T^{2}CAS FCC Compliance Test Report

CAGE Code	Initial Release Date	Revision Date	Document Number	Revision
1WYD3	4 Feb-03		8000709-001	**-**

Record of Revisions

Rev	Date	Authorization	Description of Change
-	4-Feb-03	N/A	Initial Release

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1 INTRODUCTION

T²CAS (Traffic and Terrain Collision Avoidance System) is an integrated system that provides TCAS-II, Terrain Awareness Warning System (TAWS), Reactive Windshear and GPS functions in a single LRU. The model TT-95x T²CAS units (ACSS Part Number 9000000-xx001) are based on the predecessor TCAS-2000 unit. The model TT-95x units are either 4MCU or 6MCU sized units that meet the ARINC-735 form factor requirements and are intended for the Air Transport market (see Table 1).

The model TT-950 and TT-952 units will accept both 115Vac 400 Hz and 28Vdc power inputs, while the model TT-951 unit accepts only 28 Vdc DC power input. The TT-95x units will work in un-pressurized environments. For further information on the T²CAS family of products, please refer to ACSS document 8000072-001, T²CAS Product Specification.

This document provides the FCC compliance test plan and procedures for the model TT-950 and TT-952 T²CAS units.

2 APPLICABLE T²CAS UNIT PART NUMBERS

This document shall be applicable to the following T²CAS unit model numbers/part numbers:

Model	ACSS Part Number	TAWS I/O	Internal GPS	Unit Size
TT-950	9000000-10001	Digital & Analog	No	6MCU
TT-952	9000000-20001	Digital & Analog	Yes	6MCU
AP-950	9000001-10001	-	-	ARINC 607 Type 2

Table 1: T²CAS model numbers/part numbers and key characteristics

2.1 References

Applicable industry and regulatory documents are listed here. Unless otherwise specified, all references are to the document revision levels listed here.

2.1.1 FAA Documents

Directive 8110.4B — Type Certification. April 24, 2000

AC No. 20-131A — Airworthiness and Operational Approval of Traffic Alert and Collision Avoidance Systems. March 29, 1993.

TSO-C117a — Airborne Windshear Warning and Escape Guidance Systems for Transport Airplanes.

TSO-C119b — Traffic Alert and Collision Avoidance System Airborne Equipment (TCAS-II). 14 October 1988.

TSO-C129a — Airborne Supplemental Navigation Equipment using Global Positioning System (GPS).

TSO-C151a — Terrain Awareness and Warning System.

2.1.2 RTCA Documents

RTCA DO-160D — Environmental Conditions and Test Procedures for Airborne Equipment. July 29, 1997.

RTCA DO-160D Change 1 — Change No. 1 to Environmental Conditions and Test Procedures for Airborne Equipment. December 14, 2000

RTCA DO-160D Change 2 — Change No. 2 to Environmental Conditions and Test Procedures for Airborne Equipment. June 12, 2001

RTCA DO-185A — Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment. December 16, 1997.

2.1.3 ARINC Documents

ARINC-735A	Traffic Alert and Collision Avoidance System (TCAS).

2.1.4 FCC Documents

CFR Title 47	Code of Federal Regulations - Telecommunications
Chapter 1	Federal Communications Commission
Part 2	Frequency Allocations and Radio Treaty Matters; General Rules and Regulations
Subpart J	Equipment Authorization Procedures
	Revised as of October 1, 2001

CFR Title 47	Code of Federal Regulations - Telecommunications
Chapter 1	Federal Communications Commission
Part 15	Radio Frequency Devices
Subpart A	General
	Revised as of October 1, 2001

CFR Title 47	Code of Federal Regulations - Telecommunications
Chapter 1	Federal Communications Commission
Part 87	Aviation Services
Subpart D	Technical Requirements
	Revised as of October 1, 2001

2.1.5 ACSS Documents

T²CAS Model TT-952 End Item Assembly Drawing	9000000-20001
T²CAS Model TT-952 Circuit Card Assembly - A1 Interconnect	9000005-001
T²CAS Model TT-952 Circuit Card Assembly - A2 TCAS Processor	7517925-903
T²CAS Model TT-952 Circuit Card Assembly - A3 TCAS Transmitter	7517935-902
T²CAS Model TT-952 Circuit Card Assembly - A4 Power Supply	9000015-001
T²CAS Model TT-952 Circuit Card Assembly - A5 TCAS Receiver I/O	7517945-903
T²CAS Model TT-952 Circuit Card Assembly - A7 TAWS Processor	9000020-001
T²CAS Model TT-952 Circuit Card Assembly - A8 GPS	9000025-001
T²CAS Automated Test Procedures	8000253-001
TCAS2000 Integrated Test Specification	IT7517900
T²CAS Product Specification	8000072-001
T²CAS System Description and Installation Manual	8000451-001
Labels for T²CAS/APM	9000299-001

2.2 Acronyms and Abbreviations

AC	Advisory Circular
CFR	Code of Federal Regulations
CMC	Canadian Marconi Corporation
CS	Conducted Susceptibility
EB	Engineering Bulletin

EMI	Electromagnetic Interference
ESS	Environmental Stress Screen
ESD	Electrostatic Discharge
EUT	Equipment Under Test
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
GPS	Global Positioning System
HIRF	High Intensity Radiated Fields
LISN	Line Impedance Stabilization Network
MOPS	Minimum Operational Performance Standards
NTS	National Technical Systems
RF	Radio Frequency
RFI	Radio Frequency Interference
RS	Radiated Susceptibility
RTCA	Radio Technical Commission for Aeronautics
TAWS	Terrain Avoidance Warning System
TCAS	Traffic Alert and Collision Avoidance System
T^{2}CAS	Traffic and Terrain Collision Avoidance System
TSO	Technical Standard Order
UUT	Unit Under Test

3 GENERAL INFORMATION

3.1 TYPE DESIGNATION

The equipment has been designated by ACSS as models TT-95x T²CAS Computer Units, P/Ns 9000000-20001 (TT-952), 9000000-55001 (TT-951), 9000000-1001 (TT-950).

3.2 SERVICE AND RULE FOR INTENDED OPERATION

Air Traffic Control
Part 87, Subpart A

3.3 DESCRIPTION OF EQUIPMENT

3.3.1 TAWS/Windshear Functionality

The TAWS/Windshear function is implemented as an independent processor and I/O circuitry from the TCAS function. The TAWS/Windshear circuitry is contained on a unique circuit card assembly (CCA), which is added to the existing TCAS-2000 unit design in a spare card slot

The TAWS function uses vertical speed, ground speed, track angle, flight path angle, latitude, longitude, flap status, steep approach status, static air temperature, roll angle, pressure altitude system inputs. A database, which includes terrain data, airport data, aircraft performance data and climb rate models, is used for the determination of the alerts and display of terrain information.

The TAWS/Windshear CCA will also provide a reactive windshear alert which meets the requirements of TSO-C117a. The windshear alert is active during take-off and final approach phases and produces aural and visual annunciations. The windshear alert measures vertical and horizontal components of air mass accelerations and determines if a windshear caution or warning should be generated. Windshear alert is not yet implemented; however, all current circuitry and processor will be utilized.

3.3.2 GPS Functionality

The GPS function is hosted on a self-contained GPS receiver built by Canadian Marconi. The GPS card is connected to an antenna that receives RF transmissions from the Global Position System satellites in orbit around the earth. The GPS card processes the received data and is able to calculate the position of the antenna (and therefore the aircraft) by means of triangulation. From the calculated latitude, longitude, and altitude, the GPS function can calculate velocities and accelerations as well. The data calculated by the GPS function is transmitted over an A429 bus to both the TAWS card and to other systems in the aircraft. The GPS outputs data per the ARINC 743A characteristic. The outputs consist of an ARINC 429 output, GPS Time Mark Output, and GPS Validity discrete output.

3.3.3 TCAS Functionality

3.3.3.1 Type of Emission

18MOP1D

3.3.3.2 Frequency Range

1030 + 0.01 MHz

3.3.3.3 Power Rating

0.4 to 500 Watts Peak Effective Radiated Power (Pulsed)

3.3.3.4 Final Power Amplifier

Solid State Balanced Amplifier (Class C) using two Motorola MRF10501 silicon bipolar transistors.

3.3.3.5 Active Device Functions

Function		Device Type	Manufacturer
Oscillator			
	Temperature Compensated Crystal Oscillator (TCXO)	6206	Oscillatek
	Microwave Low Noise Transistor--Amplifier	AT-41511	HP
Transmitter			
	Monolithic Amplifier .1 Watt, Microwave Pulse Power	VNA – 25	Mini-Circuit

Function		Device Type	Manufacturer
Transmitter	Transistor--Amplifier, 1 watt Microwave Pulse Power	MRF1000MB	Motorola
	Transistor--Amplifier, 5 watt Microwave Pulse Power	MRF10005	Motorola
	Transistor--Amplifier, 30 watt Microwave Pulse Power	MRF10031	Motorola
	Transistor--Amplifier, 150 watt Microwave Pulse Power	MRF10120	Motorola
	Transistor--Amplifier,	MRF10502 (2 ea)	Motorola

500 watt

Pulse Modulator			
	N Channel FET Modulator	IRFR220	Motorola
	N Channel FET Envelope Modulator	IRFR9220	International Rectifier
DPSK Modulator			
	NPN Transistor (1) Modulator	BSR14	Generic
	NPN Transistor (2) Modulator	BSR16	Generic

3.3.4 Circuit Diagram

A block diagram and schematics will be provided with the FCC Form 731 when the application for certification is filed with the FCC.

3.3.5 Instruction Book

An ACSS document, System Description and Installation Manual, 8000451-001, provides instructions for the proper installation of the T2CAS computer on a given aircraft.

3.3.6 Tune-up Procedure

No field tuning is required. Alignment is performed in the factory.

3.3.7 Oscillator Circuit

The 1030 MHz source consists of the following: 1.) a phase locked oscillator (PLO) is locked to a Temperature Compensated Crystal Oscillator (TCXO). The TCXO provides the required frequency stability for the 1030 MHz source. 2.) the output of the PLO is fed to a prescaler divider, which in turn provides the input to a multiplier circuit. 3.) the output of the multiplier is band pass filtered, and then amplified and distributed to both the receiver and transmitter circuits.

3.3.8 Frequency Stabilization

Temperature Compensated Crystal Oscillator (TCXO).

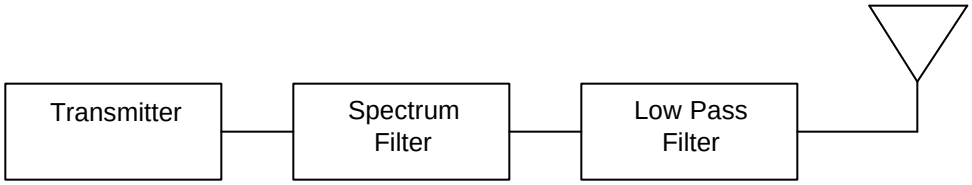
3.3.9 Modulation Limiting

Not Applicable

3.3.10 Radiated Interference Suppression

At the output of the transmitter is a two-pole high power cavity filter designed to attenuate spurious created by the DPSK modulation. This filter also offers good rejection of the even

harmonics of the carrier. Following the high power cavity filter is a five pole reflective microstrip low pass filter designed for maximum rejection of the 2nd through 9th harmonics of the carrier



The spectral output of the 1030 MHz transmitter will be limited to the following schedule:

Frequency difference (MHz from carrier)	Relative power (dB below maximum)
≥ 4, < 6	6
≥ 6, < 8	11
≥ 8, < 10	15
≥ 10, < 20	19
≥ 20, < 30	31
≥ 30, < 40	38
≥ 40, < 50	43
≥ 50, < 60	47
≥ 60, < 90	50
≥ 90	60

4 MODULATION DETAILS

4.1 ATCRBS Interrogations.

Interrogations are sent out on an intentionally jittered 1+0.2 second interval in increasing power levels according to the schedules shown in Table 4, Table 5, and Table 6. By transmitting the weakest signals first only the closest aircraft will reply. The interrogations progress in a roughly circular pattern weighted toward the front of the aircraft since that is the area from which the greatest closing speeds originate. In areas of high density the sequence is halted when the computer has reached a limit defined by a complex set of three inequalities. In this manner, interference to other TCAS equipped aircraft in the area is minimized since the strongest interrogations are the first to be dropped. The priority of elimination of steps for interference limiting is also shown in Table 4, Table 5, and Table 6. This priority is inversely related to the order of the step sequence.

Pulse Widths:	0.8 + 0.05 usec
Rise Times (10% to 90%):	≥ 0.05 usec., < 0.1 usec
Fall Times (90% to 10%):	≥ 0.05 usec., < 0.2 usec

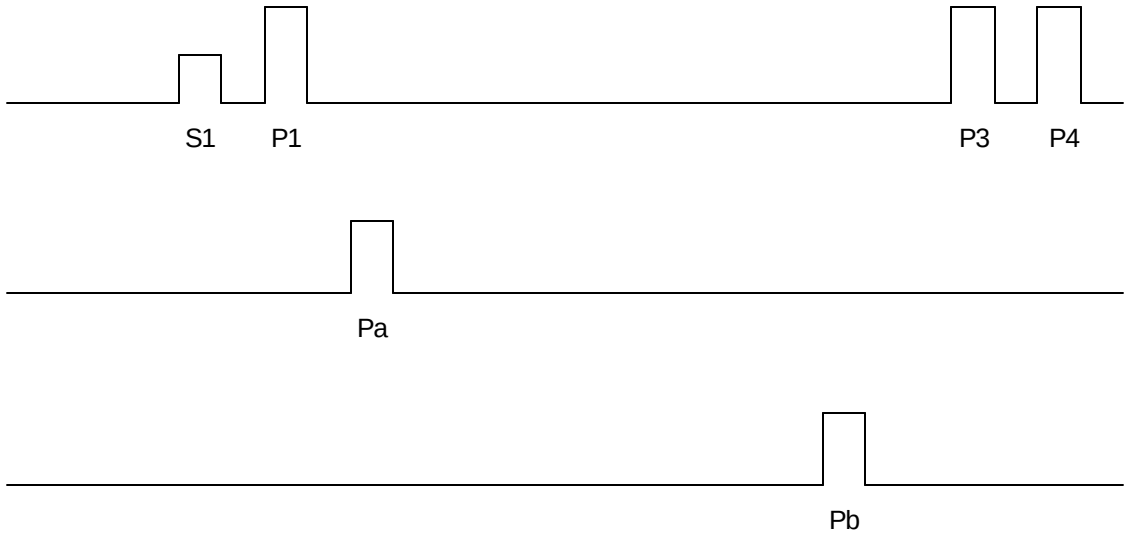


Figure 1: ATCRBS Interrogations

Pulses P1, P3, and P4 will appear in all interrogation steps of the whisper / shout sequence and will be at the same power level. Pulse S1 will appear in all steps except the initial step on each antenna direction and at a level two or three dB below the level of P1, etc. according to the schedules shown in Figures 1 through 3. The steps occur at intervals of two milliseconds until the entire program is complete. The program length depends upon the individual aircraft installation. Options are available from using either an omni-directional bottom antenna or adirectional bottom antenna. The top antenna is always directional. Pulses Pa and Pb are transmitted on the antenna. They are used for suppression of sensitivity of the receiving aircraft to the indicated pulses:

S1 = -2 microseconds
P1 = 0 microseconds
PA = 2 microseconds
PB = 19 microseconds
P3 = 21 microseconds
P4 = 23 microseconds

4.2 Mode S Interrogations

Details of the Mode S interrogations are shown in Figure 2 below. The preamble and the synchronizing phase reversal (SPR) will appear the same in all interrogations. The data block will be either 56 or 112 chips of 0.25 microseconds, depending upon the type of reply desired. The data chips will be reversed phase from their previous chips if their data bid are 1, they will remain the same phase as the previous chips is their data bits are 0. The allowable transition time of the phase reversals is a maximum of 80 nanoseconds. The Mode S interrogations are transmitted after the whisper/shout sequence of ATCRBS interrogations. When no Mode S equipped aircraft are replying, the TCAS CU sends out Mode S broadcast interrogations based upon a 10 second pattern with 2 or 3 seconds between transmissions on the four lobes of the antenna. The time remaining after the Mode S transmissions are completed is used as a listening period for other unacquired aircraft.

- Preamble Pulse Widths: 0.8 + 0.05 usec
- Rise Times (10% to 90%): < 0.1 usec
- Fall Times (90% to 10%): < 0.2 usec

Figure 2: Mode S Interrogations

Timing of the Mode S interrogations is as follows, referenced to the leading edge of the P1 pulse:

P1	0.0 microseconds
P2	2.0 microseconds
P6	3.5 microseconds
SPR	4.75 microseconds
Bit 1	5.25 microseconds
End P6	19.75 microseconds (56 bits) 33.75 microseconds (112 bits)

Table 2: Mode S Interrogation Timing

Nominal Power Levels (dB relative to full power)		
Level	**P1,P3, P4 Pulses**	**S1 Pulse**
00	-13	-16
01	-15	-18
02	-17	-20
03	-19	-22
04	-21	-24
05	-23	-26
06	-25	none

Table 3: Mode S Interrogations, Omni-Directional Antenna

Directional Antenna			
Nominal Power Levels (dB relative to full power)			
Level	**P1,P3, P4**	**S1 Pulse**	**Pa, Pb Pulse**
D0	0	-3	-2
D1	-1	-3	-3
D2	-2	-5	-4
D3	-3	-5	-5
D4	-4	-7	-6
D5	-5	-7	-7
D6	-6	-9	-8
D7	-7	-9	-9
D8	-8	-11	-10
D9	-9	-11	-11
D10	-10	-13	-12
D11	-11	-13	-13
D12	-12	-15	-14
D13	-13	-15	-15
D14	-14	-17	-16
D15	-15	-17	-17
D16	-16	-19	-18
D17	-17	-19	-19
D18	-18	-21	-20
D19	-19	-21	-21
D20	-20	-23	-22
D21	-21	-23	-23
D22	-22	-25	-24
D23	-23	-25	-25
D24	-24	-27	-26
D25	-25	-27	-27
D26	-26	--	-16 (P4 only)

Table 4: Mode S Directional Antenna Interrogation Transmission Levels

Bottom Omni-Directional Antenna			
Interference Limiting Priority / Interrogation Level			
98 / 06			
97 / 05			
96 / 04			
95 / 03			
94 / 02			
93 / 01			
92 / 00			
Top Directional Antenna			
Interference Limiting Priority / Interrogation Level			
0'	**180'**	**90'**	**270'**
91 / D26	-	-	-
90 / D25	-	-	-
89 / D24	-	-	-
88 / D23	-	87 / D26	86 / D26
85 / D22	-	84 / D25	83 / D25
82 / D21	-	81 / D24	80 / D24
79 / D20	-	78 / D23	77 / D23
76 / D19	-	75 / D23	74 / D22
73 / D18	72 / D26	71 / D21	70 / D21
69 / D17	68 / D25	67 / D20	66 / D20
65 / D16	64 / D24	63 / D20	62 / D19
61 / D15	60 / D23	59 / D18	58 / D18
57 / D14	56 / D22	55 / D17	54 / D17
49 / D12	48 / D20	47/ D15	46 / D15
45 / D11	44 / D19	43 / D14	42 / D14
41 / D10	40 / D18	39 / D13	38 / D13
37 / D9	36 / D17	35 / D12	34 / D12
33 / D8	32 / D16	31 / D11	30 / D11
29 / D7	28 / D15	27 / D10	26 / D10
25 / D6	24 / D14	23 / D9	22 / D9
21 / D5	20 / D13	19 / D8	18 / D8
17 / D4	16 / D12	15 / D7	14 / D7
13 / D3	12 / D11	11 / D6	10 / D6
9 / D2	8 / D10	7 / D5	6 / D5
5 / D1	4 / D10	3 / D4	2 / D4
1 / D0	-	-	-

(Interrogation sequence is right to left, top to bottom)

Table 5: Top Directional / Bottom Omni-Directional Interrogation Sequence

Interference Limiting Priority / Interrogation Level							
Top Directional Antenna				**Bottom Directional Antenna**			
0'	**180'**	**90'**	**270'**	**0'**	**180'**	**90'**	**270'**
113 / D26	-	-	-	112 / D26	-	-	-
111/ D25	-	-	-	-	110 / D25	-	-
109/ D24	-	-	-	108 / D24	-	-	-
107/ D23	-	-	-	106 / D23	-	-	-
-	-	105 / D26	104 / D26	-	-	103 / D26	102 / D26
101 / D22	-	-	-	100 / D22	-	-	-
-	-	99 / D25	98 / D25	-	-	97 / D25	96 / D25
95 / D21	-	-	-	94 / D21	93 / D26	-	-
-	-	92 / D24	91 / D24	-	-	90 / D24	89 / D24
88 / D20	-	-	-	87 / D20	86 / D25	-	-
-	-	85 / D23	84 / D23	-	-	83 / D23	82 / D23
81 / D19	-	-	-	80 / D19	79 / D24	-	-
-	-	78 / D22	77 / D22	-	-	76 / D22	75 / D22
74 / D18	-	-	-	73 / D18	-	-	-
-	72 / D26	71 / D21	70 / D21				
69 / D17	68 / D25	67 / D20	66 / D20				
65 / D16	64 / D24	63 / D19	62 / D19				
61 / D15	60 / D23	59 / D18	58 / D18				
57 / D14	56 / D22	55 / D17	54 / D17				
53 / D13	52 / D21	51 / D16	50 / D16				
49 / D12	48 / D20	47 / D15	46 / D15				
41 / D10	40 / D18	39 / D13	38 / D13				
37 / D9	36 / D17	35 / D12	34 / D12				
33 / D8	32 / D16	31 / D11	30 / D11				
29 / D7	28 / D15	27 / D10	26 / D10				
25 / D6	24 / D14	23 / D9	22 / D9				
21 / D5	20 / D13	19 / D8	18 / D8				
17 / D4	16 / D12	15 / D7	14 / D7				
13 / D3	12 / D11	11 / D6	10 / D6				
9 / D2	8 / D5	7 / D5	6 / D5				
5 / D1	4 / D9	3 / D4	2 / D4				
1 / D0	-	-	-	Interrogations for each sector that has a TA or RA present .			
				1/ D17	1 / D23	1 / D21	1 / D21
				1 / D16	1 / D22	1 / D20	1 / D20
				1 / D15	1 / D21	1 / D19	1 / D19
				1 / D14	1 / D20	1 / D18	1 / D18
				1 / D13	1 / D19	1 / D17	1 / D17
					1 / D18	1 / D16	1 / D16
					1 / D17	1 / D15	1 / D15
					1 / D16	1 / D14	1 / D14
					1 / D15	1 / D13	1 / D13
					1 / D14		
					1 / D13		

(Interrogation sequence is right to left, top to bottom)

Table 6: **Top Directional / Bottom Directional Interrogation Sequence**

5 DRAWINGS AND PHOTOGRAPHS

5.1 Drawings

Refer to Paragraph 2.1.5 for a list of ACSS drawings that will be furnished with the application.

5.2 Photographs

Photographs of the T²CAS unit illustrating the assembly drawings are listed below. All original photographs are available for inspection.

Figure Number	View
Figure 3	Unit Front Name Plate
Figure 4	Unit Front With Name Plate Showing
Figure 5	Unit Rear With ARINC Connector
Figure 6	View of Unit Side, Cover Removed, and Showing A8 GPS and A5 Receiver – I/O Assembly
Figure 7	View of Unit Side With A7 TAWS Processor Showing
Figure 8	View of Unit Side, A7 TAWS Removed, ShowingA2 Processor
Figure 9	View of Unit Side, A8 GPS Removed, Showing A5 Receiver - I/O Assembly with Shield
Figure 10	View of Unit Side With A5 Receiver Hinged Outward, Showing A4 Power Supply/Modulator Assembly
Figure 11	View of Unit Side with A2 Processor Removed Showing A3 Transmitter Assembly With Cover
Figure 12	View of Unit Side, A5 Receiver and Front Panel Removed, Showing A4 Power Supply/Modulator Assembly
Figure 13	View of Unit Side, A4 Power Supply/Modulator Assembly Removed, Showing A1 Interconnect Assembly
Figure 14	View of A3 Transmitter Assembly With Shield Removed
Figure 15	A8 GPS Card With Bracket Attached
Figure 16	View of A5 Receiver – I/O Assembly with Shield Removed. Side A
Figure 17	View of A5 Receiver – I/O Assembly with Cover Removed. Side B
Figure 18	View of A7 TAWS Processor With Bracket Attached

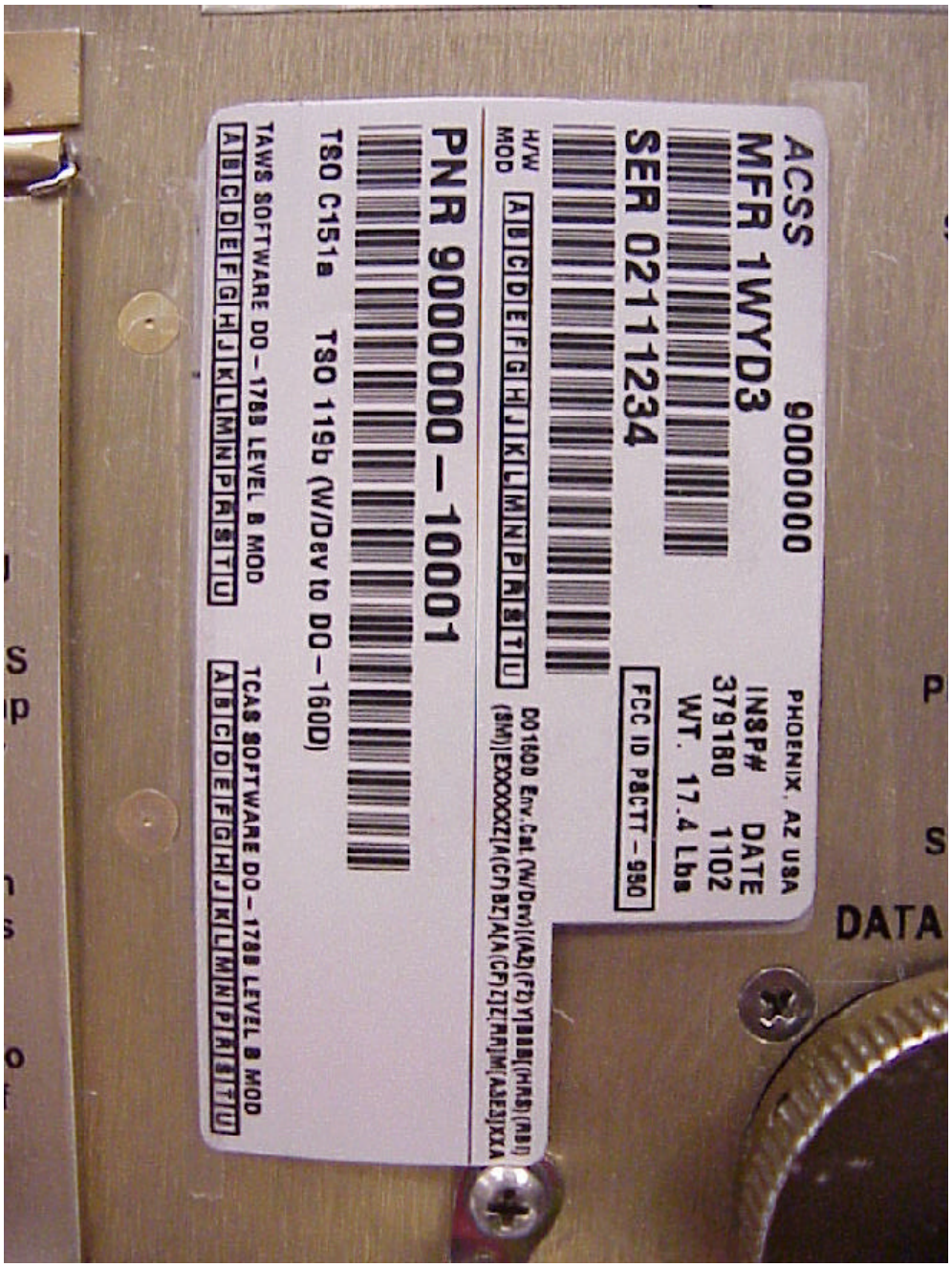


Figure 3: Unit Front Name Plate

Figure 4: Unit Front With Name Plate Showing

Figure 5: Unit Rear With ARINC Connector

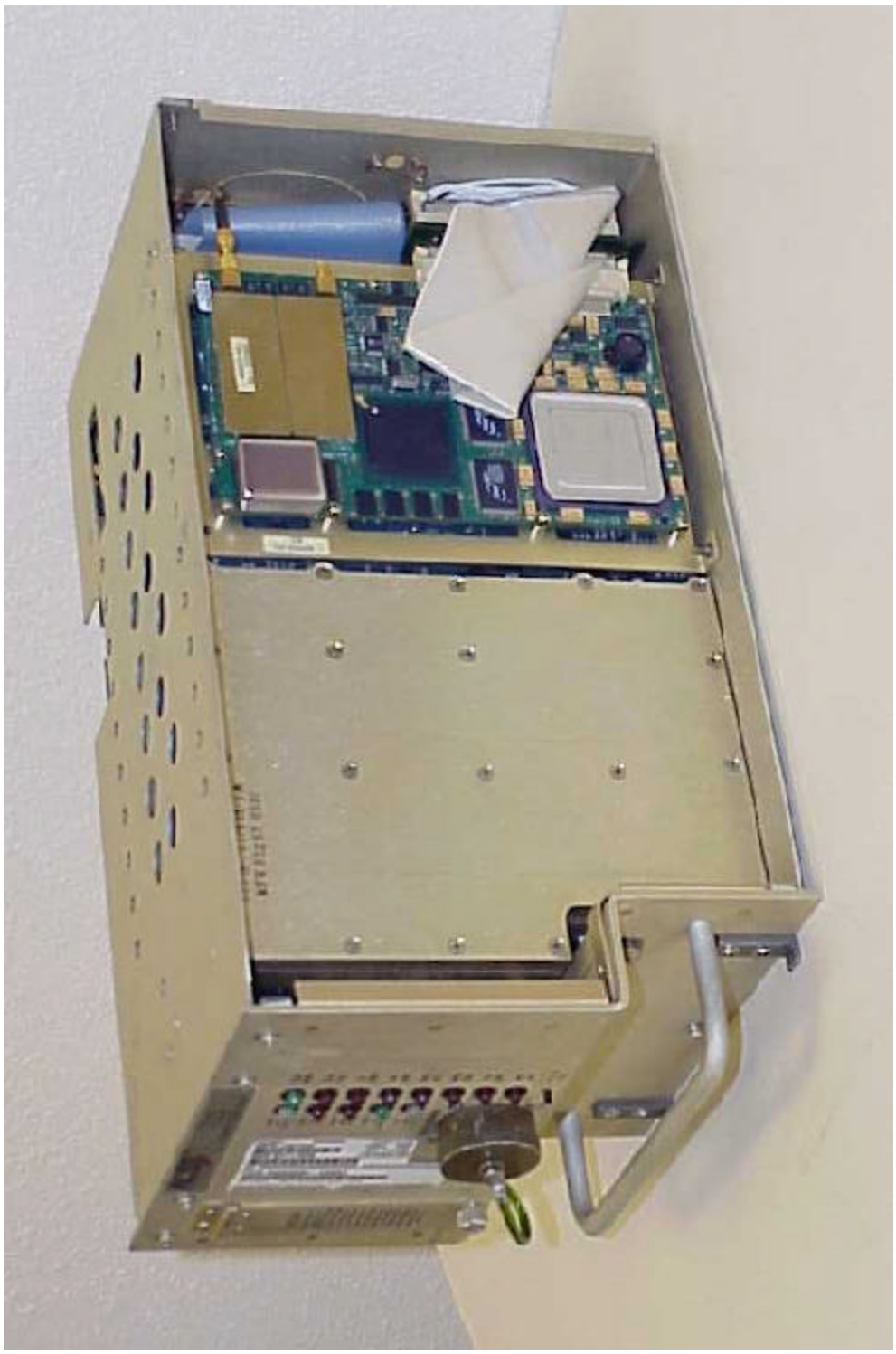


Figure 6: View of Unit Side, Cover Removed, Showing A8 GPS and A5 Receiver – I/O Assembly

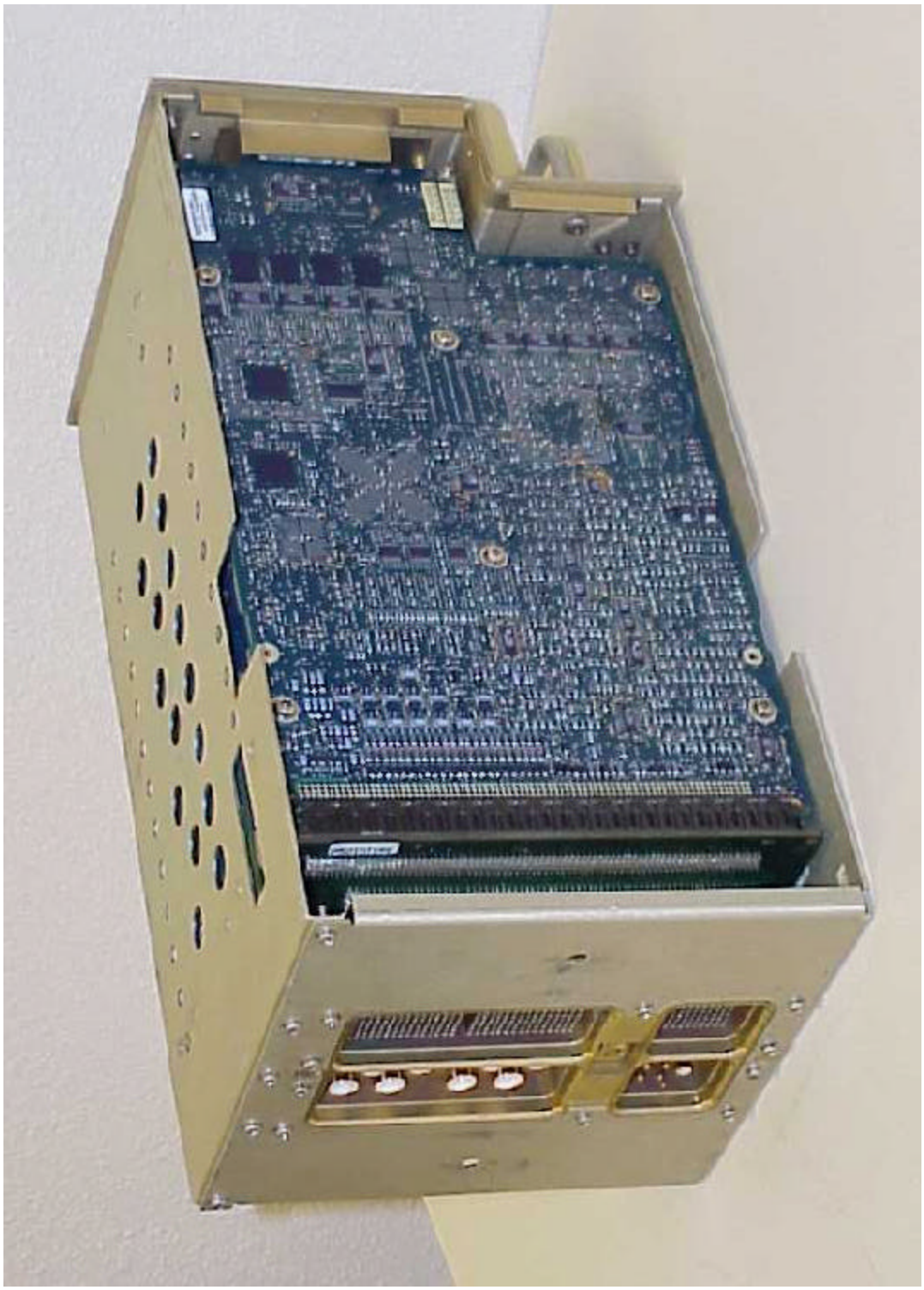


Figure 7: View of Unit Side With A7 TAWS Processor Showing

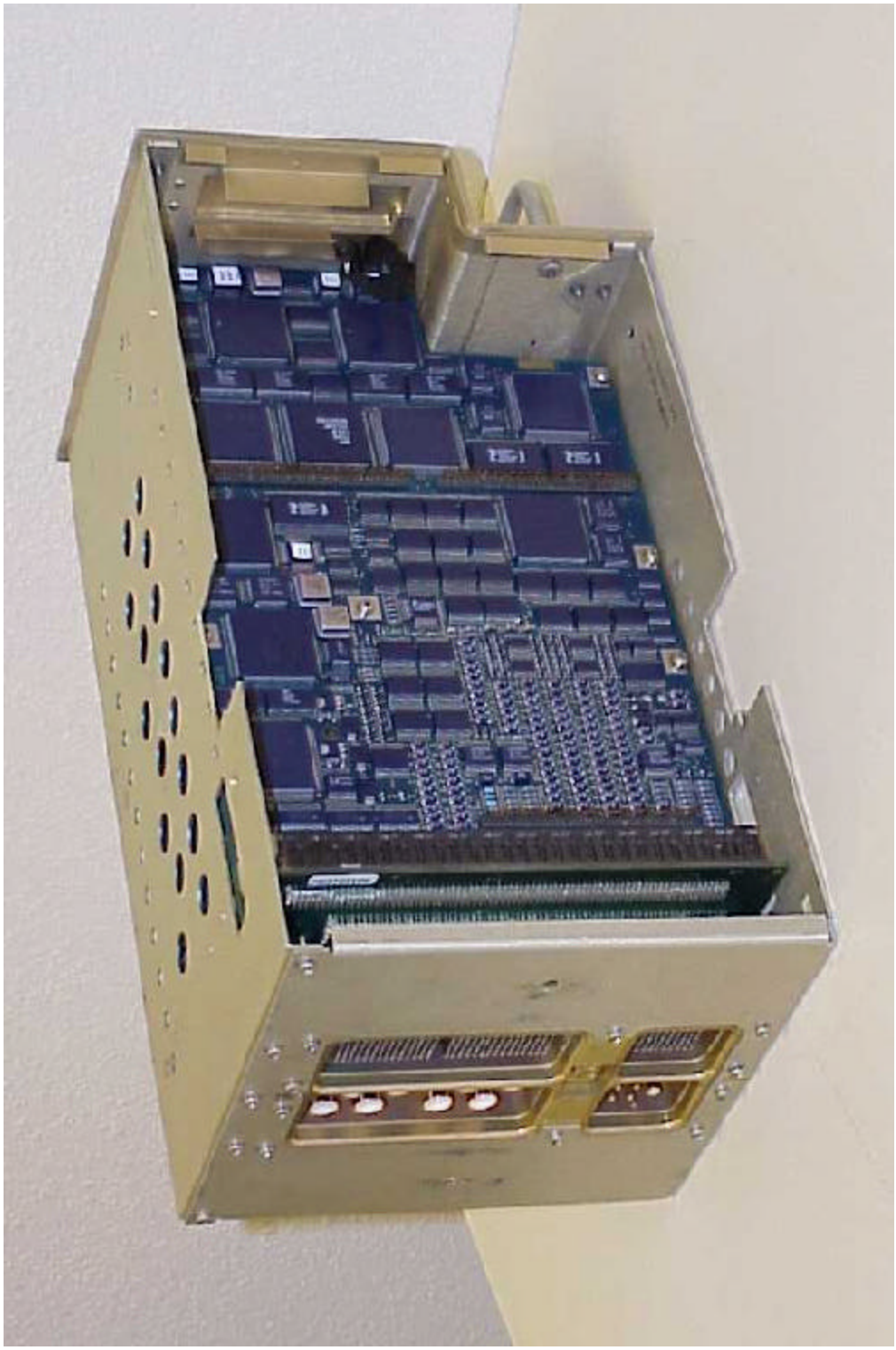


Figure 8: View of Unit Side, A7 TAWS Removed, A2 Processor Assembly Showing

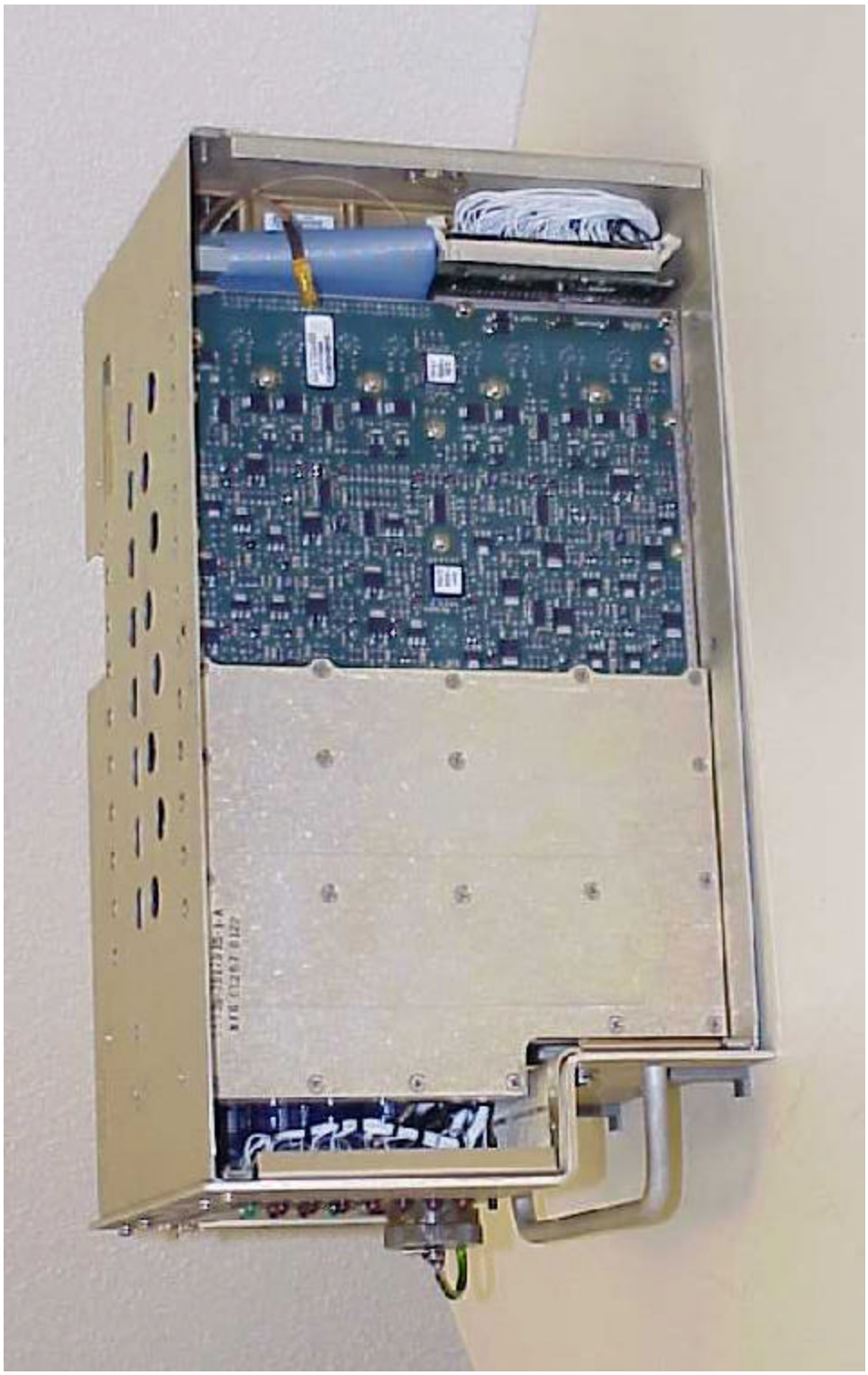


Figure 9: View of Unit Side, A8 GPS Removed, Showing A5 Receiver - I/O Assembly with Shield

Figure 10: View of Unit Side With A5 Receiver Hinged Outward, Showing A4 Power Supply/Modulator Assembly

Figure 11: View of Unit Side with A2 Processor Removed Showing A3 Transmitter Assembly With Cover