



TN70A GPS/SBAS WAAS Class Beta-1 Receiver Installation Manual



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1. Preface

1.1 Purpose

This document describes the system descriptions, and technical specification, as well as the installation, electrical and physical characteristics, limitations, environmental qualification, periodic maintenance procedures and corrective maintenance procedures for the TN70A GPS SBAS Receiver for Class Beta 1 Applications.

1.2 Scope

This document applies to the Trig TN70A GPS Receiver.

The Trig TN70A is an Accord Technologies, NexNav Max 91000S GPS receiver. No regulatory or certification specifications have been changed. Whenever this document refers to the TN70A it should be understood that it is actually a NexNav Max 91000S (Part number 91000S) GPS Receiver.

1.3 Changes from Previous Issue

None, this is the first issue.

1.4 Documents Cross Referenced

RTCA/DO-229D	RTCA Document - Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment
FAA/TSO-C145c	Technical Standard Order for Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS) GPS Augmented by Wide Area Augmented System
AC 20-138C	Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment
AC 43.13-1B	Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair
AC 43.13-2A	Acceptable Methods, Techniques, and Practices - Aircraft Alterations
RTCA/DO-160	RTCA Document – Environmental Conditions and test Procedures for Airborne Equipment
RTCA/DO-301	RTCA Document – Minimum Operational Performance Standards for Global Navigation Satellite System (GNSS) Airborne Active Antenna Equipment for the L1 Frequency Band
FAA/TSO-C190	Technical Standard Order for Active Airborne Global Navigation Satellite System (GNSS) Antenna
FAA/TSO-C144a	Technical Standard Order for Passive Airborne Global Navigation Satellite Systems (GNSS) Antenna
AC 20-165A	Airworthiness Approval of Automatic Dependent Surveillance-Broadcast (ADS-B) Out systems

1.5 Terms and Definitions

DAL	Design Assurance Level
EGNOS	European Geostationary Navigation Overlay Service
FAA	Federal Aviation Administration
FD/FDE	Fault Detection and Exclusion
GAGAN	GPS Aided Geo Augmented Navigation
GNSS	Global Navigation Satellite Systems

GNSSU	Global Navigation Satellite Sensor Unit
GPS	Global Positioning System
GPSB	Global Positioning System Satellite Based Augmentation System
LNAV	Lateral Navigation
MSAS	Multi-functional Satellite Augmentation System
NMEA	National Marine Electronic Association
PVT	Position, Velocity and Time
RAIM	Receiver Autonomous Integrity Monitoring
PRAIM	Predictive Receiver Autonomous Integrity Monitoring
RF	Radio Frequency
SATCOM	Satellite Communication
SBAS	Satellite Based Augmentation System
TSO	Technical Standard Order
VHF	Very High Frequency
WAAS	Wide Area Augmentation System

2. Hardware MOD Level History

The following table identifies hardware modification (MOD) levels for the TN70A product.

The MOD levels are listed with the associated service bulletin number, service bulletin date and purpose of the modification.

MOD Number	SERVICE BULLETIN NUMBER	SERVICE BULLETIN DATE	PURPOSE OF THE MODIFICATION
1	-	-	Application of RTV to selected components on power supply CCA for improved robustness to vibration. Reference ECO-100032 Rev. 1.
2	AT-SB-20210806	2021-08-06	Application of Loctite 222 to screws securing the heatsink to the chassis for improved robustness to vibration. Reference ECO-100055 Rev. 1.

3. Introduction

3.1 Equipment Description

The TN70A GPS SBAS Class Beta-1 Receiver is a satellite receiver that utilises signals coming from Global Positioning System (GPS) satellite constellation and satellite-based augmentation systems (SBAS) such as the USA Wide Area Augmentation System (WAAS), European EGNOS, Indian GAGAN and the Japanese MSAS. The TN70A is limited to only using SBAS systems that are compatible with WAAS.

The primary function of the TN70A Receiver is to compute the Position, Velocity and Precise Time (PVT). It also computes the integrity of the PVT from the SBAS signal, when available. The TN70A detects and excludes failed satellites (FD/FDE) using Receiver Autonomous Integrity Monitoring (RAIM) algorithm, whenever there are an adequate number of tracked satellites.

The sensor unit communicates with other avionics through a serial communication link.

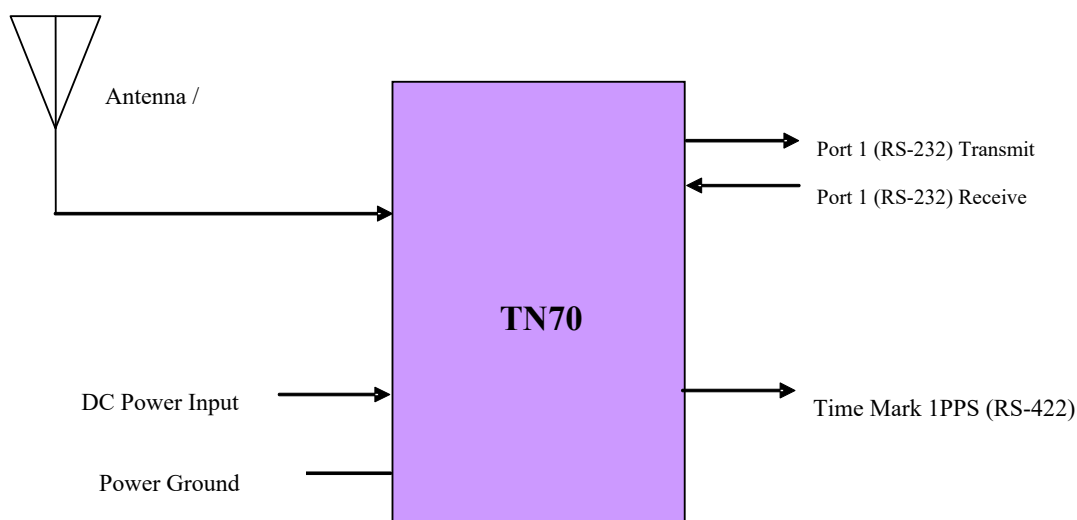


Figure 1: TN70A Interface Diagram

3.2 Technical Specification

The following table describes the technical specification of TN70A Unit

Table 1: Technical Specification

Characteristics	Parameter	Specification
Conformity	RTCA	DO-229D DO-254, Level B DO-178B, Level B DO-160
	FAA	TSO-C145c Class Beta – 1
General	Type	1575.42 MHz L1, C/A code receiver with SBAS capability
Number of Channels		12 GPS and 3 SBAS/WAAS parallel channels
Position Update Interval		1 Hz (1 second)
Sensitivity	Tracking	-140 dBm
	Reacquisition	7 seconds typical at -130 dBm GPS 10 seconds typical at -130 dBm SBAS
Position Accuracy	RMS Horizontal with WAAS	1 metres, RMS
	RMS Vertical with WAAS	2 metres, RMS
1 PPS	Pulse per seconds	30 ns, RMS
Altitude		Maximum 18287 metres
Dynamics	Speed, acceleration and jerk	Per DO-229D Requirements
	Velocity	Maximum 513 m/s
	Accuracy	0.1 m/s RMS
TTFF (Time To First Fix)	Cold start	≤ 120 seconds at -130 dBm
	Warm Start	75 seconds at -130 dBm (typical)
Integrity Monitoring	RAIM	SBAS integrity incorporated
	FD/FDE	FD/FDE incorporated
	Alert	Navigation alert as per DO-229D
	BIT	Comprehensive power on and online self tests
Design Assurance	Hardware	Per RTCA DO-254, Level B
	Software	Per RTCA DO-178B, Level B
Communication	Serial Port	Port1: RS-232, 19.2 kbps (NexNav Legacy Protocol)
	P/N 91000S	Port2: Reserved
	Time Mark	RS-422 One PPS

Characteristics	Parameter	Specification
	Software Protocol	NexNav Binary Protocol
SATCOM Compatibility		Compatible on aircraft equipped with SATCOM, when installed with a TSO-C190() approved antenna.
Environmental Characteristics	DO-160	As per environmental qualification form in Appendix A.
Electrical Characteristics	Power Supply	14 VDC to 28 VDC (nominal) 9-32 VDC (operational)
	Antenna Power Supply	5 VDC, 100 mA max
	Power	≤ 5.0 W
Physical Characteristics	Dimension	5.2"W x 6.6"D x 1.8"H
	Weight	≤ 1.5 lbs
	Antenna Connector	TNC RF connector, Female
	I/O Connector	25 pin D, receptacle

3.3 Certification

The TN70A Receiver conforms to TSO-C145c Class Beta 1 without any deviations. It also meets RTCA/DO-160 environmental specifications and has been developed in accordance with RTCA/DO-178B level B and RTCA/DO-254 level B design assurance level. The Environmental Qualification Form is included in Appendix A of this document.

Table 2: Deviations

Deviations	
TSO-C145c	No deviations from TSO-C145c
DO-229D	No deviations from RTCA/DO-229D

4. Regulatory Compliance and Limitations

4.1 Operational Capability

The equipment is FAA TSO-C145c Class Beta 1 Approved. It can be operated in Oceanic, En-route, Terminal, LNAV airspace and Beta 1 applications.

4.2 Baro Altitude Aiding

TN70A is capable of accepting altimeter data corrected for the local barometric pressure setting. However, the receiver does not depend upon the baro altimeter aiding to satisfy the FD/FDE integrity requirements of DO-229D.

4.3 Limitations

The conditions and tests required for TSO approval of this article are minimum performance standards. Those installing this article, on or in a specific type or class of aircraft, must determine that the aircraft installation conditions are within the TSO standards. TSO articles must have separate approval for installation in an aircraft. The article may be installed only according to AC 20-138B applicable airworthiness requirements.

4.4 Antennas

An active antenna with ≥ 26.5 dB gain meeting the functional requirements of RTCA/DO-301 and which has TSO-C190 approval is recommended. An active antenna contains a low noise amplifier which is powered by the GNSSU via the antenna coaxial cable. The GNSSU will provide 5.0 VDC power to the antenna. Maximum current is 100 mA.

Table 3 provides the recommended antennas for use with TN70A.

Table 3: Recommended Antenna

Antenna Manufacturer	Antenna Model	TSO Approval
R. A. Miller (RAMI)	Trig TA70	C190
R. A. Miller (RAMI)	AV-801	C190
Aero Antenna Technology	AT2300-226	C190
Cobham Antennas (Comant)	CI 429-200	C190
Sensor Systems	S67-1575-135	C190
Sensor Systems	S67-1575-137	C190
Sensor Systems	S67-1575-145	C190

Note: For new antenna installations use of a TSO-C190 antenna is highly recommended

4.5 Design Assurance Level

The TN70A software is developed as per DO-178B Level B.

The TN70A hardware (FPGA) is developed as per DO-254 Level B.

DAL C is required for Part 23 Category IV (Commuter Class) aircraft for Major Failure condition. This Class typically carries the same requirements as Part 25 applications. Part 25 aircraft may be required to install dual systems depending on the specific application.

DO-229D specifies DAL C for Class Beta-1 receivers.

4.6 Environmental Qualification

The TN70A receiver is tested for environmental conditions specified in relevant sections of DO-160. The Environmental Qualification Form is included in Appendix A of this document.

4.7 Scheduled and Unscheduled Maintenance

There is no requirement for periodic service, inspection or preventive maintenance for continued airworthiness of the TN70A.

5. Installation Overview

5.1 Introduction

Careful planning and consideration of suggestions in this section are required to achieve the desired performance and reliability from the TN70A Receiver.

The installation instructions meet the guidance provided in AC 20-138B “Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment”.

5.2 Antenna Specification

The antenna performance is critical to operation of GPS/SBAS receiver. The recommended antenna is a DO-301 compliant antenna meeting the requirements of TSO-C190. For installations where the aircraft has an existing antenna complying with DO-228 (TSO-C144a), the TN70A may be installed utilising this antenna, as per DO-229D Note 1, Section 2.1.1.10.

The performance of the TN70A is affected by the gain, noise figure, impedance, and frequency selectivity characteristics of the antenna. TN70A should be used only with the recommended antenna and cable. Use of other antennas or cables may not meet all the performance characteristics specified in DO-229D.

5.2.1 Antenna Power

The TN70A receiver utilises an active antenna which means the antenna includes a low noise amplifier. The power for the low noise amplifier is provided from the GPS receiver via the antenna coax cable.

5.2.2 Recommended Cable

RG 400 or RG142 is recommended. A maximum length of 50 ft is recommended. The cable including connectors, loss should not exceed 10dB.

5.3 Compatibility with SATCOM Environment

The performance of the TN70A is unaffected when operating in a SATCOM environment. The performance of the TN70A Receiver is specification compliant for SATCOM compatibility per DO-229D.

6. Installation Procedure

6.1 Unit Mounting

The TN70A unit is designed to mount in any convenient location in the aircraft. Consideration should be given to the length of the antenna coax cable when selecting a location.

Attach the TN70A Receiver firmly to the airframe. The chassis of the unit must be properly grounded to the aircraft.

6.2 Cabling and Wiring Considerations

The equipment wiring should be performed in accordance with AC 43.13-1B Chapter 11. Ensure that the cable is not routed close to high-energy sources. Use of 22 AWG wire is recommended for all connections other than coax.

6.3 Air Circulation and Cooling

The TN70A unit does not require external cooling. However, as with all electronic equipment, lower operating temperatures extend equipment life.

6.4 Materials Supplied

The TN70A kit contains the following items:

Unit Description	Qty	Trig P/N	Manufacturer	Manufacturers P/N
TN70A GPS Receiver	1	02474-00	Accord Technologies	91000S
TN70 Installation Kit	1	01380-00	n/a	n/a

The TN70A installation kit includes the following items:

Unit Description	Qty	Trig Part Number
Connector, coaxial TNC straight	1	00723-00
Connector, coaxial TNC right angle	1	01383-00
Headshell, 25 way	1	00726-00
25 way D-type, Female	1	00866-00
Crimp Terminal, Female, 22-24 AWG	14	00730-00

6.5 Materials Required (Not Supplied):

The TN70A Receiver is intended to be connected using wire suitable for aircraft. The following wire types are recommended.

Shielded cable should meet the following standard:

2 Core 22AWG Shielded cable , wire code: Mil Spec 27500-22TG2T14

3 Core 22AWG Shielded cable , wire code: Mil Spec 27500-22TG3T14

Hook-up wire should be 22AWG to Mil Spec 22759/16-22

RG400 or RG142 is recommended to be used for the antenna cable

6.6 GPS/SBAS Antenna Location

The GPS/SBAS antenna mounting location and cable connections are very important. The antenna should not be mounted close to VHF COM transmitter antennas, and other antennas emitting high power. Special care

should be taken to ensure that the GPS antenna is not mounted in close proximity to antennas that may emit harmonic interference at the L1 frequency of 1575.42 MHz. Refer to AC 20-138C “Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment” for additional information and guidelines. For best performance, select a location with an unobstructed view of the sky above the aircraft when in level flight.

For installations on rotorcraft, ensure that the rotor blades do not interfere with the GPS/SBAS received signal. This problem has been experienced in some rotorcraft and varies with rotation rate.

6.7 GPS/SBAS Antenna and Cable Installation

Antennas with TSO-C190 are highly recommended for the installations. Table 3 provides the recommended antennas for use with the TN70A.

Once the antenna mounting position has been prepared, route the coaxial cable from the antenna to the TN70A Receiver. Proper selection of coaxial cable and assembly of connectors are critical to GPS signal performance. The recommended cable is RG 400. Connector losses should be considered when computing the cable loss. Total cable loss including connectors, should be less than 10dB.

6.8 System Interconnections

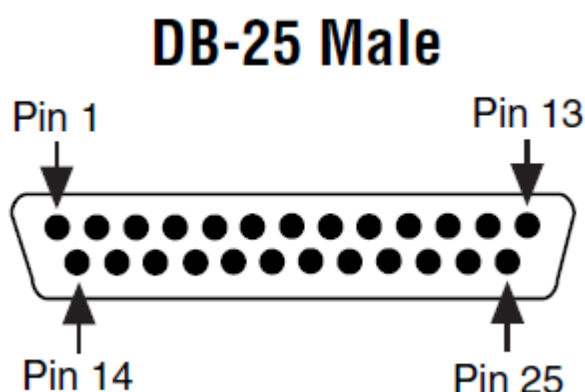
The TN70A Receiver includes one DB-25 male, plug connector. The pin outs are per the following table:

Table 4: Connector Interface

Pin Number	Input/ Output /GND	Signal	Brief Description
1	NA	NC	Reserved
2	Output	One PPS RS-422 (1 PPS Y)	RS-422 Differential PTTI signal (TTL)
3	NA	NC	Reserved
4	NA	NC	Reserved
5	GND	NC	Reserved
6	Input	Power input (9-32 Vdc)	Power Line
7	Out	RS-232 TX (Port 1)	RS-232 Communication Transmit port (NexNav Protocol)
8	NA	Reserved	Reserved
9	GND	NC	Reserved
10	Signal Gnd	RS-232 Signal Ground (Port 1)	RS-232 Communication Signal Ground
11	GND	NC	Reserved
12	NA	NC	Reserved
13	NA	NC	Reserved
14	GND	One PPS Shield Ground	One PPS Shield Ground
15	Output	One PPS RS-422 (1 PPS Z)	RS-422 Differential PTTI signal (TTL)
16	GND	One PPS Shield Ground	One PPS Shield Ground
17	NA	NC	Reserved
18	GND	NC	Reserved
19	GND	Power return	Power return
20	Input	RS-232 RX (Port 1)	RS-232 Communication Receive Port
21	NA	Reserved	Reserved
22	GND	NC	Reserved

23	NA	Reserved	Reserved
24	NA	NC	Reserved
25	GND	NC	Reserved

6.8.1 Main Connector



6.9 Electrical Load Assessment

The GNSS equipment should be installed after completing an electrical load analysis in accordance with AC 43.13-1B, Chapter 11 on the aircraft. The electrical load requirements of the GPS SBAS equipment are provided in Table 5.

The receiver operates from 9-32 Vdc with full performance.

An electrical load analysis should be completed on each aircraft prior to installation. Use below table for computation.

Table 5: Electric Load Analysis

Input Voltage		14 VDC	28 VDC
Current Consumption	Typical	0.27 A	0.14 A
	Maximum	0.36A	0.18 A
Power	Typical	3.8 W	3.8 W
	Maximum	5.0W	5.0W

6.10 Aircraft Wiring

6.10.1 Port 1 (RS-232 TX/RX I/O)

Use 3 conductor shielded 22 gauge wiring. The Signal Ground should be an independent conductor. Do not use the shield for the Signal Ground. Terminate the shield at both ends with a short 22 gauge wire not more than 3 inches in length. All shields may be connected to this short wire. The shield wire should be terminated on the connector shell or an external connection on the LRU. Do not terminate to a connector contact as this will cause the shield to be terminated inside the enclosure.

6.10.2 PPS Y&Z

Use 2 conductor shielded 22 gauge wiring. Terminate both shields to a single wire and then to Pins 14 & 16 respectively per the drawing.

6.10.3 Unit Power wiring

Use 22 gauge 2-conductor shielded wiring for providing power to the unit. Use one conductor for Power Input and one conductor for Power Return. The shield should be terminated outside the enclosure.

6.11 Wiring Diagram

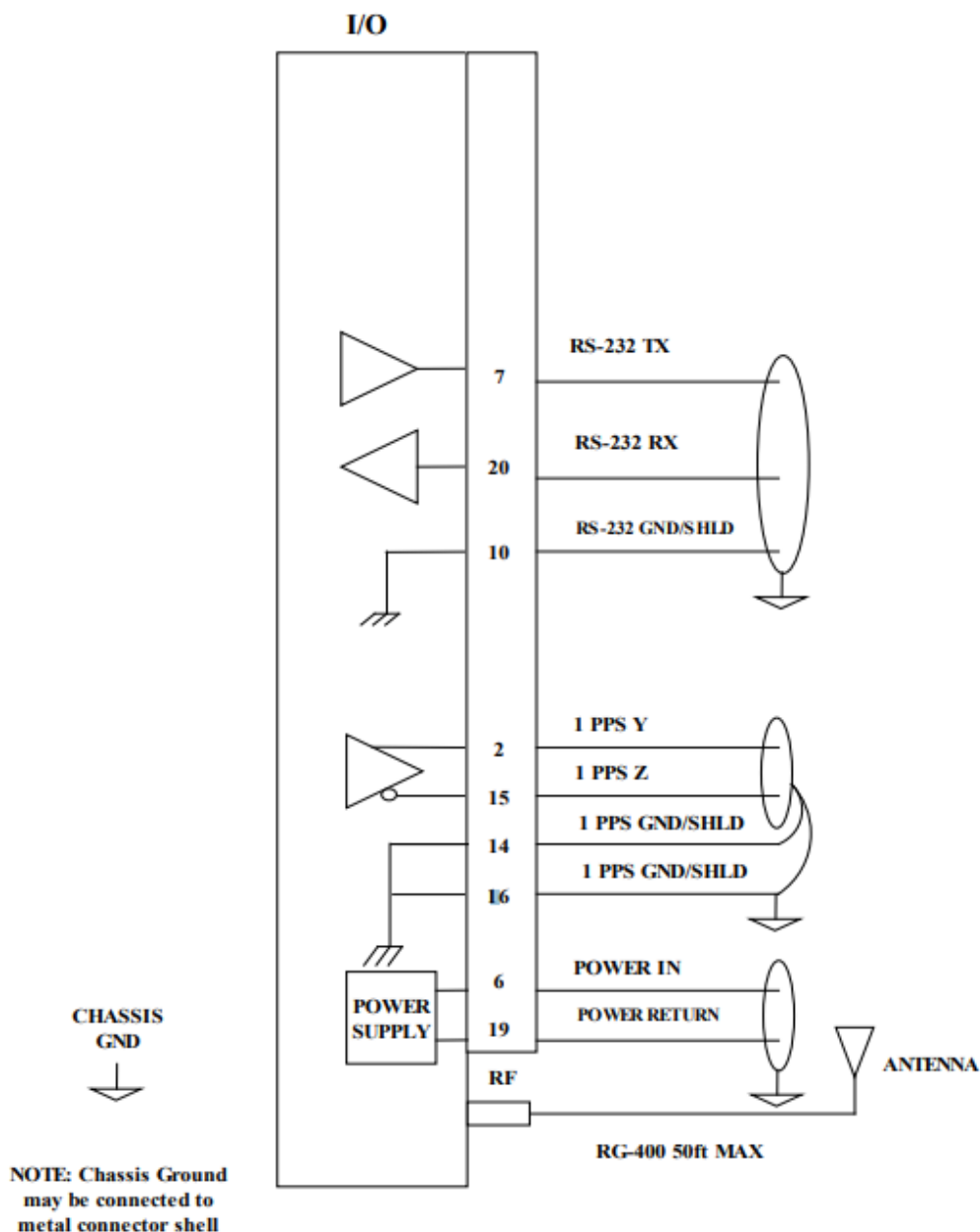


Figure 2: Wiring Diagram

6.12 Serial Data Communication

The TN70A Receiver interfaces with other avionics by transmitting messages through RS-232 protocol. There are two RS-232 ports available. Port 1 utilises the NexNav Legacy protocol and can be used to provide GPS data to a Trig transponder as part of an ADS-B solution.

The table below characterises the RS-232 port.

Table 6: RS-232 Ports

Protocol	NexNav P/N 91000S (Port 1)
RS-232 Transmit	PIN-7
RS-232 Receive	PIN-20
RS-232 Signal Ground	PIN-10
Baud Rate	19200 bps

All protocols transmit navigation messages intended for air-borne navigation and surveillance. The NexNav protocol has the capability to receive messages from other avionics.

6.13 Software Installation

The TN70A Receiver is preloaded with the approved software build. No additional software is required for operation.

6.14 Operating Instructions

Upon power up after the installation, the TN70A Receiver computes aircraft Position, Velocity, and Precise Time (PVT) within the specified time when the antenna is exposed to the open sky. The receiver transmits the PVT and integrity information through the serial communication link to the connected avionics system.

6.15 VHF Com Interference Testing

Susceptibility to harmonics of VHF COM transceivers shall be evaluated. If problems arise, then more isolation or greater distance may be required between the GPS and COM antennas to reduce or eliminate the harmonic interference.

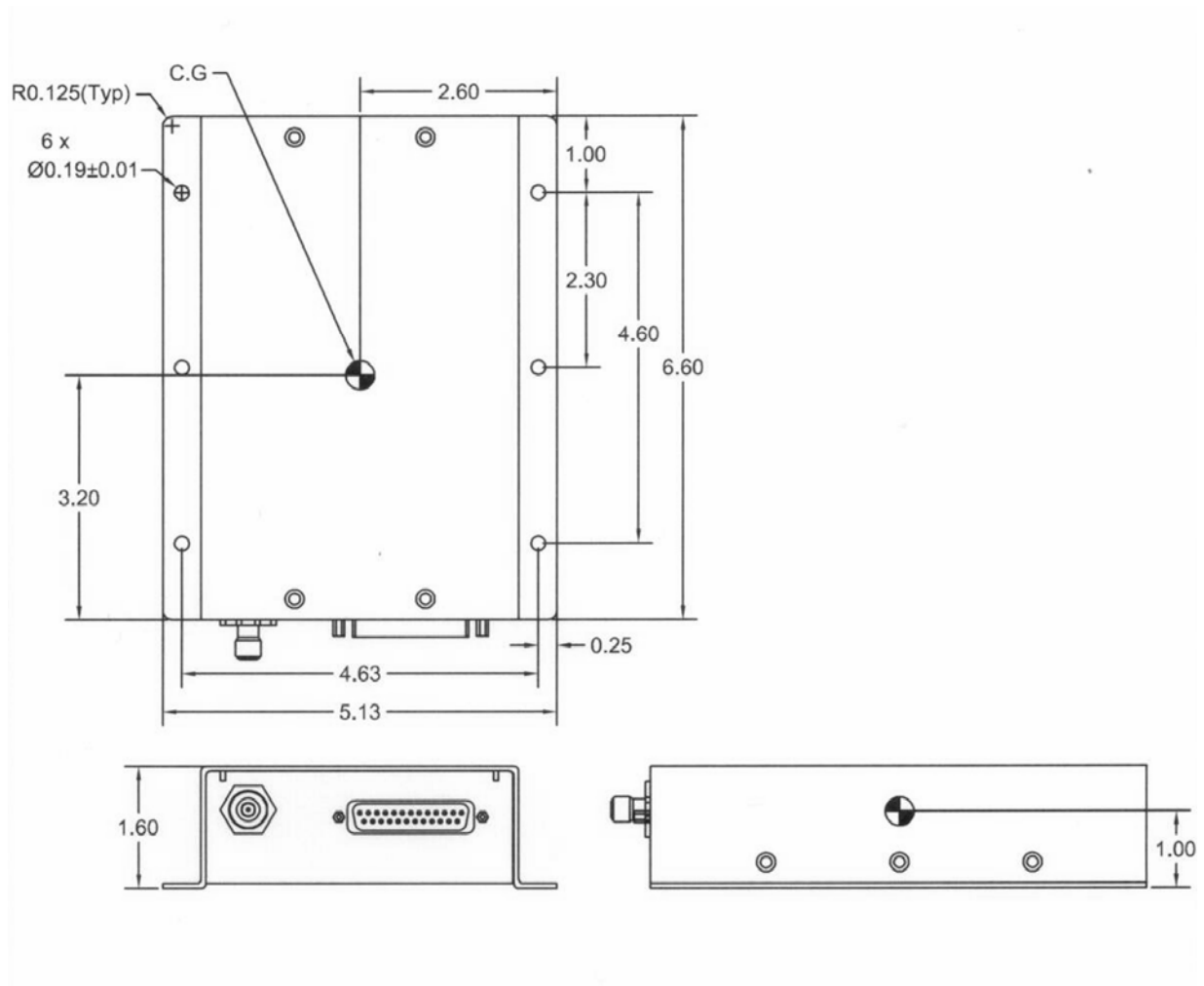
Confirm compatibility by tuning the VHF Com transceivers to the following frequencies and then check for flags or alerts for the avionics that are connected to the NexNav GPS, when transmitting or receiving.

VHF Com Freq

121.150 MHz
121.175 MHz
121.200 MHz
131.200 MHz
131.250 MHz
131.300 MHz

6.16 Physical Characteristics

Figure 3 shows the TN70A Receiver physical dimensions.



(Dimensions in Inches)

Figure 3: TN70A Physical Dimensions

Appendix A - Environmental Qualification Form

Nomenclature	NexNav mini 91000S : NexNav GPS-SBAS Receiver
Part Number	91000S
TSO Number	TSO-C145c
Manufacturer	Accord Technology LLC
Address	347 N. Edgewood Lane, Suite 180, Eagle, ID 83616
Standard document	DO-160
Date Tested	June 2007 through August 2007

Conditions	Revision	Section	Qualification Category
Temperature and Altitude	G	4.0	D2
Temperature Variation	G	5.0	B
Humidity	E	6.0	A
Operational Shocks and Crash Safety	E	7.0	B
Vibration	E	8.0	S (Curve B3)
	E	8.0	U (Curve G)
	G	8.0	R (Curve C1)
Explosion Atmosphere	E	9.0	X (Not Tested)
Waterproofness	E	10.0	W
Fluids Susceptibility	E	11.0	X (Not Tested)
Sand and Dust	E	12.0	X (Not Tested)
Fungus Resistance	E	13.0	F (Analysis)
Salt Fog	E	14.0	X (Not Tested)
Magnetic Effect	E	15.0	A
Power Input	E	16.0	B
Voltage Spike	E	17.0	B
Audio Frequency Conducted Susceptibility – Power Inputs	E	18.0	B
Induced Signal Susceptibility	E	19.0	A
Radio Frequency Susceptibility (Radiated and Conducted)	E	20.0	W
Emission of Radio Frequency Energy	G	21.0	M
Lightning Induced Transient Susceptibility	G	22.0	B2K3L3
Lightning Direct Effects	E	23.0	X (Not Tested)
Icing	E	24.0	X (Not Tested)
Electrostatic Discharge (ESD)	E	25.0	A
Fire, Flammability	E	26.0	C (Analysis)

The TN70A has been tested in accordance with MIL-STD-810 and found compliant with methods and paragraphs as shown in the table below.

Conditions	Revision	Method	Paragraph
Contamination by Fluids	F	504	4.5.2
Humidity	F	507.4	4.5.2
Salt Fog	F	509.4	4.5.2
Sand and Dust (Procedure I – Blowing Dust)	F	510.4	4.4.2
Explosive Atmosphere	F	511.4	4.5.2
Acceleration (Procedure I – Structural Test)	F	513.5	4.4.2
Shock (Procedure VI – Bench Handling)	F	516.5	4.5.7

Appendix B - Guidance for interfacing with ADSB Systems

This appendix provides the general guidance for installing the GPS SBAS receiver with the ADSB systems. Appendix 2 of Advisory circular AC 20-165A, “Airworthiness Approval of Automatic Dependent Surveillance-Broadcast (ADS-B) Out systems” provides the guidance for all types of position sources used to interface with the ADSB systems. Below table provides the compliance to the advisory circular AC 20-165A in view of GPS SBAS TN70A Class Beta-1 receiver.

Table 7: ADS-B installation Compliance Table

AC 20-165A Appendix 2 Para #	AC 20-165A Appendix 2 Paragraph	Compliance with TN70A
3.a. 4.a	Position (Lat/Long)	This has been verified as part of the TSO-C145C in compliance to DO-229D Section 2.1.2.6. Lat/Long is transmitted as part of Navigation Data message (Message ID 0x51)
3.b. 4.k	Horizontal Velocity	This has been verified with the test defined in AC 20-138C. North/south and east/west velocities are transmitted as part of Navigation Data message (Message ID 0x51).
3.b. 4.l	Groundspeed	Ground Speed is transmitted as part of ADSB Aid message (Message ID 0x4A). Ground Speed is computed from North and East Velocity using the equation. $\text{Ground Speed} = \sqrt{(\text{NorthVel})^2 + (\text{EastVel})^2}$. The north and east velocity components used to compute the ground speed is also independently transmitted in the Navigation Data message.
3.c. 4.h.	Horizontal Position Accuracy	Horizontal Position Accuracy is HFOM, which is transmitted as part of Navigation Data message (Message ID 0x51). This has been qualified as part of TSO-C145C approval.
3.d. 4.o.	Vertical Position Accuracy	The vertical position accuracy has been verified as per the test procedure described in Section 2.5.8.3 of DO-229D. The horizontal and vertical position is computed using the general weighted least squares where the weights have been used as per appendix J of DO-229D. The VFOM is also transmitted as part of Navigation Data message (Message ID 0x51). This has been qualified as part of TSO-C145C approval.
3.e. 4.d.	Horizontal Position Integrity	Horizontal Position Integrity (HPL) value is transmitted as part of Navigation Data message (Message ID 0x51). The HPL _{FD} is

AC 20-165A Appendix 2 Para #	AC 20-165A Appendix 2 Paragraph	Compliance with TN70A
		<p>transmitted from bytes 55-58 and HPL_{WAAS} is transmitted from bytes 59-62. The validity for the HPL is transmitted in bytes 3-4 in the Navigation Data message.</p> <p>HPL is computed in compliance with TSO-C145C requirement.</p>
3.e.(1) 4.p	Mode Output	<p>The position source provides integrity using GPS and SBAS satellites and operates in only one mode (indicating horizontal position with at least 99.99999% probability under fault free condition).</p>
3.e.(2) 4.g.	Integrity Validity Limit Non-augmented GPS outputting integrity <0.1 NM	<p>During non-augmented mode, the GPS Receiver does not limit the HPL output value to 75m if the HPL value becomes less than 75m. However bit 0 of Byte# 10 of ADSB Aid Message (Message ID: 0x4A) indicates this condition.</p> <p>If bit 0 is set, it indicates that the HPL_{FD} in Navigation Data message is less than 75 metres (this HPL is computed in non-augmented mode).</p> <p>This bit will be 'Zero' if the receiver is computing SBAS based HPL (HPL_{WAAS}) or if the HPL_{FD} is greater than 75 metres.</p> <p>Note : This bit should be ignored, if the Bit 6 and 7 in the byte 2-3 of the message 'Navigation Data' indicates invalid.</p>
3.e.(3) 4.f.	Integrity Fault	<p>The Integrity fault is transmitted in Byte #2 of the Navigation Data (Message ID: 0x51). There is an integrity fault if the Byte #2 (Nav Sate) value becomes 6. This is indicated to the HOST within 1 second</p>
3.f. 4.e	Position Integrity (Probability)	<p>The receiver provides HPL_{FD} and HPL_{SBAS} as per DO-229D and in compliance with TSOC-145c.</p> <p>Complies with SBAS requirement defined in 2.1.2.2.2.1 of DO-229D and FDE requirements in section 2.1.2.2.2.2 of DO-229D.</p>
3.g. 4.t	Signal-in-Space Error Detection	<p>The GPS SBAS Receiver complies with the MOPS requirements Section 2.1.1.2 and 2.1.2.2.2.2 where the requirement for SIS error detection is specified.</p>
3.h. 4.n.	Horizontal Velocity Accuracy	<p>The GPS SBAS receiver computes HFOM_v and VFOM_v and transmits them through the Auxiliary Navigation message (0x80).</p> <p>Bytes 3 through 6 represent the HFOM_v.</p> <p>Bytes 7 through 10 represent the VFOM_v.</p> <p>Tests have been performed as per AC 20-138C, Appendix 4 and the results are part of the system test report.</p> <p>The GPS SBAS Receiver supports NAC_v = 2.</p>
3.i.	Design Assurance	<p>Supports Major failure effect. Software is compliant with DO-178B level C and complex hardware is compliant with DO-254 level C.</p>

AC 20-165A Appendix 2 Para #	AC 20-165A Appendix 2 Paragraph	Compliance with TN70A
3.j. 4.i.	Geometric Altitude (Height Above Ellipsoid)	<p>The GPS Receiver computes the Geometric Altitude (Height Above the Ellipsoid) and transmits it through the Navigation Data Label (Message ID 0x51).</p> <p>The vertical position accuracy has been verified as per the test procedure described in Section 2.5.8.3 of DO-229D.</p> <p>The horizontal and vertical position is computed using the general weighted least squares where the weights have been used as per appendix J of DO-229D.</p> <p>Geometric Altitude is transmitted in Byte # 25-32 as part of Navigation Data message (Message ID 0x51).</p>
3.k. 4.j	Update Rate	Position update rate is 5Hz
3.l. 4.b	Position Source Latency	<p>Position Source latches measurements and computes the position at UTC second boundary and at 5Hz interval.</p> <p>The uncompensated latency i.e the time interval between time of measurement and time to transmit position, velocity and FOM information is less than 150 msec from the measurement time and well within the 200 msec requirement specified in the AC 20-165A.</p>
3.m. 4.m.	Time of Applicability	<p>For each position, the GPS SBAS receiver outputs velocity, horizontal accuracy metric (HFOM) and horizontal integrity metric (HPL) in the Navigation Data message (Message ID: 0x51). The horizontal velocity metric (Velocity HFOM) is transmitted in Auxiliary Navigation Message (Message ID: 0x80).</p> <p>The HPL and HFOM computation is performed at 5Hz rate and is within the integrity, time-to-alert requirement of DO-229D.</p>
3.n. 4.s.	Time Mark	<p>The UTC time mark is transmitted as differential signals on pins 2 and 15 of the 25 PIN connector (DB-25 male connector).</p> <p>Refer to Figure 4 for the relationship between Time Mark and the applicability of Position data.</p>
3.o. 4.c	Availability	As per Table 14 of AC 20-165A the estimated GNSS availability of GPS/SBAS with TSOC-145 is greater than or equal to 99.9%.
4.q.	Approach Mode Integrity	NA, the integrity output need not be scaled, since the GPS SBAS receiver does not support LNAV/VNAV or LP/LPV mode of operation.
3.b. 4.r.	(true) Ground Track (angle)	The ground track angle is transmitted as part of ADSB Aid Message (Message ID:0x4A) in byte # 6-9.

AC 20-165A Appendix 2 Para #	AC 20-165A Appendix 2 Paragraph	Compliance with TN70A
4.r.	Ground Track Validity	<p>If the Ground speed is less than 7 knots, then the validity of the Ground track (bit #1 in Byte# 10) in ADSB Aid Message (Message ID: 0x4A) becomes 1.</p> <p>This indicates that the track angle is invalid.</p> <hr/> <p>The track angle is derived from the North and East Velocity components using the equation</p> $\text{Track angle} = \tan^{-1}\left(\frac{\text{EastVelocity}}{\text{NorthVelocity}}\right)$ <p>The accuracy of the track angle decreases at lower speed.</p> <p>The Heading error is proportional to $\frac{\sigma_v^2}{V^2}$.</p> <p>Where the σ_v is the standard deviation of the velocity error and V is the speed of the vehicle.</p>
5.	Tightly Coupled GNSS/ IRS Position Sources	Not Applicable.
6.	Non GNSS Position Sources	Not Applicable.
7.	Future Position Sources	Not Applicable.

Time of Applicability for TN70A

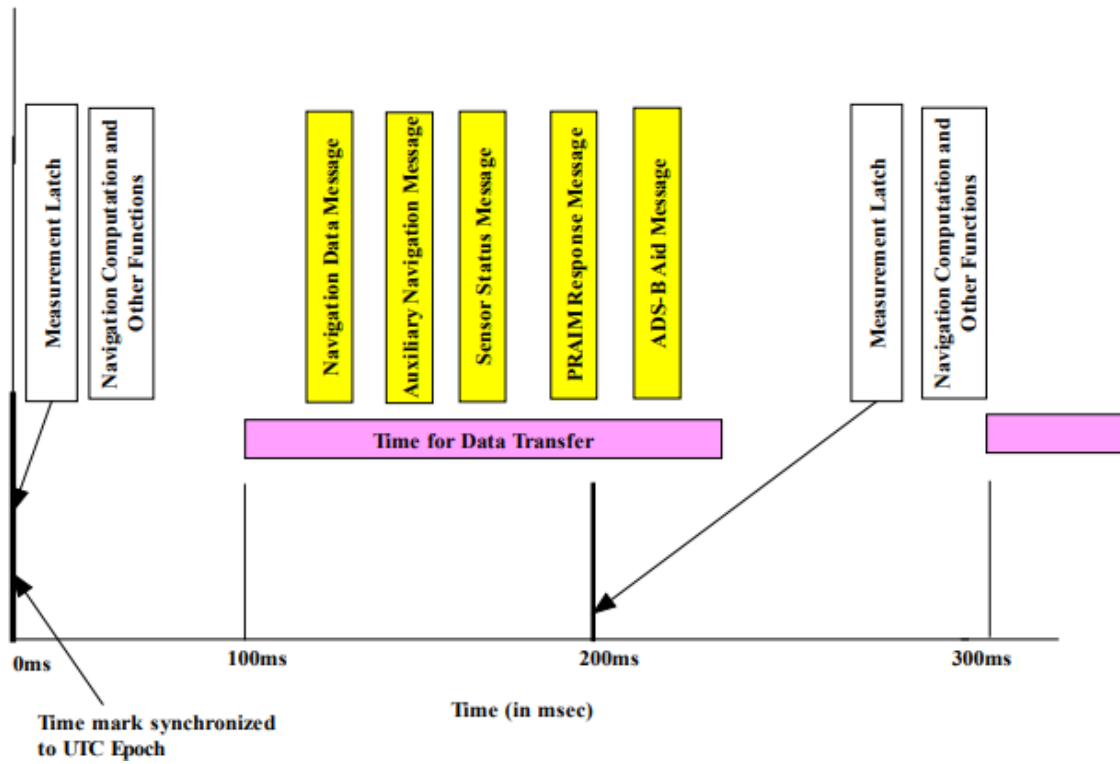


Figure 4 : Time of Applicability for TN70A