7	CLK_6	Clock line 6
8	CLK_7	Clock line 7
9	PH_0	Phase line 0
10	PH_1	Phase line 1
11	PH_2	Phase line 2
12	PH_3	Phase line 3
13	PH_4	Phase line 4
14	PH_5	Phase line 5
15	PH_6	Phase line 6
16	PH_7	Phase line 7
17	+5V_EN_1	+5V Power supply 1 enable
18	+5V_EN_2	+5V Power supply 2 enable
19	-5V_EN_1	-5V Power supply 1 enable
20	-5V_EN_2	-5V Power supply 2 enable
21	+5V_ANT_1	Side 1 +5V power input
22	+5V_ANT_1	Side 1 +5V power input
23	+5V_ANT_1	Side 1 +5V power input
24	+5V_ANT_2	Side 2 +5V power input
25	+5V_ANT_2	Side 2 +5V power input
26	+5V_ANT_2	Side 2 +5V power input
27	-5V_ANT_1	Side 1 -5V power input
28	-5V_ANT_1	Side 1 -5V power input
29	-5V_ANT_2	Side 2 -5V power input
30	-5V_ANT_2	Side 2 -5V power input
31	28V_IN_F	28V Power monitor - IN
32	28V_RTN_F	28V Power monitor - RTN
33	GND	System ground
34	GND	System ground
35	GND	System ground
36	GND	System ground
37	GND	System ground
38	GND	System ground
39	GND	System ground
40	GND	System ground
41	GND	System ground
42	GND	System ground
43	GND	System ground
44	GND	System ground

Table 5.9-4 Connector J8 Pinouts

6. SOFTWARE INTERFACE

The software requirements are described in Boeing Software Specification Document No XPAA-093.

7. VALIDATION INTERFACE

7.1. List of Validation Functions

On orbit validation functions are described in the SOW. Housekeeping parameters recorded are voltages and currents supplied by each dc-to-dc converter, and the temperatures of the array baseplate and the ESN lid. Computation of the correct phases for a given θ and ϕ is verified by recording the 64 4-bit phase values transmitted to the 8 x 8 array together with the values of θ and ϕ received from the attitude control system.

7.2. Implementation of Validation Functions

7.2.1. Array Voltages

The +5V and -5V voltages supplied to each antenna array side are obtained by measuring the voltage at the array side of the resistor in series with dc to dc converter as shown in Figure 7.2-1.

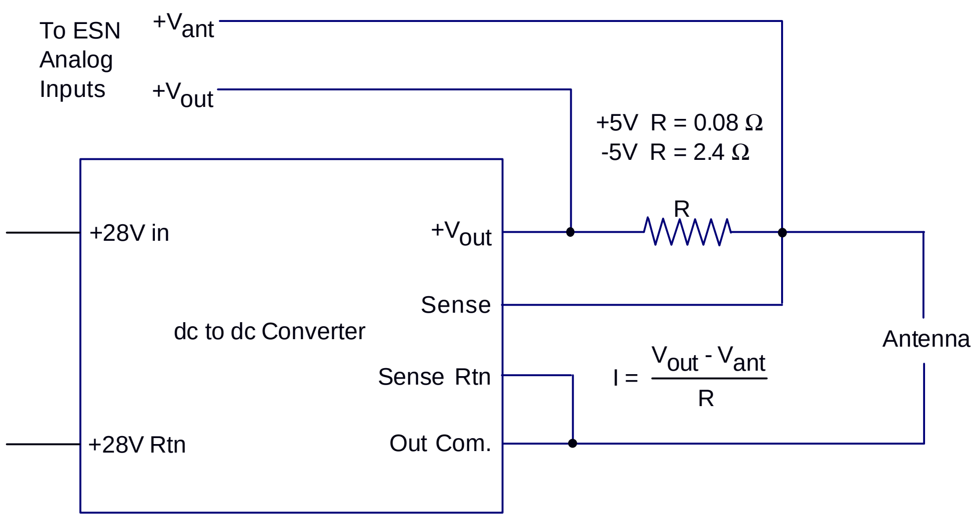


Figure 7.2-1. Antenna Power Supply Voltage Current Measurement Network

7.2.2. Array Currents.

The +5V and -5V currents supplied to each side antenna array are obtained as shown in Figure 7.2-1 by measuring the voltage drop across a resistor in series with the dc to dc converter and the antenna. The series resistors are chosen to provide a 2% precision current measurement assuming 0V to +10V, and +10V to -10V analog voltage ranges for the +5V and -5V lines respectively, and 12-bit A to D conversion.

7.2.3. Temperature Measurements

The temperatures of the center of the array pressure plate and the ESN lid will be measured using thermistors as shown in Figure 7.2-2.

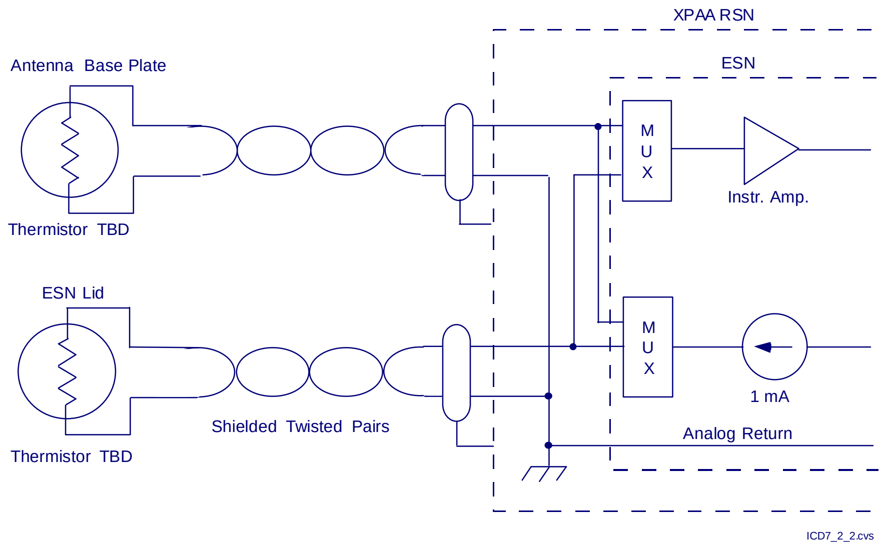


Figure 7.2-2. Temperature Measurement Interface

7.2.4. Phase Bit Verification

The contents of the memory array containing the 64 4-bit phase values (256 bits) will be retrieved and telemetered together with the commanded pointing angles. Further information as to formats is given in XPAA 093.

7.3. Ranges of Validation Functions

The expected values and acceptable ranges of the measured parameters are given in Figure 7.3-1. Possible failure modes that will be detected are also given.

Parameter	Expected Value	Acceptable Range	Failure Mode Identified
+5V Antenna Side A	5.0 V	+/- 0.1 V	Power supply/catastrophic hardware failure
+5V Antenna Side B	5.0 V	+/- 0.1 V	Power supply/catastrophic hardware failure
-5V Antenna Side A	-5.0 V	+/- 0.1 V	Power supply/catastrophic module failure
-5V Antenna Side B	-5.0V	+/- 0.1 V	Power supply/catastrophic module failure
Pos. Current Side A	3.0 to 3.9 A*	+/- 0.3 A$^+$	Module failure
Pos. Current Side B	3.0 to 3.9 A*	+/- 0.3 A$^+$	Module failure
Neg. Current Side A	-90 to -130 mA*	+/- 10 mA$^+$	Module failure, SEL
Neg. Current Side B	-90 to -130 mA*	+/- 10 mA$^+$	Module failure, SEL
Pressure Plate Temp.	10^{o}C above cold plate*	+2^{o}C > expected T	Module failure
ESN Lid Temp.	TBD	TBD	TBD
Phase Bit Array	Precalculated values	No variation	RSN failure, software error

Figure 7.3-1. Measured Parameter Values and Ranges

Notes

* =Nominal Values. Final values determined after integration and testing
$^+$ = Will depend upon array temperature
SEL = Single Event Latch-up

7.4. Telemetry Frequency

Housekeeping parameters are measured continuously including during antenna non-operating periods. Housekeeping data and phase values are telemetered to the spacecraft C&DH system every 8 seconds and telemetered to ground upon command.

7.5. RF Ground Test

7.5.1. Purpose

Functional testing of the antenna in the laboratory and in the thermal vacuum environment is required to verify general antenna performance. A test hood, which can be fitted over the antenna, has been designed and built. The hood comprises a stainless steel box lined with microwave absorbing material, and a probe to couple out a small fraction of the radiated energy. The hood will provide a measure the total power radiated by the antenna, but no pointing information.

7.5.2. Mechanical Design

A drawing of the hood, Figure 8.1-3 shows the aluminum enclosure, lid and probe. The inside of the enclosure and the inner surface of the lid are lined with Eccosorb SF microwave absorbing material previously outgassed by heating in an oven for 16 hours at 177 ^{o}C. A low outgassing adhesive, GE RTV 566 is used to attach the Eccosorb to the aluminum surface.

The hood is secured to the antenna by the two antenna mounting bolts in the center of the X edges. These bolts must first be removed, the hood mounted over the antenna, and the bolts replaced. The bolts should be torqued to 91 inch lbs. The RF cable must also be removed before mounting and replaced after mounting the hood.

Note: The mechanical configuration of the test hood requires that any MLI blankets around the sides of the antenna or on its mounting flange be removed prior to its installation.

7.5.3. Electrical Design

The probe in the center of the lid of the hood couples a small fraction of the radiated power. The connector is a UG-58A N-series female panel mount connector. The coupling coefficient is of the order of -20 dB. The value of the coefficient will be revised after final testing of the antenna at Boeing.

8. Antenna Mechanical Drawings

8.1. Antenna Mechanical Drawings

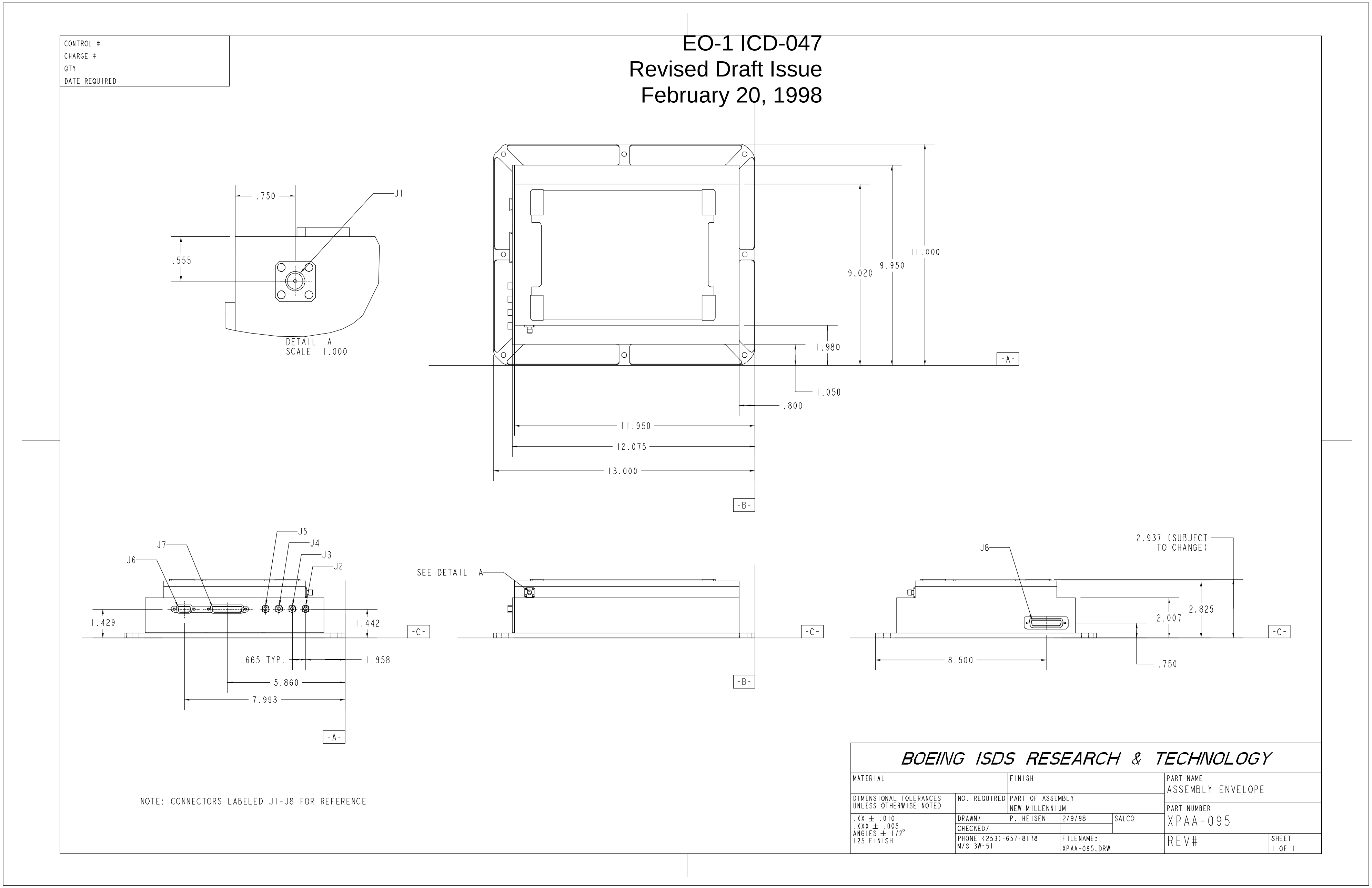


Figure 8.1-1 Antenna Mechanical Drawing

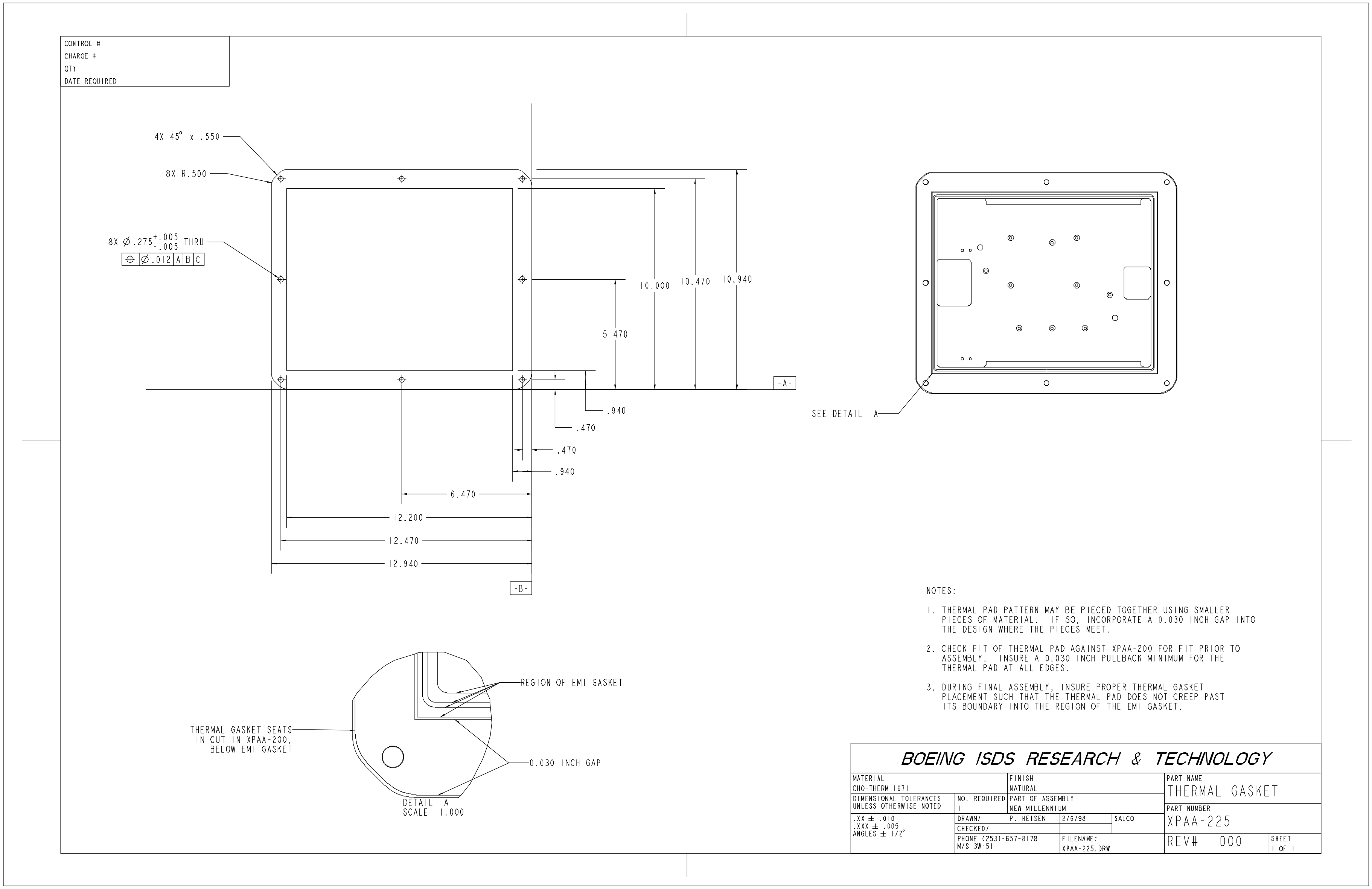


Figure 8.1-2. Antenna Footprint

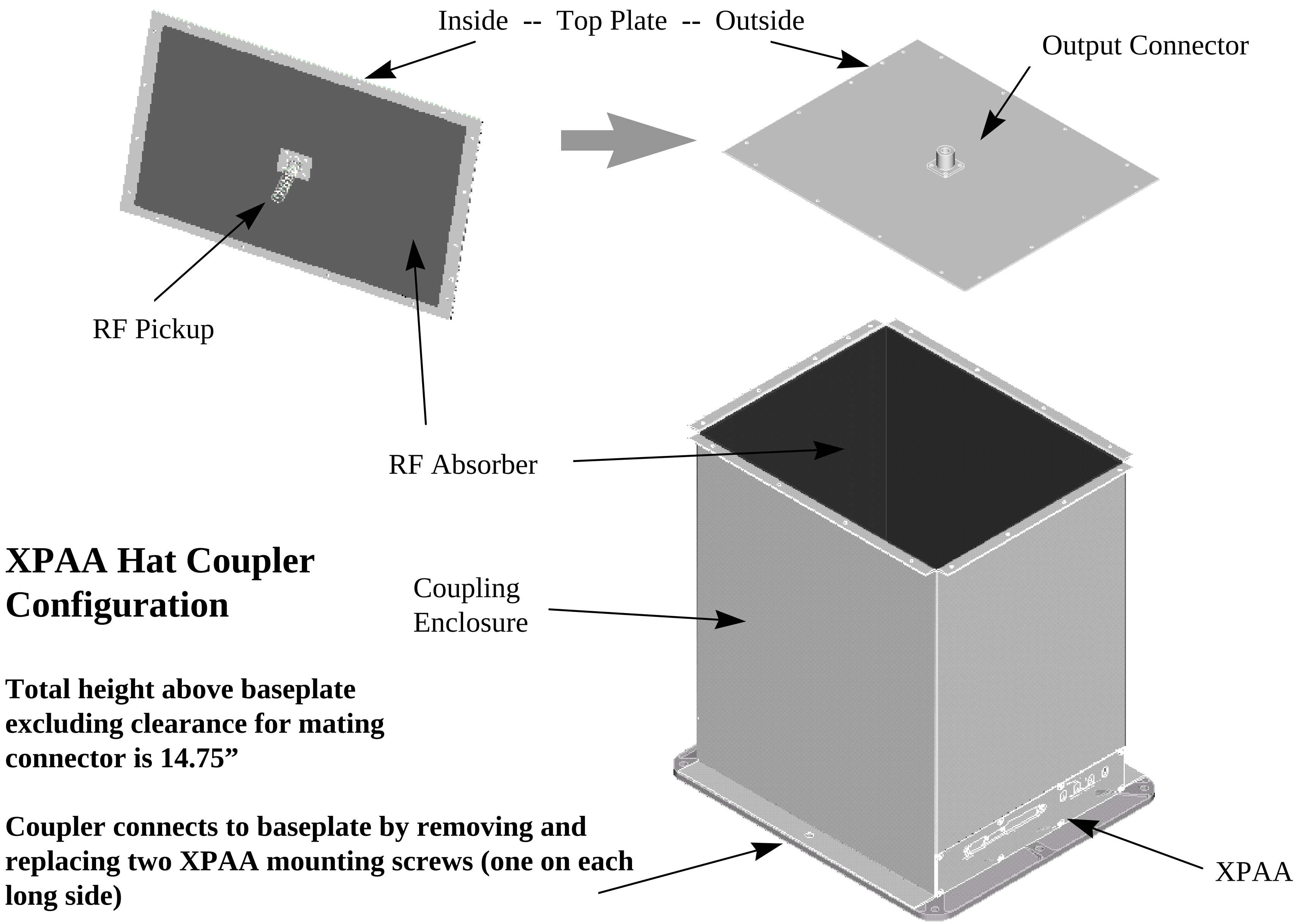


Figure 8.1-3. Test Hood

Date: Tue, 10 Mar 1998 08:52:12 -0500 (Eastern Standard Time)
From: Administrator@hst-nic.hst.nasa.gov
Reply-to: (Nicholas Speciale)
Subject: CCR:0004 - DUE: 01/19/98   ROUTINE Level-2 Nicholas Special WWW-COMMENTS

USER :   (Nicholas Speciale) sent the following comments on :

Date: 03/10/1998
CCR Number: 0004
Sponsor: K. Perko/NMP-XPAA Lead
Due Date: 01/19/98

CCR Title: BASELINE EO-1 X-BAND PHASED ARRAY ANTENNA SYSTEM ICD-047

Remote host: 128.183.212.178 Email Address:

APPROVAL STATUS: APPROVED
Note:

COMMENTS:

EO-1 CCR SPONSOR RECOMMENDATION FORM

CCR NUMBER: 0004R1
CCR TITLE: B/LEO-1 X-BAND PHASED ARRAY ANTENNA SYS

CCR SPONSOR: K.PERKO

SUMMARY OF COMMENTS RECEIVED: (list Level 4 CCB and internal reviewers who had comments and address those comments)

NONE

SPONSOR RECOMMENDATION: (Make changes to document where indicated, reference Sponsor Comments for changes to be implemented.)

COMMENTS: Approve as written.

Approve ___X___Approve with Change __________Disapprove_________

SPONSOR/ORGANIZATION: K. PERKO
DATE: 4/9/98