

REQUEST FOR ADDITIONAL TEST LOCATIONS

Pursuant to Section 5.3 (f), Section 5.51 and Section 5.53 of the Federal Communications Commission (“FCC”) rules, 47 C.F.R. §§ 5.3 (f), 5.51, 5.53 (2017), Southwest Research Institute (“SwRI”) respectfully requests a modification of its experimental license issued under call sign WF2XCH, 0223-EX-CR-2017, to operate from additional locations at its campus for purposes of testing the performance, functionality and safety of autonomous vehicle technology prior to any real-world application in an indoor laboratory environment.

In support of SwRI’s request, which is in compliance with NTIA Manual Paragraph 8.3.28, the following is shown:

1) Applicant’s Address, Background and FRN:

Southwest Research Institute is headquartered at 6220 Culebra Road, San Antonio, TX 78238-5166. It is an independent, not-for-profit, applied engineering and development organization devoted to technology research, design and development. It conducts business with the industry and government entities (in the U.S. and other friendly nations) on a worldwide basis. Approximately 50% of the SwRI’s business is for the U.S. Government. Its FCC Registration Number (“FRN”) is 0004074217.

2) Background and Need for License Modification:

SwRI is a leader in the field of intelligent vehicles and autonomous vehicle technology for both commercial and United States military applications. It is continuously engaged in product development, testing and refinement of its autonomous vehicle systems and technology, including the testing and debugging of developed technology, and GPS signals constitute a fundamental component of that technology.

SwRI product development and refinement efforts require substantial testing of applicable technologies utilizing GPS signals in a laboratory environment. Under the proposed modification to its current license, SwRI will transmit GPS signal input to SwRI hardware while indoors and wholly within the SwRI laboratory facilities. The transmission of GPS input is necessary to accurately test the performance, functionality and safety of autonomous vehicle technology prior to any real-world applications and to refine and debug existing technology. A modification of its license is needed so that it may transmit GPS signals at additional test locations so that it may conduct safe and secure testing and development of autonomous vehicle technologies at its indoor facilities as identified below to obtain real-world data and test and improve its autonomous vehicle technologies.

3) Location of Additional Sites:

The proposed tests will be conducted on the campus of Southwest Research Institute, 6220 Culebra Road, San Antonio (Bexar County), Texas. The campus is comprised of approximately 1200 acres, an area entirely under the control of SwRI.

Specifically, the proposed tests will be conducted within Buildings 290 and 290A, which are close to other buildings where SwRI is already authorized to conduct related indoor GPS operations under its existing license, issued under call sign WF2XCH. The coordinates of the two sites are NL 29-26-31.0; WL -98-36-04.8 (Building 290) and NL 29-26-30.0; WL -98-36-06.4 (Building 290A), which are approximately 53 meters from each other.

4) FCC Station Codes:

The FCC radio service code and station class code for the proposed operation are "XT" and "FX," respectively.

5) Equipment To Be Used:

SwRI proposes to operate a single transmitter capable of operating on the channels listed in Section 6. Specifically, it proposes to deploy a transmitter (Model L1/L2GHNRRKIT) manufactured by GPS Networking. The technical specifications of the equipment are provided under Attachment A.

6) Frequencies Desired:

As stated in Section 2 above, SwRI seeks to obtain real-world data samples of the characteristics of GPS transmissions. Thus, it is critical for SwRI to conduct tests centered on GPS channels 1227.6 MHz and 1575.42 MHz. SwRI recognizes that the use of certain frequencies will require coordination through the Interdepartment Radio Advisory Committee ("IRAC"), and it is amendable to coordinating with Federal government personnel prior to commencing any transmissions.

7) Power Level:

SwRI will operate with the minimum necessary power to conduct its tests, and in no event will that level exceed the levels set out in the table provided under Attachment B. Specifically, the maximum equivalent isotropically radiated power ("EIRP") will be such that the calculated emissions are no greater than -140 dBm/24 MHz as received by an isotropic antenna at a distance of 100 feet (30 meters) from where the tests are being conducted. A link budget showing compliance with this requirement is provided in the table under Attachment B and is based on free space propagation with no allowance for additional attenuation (e.g., building attenuation).

8) Type of Emission, Modulation Technique, and Bandwidth Required:

The primary emission designator for the proposed operations is 2M46G3D, as indicated on the accompanying FCC Form. Other emission modes and modulation techniques may be utilized, but in no event will the emissions extend beyond the limits associated with the above-referenced emission.

SwRI does not propose to supply station identification as set forth in Section 5.115 of the Commission's Rules, 47 C.F.R. § 5.115 (2017),

9) Antenna Information and Compliance with Human Exposure Limits:

SwRI will comply with all Federal Aviation Administration ("FAA") and FCC rules and regulations regarding the installation and operation of antennas and their support structures. The antenna to be deployed under the authority requested will not extend more than six meters more than six meters above the building.

10) Restrictions on Operation:

GPS users in the area of potential interference to GPS reception will be notified that GPS information may be impacted during testing. In addition, it will post signs on doors to the test area notifying that, "GPS re-radiator is in use and the GPS information you receive may be in error."

SwRI also understands that: (a) permission to operate has been granted under experimental authority issued by the Federal Communications Commission, is strictly temporary, and may be cancelled at any time and that (b) operation is subject to the condition that it not cause harmful interference.

Moreover, SwRI does not propose to market, sell, or lease unapproved equipment to end users or conduct a market study in conjunction with these tests. After the completion of the tests, SwRI will recover all devices that do not comply with FCC regulations.

11) Interference Protection/Stop Buzzer Contact Information:

As noted above, GPS users in the area of potential interference to GPS reception will be notified that GPS information may be impacted during testing. It also understands that it may be required to discontinue its operations immediately, if any interference occurs. SwRI does not expect interference to occur, however, as its tests will be conducted only on a limited basis and only periodically during the term of its experimental license. Moreover, SwRI personnel will be monitoring the RF spectrum and will take steps to minimize any potential for interference.

In that regard, SwRI advises the Commission that Christopher Mentzer is the technical contact overseeing these tests. He will be personally responsible for the operations and will serve as the "stop buzzer" in the event that operations must be terminated because of any interference concerns. Mr. Mentzer can be reached at (210) 522-4240, email christopher.menzer@swri.org

12) Application Contact Information:

Company Contact:

Monica R. Trollinger
General Counsel
6220 Culebra Road
San Antonio, TX 78238-5166
Telephone: (210) 522-6024
Facsimile: (210) 522-5839
mtrollinger@swri.org

"Stop Buzzer" Contact:

Christopher I. Mentzer
Intelligent Systems
Div. 10, Building 51
PO Drawer 28510
6220 Culebra Road
San Antonio, TX 78228-0510
Telephone: (210) 522-4240
christopher.mentzer@swri.org

Legal Contacts:

David E. Hilliard
Kurt E. DeSoto
Wiley Rein LLP
1776 K Street, N.W.
Washington, DC 20006
Telephone: (202) 719-7000
Facsimile: (202) 719-7207
Email: dhilliard@wileyrein.com
Email: kdesoto@wileyrein.com

ATTACHMENT A
Equipment Specifications



L1/L2GHNRRKIT

L1/L2 GNSS Hanger Networked Re-Radiating Kit Technical Product Data



Features

- **Amplified L1/L2 GNSS Roof Antenna**
Gain $\geq 33\text{dB}$
- **Re-Radiating Amplifier with Power Supply**
Typical Gain 30dB
- **Optional Mounting Kit Hardware**
Roof Antenna Mount & Adjustable Re-Radiating Mount
- **Variable Gain Option**
Re-Radiating Amp Gain Varies from approx 0-23 dB gain
- **Variable Gain Option with LCD Display**
Push Button Control in 1dB Increments 0-30dB gain

Description

The GPS L1/L2 GNSS Hanger Re-Radiating Kit (L1/L2GHNRRKIT) is a complete re-radiating system that allows re-radiation of the GPS L1/L2 signal as well as the other GNSS frequencies (including Galileo, GLONASS, Beidou and Omnistar indoors). The L1/L2GHNRRKIT consists of an active L1/L2 GNSS roof antenna, a re-radiating amplifier with a wall mount plug-in transformer that powers the entire system, and a passive L1/L2 GNSS re-radiating antenna. The GNSS signals from the roof antenna are amplified and radiated indoors. Thus, if a receiver has line of sight with the re-radiating antenna, it can receive the GNSS signal indoors up to 100 feet. A cable from the roof antenna to the re-radiating kit is required and can be purchased separately.

Roof Antenna Specifications, $T_A = 25^{\circ}\text{C}$

Parameter	Conditions	Min	Typ	Max	Units
Frequency	See Active Antenna Specifications page 5				GHz
Bandwidth					MHz
Out Imped. ⁽¹⁾			50		Ω
Pre-Amp Gain			30	33	dB
Noise Figure			2.0		dB
Output SWR				2.0:1	-
Filtering	See Active Antenna Specifications page 5				dB
					dB
Req. DC Input V.		4.5		24	Vdc
Current			22		mA

RF Connector Options		
Connector Options	CONNECTOR STYLE	CHARGE
	Type N-female	NC

Re-Radiating Amplifier Electrical Specifications, $T_A = 25^{\circ}\text{C}$

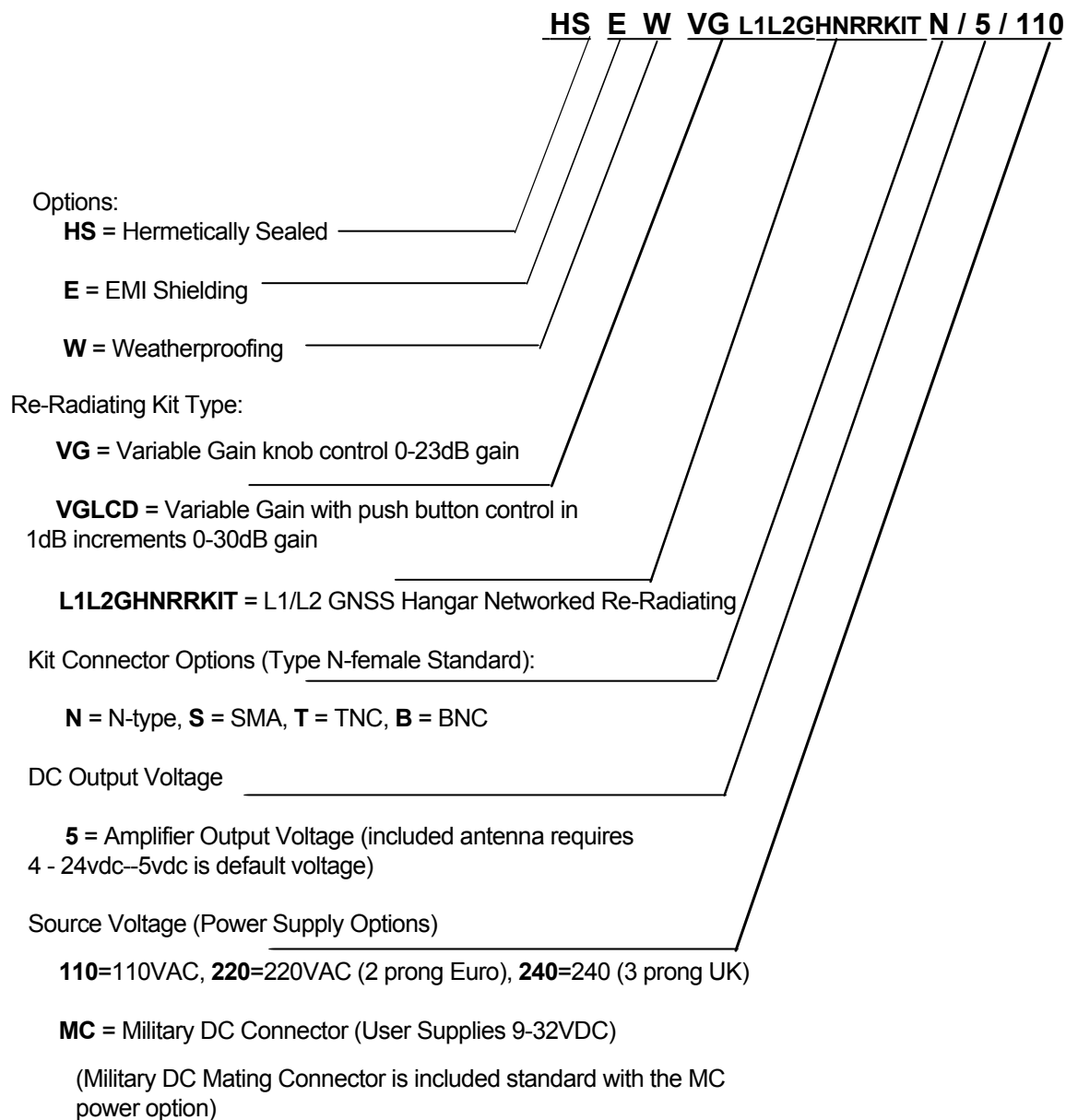
Parameter	Conditions	Min	Typ	Max	Units
Freq. Range	Ant – J1	1.1		1.7	GHz
In/Out Imped.	Ant, J1		50		Ω
Gain ⁽¹⁾					dB
		29	30	31	dB
Input SWR ⁽²⁾	J1 - 50 Ω			1.8:1	-
Output SWR	Ant - 50 Ω			1.8:1	-
Noise Figure	Ant – J1		3.3	3.5	dB
Current			33	40	mA
Gain Flatness	L1 – L2 ; Ant – J1		0.5	1	dB
Reverse Isolation	J1 – Ant	35			dB
Group delay Flatness	$\tau_{d,max} - \tau_{d,min}$: Ant – J1			1	ns

Re-Radiating Amp System Power Supply Options		
Source Voltage Options	VOLTAGE INPUT	STYLE
	110VAC	Transformer (Wall Mount)
	220 VAC	Transformer (Wall Mount)
	240 VAC (United Kingdom)	Transformer (Wall Mount)
	Customer Supplied DC 9-32 VDC	Military Style Connector
Re-Radiating Amp Gain Control Options		
Standard Gain	30 dB (Custom Gain between 0-30dB available upon request)	
Variable Gain	$-3 \leq \text{Gain} \leq 23\text{dB}$	
Variable Gain with LCD Display	0-30dB gain range with push button control in 1dB increments	

Re-Radiating Antenna Electrical Specifications, $T_A = 25^{\circ}\text{C}$

Parameter	Conditions	Min	Typ	Max	Units
Frequency	See Passive Antenna Specifications page 6				GHz
Bandwidth					MHz
Impedance			50		Ω
Peak Gain			3		dBic
Output SWR				1.5:1	-
Polarization			RHCP		-

Part Number Configuration

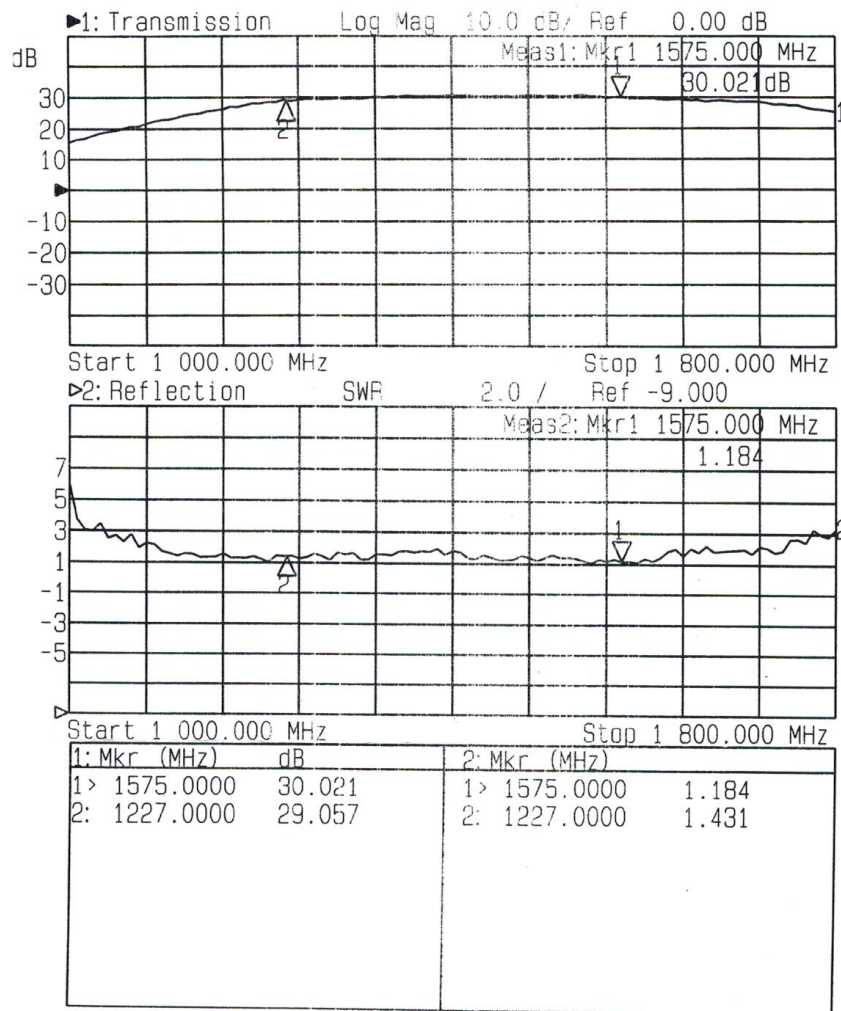


Contact GPS Networking Technical Support at 719-595-9880 or salestech@gpsnetworking.com for any questions regarding non-standard configurations and corresponding part numbers)

Performance:

NRRKAMP (Re-Radiating Kit Amp Standard Gain)

Input SWR (Ant. Port) and Frequency Response: Ant. To J1) (Typical, type N connectors):

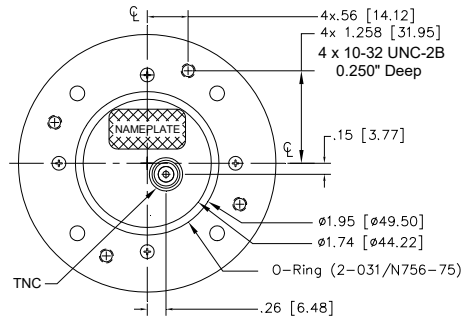
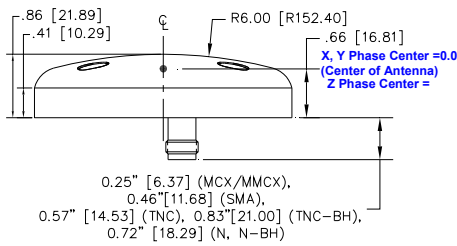
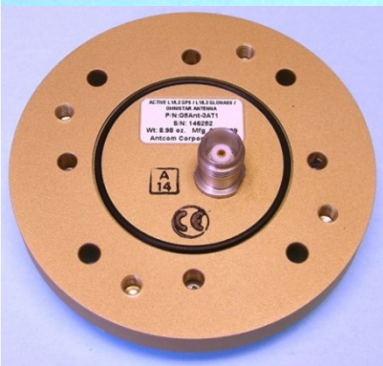
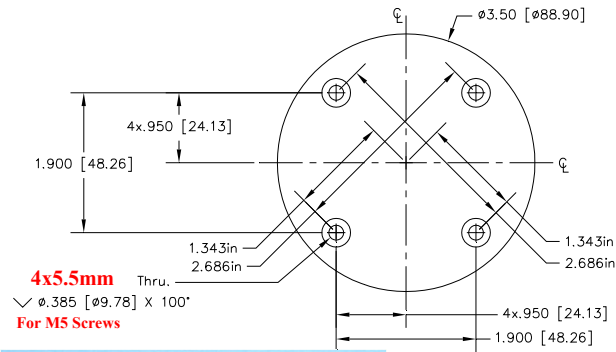


Specifications:

L1L2GGPSA (L1/L2 GNSS Active Antenna-Outdoor)

Includes all GNSS Frequencies

SPECIFICATIONS



ELECTRICAL:

	L5 GPS E5, E5a, E5b Galileo L5 IRNSS	L2 GPS B2 Compass	L2 GLONASS E6 Galileo B3 Compass	OmniSTAR / L-Band L6 Galileo B1 Compass	L1 GPS E1, E2 Galileo L1 IRNSS	L1 GLONASS
FREQUENCY:	1176.45 ± 12 MHz 1164.45 - 1219.14 MHz 1176.45 ± 15 MHz	1227.60 ± 12 MHz 1207.14 ± 10 MHz	1252.50 ± 7.5 MHz 1266.75 - 1290.75 MHz 1268.52 ± 10 MHz	1542.50 ± 14.0 MHz 1542.50 ± 5.0 MHz 1561.098 ± 10 MHz	1575.42 ± 15.0 MHz 1575.42 ± 17.0 MHz 1575.42 ± 12.0 MHz	1609 ± 7.0 MHz
RADIATION PATTERN:	HEMISPHERICAL					
POLARIZATION:	RHCP	RHCP	RHCP	RHCP	RHCP	RHCP
VSWR:	< 2.0:1	< 2.0:1	< 2.0:1	< 2.0:1	< 2.0:1	< 2.0:1
IMPEDANCE:	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms	50 ohms
ANTENNA GAIN (dBic):	Free Space 4 ft G.P.	Free Space 4 ft G.P.	Free Space 4 ft G.P.	Free Space 4 ft G.P.	Free Space 4 ft G.P.	Free Space 4 ft G.P.
@ 90 ° (ZENITH):	-	+ 2.6	+ 0.0	+ 2.1	+ 4.0	+ 3.0
@ 10 ° Elevation:	-	- 3.5	- 6.5	- 4	- 2.7	- 3
@ 20 ° Elevation:	-	- 2.0	- 4.7	- 3	- 1.9	- 2
@ 30 ° Elevation:	-	- 0.4	- 3.4	- 2	- 0.5	- 1
@ 60 - 90 ° Elevation:	> -4	> 1.3	> -1.5	> -0.1	> -0.5	> -0.2
BEAM WIDTH (3dB):	110 Deg.	120 Deg.	110 Deg.	110 Deg.	145 Deg.	150 Deg.
AXIAL RATIO:	1.5 dB	2 dB	1 dB	2 dB	1 dB	2 dB
LIGHTNING PROTECTION:	DC GROUNDING					
LNA GAIN:	35 dB	35 dB	35 dB	33 dB	33 dB	33 dB
LNA NOISE FIGURE:	3.0 dB	3.0 dB	3.0 dB	3.0 dB	3.0 dB	3.0 dB
LNA P1dB Out:	+13 dBm	+13 dBm	+13 dBm	+13 dBm	+13 dBm	+13 dBm
LNA DC POWER:	2.5V/20mA, 3V/23mA, 3.3V/35mA, (2.5-24)V/≤50mA					
POWER HANDLING:	1 Watt CW. Optional: 10 Watts 1 Microsec Pulse (-AL-)					

MECHANICAL:

SIZE:	DIAMETER: 3.50 in. [88.90 mm] HEIGHT: 0.86 in. [21.89 mm]
WEIGHT:	9 oz. (256 g)
FINISH:	SKYDROL RESISTANT POLYURETHANE ENAMEL BASE IRIDITE PER MIL-C-5541F CLASS 1A GLOSS WHITE #17925 PER FED-STD-595B
COLOR:	6061-T6 ALUMINUM ALLOY BASE
MATERIAL:	COMPOSITE RADOME, IMPACT, ABRASION, UV, SOLVENT, SKYDROL RESISTANCE, AND FIRE RETARDANT
CONNECTOR:	TNC FEMALE (OPTION: SMA, BNC, TNC Bulkhead, N, N Bulkhead, MCX, MMCX)

ENVIRONMENTAL:

TEMPERATURE:	-67 °F TO +185 °F [-55 °C TO +85 °C] (Operational) -85 °F TO +302 °F [-65 °C TO +150 °C] (Storage)
ALTITUDE:	70,000 ft.
VIBRATION:	> 30 G's
LEAKAGE:	HERMETICALLY SEAL
HAILSTONES:	< 0.5" Dia.

FEDERAL & MILITARY SPECIFICATIONS:

DESIGN TO:	FAA TSO-C144, DO-160D, D0-228, MIL-C-5541, MIL-E-5400, MIL-I-45208A, MIL-STD-810, AND SAE J1455
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QUANTITY REQD	DESCRIPTION	PART NO
4	M5 Screws	
4	Washer, Custom C'Sink	3G15P1001-70
1	O-Ring or Gasket	2-031/N756-75 or 3G15P1001-3G

P/N: G5Ant-3AT1 Connector Color

SIZE:	LNA:	CABLE'S LENGTH:	CONNECTOR:	COLOR:
1. 2" SQ	42. ARINC 743	X: NO CABLE	S: SMA, B: BNC	-1: GLOSS WHITE #17925 PER FED-STD-595B
1.9. 1.9" SQ	52. 2.6" DIA. ON 5" GROUND PLANE		M: MCX, MM: MMCX	-2: LUSTERLESS GRAY #36320 PER FED-STD-595B
2. 2.6" DIA	72. 7" DIA. CHOKER RING		N: N, NB: N-Bulkhead	-3: OLIVE DRAB GREEN #34094 PER FED-STD-595B
3. 3.5" DIA			T: TNC, TB: TNC-Bulkhead	-4: LUSTERLESS BLACK #37038 PER FED-STD-595B
-5: TAN # FS 23446 or 33446, FED-STD-595				

3.5in Dia.
L1L2GLonass/L1L2GPS/OmniStar
G5 ANTENNA
D|3CVE1| G5Ant-3AT1 |
SCALE 1/1 SHEET 1 OF 1

Specifications:

L1L2GRRKPA-N (L1/L2 GNSS Passive retransmit antenna-indoor)

Includes all GNSS Frequencies

SPECIFICATIONS

ELECTRICAL:

	L5 GPS E5, E5a, E5b, Galileo L5 IRNSS 1176.45 ± 12.0 MHz 1164.45 - 1219.14 MHz 1176.45 ± 15.0 MHz	L2 GPS B2 Compass 1227.60 ± 12.0 MHz 1207.14 ± 10.0 MHz	L2 GLONASS E6 Galileo B3 Compass 1252.50 ± 7.5 MHz 1266.75 - 1290.75 MHz 1268.52 ± 10.0 MHz	OmniSTAR / L-Band L6 Galileo B1 Compass 1542.50 ± 14.0 MHz 1542.50 ± 5.0 MHz 1561.098 ± 10.0 MHz	L1 GPS E1, E2 Galileo L1 IRNSS 1575.42 ± 15.0 MHz 1575.42 ± 17.0 MHz 1575.42 ± 12.0 MHz	L1 GLONASS 1603 ± 7.0 MHz
FREQUENCY:						
RADIATION PATTERN:						
POLARIZATION:						
VSWR:						
IMPEDANCE:						
ANTENNA GAIN (dBic):						
@ 90° (ZENITH):	Free Space - 7	Free Space - 3	Free Space - 0.8	Free Space - 1.9	Free Space - 4.1	Free Space - 2.0
@ 10° Elevation:	- 13	- 10	- 5.6	- 5.7	- 2.8	- 5.1
@ 20° Elevation:	- 11	- 9	- 3.9	- 3.9	- 1.9	- 4.1
@ 30° Elevation:	- 10	- 8	- 2.6	- 2.6	- 0.4	- 2.6
@ 60 - 90° Elevation:	> - 8	> - 5	> - 1	> - 2.4	> - 2.9	> - 1.8
BEAM WIDTH (3dB):	105 Deg.	100 Deg.	105 Deg.	95 Deg.	95 Deg.	95 Deg.
AXIAL RATIO:	1.5 dB	3 dB	1 dB	1 dB	1 dB	2 dB
LIGHTNING PROTECTION:						
LNA GAIN:	N/A	N/A	N/A	N/A	N/A	N/A
LNA NOISE FIGURE:	3.0 dB	3.0 dB	3.0 dB	3.0 dB	3.0 dB	3.0 dB
LNA P1dB Out:	+13 dBm	+13 dBm	+13 dBm	+13 dBm	+13 dBm	+13 dBm
LNA DC POWER:						
POWER HANDLING:						

MECHANICAL:

SIZE:	DIAMETER: 2.63 in. [66.8 mm] HEIGHT: 0.985 in. [25 mm]
WEIGHT:	5.5 oz. (156 g)
FINISH:	SKYDROL RESISTANT POLYURETHANE ENAMEL BASE IRIDITE PER MIL-C-5541F Class 1A
MATERIAL:	6061-T6 ALUMINUM ALLOY BASE COMPOSITE RADOME, IMPACT, ABRASION, UV, SOLVENT, SKYDROL RESISTANCE, AND FIRE RETARDANT
CONNECTOR:	TNC FEMALE BULKHEAD CONNECTOR (OPTION: SMA, BNC, N, N Bulkhead, MCX, MMCX)

ENVIRONMENTAL:

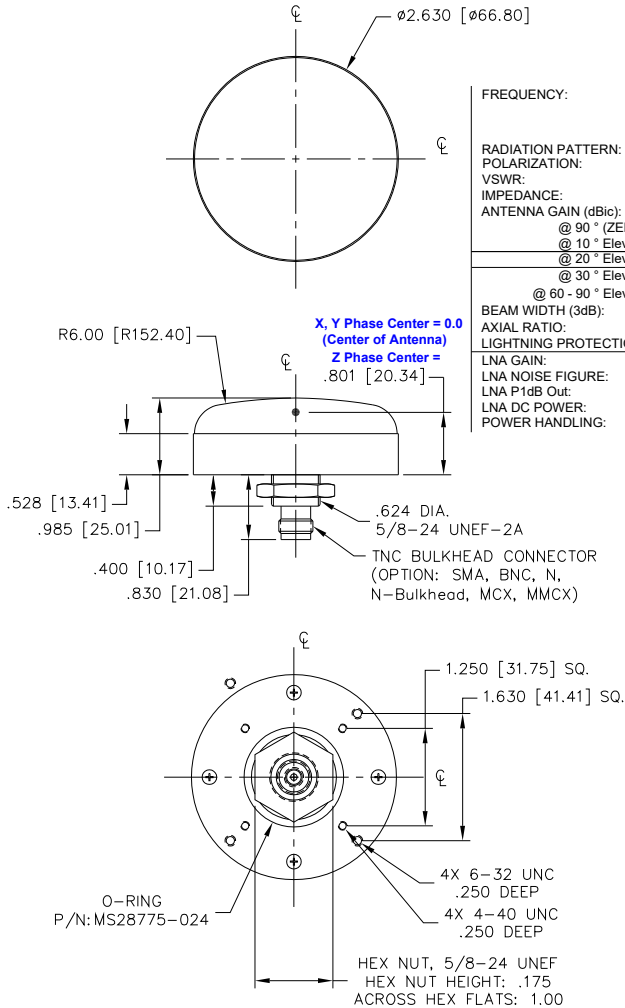
TEMPERATURE:	-67 °F TO +185 °F [-55 °C TO +85 °C] 70,000 ft.
VIBRATION:	> 30 G's HERMETICALLY SEAL

FEDERAL & MILITARY SPECIFICATIONS:

FAA TSO-C144, DO-160D, D0-228, MIL-C-5541,
MIL-E-5400, MIL-I-45208A, MIL-STD-810, AND SAE J1455

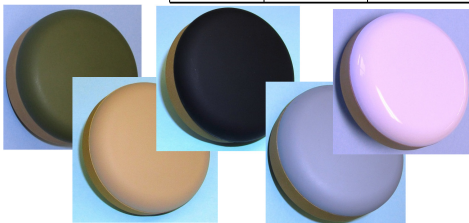
ACCEPTANCE TEST PROCEDURE:

ATP-GPS-L1L2-100



P/N: G5Ant-2PN4

SIZE:	LNA:	CABLE'S LENGTH:	CONNECTOR:	COLOR:
1: 2" SQ.	A: WITH LNA	X: NO CABLE	S: SMA; B: BNC	-1: GLOSS WHITE #17925 PER FED-STD-595B
1.9: 1.9" SQ.	P: WITHOUT LNA		M: MCX; MM: MMCX	-2: LUSTERLESS GRAY #36320 PER FED-STD-595B
2: 2.6" DIA.			N: N; NB: N-Bulkhead	-3: OLIVE DRAB GREEN #34094 PER FED-STD-595B
3: 3.5" DIA.			T: TNC; TB: TNC-Bulkhead	-4: LUSTERLESS BLACK #37038 PER FED-STD-595B
4: MINI ARINC			TNB: TNC-Bulkhead with N-connector Thread on Bulkhead	-5: TAN #: FS 23446 or 33446, FED-STD-595



Mechanical

Re-Radiating Kit Amplifier

Dimensions: Height: 1.3"

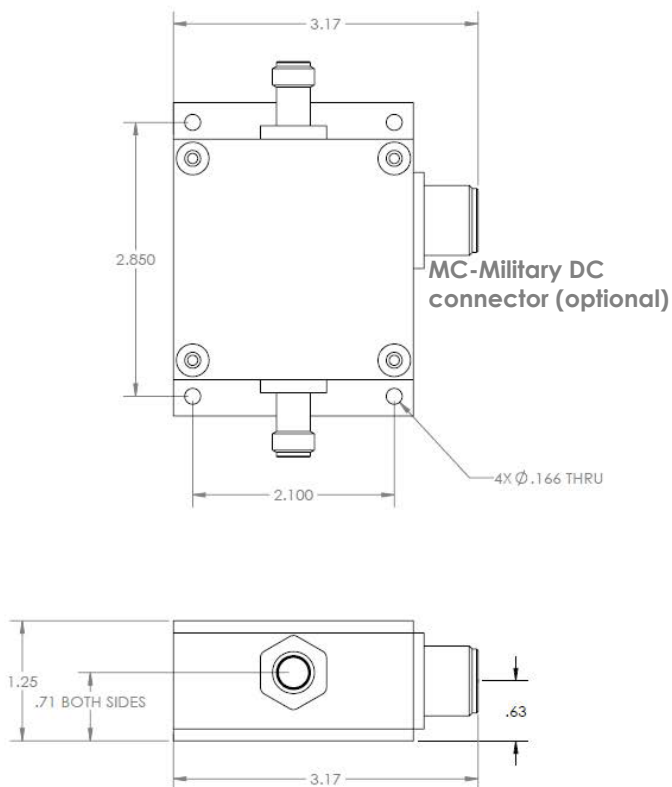
Length (not including connectors) Body: 2.5"
Base Plate: 3.25"

Width (not including connectors): 2.5"

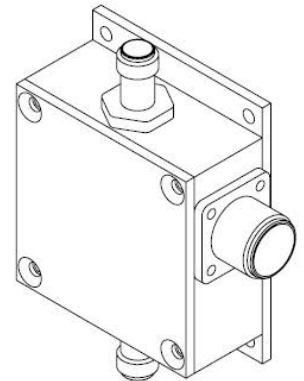
Weight: 11 oz. (316 grams)

Operating Temp. Range: -40° to + 75°C

Finish Housing and Base Plate: ELECTROLESS NICKEL PLATED
MIL-C-26074C CLASS 1, .0001-.0003 MAX
Finish Lid: ANODIZE, TYPE II, CLASS 2, BLACK, per MIL-A-8625



REVISIONS				
ZONE	REV.	DESCRIPTION	REV. BY	DATE
1	A	INITIAL RELEASE	1	---



GPS NETWORKING		ASSY, 1X1 STANDARD				Do Not Scale Drawing Remove All Burrs And Sharp Edges To .000 Round Max
Design	Drawn	Check	Eng	Rev	Rev	
BPC	09/04/15					
Drawn By	Check	Eng	Rev	Rev	Rev	
Scale	Quantity / Unit Key	Material	See Note			
Part Number	Material	Part Key				
Design Number						
ASSY, 1X1 STANDARD	DEF	Rev	Sheet	1 OF 1		
	B	A				

ATTACHMENT B

Budget Link Calculations

The following calculations represent the architecture of SwRI's proposed GPS re-radiation configuration and the signal power calculations which demonstrates compliance with NTIA Manual 8.3.28.

	Individual element	Cumulative total
GPS signal received power from GPS spacecraft	-130	-130 dBm
Receive Antenna pattern gain (estimated)	3	-127
Receive Antenna amplifier gain (data sheet)	33	-94
Transmission line loss to re-radiator antenna (estimated)	-27	-121
Re-radiator amplifier (data sheet)	30	-91
Re-radiator antenna gain (estimated)	3	-88
<u>Free space path loss (FSPL) at 100 feet inside Building 178</u>	<u>-66</u>	<u>-154 dBm</u>

These calculations indicate that SwRI will not re-radiate GPS signals greater than -140dBm/24 MHz at 100 feet from the re-radiation source.