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System Description, Installation, and Maintenance Manual

VersaWave + 5G

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Contents

Introduction

1. How to Use This Manual

A. General

(1) This manual provides information about the installation of the VersaWave + 5G UAV System.

(2) Standard maintenance procedures that technicians must know are not given in this manual.

(3) This publication is written in agreement with the ATA Specification

(4) Warnings, cautions, and notes in this manual give the data that follows:

(5) A WARNING gives a condition or tells personnel what part of an operation or maintenance procedure, which if not obeyed, can cause injury or death.

(6) A CAUTION gives a condition or tells personnel what part of an operation or maintenance procedure, which if not obeyed, can cause damage to the equipment.

(7) A NOTE gives data, not commands. The NOTE helps personnel when they do the related instruction.

(8) Warnings and cautions go before the applicable paragraph or step. Notes follow the applicable paragraph or step.

B. Observance of Manual Instructions

(9) All personnel must carefully obey all safety, quality, operation, and shop procedures for the unit.

(10) All personnel who operate equipment and do maintenance specified in this manual must know and obey the safety precautions.

C. Units of Measure

(11) Measurements, weights, temperatures, dimensions, and other values are expressed in the USMS followed by the appropriate SI metric units in parentheses. Some standard tools or parts such as drills, taps, bolts, nuts, etc. do not have an equivalent.

D. Illustration

(12) Supplemental illustrations use a suffix number to the basic figure number. For example, if Figure 501-5 is used, it signifies that it is an illustration of the item identified by index number 5 in Figure 501.

(13) Illustrations with no specific designation are applicable to all units.

E. Scope

(14) This manual provides detailed information for avionics technicians about the wiring, installation, and setup of every component of the VersaWave + 5G. This manual includes information for end users about how to operate the VersaWave + 5G. The VersaWave + 5G connects to the Inmarsat satellite network and is intended for use on UAVs for command, control and streaming back of live video and other mission data.

F. Hardware Part Numbers

(15) The SATCOM products are identified by the hardware part numbers indicated in Table 1.

(16) Where:

- A change to form fit or function will be reflected in a new base part number.

G. Organization

(17) See Table of Content for the installation manual organization.

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- Telephone: +1 602 365 7020 (option 7 for Activations)
- Email: FSSactivations@Honeywell.com

E. References

(1) Honeywell/Vendor Publications

(a) Related Honeywell publications in this manual are shown in the list that follows:

- Not applicable.

(b) Other Publications:

- The United States GPO Style Manual (available at http://www.gpo.gov/fdsys/pkg/GPO-STYLEMANUAL-2008/content-detail.html)
- IEEE Std 260.1, Standard Letter Symbols for Units of Measurement (available from the
- American National Standards Institute at http://www.ansi.org)
- ASME Y14.38, Abbreviations for Use on Drawings and Related Documents (available from the American National Standards Institute at http://www.ansi.org)
- ASME Y14.5, Dimensioning and Tolerancing (available from the American National Standards Institute at http://www.ansi.org)
- ANSI/IEEE Std 91, Graphic Symbols for Logic Functions (available from the American National Standards Institute at http://www.ansi.org)
- CAGE codes and manufacturers' addresses are available at https://cage.dla.mill
- IEEE 315/ANSI Y32.2, Graphic Symbols for Electrical and Electronics Diagrams (available from the American National Standards Institute at http://www.ansi.org).

3. Acronyms and Abbreviations

A. General

(1) The abbreviations are used in agreement with ASME Y14.38.

(2) Acronyms and non-standard abbreviations used in this publication are listed in Table 1

Table 1 - List of Acronyms and Abbreviations

TERM	FULL TERM
AAC	Aeronautical Administrative Communication
ACARS	Aircraft Communications Addressing and Reporting System
ACD	Aircraft Control Domain
AES	Aircraft Earth Station
AMSS	Aeronautical Mobile Satellite Services
ANSI	American National Standards Institute
AOC	Aeronautical Operational Control
APC	Aeronautical Passenger Communications
ARINC	Aeronautical Radio, Incorporated
ASME	American Society of Mechanical Engineers
ATA	Air Transport Association
ATC	Air Traffic Control
ATE	Automated Test Equipment
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
AWG	American Wire Gage
BGAN	Broadband Global Area Network
C	Celsius
CAGE	Commercial And Government Entity
CFR	Code of Federal Regulation
CRC	Cyclic Redundancy Check
CS	Circuit Switched
DAH	Design Approval Holder
DAL	Design Assurance Level
DSP	Digital Signal Processor
EASA	European Aviation Safety Agency
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMI	Electro-Magnetic Interference
EMS	EMS Technologies
ESDS	Electrostatic Discharge Sensitive
F	Fahrenheit
FCC	Federal Communications Commission
GPO	Government Printing Office
GES	Ground Earth Station
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
HPA	High Power Amplifier
HTTP	HyperText Transfer Protocol
in.	Inches
ICD	Interface Control Document
IP	Internet Protocol
ISEDC	Innovation, Science and Economic Development Canada
ISO	International Standards Organization
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers

IPC	Illustrated Parts Catalog
LED	Light Emitting Diode
LGA	Low Gain Antenna
MCU	Micro Controller Unit
mm	Millimetre
MOPS	Minimum Operational Performance Standards
MPS	Minimum Performance Standards
NA	Not Applicable
NGSS	Next Generation Satellite Services
OPS	Operational Program Software
PN	Part Number
Pub.	Publication
PBA	Printed Board Assembly
PDP	Packet Data Protocol
PPPoE	Point-to-Point Protocol over Ethernet
RF	Radio Frequency
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automotive Engineers
SATCOM	Satellite Communications
SBB	Swift Broad Band
SDIM	System Description and Installation Manual
SDU	Satellite Data Unit
SIM	Subscriber Identity Module
SITA	Société Internationale de Télécommunications Aéronautiques
SI	International System of Units
TCCA	Transport Canada Civil Aviation
TLS	Transport Layer Security
UAV	Unmanned Aeronautical Vehicle
USMS	United States Measurement System
UMTS	Universal Mobile Telecommunications Service
USIM	UMTS Subscriber Identity Module
VAM	Value Added Manufacturer
VoIP	Voice over IP

System Description

1. General Information

A. General

VersaWave + 5G is a lightweight, integrated mobility solution providing seamless satellite, cellular, Wi-Fi and external Line of Sight (LoS) modem communication connectivity between mobile platform and user's control station. While primarily destined for aeronautical solutions it can be equally deployed on many mobile platforms, including but limited to UAV's, UAM, AAM, airplanes, unmanned in air, ground, or even marine environments.

The VersaWave + 5G system is designed and is qualified for operation in the Inmarsat BGAN network offering Class 15 and Class 7BGAN services. It is also intended for future Class 16 and 4 services. Cellular datalink provides GUI configurable 3G, LTE as well as 5G connectivity with worldwide roaming capabilities. System, Wi-Fi is provided for the system configuration prior mission start supporting IEEE 802.11a/b/g/n/ac standards. VersaWave + 5G also includes support for Bluetooth connectivity which can be enabled or disabled depending on user needs. Ver

Note that this is not a safety certified product. Do not use this as part of a safety related function.

Internally to the remote platform, the VersaWave + 5G system provides

- 2 LAN ethernet links for local communication within remote platform
- Serial connection for the LoS radio configuration and traffic routing.
- Total of 2 USB2.0 host ports and 1 CAN bus interface for future expansion

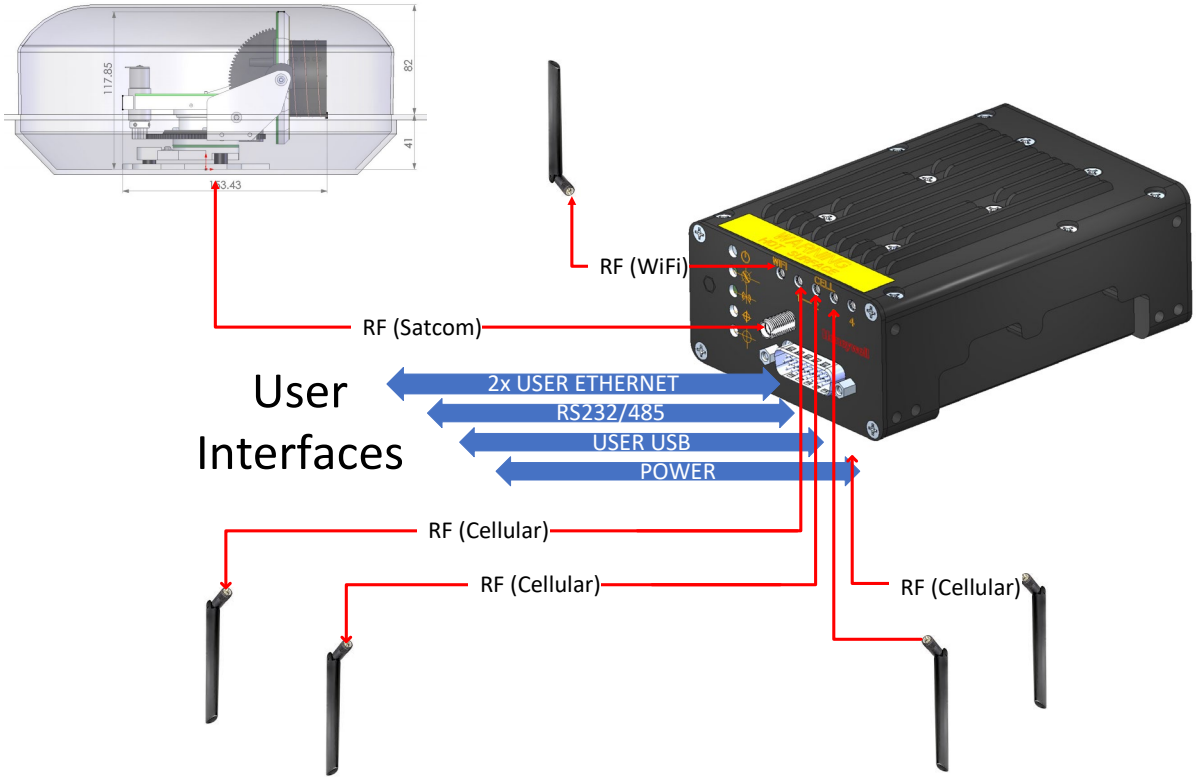
The VersaWave + 5G system operates out of nominal 28Vdc power line with maximum power consumption rating 100W.

B. System Assembly

The VersaWave + 5G system makes up the AES portion of the network and consists of the following elements:

- Satellite Data Unit, referred to as the Indoor Unit (IDU),
- USIM Modules (UM), for Satcom,
- Two Active SATCOM Antenna Options
    - Class 15 Low Gain Omnipolar, or
    - Class 7 Intermediate Gain Directional
- RF Interconnect Cable,
- The following items are not provided with the kit as they may vary depending on customer needs; Power & Communication cable harness (design details contained in Section xx)
- Cellular SIM – provided direct from Honeywell Airtime Activations team,
- Cellular / GPS and Wi-Fi Antennas with cables (Commercial off the shelf items)

Figure 1 – VersaWave + 5G System diagram

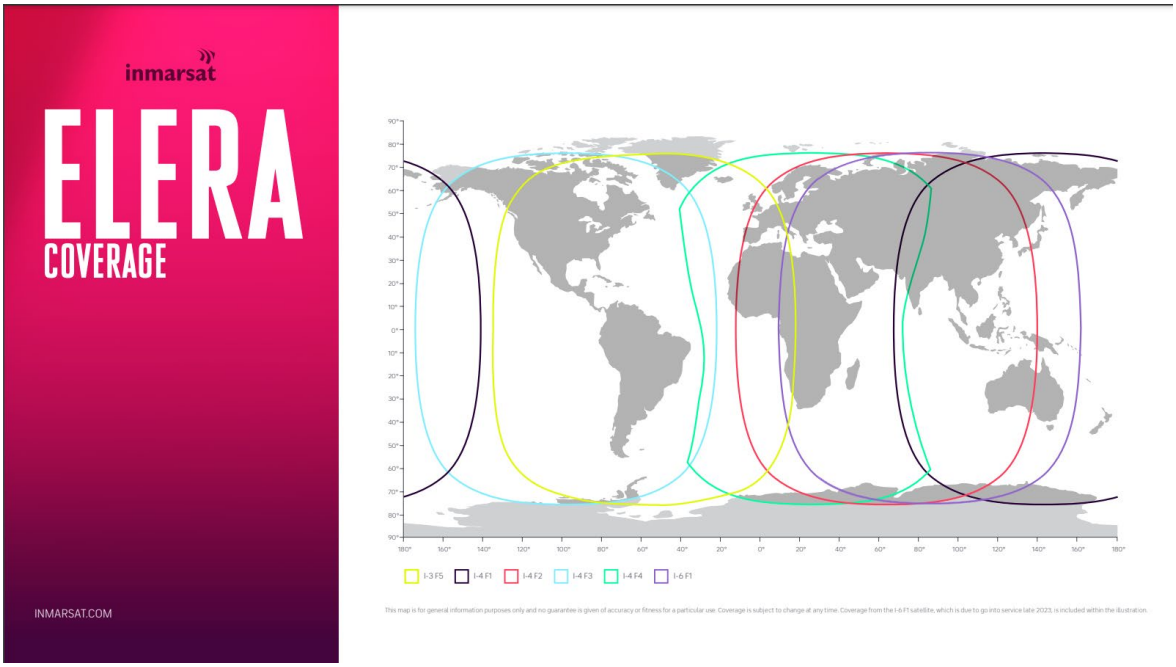


C. Inmarsat Satellite Network

The Inmarsat Satellite Communications Network consists of:

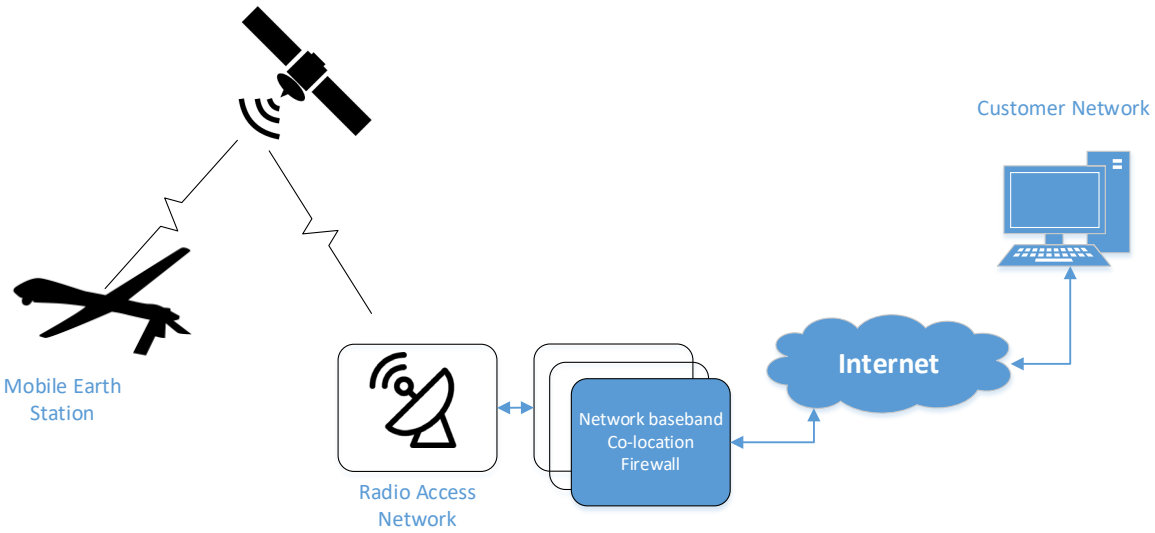
- A space segment formed by the Inmarsat-4 (I-4/I-4A) geostationary satellites.
- Future Inmarsat I-6 constellation
- A terrestrial ground infrastructure formed by the Satellite Access Stations (SAS) for SwiftBroadband
- Terrestrial interconnect networks
- Aircraft Earth Stations (AES)
- A Network Control Center and a Business Support System.

Figure 2 - Inmarsat Satellites



The coverage area of the satellites is formed through the use of a global beam, regional beams and narrow spot beams. The services offered in a given region will operate from a single Inmarsat satellite at any one time. There are typically multiple satellites available to the antenna at any given time.
The user links are in L-band (1.5/1.6 GHz). The basic configuration of the I-4/I-6 network in relation to aircraft user terminal functionality is depicted in the figure below.

Figure 3 – Inmarsat Satellite Network diagram



Users must activate the Satcom USIM provided with the hardware prior to connecting to the Inmarsat Satellite Network. Various satcom data plans are available for selection based upon connectivity needs.

E: fssactivations@honeywell.com

P: +1 602 365 7020 (option 7 for sales)

D. Cellular network provisioning

Cellular connectivity is established using Honeywell's Global Cellular Services and/or Honeywell's Regional networks. Users should use the following link to activate cellular services. Honeywell's activation team will ship out the applicable USIM based on service selected. The product also supports the use of ESIM's when available.

E: fssactivations@honeywell.com

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E. Hardware Part Numbers

VersaWave + 5G systems are available in kits dedicated to various installations. Table 2 shows the applicable components comprising the VersaWave + 5G terminal.

Table 2 – VersaWave + 5G Component List

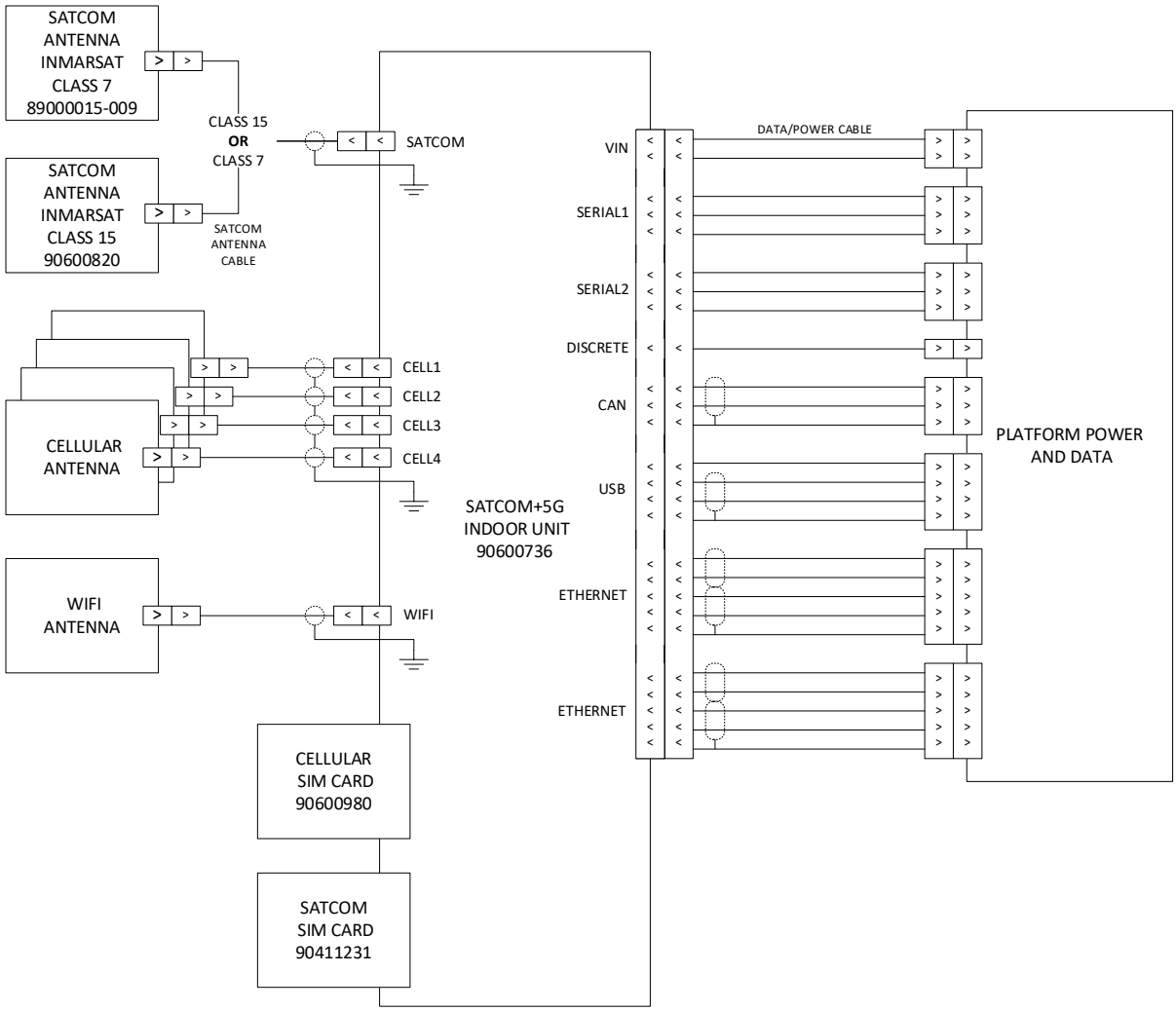
Component Name	**Component Part Number**	**Comment**
Class 15 UAV Terminal	**90411330-001**	**Shipset level PN**
VersaWave + 5G Indoor Unit	90600736	
Class 15 Low Gain Antenna	89000015-009	
Coax Cable	90600596	
SATCOM SIM Card	90411231	
Class 7 UAV Terminal	**90411330-002**	**Shipset level PN**
VersaWave + 5G Indoor Unit	90600736	
Class 7 Intermediate Gain Antenna	90600658	
Coax Cable	90600596	
SATCOM SIM Card	90411231	
Generic and Optional Components	**n/a**	
Cellular SIM Card	90600980	Item mailed at activation
VersaWave + 5G Indoor Unit Outline and Interconnect	90600734	
Customer Supplied Components		
Cellular Antenna	TG.55.8113	5G/4G Monopole Antenna with SMA(M) connector by Taoglas Limited.
Cellular Antenna Cable	415-0071-MM250	MMCX(M) to Bulkhead SMA(F), 250mm long by Cinch Connectivity

		Solutions Johnson.
Wi-Fi Antenna	001-0009	2.4/5GHz Dipole Antenna with Reverse Polarity SMA(M) connector by TE Connectivity Laird.
Wi-Fi Antenna Cable	65530260515305	MMCX(M) to Bulkhead Reverse Polarity SMA(F), 150mm long by Würth Elektronik.
Data/Power Connector Housing	1757824-2	26-way, D-Sub high density, female by TE Connectivity.
Data/Power Connector Contacts	204351-1	Female, size 22, 28 to 22 AWG, 5A by TE Connectivity.
Data/Power Connector Shell	SPC20349	D-Sub shell size DA by Multicomp Pro
Data/Power Connector Cable	To suit customer installation	

□ Installation

1. General

Figure 4 - Terminal Outline



2. Satcom Antenna Cable

A. Overview

Figure 5 - Satcom Antenna Cable (90600596)

(1) The Satcom RF Cable connects the IDU to the Satcom Antenna. It carries RF, control, and DC power to the antenna.
(2) The cable consists of an SMA male connector at the IDU end, a length of coaxial cable and a TNC right angle male connector at the antenna end.
(3) The Honeywell part number 90600596 will be supplied with the terminal, which is a 0.5m cable.
(4) Alternative cable lengths can be made by the user following the specification in Table 3 and Table 4.

B. Safety Warnings

(1) There are no safety warnings specific to the Satcom Antenna cable.

C. Installation

(1) Do not plug or unplug the Satcom Antenna cable from either the IDU or Antenna while power is supplied to the IDU. Doing so may result in damage to either the IDU or Antenna.
(2) The installer should connect the Indoor Unit and Antenna with supplied RF cable.
(3) The RF cable has a fixed RF loss requirement and should not be substituted or shortened, or the terminal will not function properly.
(4) The RF connector torque settings depend on the connector and the recommendations are given in Table 3.
(5) The antenna mounting, indoor unit mounting, and cable routing should be such to avoid sharp bends in the RF cable. The bending radius of each cable type that should be respected is given in Table 3.
(6) The cable should be routed below any ground plane level.
(7) The cable should not be in tension.
(8) The cable should not be routed near high voltage sources or flammable fluid.
(9) The cable should be maintained within the terminal’s environment parameters.

Table 3 – Satcom Antenna Cable Properties

Cable ID	Coax Length (m)	Bending Radius (Installation, m)	Bending Radius (Repeated, cm)	SMA Torque (Nm)	TNC Torque (Nm)	Weight (g)	Temperature Range (°C)
1	0.5	0.007	2.5	0.3 – 0.6	0.5 – 0.7	36	-40 to +85
2	1	0.0013	5.1	0.8 – 1.1	0.5 – 0.7	51	-40 to +85
3	1.5	0.0019	6.3	0.8 – 1.1	0.5 – 0.7	106	-40 to +85
4	2.87	0.0025	10.2	0.3 – 0.6	0.5 – 0.7	336	-40 to +85

Table 4 - Satcom Antenna Cable Parts

Cable ID	SMA Part	SMA Manufacturer	Coax Length (cm)	Coax Part	Coax Manufacturer	TNC Part	TNC Manufacturer	Honeywell Part
1	132114	Amphenol Times Microwave	50	LMR-100A	Amphenol Times Microwave	122148	Amphenol Times Microwave	90600596
2	TC-195-SM-SS-X	Amphenol Times Microwave	100	LMR-195	Amphenol Times Microwave	122108	Amphenol Times Microwave	N/A
3	TC-240-SM-SS-X	Amphenol Times Microwave	150	LMR-240	Amphenol Times Microwave	TC-240-TM-X	Amphenol Times Microwave	N/A
4	TC-400-SM-X	Amphenol Times Microwave	287	LMR-400	Amphenol Times Microwave	TC-400-TM-X	Amphenol Times Microwave	N/A

D. Maintenance

(1) The cable should be inspected regularly for general condition, chafing, kinking and routing.

E. Fault Finding

(1) Power off the IDU prior to disconnecting power or RF cables.
(2) Disconnect the Satcom Antenna Cable from both the antenna and IDU before fault finding.
(3) Inspect for damage including but not limited to the center pin, contacts, cable,
(4) Check that the resistance between the centre conductor and screen is at least 1 Mega Ohms.
(5) Check that the resistance of the centre conductor from one end of the cable to the other is less than 0.5 Ohms.
(6) Check that the resistance of the screen from one end of the cable to the other is less than 0.5 Ohms.

3. Data/Power Cable Assembly (Not Provided within Kit)

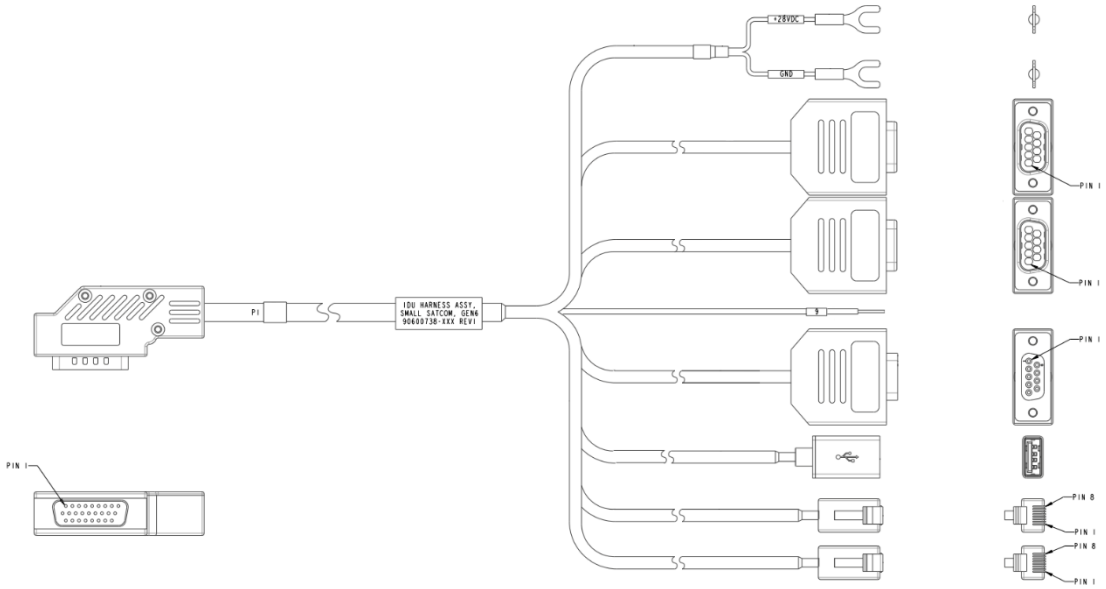
A. Overview

Figure 6 - Power/Data Cable Assembly (90600882)

The Data Cable is not provided with the hardware shipment as it is specific to each users specific needs. When designing please consider the following;

(1) The Power/Data Cable Assembly connects the IDU to the aircraft systems. It connects the IDU to the aircraft DC power supply and computer interfaces.
(2) It is expected that customers will design and build cable assemblies customised to their aircraft and requirements.
(3) Figure 7 below illustrates what a fully populated cable assembly could look like.

Figure 7 – Example of a Fully Populated Power Data Cable Assembly



A. Safety

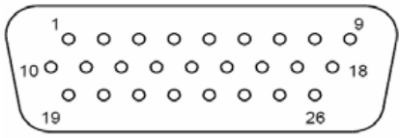
(1) A key requirement of the cable assembly is that the power pins and cables can carry a minimum of 5A. This is the maximum current that may be draw by the IDU. Close attention must be made to the chosen connector pins, cable size, cable insulation and cable routing to

ensure that they can carry this sustained current without overheating. Note: connectors of a solder bucket type typically have a maximum current rating of 3A and so may not be suitable.

B. Installation

(2) Figure 8 below illustrates the pin numbering of the Power/Data connector. The diagram shows the view looking towards the IDU front panel.

Figure 8 - P1 Pin Numbering (Looking at Indoor Unit)



(3) Table 5 below lists suitable parts for the mating connector used in a power/data cable assembly.
(4) The user shall allow for voltage drop over the power supply cables. The Satcom Antenna may have a tight operating voltage range, specified at the input to the IDU.
(5) The USB interface can supply a maximum of 500mA at 5VDC.

Table 5 - Power Data Cable Assembly Suitable Parts

Part	Specification	Part Number	Manufacturer
Housing	26-way, D-Sub high density, female.	1757824-2	TE Connectivity
Contacts	Female, size 22, 28 to 22 AWG, 5A.	204351-1	TE Connectivity
Cover	D-Sub shell size DA	SPC20349	Multicomp Pro

Table 6 – Power Data Cable Assembly Termination Table

From Connector				Cable		To Connector		
Ref Des	Pin	Signal	Signal Type	Wire Type	Wire Group	Ref Des	Pin	Signal
P1	9	V_IN	POWER	AWG 22	3	PWR +28VDC	SPADE TONGUE	V_IN
	8	GND	GND	AWG 22	4	PWR GND	SPADE TONGUE	GND
	1	UART1_TX	SERIAL1 RS232	AWG 28	5	SERIAL1 DB9	2	UART1_RX
	19	UART1_RX					3	UART1_TX
	10	UART1_GND					5	UART1_GND
	2	UART2_TX	SERIAL2 RS232/485	AWG 28	6	SERIAL2 DB9	2	UART2_RX
	20	UART2_RX					3	UART2_TX
	11	UART2_GND					5	UART2_GND
	21	PPS_IN/OUT	DISCRETE	AWG 28	9	DISCRETE		PPS_IN/OUT
	12	CAN_H	CAN FD	STP AWG 28	7	CAN DB9	7	CAN_H
	13	CAN_L					2	CAN_L
	22	CAN_GND		AWG 28			3	CAN_GND
	17	USB_VBUS	USB 2.0	AWG 28	8	USB	1	USB_VBUS
	16	USB_DP		STP AWG 28			3	USB_DP
	15	USB_DN					2	USB_DN

	14	USB_GND		AWG 28			4	USB_GND
	6	ETH1_RXN	ETHERNET 10/100	STP AWG 28	1	ETH1 RJ45	6	ETH1_RXN
	5	ETH1_RXP					3	ETH1_RXP
	4	ETH1_TXN		STP AWG 28			2	ETH1_TXN
	3	ETH1_TXP					1	ETH1_TXP
	7	ETH1_GND		Shield		-	-	-
	26	ETH2_RXN	ETHERNET 10/100	STP AWG 28	2	ETH2 RJ45	6	ETH1_RXN
	25	ETH2_RXP					3	ETH1_RXP
	24	ETH2_TXN		STP AWG 28			2	ETH1_TXN
	23	ETH2_TXP					1	ETH1_TXP
	18	ETH2_GND		Shield		-	-	-

(1) The cables should not be routed near high voltage sources or flammable fluid.
(2) The cables should not be routed near sources of EMI, for example motors or RF transmitters.
(3) The cables should be maintained within their environmental specification.
(4) Terminate shields at one end only, to avoid creating earth loops.
(5) Terminate shields together inside the back shell, to reduce the possibility of EMI leakage.
(6) For twisted pairs, minimise how much of the pair is un-twisted prior to termination in a connector to minimise EMI.

C. Maintenance

(1) The cable assemble should be inspected regularly for general condition, chafing, kinking and routing.

D. Fault Finding

(1) Power down the terminal and disconnect the cable at both ends prior to testing.
(2) Check that the continuity of each wire in the cable assembly between the two end connectors.
(3) Inspect inside the connectors to ensure that there are no bridges between connector pins, for example from straw conductors or solder bridges.

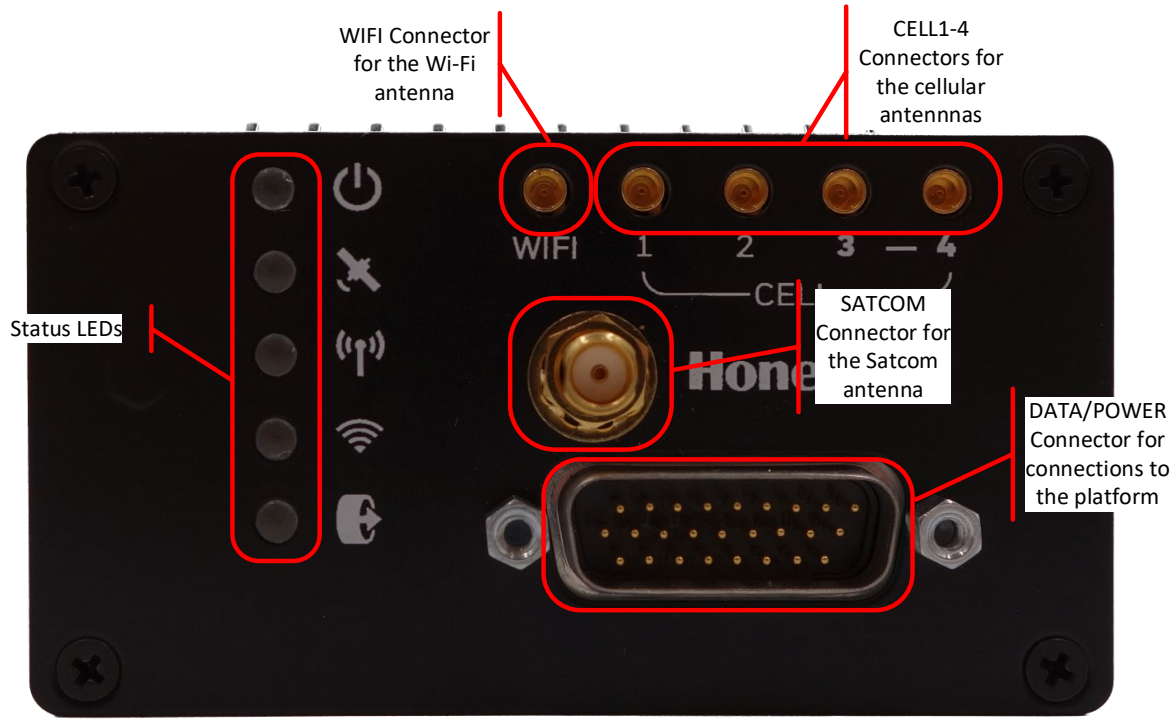
4. IDU

A. Overview

Figure 9 - Indoor Unit

(1) The Indoor until houses the radio modems, an application processor, platform interfaces and power protection circuitry.

Figure 10 - Front Panel Details



(2) The interfaces and functionality enabled in the IDU is determined by the software version it runs. See Section 5 Indoor Unit Software for more details.

Table 7 - Indoor Unit Platform Interfaces

Interface	Limits	Notes
Serial 1	RS-232 voltage levels. 1 Mbits/s maximum bitrate.	
Serial 2	RS-232 or RS-485 voltage levels 1 Mbits/s maximum bitrate.	Software selectable between RS-232 and RS-485. 120Ω termination resistor when in RS-485 mode.
Discrete	Input: Low < 0.8 V, High > 2 V. Output: Low 0v, -12mA. High 3.3 V, 12 mA.	Software selectable as input or output. Software selectable pullup resistor (24kΩ).
CAN	Up to 5 Mbits/s.	
USB	2.0 Standard 5 V, 500 mA maximum supply.	
Ethernet 1	10/100Mbps	UDP/TCP/ICMP @ 192.168.1.1, secured http
Ethernet 2	10/100Mbps	UDP/TCP/ICMP @ 192.168.1.2, secured http

Figure 11 - Indoor Unit Specifications

Component	Characteristic	Specification
Indoor Unit	Part Number	90600736
	Length	4.88 +/- 0.01 in. (124.0 mm) (to front panel surface)
	Width	3.41+/- 0.01 in. (86.6 mm)
	Height	1.94 +/- 0.01 in. (49.3 mm)
	Weight	1.27 Lbs (580 grams) typical
	Cooling	Passive Cooling
	Maintenance	No scheduled maintenance required
	FCC ID	K6KSATCOM5G
	IC ID	1275B-SATCOM5G
	Antenna Connector Type	SMA (Female)
	Storage Temperature	-55 to 85°C (-67 to 185°F)
	Operating Temperature	-40 to 55°C (-40 to 131°F)
	Designed to	
	Environmental Categories	

B. Safety warnings

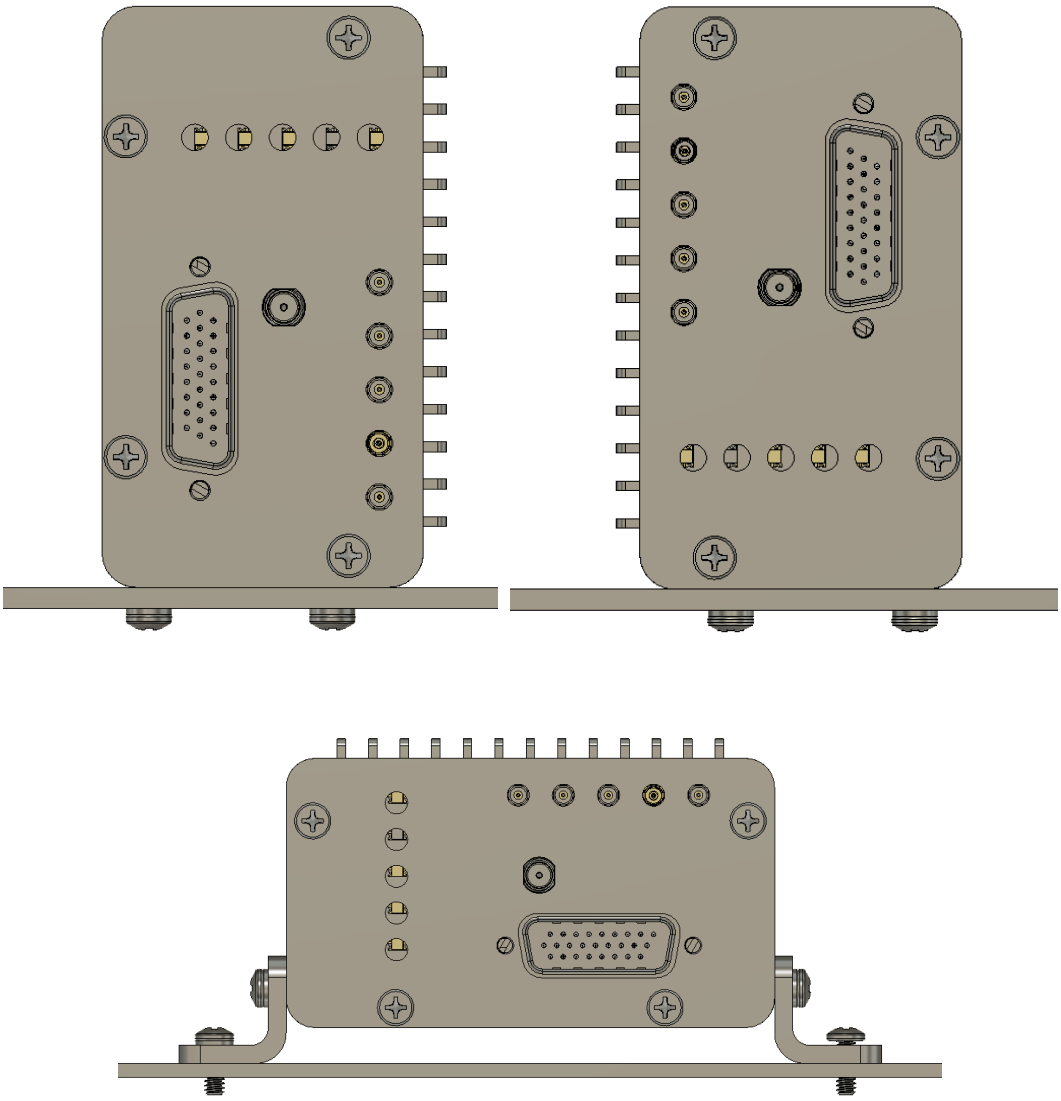
(1) The case of the IDU can become very hot. Allow the IDU to cool down after operation and exercise due caution before touching the antenna or surrounding structures.

Figure 12 - IDU Antenna Heat Warning

C. Installation

(1) The IDU has six threaded holes on both the left and right faces to enable the unit to be securely mounted to the airframe.
(2) These holes are threaded for a #6-32 screw and are 0.138 in. deep.
(3) The screws should be tightened to 5-6 +/- 0.5 in/lb
(4) The IDU can be mounted on its bottom or on either the left or right faces.

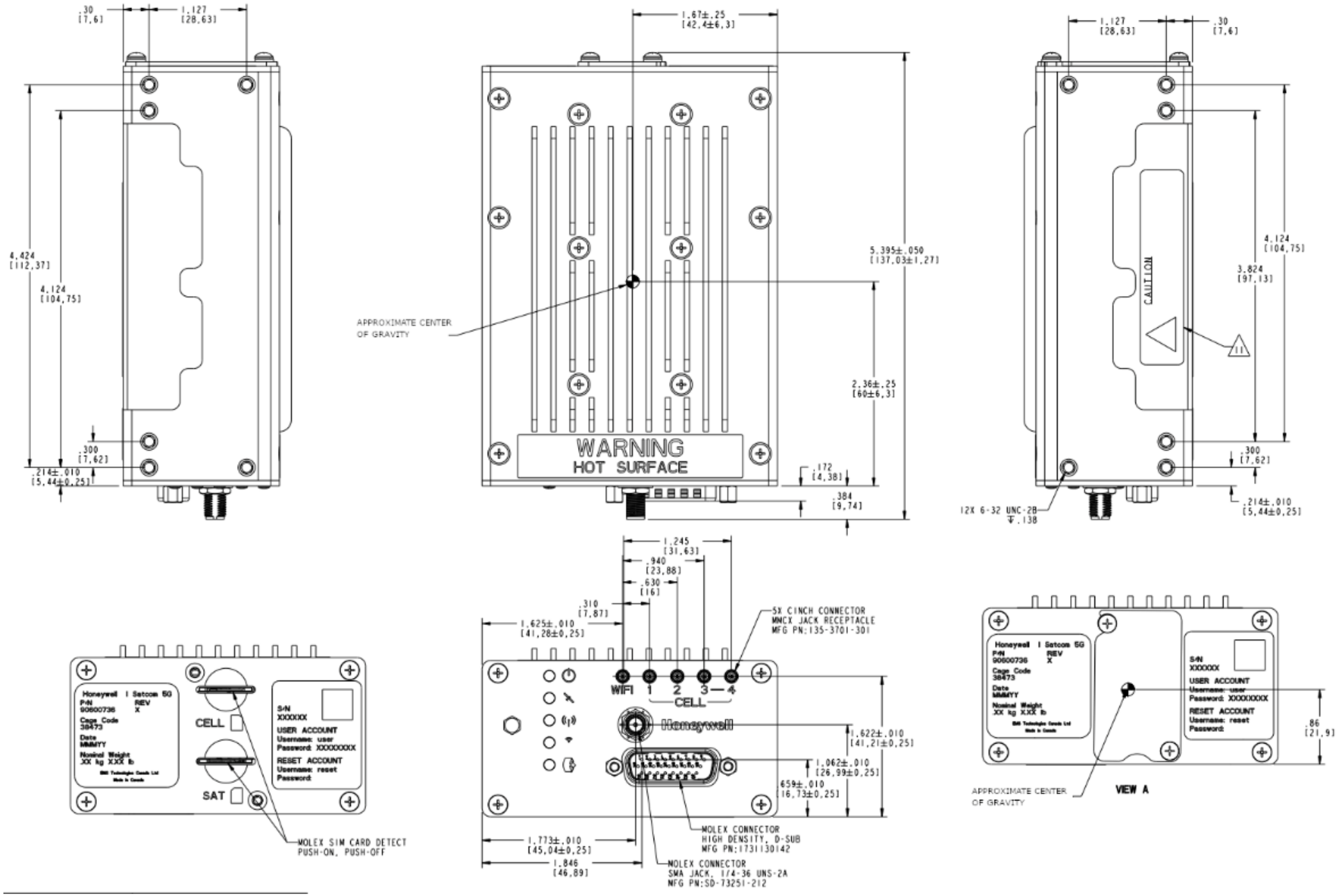
Figure 13 - Indoor Unit Mounting Positions



(2) If the IDU is mounted on its bottom, a 0.25-inch, 6.4 mm gap between the bottom surface of the IDU and the mounting surface should be provided, to allow for convection airflow to cool the bottom and lower edges of the IDU. The figure above demonstrates one of many potential methods to mount on the bottom surface.

(3) See Figure 14 for the mounting hole locations.

Figure 14 - Indoor Unit Dimensions



(4) The IDU relies on convection airflow for cooling, ensure there is sufficient space around the IDU for this.

(5) On the rear face, behind a removable panel, are slots for both the Satcom and Cellular SIM cards. Either ensure there is access to these when the IDU is mounted or that the IDU can be removed if/when the SIM cards need to be changed.

Figure 15 - SIM Card Insertion

(6) The SIM cards are inserted with the corner cut-out towards the front. The Cellular SIM card has the contacts facing up. The Satcom SIM has the contacts facing down.

(7) Insert the SIM cards until a click is felt. To extract the SIM cards, press in until a click is felt. The SIM cards should then spring back out.

(8) The Indoor Unit itself can be powered from 9V to 32.5V DC. However, if a Satcom Antenna is used, the antenna may reduce the acceptable voltage range.

Table 8 - Indoor Unit Supply Voltage

	IDU Power Supply Range
Indoor Unit Only	9V – 32.5V
Cellular Modem	9V – 32.5V
Wi-Fi Modem	9V – 32.5V
Inmarsat Class 15 Antenna	27V – 30V
Inmarsat Class 7 Antenna	24V – 31V

(9) The Indoor Unit voltage specification is defined as at the IDU front panel connector. Voltage loss due to cable resistance up to the IDU connector must be allowed for.

(10) The Indoor Unit feeds the input power to the Satcom antenna, via a switch, to power an active Satcom antenna. It can supply up to 80W to the active antenna.

(11) The Satcom antenna supply will only be enabled when the voltage supply to the IDU is within the acceptable range for the configured Satcom antenna.
(12) The maximum current draw by the IDU is 4A. Ensure that the power supply and cabling can sustain this load without overheating.
(13) The power consumed by the Indoor Unit is a combination of the power consumed by the IDU itself and the power consumed by the Satcom antenna.
(14) Actual power consumption see can vary from the typical figures given Table 9, they are provided as a guide.

Table 9 - Typical Indoor Unit Power Consumption

Use Case		Power	Example
Satcom	Cellular		
Not Attached	Standby	4.5W	The IDU is powered up but not actively doing anything.
Not Attached	Active	10.9W	Passing data at 10Mbps.
Class 15 Standby	Standby	16.8W	
Class 15 Standby	Active	18.2W	Passing 10Mbps data.
Class 15 Command & Control	Standby	23.8W	Passing 20kbps data.
Class 15 Max	Standby	47.6W	Passing 200kbps data.
Class 7 Standby	Standby	19.6W	
Class 7 Standby	Active	21.0W	Passing 10Mbps.
Class 7 Command & Control	Standby	28.4W	Passing 50kbps.
Class 7 Max	Standby	49.0W	Passing 500kbps.

(15) The USB interface can supply a maximum of 500mA at 5VDC, which will increase the power consumed by the IDU.

D. Maintenance

(1) The IDU can be cleaned with a microfibre or soft cotton cloth dampened with water.
(2) Chemical cleaning agents should not be used.
(3) The IDU should be inspected regularly for general condition and integrity of the mounting and connectors.
(4) There are no user serviceable parts inside the IDU. The user must not disassemble the IDU as it risks damaging the IDU.
(5) The IDU contains parts that are susceptible to electrostatic discharge.

Figure 16 - IDU ESD Warning

E. Fault Finding

(1) The IDU contains a buzzer, which beeps on power up.

Figure 17 - IDU Status LEDs

Power Status
No light – no power
Red – voltage outside IDU range
Orange – voltage outside Satcom antenna range
Green – voltage withing Satcom antenna range

Satcom Status
No light – Satcom disabled
Red – critical fault that cannot be automatically recovered from
Orange – fault/issue that is temporary e.g. lost signal
Green – no faults/issue

Cellular Status
No light – Cellular disabled
Red – critical fault that cannot be automatically recovered from
Orange – fault/issue that is temporary e.g. lost signal
Green – no faults/issue

Line of Sight Radio Status
No light – LoS disabled
Red – critical fault that cannot be automatically recovered from
Orange – fault/issue that is temporary e.g. lost signal
Green – no faults/issue

Transparent Tunnel Status
No light – Tunnel disabled
Red – critical fault that cannot be automatically recovered from
Orange – fault/issue that is temporary e.g. lost connection
Green – no faults/issue

F. Environmental Specification

(1) The IDU has been tested to, but not certified to, the DO-160G standard.

Test Description	RTCA/DO-160G Section (MIL-STD-810C/704C/461F)	RTCA/DO-160G Category	Exceptions/Notes
Operating Low Temperature	4.5.2	A2	Extend to -40°C
Operating High Temperature	4.5.4	A2	Restrict to +55°C
Ground Survival Low Temperature	4.5.1	A2	Extend to -55°C
Ground Survival High Temperature	4.5.3	A2	Extend to +85°C
Altitude Test	4.6.1	A2/F1	A2 < 15,000ft F1 > 15,000ft <= 55,000ft
Decompression	4.6.2	A2	55,000ft
Temperature Variation	5	C	
Humidity	6	A	MIL-STD-810C Procedure I

Operational Shock and Crash Safety	7 (516.2)	A	DO-160G section 7.2 and 7.3
Vibration	8	S	DO-160 Performance curve C DO-160 Cat U Curve G
Waterproofness	10	Y	
Sand and Dust	12	D	
Salt Fog	14	S	
Magnetic Effects	15		
Power Input (DC)	16	BXX	Modified to operational voltage range +27 to 30 Volts DC
Voltage Spike	17	B	
Audio Frequency Conducted Susceptibility – Power Inputs	18	B	
Induced Signal Susceptibility	19	BCX	
RF Susceptibility	20	R	
Emission of RF Energy	21	M	
Electrostatic Discharge	25	A	

5. Indoor Unit Software

A. Overview

B. V1 Software

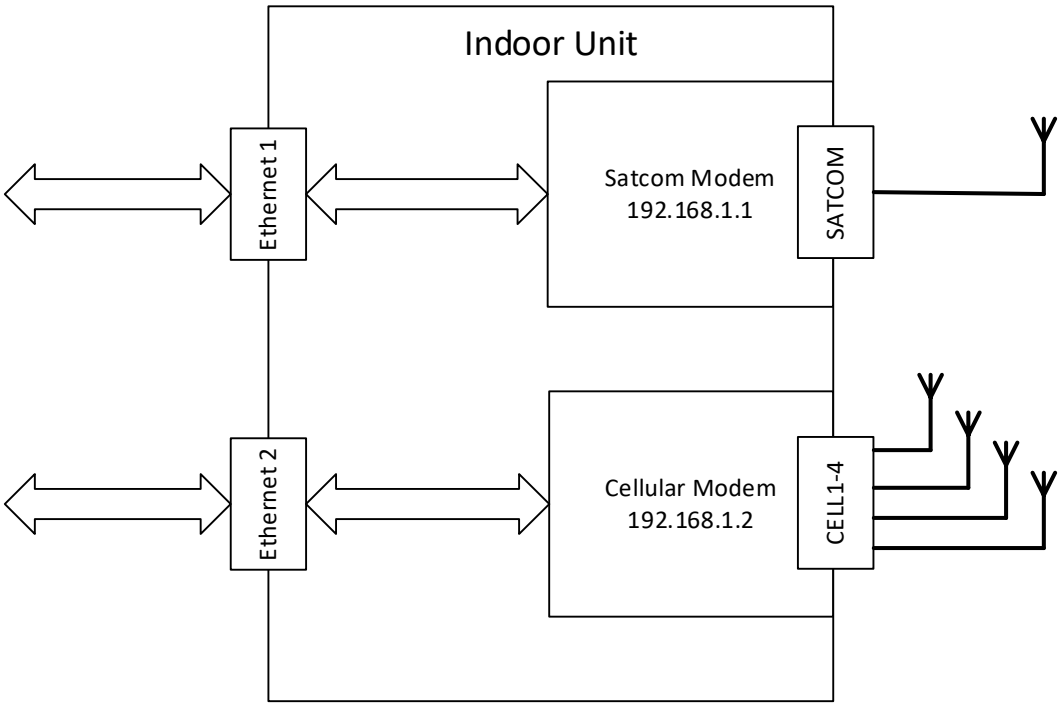
(1) The V1 software allows the user to directly access the Satcom and Cellular modems.

(2) Each modem is accessible via a specific Ethernet port.

Table 10 - V1 Software Feature Support

Feature	Support
Satcom Class 15	✓
Satcom Class 7	✓
Cellular	✓
Wi-Fi	×
Line of Sight Radio Interface	×
Serial 1	×
Serial 2	×
Discrete	×
CAN	×
USB	×
Ethernet 1	✓ (Connected only to Satcom modem)
Ethernet 2	✓ (Connected only to Cellular modem)
Transparent Tunnel	✓

Figure 18 - V1 Software IP Routing



C. V2 Software

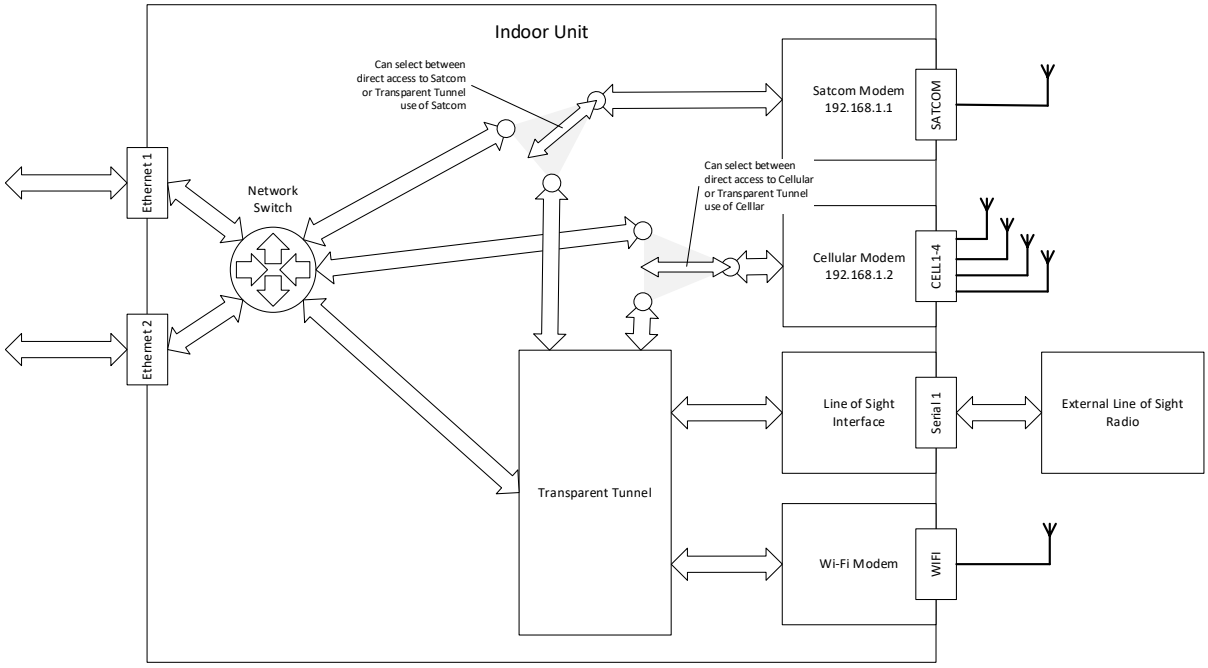
(1) The V2 software add the Transparent Tunnel feature and allows the use of either Ethernet port for any function.

(2) Transparent Tunnel allows the user to set up a link between the terminal ground equipment. The link can be configured to use one or many of the modems and to automatically (and transparently) switch between the links depending on their availability.

Table 11 - V2 Software Feature Support

Feature	Support
Satcom Class 15	✓
Satcom Class 7	✓
Cellular	✓
Wi-Fi	✓ (only for use by Transparent Tunnel feature)
Line of Sight Radio Interface	✓ (only for use by Transparent Tunnel feature)
Serial 1	Interface to optional external Line of Sight radio.
Serial 2	×
Discrete	×
CAN	×
USB	×
Ethernet 1	✓
Ethernet 2	✓
Transparent Tunnel	✓

Figure 19 - V2 Software IP Routing



D. Installing Software

6. Class 15 Satcom Antenna

A. Overview

Figure 20 - Class 15 Antenna

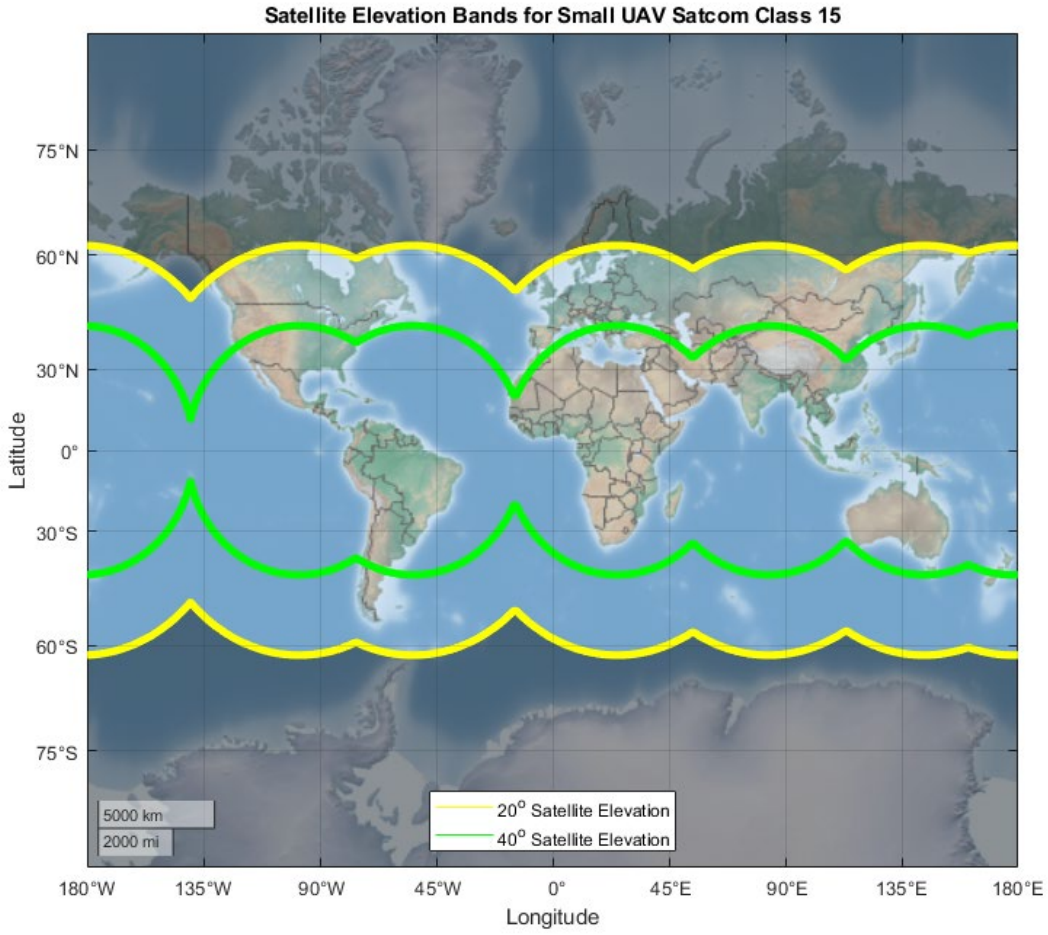
(1) Connecting the Class 15 Antenna to the Indoor unit allows the Indoor Unit to operate on the Inmarsat SwiftBB satellite network.
(2) The antenna is omni-directional. As such the system does not need to be provided with any navigational data or to track the satellite orientation.

Table 12 - Class 15 Equipment Class and Subclass Identification

EQUIPMENT CLASS IDENTIFIER	DESCRIPTION
AES	Aircraft Earth Station
Class 15	A Class 15 transceiver is defined as a transceiver unit capable of operating within an AES15 system, which uses a Low Gain Antenna (LGA). It includes the Indoor Unit and Antenna.

(1) Class 15 offers both streaming connection types (guaranteed data rate, charged by time) or 8, 16, 32 and 64kbps as well as the Background connection type (best effort service, charged by the MB).
(2) Class 15 supports bitrates of up to 200kbps with the Background connection type.
(3) Class 15 terminals work for satellite elevations (angle of the satellite above the horizon) of greater than 20 degrees.
(4) This antenna requires a ground plane of greater than 240mm diameter when the satellite is between 20- and 40-degrees elevation. Above 40 degrees elevation it requires a ground plane of greater than 180mm diameter. See Appendix C – Class 15 Ground Plane Electrical Performance for more details.
(5) Figure 21 shows the approximate location of these elevation bands.

Figure 21 - Class 15 Elevation Bands



(6) The data rate through the VersaWave terminal is dependent upon many factors such as size of ground plane, network congestion, satellite selection, multipath fading, satellite elevation, UAV banking etc. In general, the satellite with the highest elevation will work best and severe banking away from the satellite should be avoided.

(7) The following charts provide an indication of how maximum data rates can be affected by banking towards the satellite (positive) or away from the satellite (negative), depending on satellite elevation, when T4.5 bearers are being used. Satellite elevation can be obtained via the webUI or by using a satellite pointer app. Refer to Figure 22 & Figure 23 for effect of banking on data rate. In Figure 22 & Figure 23, if the signal is synced, the connection is maintained. If it is below the threshold, the connection will be lost.

Figure 22 - Class 15 Effect of Banking on Forward Data Rate

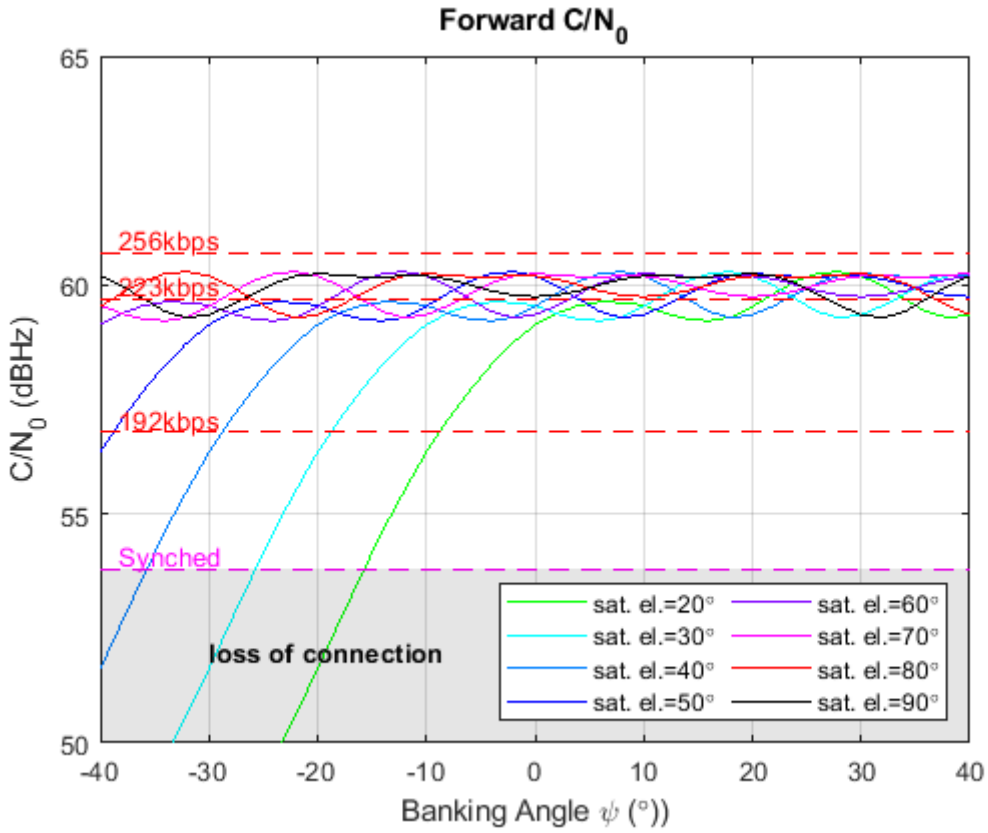


Figure 23 - Class 15 Effect of Banking on Return Data Rate

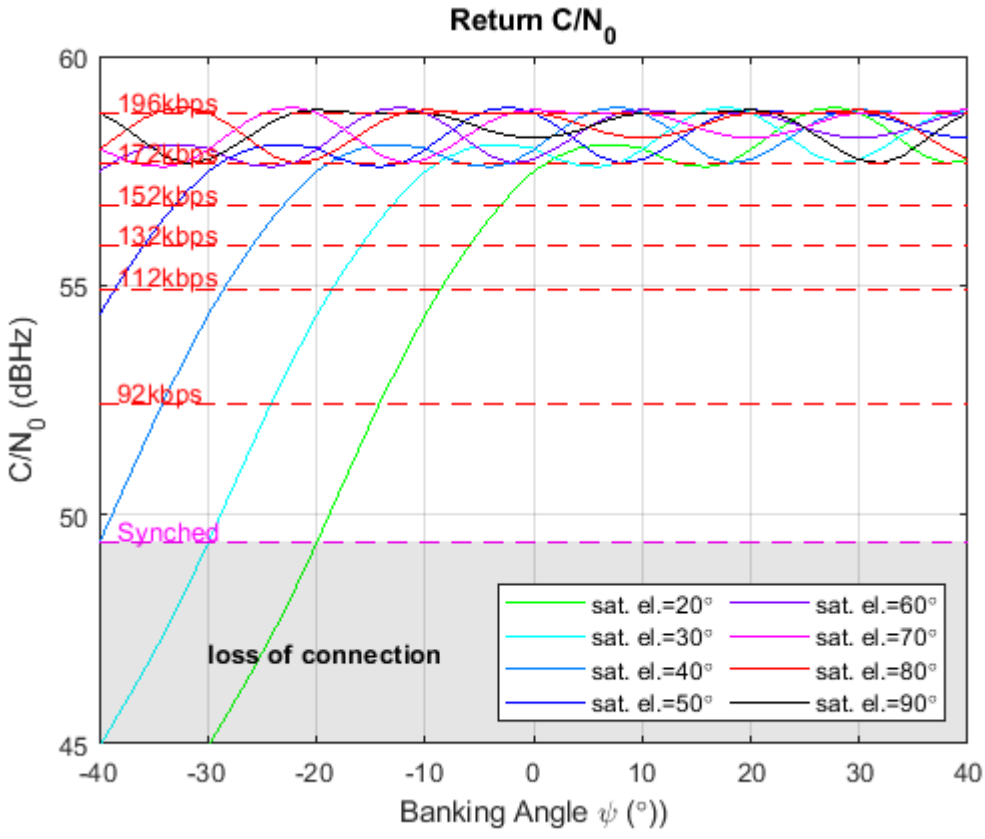


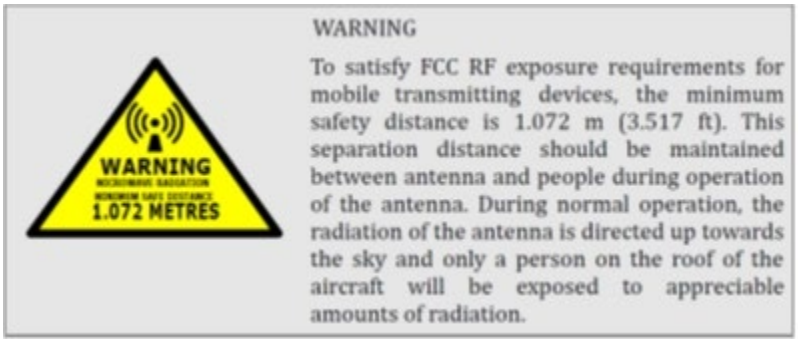
Table 13 - Class 15 Antenna Specifications

Component	Characteristic	Specification
Class 15 Antenna	Part Number	89000015-009
	Length	5.6 in. (142.24 mm) maximum
	Width	4.4 in. (111.76 mm) maximum
	Height	2 in. (50.8 mm) maximum
	Weight	1.06 Lbs (0.482 Kg) maximum
	Cooling	Passive Cooling
	Maintenance	No scheduled maintenance required
	EIRP	11.4 dBW nominal
	TX Operating Frequency	1626.5-1660.5 MHz and 1668-1675 MHz (XLB)
	RX Operating Frequency	1518.0-1559.0 MHz
	Modulation	G1D, G1E, G1W
	Emission Designation	1K69G1D, 1K69G1E, 1K69G1W
	FCC ID	A6L1595-13
	IC ID	9231AAT1595-13
	Antenna Connector Type	TNC (Female)
	Storage Temperature	-55 to 85°C (-67 to 185°F)
	Operating Temperature	-40 to 55°C (-40 to 131°F)
	Designed to	RTCA DO-160D Change 3 and DO-160G
	Environmental Categories	F2-AB [BD] [S(CLMY)U(FF1)] HSFSFSZAAZ [ZCEZWE] [RYR] H [A4J4L4] [2A2A] CA
	RF Exposure Limit	3.517 ft (1.07 m)

B. Safety warnings

(1) The safety distance between operator and antenna is 3.517 ft (1.07 m). This assumes that the antenna is continuously transmitting at its maximum power.

Figure 24 - Class 15 Antenna RF Exposure Warning



(2) The Indoor Unit should be isolated from the UAV power supply prior to any maintenance to avoid any possibility of personnel being irradiated.
(3) The antenna base plate can become very hot. Allow the antenna to cool down after operation and exercise due caution before touching the antenna or surrounding structures.

Figure 25 - Class 15 Antenna Heat Warning

C. Installation

(4) The antenna is mounted to the aircraft with four screws through the bottom surface of the antenna. It connects to the IDU with a single TNC connector that also projects down through the bottom surface. Refer to Figure 26 for the location and size of these projections.
(5) The antenna receives its power through the Satcom Antenna Cable from the IDU. The Class 15 antenna requires that the IDU supply voltage is between 27VDC and 30VDC. The antenna will be disabled if the IDU supply voltage falls outside of these limits.
(6) The antenna should be mounted so that it is in a horizontal plane when the UAV is flying straight and level.
(7) The antenna should be positioned on the upper surface of the fuselage, near the centreline of the UAV so that it has an unobstructed view of elevations above 5° for all azimuths. The connective performance for elevations below 20° will be degraded.
(8) The antenna should not adversely affect the control surfaces of the UAV.
(9) Separation resulting in greater than 42 dB isolation should be provided between the antenna and any other GPS antennas on the UAV at 1559 to 1605 MHz and 1626.5 to 1675.0 MHz (Satcom band), 32 inch is typically required. If GLONASS is being used, the separation between the antenna and the GLONASS antenna should be sufficient to provide 50 dB isolation between them at 1559 to 1610 MHz and 1626.5 to 1675.0 MHz (Satcom band), 83 inch is typically required.
(10) GNSS antennas on the UAV should be compliant on DO-229D or later.
(11) The antenna mounting should be capable of dissipating at least 60W of heat from the antenna when in use.
    a. The heat load is primarily through the bottom metal surface of the antenna. Ensure that the mounting either conducts the heat away from the antenna or that there is sufficient airflow over the bottom of the antenna to take the heat out. See

b. Appendix B – Class 15 Ground Plane Thermal Performance for more information.

(12) The antenna should be mounted on, and electrically bonded to, a ground plane.
   a. The ground plane affects the antenna gain pattern. The larger the ground plane is the more reliable the satellite signal will be, particularly for lower satellite elevations.
   b. When operating with a satellite elevation above 40°, a minimum ground plane of 7.09 in. (180 mm) diameter should be used. When operating with a satellite elevation of between 20° to 40° elevation, a minimum ground plane of 9.45 in. (240 mm) diameter should be used. See Appendix C – Class 15 Ground Plane Electrical Performance for more information.
   c. The ground plane should be a conductive surface, level with the bottom surface of the antenna.
   d. The ground plane should have a resistivity of 6μΩ/cm or better.
   e. Where the ground plane leaves the plane of the bottom of the antenna, for example following the curve of a fuselage, its efficiency will drop.

(13) The antenna has a provision for mounting on the top surface of a UAV fuselage.
   a. The hole for the RF connector should be 0.63 in. (16 mm) diameter.

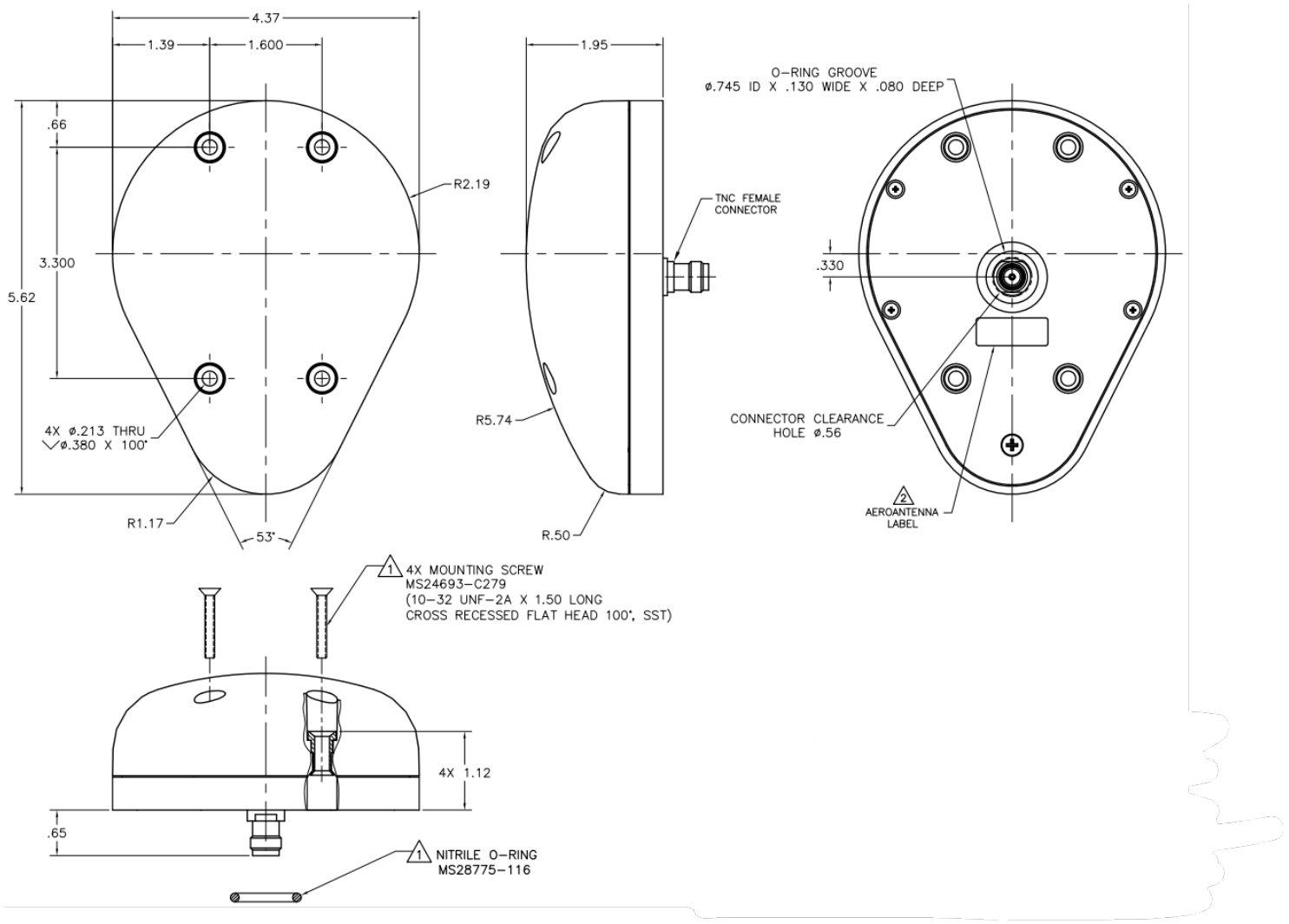
(14) The O-ring for sealing the fuselage against water ingress should be fitted on the antenna.

(15) On metal skinned UAV's the thermal and ground plane requirements may be met if the antenna is thermally and electrically bonded to the surface of the aircraft. If the surface requires preparation to achieve electrical bond, refer to SAE AR 1870 Section 5.
   a. The electrical bond between the antenna and local structure must be less than or equal to 3 milliohm direct current (DC) resistance. Compliance should be verified using a calibrated milliohm meter.
   b. Any paint removed from the UAV skin to meet the bonding requirement should have a corrosion resistance protective coating applied that meets MIL-DTL-5541 TY II CL3 or MIL-C-5541 CL3, commonly known as Alodine.
   c. A doubler plate fabricated by the installer is normally used.

(16) On composite UAVs, additional structure may need to be added to meet the antenna thermal and ground plane requirements.
   a. The electrical bond between the antenna and ground plane must be less than or equal to 3 milliohm direct current (DC) resistance. Compliance should be verified using a calibrated milliohm meter.
   b. 2000 series aluminium or copper is recommended to meet the ground plane conductivity requirements.
   c. Normally, carbon fibre structures have too high a thermal and electrical resistance to meet the thermal and ground plane requirements.

(17) The antenna should be secured to the airframe using the 4 mounting screws supplied (MS24693-C279: 10-32 UNF-2A X 1.50 long cross recessed flat head 100°, SST).
   a. The antenna mounting screws should be torqued to 2.37 to 2.60 N.m (21.0 to 23.0 in-lbs).
   b. If sealing of the antenna holes is needed, then RTV is recommended to be applied around the edge of each hole between both the UAV skin and ground plane and the ground plane and antenna. Ensure that the antenna remains in electrical contact with the ground plane.

Figure 26 - Class 15 Antenna Dimensions



D. Maintenance

(1) The Indoor Unit should be isolated from the UAV power supply prior to any maintenance to avoid any possibility of personnel being irradiated.
(2) The antenna can be cleaned with a microfibre or soft cotton cloth dampened with water.
(3) Chemical cleaning agents should not be used.
(4) The antenna should be inspected every year for general condition and integrity of the mounting and connector.
(5) The electrical bonding between the antenna and ground plane should be tested every 2 years.
(6) There are no user serviceable parts inside the antenna. The user must not disassemble the antenna as it risks damaging the antenna.
(7) The antenna contains parts that are susceptible to electrostatic discharge.

Figure 27 - Class 15 Antenna ESD Warning

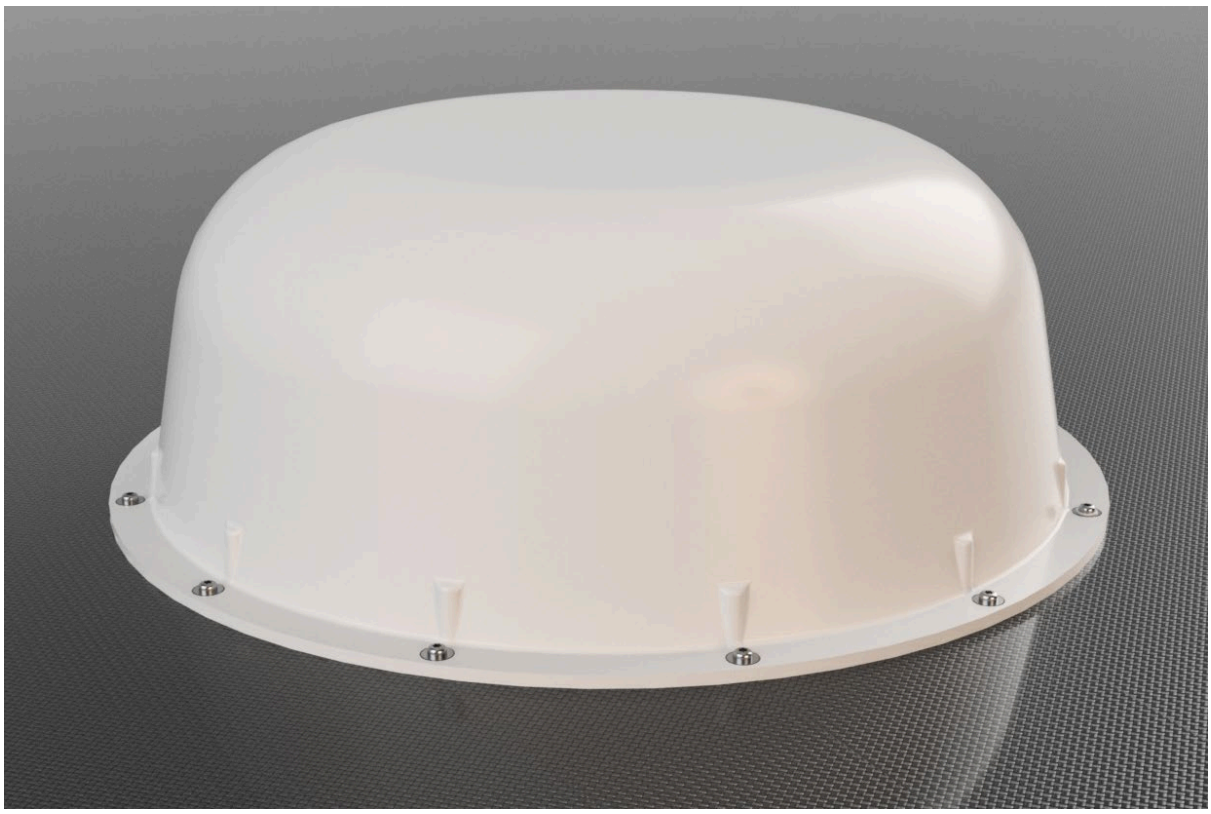
E. Fault Finding

F. Environmental Specification

7. Class 7 Satcom Antenna

A. Overview

Figure 28 - Class 7 Antenna



(1) Connecting the Class 7 Antenna to the Indoor unit allows the Indoor Unit to operate on the Inmarsat SwiftBB satellite network.
(2) The antenna is mechanically steered, directional antenna. The antenna contains tracking circuitry and so the system does not need to be provided with any navigational data.

Table 14 - Class 15 Equipment Class and Subclass Identification

EQUIPMENT CLASS IDENTIFIER	DESCRIPTION
AES	Aircraft Earth Station
Class 7	A Class 7 transceiver is defined as a transceiver unit capable of operating within an AES7 system, which uses an Intermediate Gain Antenna (IGA). It includes the Indoor Unit and Antenna.

(3) Class 7 offers both streaming connection types (guaranteed data rate, charged by time) of 8, 16, 32, 64 and 128kbps, HDR streaming connections (guaranteed frequency allocation, best effort data rate, charged by time) and the Background connection type (best effort service, charged by the MB).
(4) The streaming classes are guaranteed to be available when the satellite elevation is above 10 degrees. Below this connection types are provided on a best effort basis (i.e., the connection type will be allowed if the local conditions enable it).
(5) The HDR streaming class guarantees that the terminal is allocated a fixed amount of frequency spectrum rather than a certain bitrate. The bitrate achieved depends on the local

conditions, for example the satellite elevation, reflections from nearby buildings or water and nearby sources of interference. HDR can achieve >500kbps in good conditions.

(6) Class 7 supports bitrates of up to 332kbps with the Background connection type.

(7) The antenna can be used with or without a ground plane.

(8) The antenna has a single, coaxial, connection to the IDU. It has a single TNC connector that projects down through the bottom surface. Refer to Figure 33 for the location and size of this projection.

(9) The antenna has three mounting methods, the first recessed into a surface, the second on top of a surface and the third without the radome, inside the aircraft and on top of a surface.

(10) The antenna can track the satellite at the rates given in Table 15. Initial, fast, movements of the aircraft are allowed for in the beam width, with the tracking to compensate for sustained movements. The beam widths defined here are for no loss in Satcom performance.

Table 15 - Class 7 Antenna Tracking Rates

Axis	Beam Width (0.6dB loss)	Tracking Rate
Azimuth	±10 degrees	20 degrees/second
Elevation	±20 degrees	5 degrees/second

(11) Unlike an electronically steered antenna, this antenna maintains its performance at all satellite elevations.

(12) To help mitigate the effects of banking, the minimum elevation angle of the antenna is -10 degrees (i.e., below the horizon).

(13) Figure 21 shows the approximate operating range of the antenna (a minimum of 5^{o} satellite elevation).

Figure 29 - Class 7 Operating Range

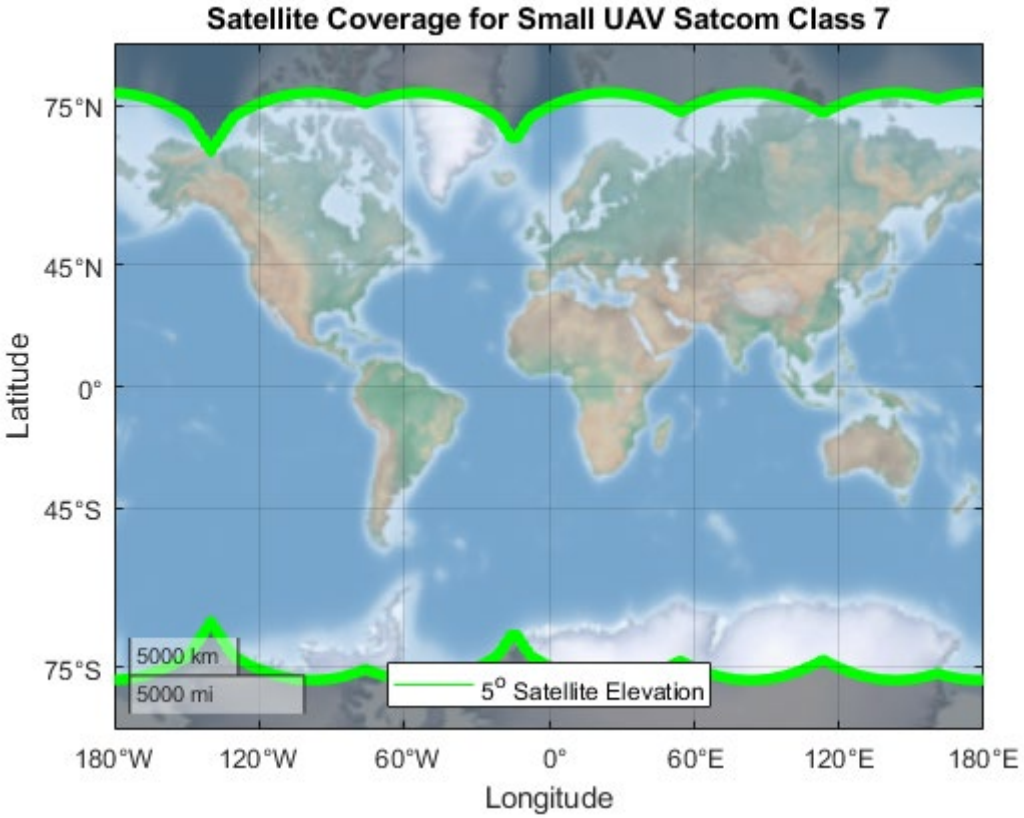


Table 16 - Class 7 Antenna Specifications

Component	Characteristic	Specification
Class 7 Antenna	Part Number	90600820
	Diameter	12.44 in. (316.0 mm) radome maximum 13.55 in. (344.1 mm) mounting flange.
	Height	5.55 in. (141.1 mm) top of radome to bottom of radome. 4.73 in. (120.1 mm) top of radome to bottom of mounting flange.
	Weight	4.16 Lbs (1.89 Kg) including radome. 2.38 Lbs (1.08 Kg) excluding radome.
	Cooling	Passive Cooling
	Maintenance	No scheduled maintenance required
	Nominal EIRP	15.1 dBW nominal
	TX Operating Frequency	1626.5-1660.5 MHz and 1668-1675 MHz (XLB)
	RX Operating Frequency	1518.0-1559.0 MHz

	Modulation	
	Emission Designation	
	FCC ID	
	IC ID	
	Antenna Connector Type	TNC (Female)
	Storage Temperature	
	Operating Temperature	-40 to 55°C (-40 to 131°F)
	Designed to	
	Environmental Categories	
	RF Exposure Limit	3.28 ft (1.0 m)

B. Safety warnings

(1) The safety distance between operator and antenna is 3.28 ft (1.0 m). This assumes that the antenna is continuously transmitting at its maximum power.

Figure 30 - Class 7 Antenna RF Exposure Warning

(2) The Indoor Unit should be isolated from the UAV power supply prior to any maintenance to avoid any possibility of personnel being irradiated.

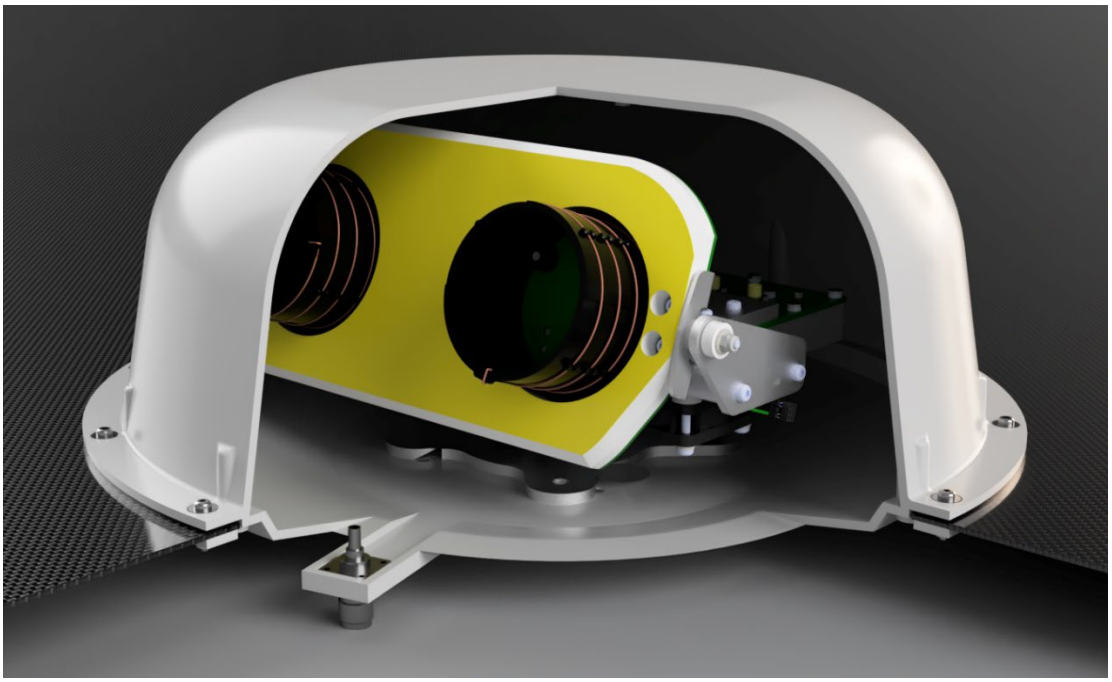
C. Installation

(1) The antenna weighs 4.16 pounds (1.89Kg) including the radome. Without the radome it weighs 2.38 Lbs (1.08 Kg).

(2) The antenna can be mounted with or without a ground plane.

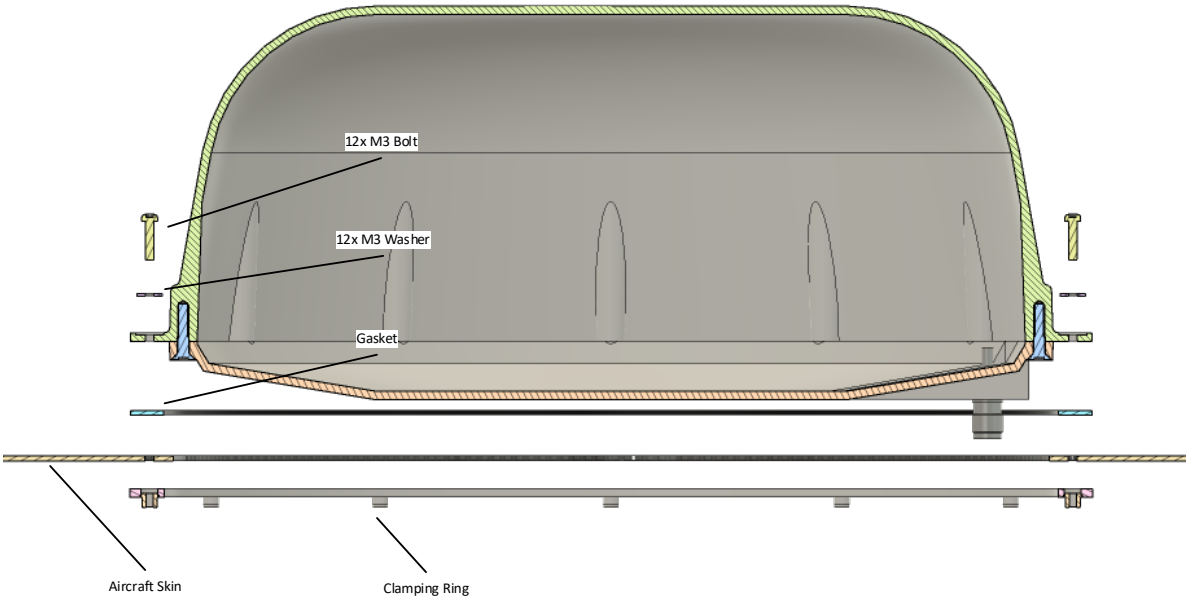
(3) The primary mounting method for the antenna is recessed into a flat surface and secured with bolts through a flange around the edge of the antenna, through the surface material and into a clamping ring. Refer to Figure 33 for the locations of these holes.

Figure 31 - Class 7 Recessed Mounting Cutaway



(4) The primary mounting method provides the optimum performance for both environmental sealing and maximum air speed.

Figure 32 - Class 7 Antenna Recessed Mounting Section



(5) The antenna ca also be mounted on its base. It can be secured with bolts going up through the mounting surface and into threaded holes in the radome. A hole also needs to be provided for the TNC connector to project through.

(6) If sealing of the antenna holes is needed, then RTV is recommended to be applied around the edge of each hole between both the mounting surface and the antenna radome.

Figure 33 - Class 7 Antenna Surface Mount

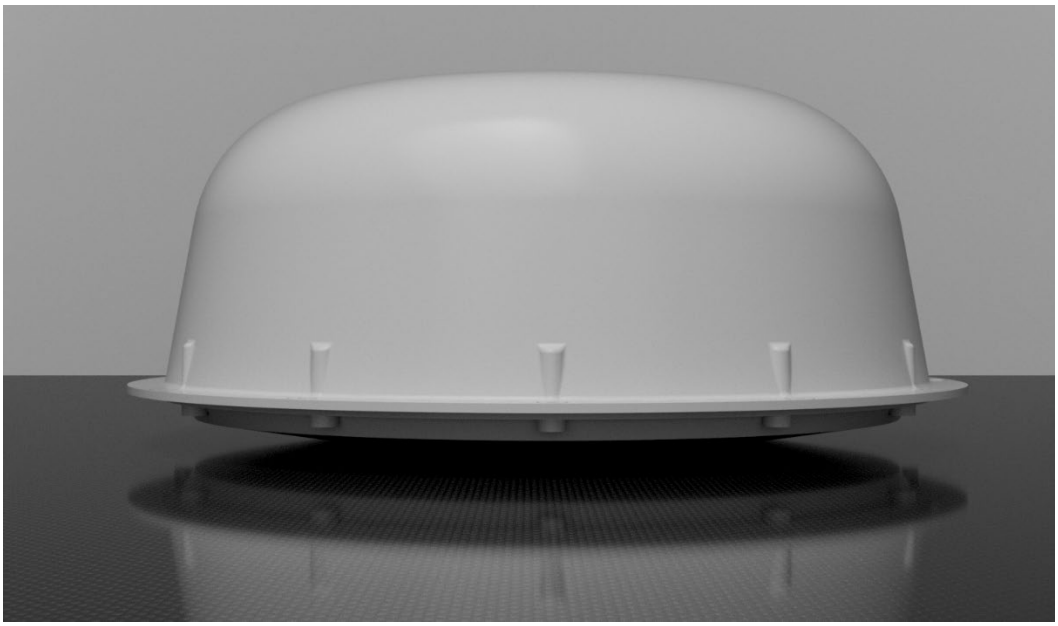
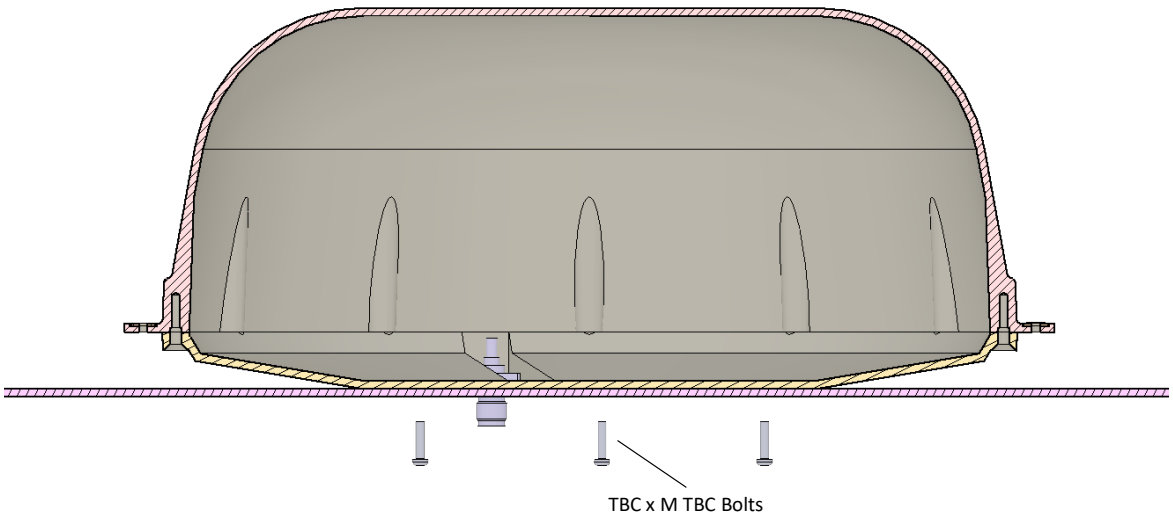


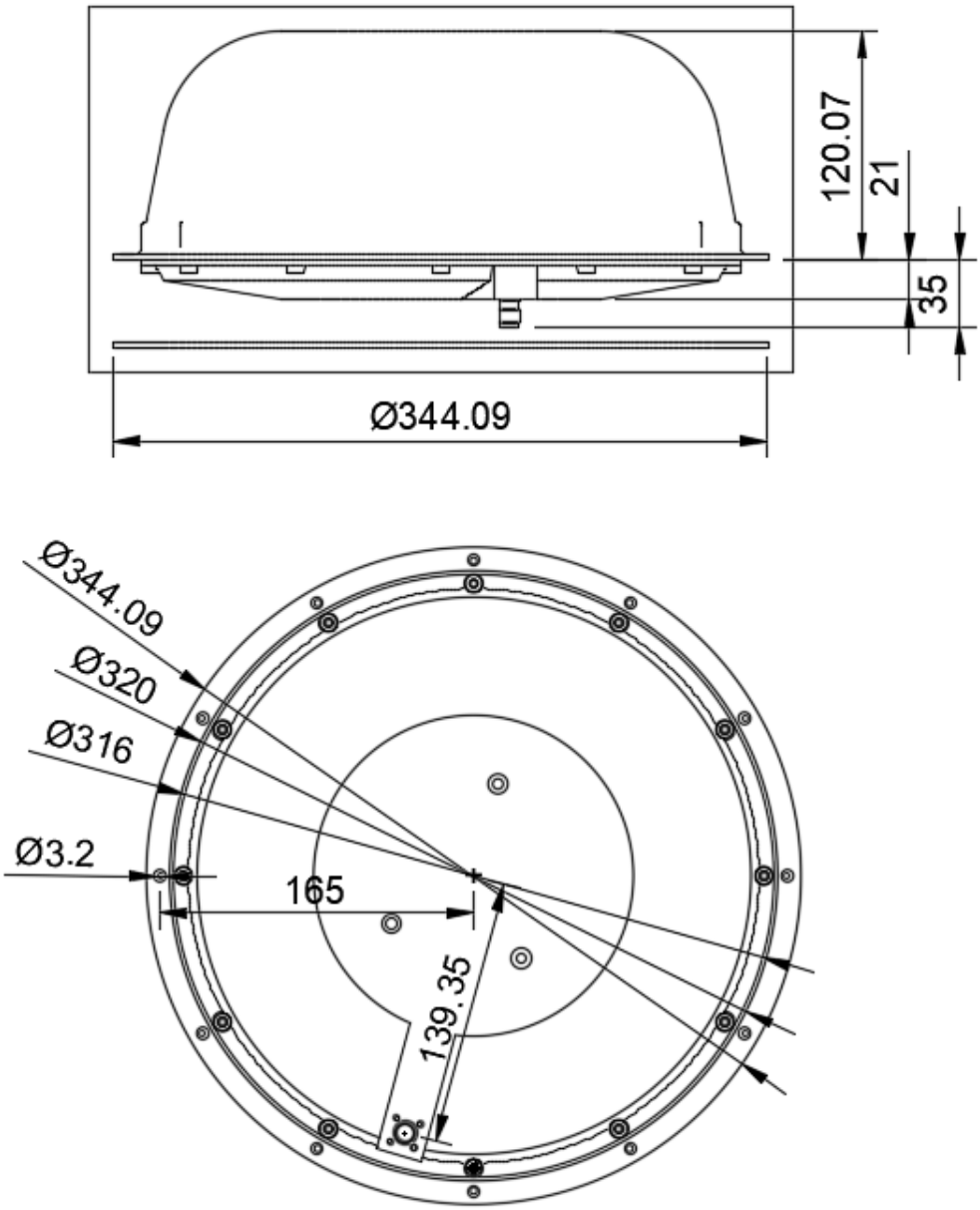
Figure 34 - Class 7 Antenna Surface Mount Section



(7) The antenna can also be mounted without the radome. In this case it must be ensured that the surrounding aircraft structure is RF transparent (at 1.5 to 1.7 GHz).

(8) If this is done, ensure that the entire swept volume of the antenna is always clear from any interference e.g., cables.

Figure 35 - Class 7 Antenna Dimensions



(9) The antenna receives its power through the Satcom Antenna Cable from the IDU. The Class 7 antenna requires that the IDU supply voltage is between 24VDC and 31VDC. The antenna will be disabled if the IDU supply voltage falls outside of these limits.

(10) The antenna should be mounted so that it is in a horizontal plane when the UAV is flying straight and level.

(11) The antenna should be positioned on the upper surface of the fuselage, near the centreline of the UAV so that it has an unobstructed view of elevations above 5° for all azimuths.

(12) The antenna should not adversely affect the control surfaces of the UAV.

(13) Separation resulting in greater than 40dB isolation should be provided between the antenna and any other GPS antennas on the UAV at 1559 to 1605 MHz and 1626.5 to 1675.0 MHz (Satcom band), 40 inches is typically required. If GLONASS is being used, the separation between the antenna and the GLONASS antenna should be sufficient to provide

40 dB isolation between them at 1559 to 1610 MHz and 1626.5 to 1675.0 MHz (Satcom band), 120 inch is typically required.

(14) GNSS antennas on the UAV should be compliant on DO-229D or later.

D. Maintenance

(1) The Indoor Unit should be isolated from the UAV power supply prior to any maintenance to avoid any possibility of personnel being irradiated.
(2) The antenna can be cleaned with a microfibre or soft cotton cloth dampened with water.
(3) Chemical cleaning agents should not be used.
(4) The antenna should be inspected every year for general condition and integrity of the mounting and connector.
(5) There are no user serviceable parts inside the antenna. The user must not disassemble the antenna as it risks damaging the antenna.
(6) The antenna contains parts that are susceptible to electrostatic discharge.

Figure 36 - Class 7 Antenna ESD Warning

E. Fault Finding

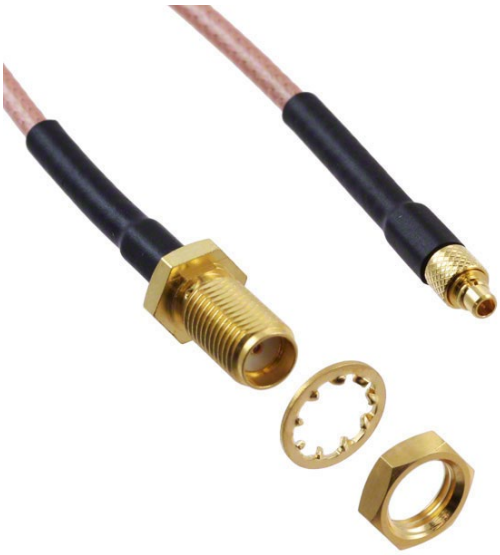
F. Environmental Specification

8. Cellular Antennas

A. Overview

Figure 37 - Cellular Antenna

Figure 38 – IDU to Cellular Antenna cable



(1) The cellular modem inside the IDU supports both 4G and 5G as well as 4x4 MIMO.
(2) For full operation, four cellular antennas need to be connected to the IDU.
(3) The cellular antenna specification is given in Table 10. To maintain the cellular certification, the antennas and antenna cables specified in Table 17 must be used.

B. Safety warnings

(1) There are no safety warnings specific to the cellular antennas.

C. Installation

Table 17 - Cellular Antenna Part Numbers

Part	Specification	Part Number	Manufacturer

Antenna	5G/4G Monopole Antenna with SMA(M) connector	TG.55.8113	Taoglas Limited
Antenna Cable	MMCX(M) to Bulkhead SMA(F), 250mm long	415-0071-MM250	Cinch Connectivity Solutions Johnson

(2) Mount the antennas at least 200mm from other antennas (for example the Wi-Fi and Satcom antennas).
(3) Each antenna should be installed where they will have at least 20dB of isolation between them. Angling the antennas away from each other helps to achieve this. A separation of 20cm will typically achieve this.
(4) Install the antennas where they will have clear access to the radio signals from base stations. They should not be installed inside metal structures.
(5) The antenna included a hinge at the base, allowing it to be angled from projecting straight out from the mounting surface to parallel to the mounting surface.
(6) The antenna has the highest performance when not mounted on a ground plane.
(7) If mounted on a ground plane, angling the antenna so it is parallel with the mounting surface reduces its performance.
(8) The cables should not be routed near high voltage sources or flammable fluid.
(9) The cables should not be routed near sources of EMI, for example motors or RF transmitters.
(10) The cables should be maintained within their environmental specification of -40^{o}C to +85^{o}C.
(11) Table 18 shows how each of the four antennas is used by the cellular modem.

Table 18 - Cellular Antenna Use

Cellular Antenna	Use
CELL1	MIMO
CELL2	MIMO
CELL3	Secondary (Diversity) Tx/Rx & GNSS
CELL4	Primary Tx/Rx

(12) Table 19 details the bands supported by the cellular antennas and modem.

Table 19 - Supported Cellular Bands

	Supported Bands
4G	1,2,3,4,5,7,8,12,13,14,17,19,20,25,26,28,29,30,32,38,40,41,42,43,48,66,71
5G	N1,N2,N3,N5,N28,N41,N66,N71,N77,N78,N79

D. Maintenance

(1) The antenna should be inspected every year for general condition and integrity of the antenna, mounting and connector.
(2) The cable should be inspected every year for general condition, chafing, kinking and routing.

E. Fault Finding

(1) Check that the resistance between the centre conductor and screen of the cable is at least 1M ohms.

(2) Check that the resistance of the centre conductor from one end of the cable to the other is less than 0.25 ohms.
(3) Check that the resistance of the screen from one end of the cable to the other is less than 0.25 ohms.

9. Wi-Fi Antenna

A. Overview

Figure 39 - Wi-Fi Antenna

Figure 40 - Wi-Fi cable

(1) The Wi-Fi modem supports both the 2.4GHz and 5GHz bands, but not simultaneously. It supports both the AC and N standards.
(2) For operation, one Wi-Fi antenna needs to be connected to the IDU connector labelled WIFI.
(3) The Wi-Fi antenna specification is given in Table 20. To maintain RF certification the specified antennas and antenna cables must be used.

B. Safety warnings

(1) There are no safety warnings specific to the cellular antennas.

C. Installation

Table 20 - Wi-Fi Antenna part numbers

Part	Specification	Part Number	Manufacturer
Antenna	2.4/5GHz Dipole Antenna with Reverse Polarity SMA(M) connector	001-0009	TE Connectivity Laird

Antenna Cable	MMCX(M) to Bulkhead Reverse Polarity SMA(F), 150mm long	65530260515305	Würth Elektronik

(1) Mount the antenna at least 200mm from other antennas (for example the Cellular and Satcom antennas).
(2) Install the antenna where it will have clear access to the radio signals It should not be installed inside metal structures.
(3) The cable should not be routed near high voltage sources or flammable fluid.
(4) The cable should not be routed near sources of EMI, for example motors or RF transmitters.
(5) The cable should be maintained within its environmental specification of -40^{o}C to +85^{o}C.

D. Maintenance

(1) The antenna should be inspected every year for general condition and integrity of the antenna, mounting and connector.
(2) The cable should be inspected every year for general condition, chafing, kinking and routing.

E. Fault Finding

(1) Check that the resistance between the centre conductor and screen of the cable is at least 1M ohms.
(2) Check that the resistance of the centre conductor from one end of the cable to the other is less than 0.25 ohms.
(3) Check that the resistance of the screen from one end of the cable to the other is less than 0.25 ohms.

10. System Validation

11. System Operation

Appendix A – Certification and Reference Documents

1) General
   A) Reference Documents
      (1) SP-90600571 - Small SATCOM External ICD.
      (2) SP-90600570 - Small SATCOM System Requirements Document.
   B) Regulatory
      (1) 47 CFR, US FCC Title 47 CFR: Part 87 for Aeronautical classes (section §87.139 Emissions Limitations).
      (2) European Regulation (EC) No. 1907/2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH).
2) Radio Transmission Licensing
   A) FCC and IC
      (1) This product has been certified with the following license Ids:
         - FCC-ID: K6KSATCOM5G.
         - IC-ID: 1275B-SATCOM5G.
      (2) This product contains modules certified with the following FCC IDs:
         - RI7FN990A28
         - FB-1004
      (3) This product contains modules certified with the following ISED IDs:
         - IC: 5131A-FN990A28
         - IC: 5969A-1004
      (4) The radio transmission is licensed in accordance to 47 CFR part 87 [RD7] by the operator of the aircraft or fleet
      (5) As per 47 CFR part 87.39 the acceptability of the equipment for licensing is achieved by obtaining FCC certification, as per 47 CFR [RD7] part 2 Subpart J Section 2.1033. The FCC ID received is marked on the physical nameplate of all non-prototype certified equipment.
      (6) Pursuant to section 1.925 of 47 CFR of the Commission's rules, Honeywell International Inc. has been granted waivers of Sections 87.131, 87.133, 87.137, 87.139(i)(1) and 87.141(j) of the FCC rules. The waivers of these sections permit the FCC certification of the Small SATCOM transceiver to support the Inmarsat SwiftBroadband aircraft communications services. The waivers of these sections have been granted unconditionally. This device has been tested and found to comply with the remaining sections of Part 87 of the FCC rules, therefore the conditions of the waiver are met at all times.
      (7) As per Canadian Radio Communication Regulations SOR/96-484 [RD15], 21(1) Innovation, Science and Economic Development Canada (ISEDC) Technical Acceptance Certification is required. The ISEDC ID received is marked on the physical nameplate of all non-prototype certified equipment.
      (8) The FCC and ISEDC complies with DO-262D section 2.1.3 Note 1.
      (9) NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

(10) NOTICE: Changes or modifications made to this equipment not expressly approved by EMS Technologies Canada, Ltd., a wholly owned subsidiary of Honeywell International Inc. may void the FCC authorization to operate this equipment.

(11) NOTICE: This device complies with Part 15 of the FCC Rules [and with Industry Canada licence-exempt RSS standard(s)]. Operation is subject to the following two conditions: this device may not cause harmful interference, and this device must accept any interference received, including interference that may cause undesired operation (Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: l'appareil ne doit pas produire de brouillage, et l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement).

(12) Radio frequency radiation exposure Information: This equipment complies with FCC and IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 107 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

B) European Technical Standards Institute (ETSI)

(1) Satellite Earth Stations and Systems (SES); Harmonised Standard for Aircraft Earth Stations (AES), providing Aeronautical Mobile Satellite Service (AMSS)/Mobile Satellite Service (MSS) and/or the Aeronautical Mobile Satellite on Route Service (AMS(R)S)/Mobile Satellite Service (MSS), operating in the frequency band below 3 GHz covering the essential requirements of article 3.2 of the Directive 2014/53/EU, ETSI EN 301 473 V2.1.2 (2016-11).

Appendix B – Class 15 Ground Plane Thermal Performance

To assist with designing the antenna ground plane to dissipate the antenna thermal load, a range of empirical measurements are provided here to provide guidance. These measurements were taken with an antenna mounted, together with a range of ground plane sizes, onto a carbon fibre sheet to simulate a possible installation. Some key points are:

- Mounting the ground plane flat to a surface limits the airflow cooling to one side of the ground plane only. If any part of the ground plane has airflow on both sides, for example the edges due to the curvature of a fuselage, then the cooling performance will be improved.
- Carbon fibre is a good thermal insulator, so limits conductive cooling into the airframe.

Testing was both with still air (to simulate the aircraft sitting on a runway) and with a slow airflow (to simulate slow flight). Unless noted the antenna was tested in the worst case for heat dissipation, when the terminal is transmitting continuously at maximum power (200kbps data rate from the aircraft to the ground). The temperature was measured at the antenna's bottom plate, adjacent to the TNC connector. The ambient temperature was 22^{o}C (71.6 ^{o}F) but the plots show the temperature rise above ambient. There was no direct solar lighting, solar loading needs to be allowed in addition. The ground planes were made from 1050 grade aluminium. Refer to Figure 41 & Figure 42.

NOTE: In Figure 43, for the no ground plane case, the temperature rise was 81.2^{o}C (178.2 ^{o}F) above ambient.

Figure 41 - Class 15 Antenna Temperature Rise in Still Air

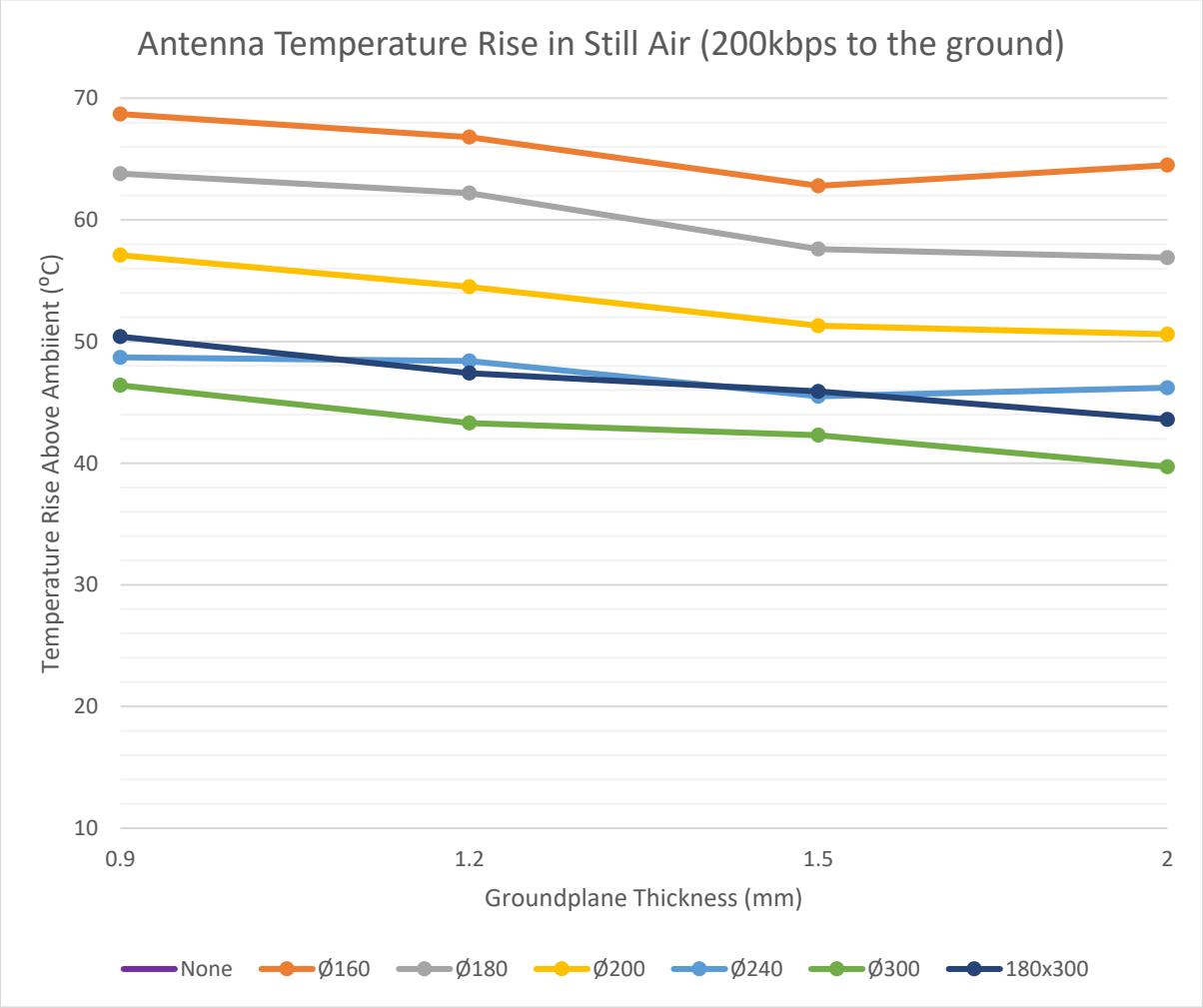
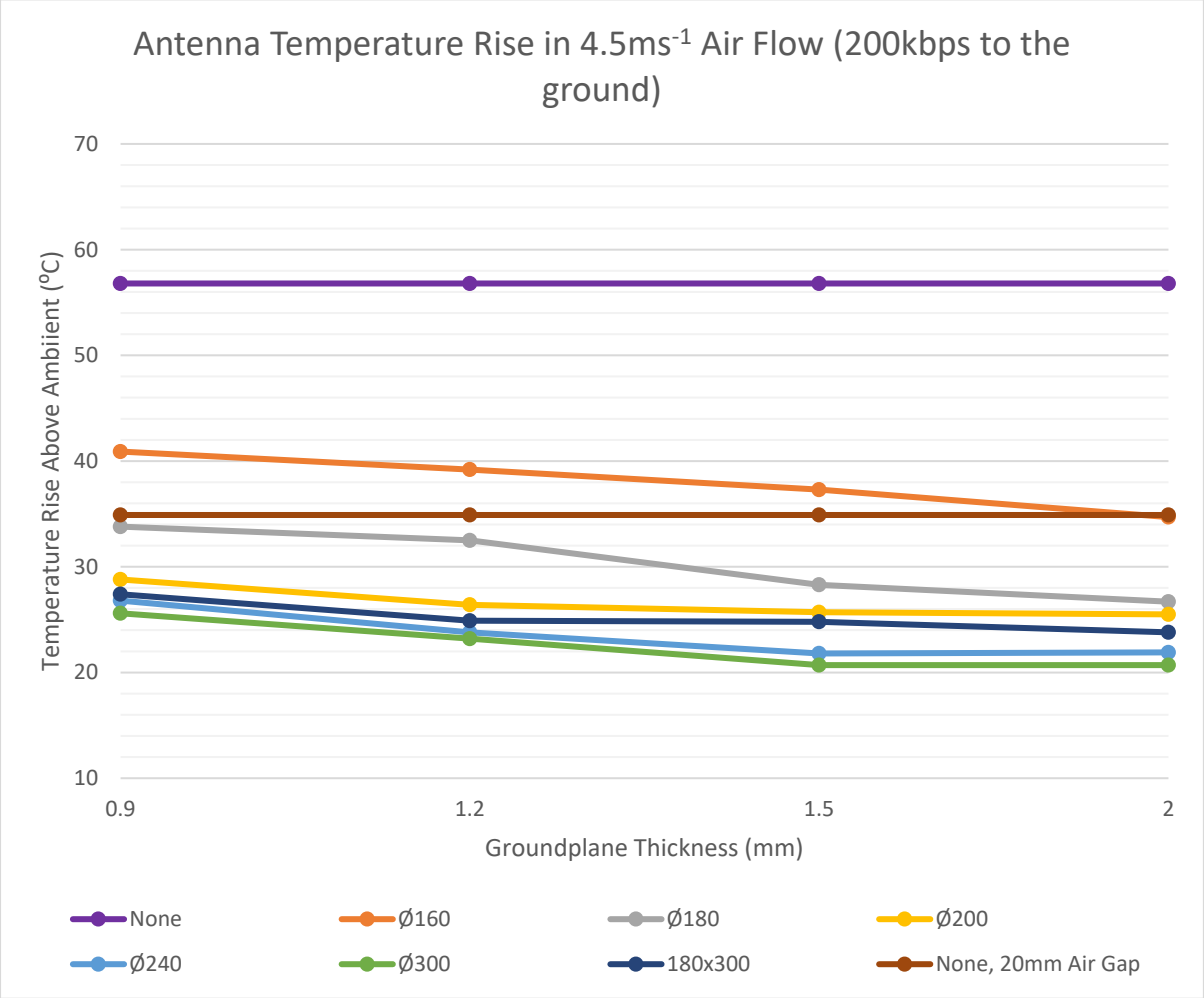
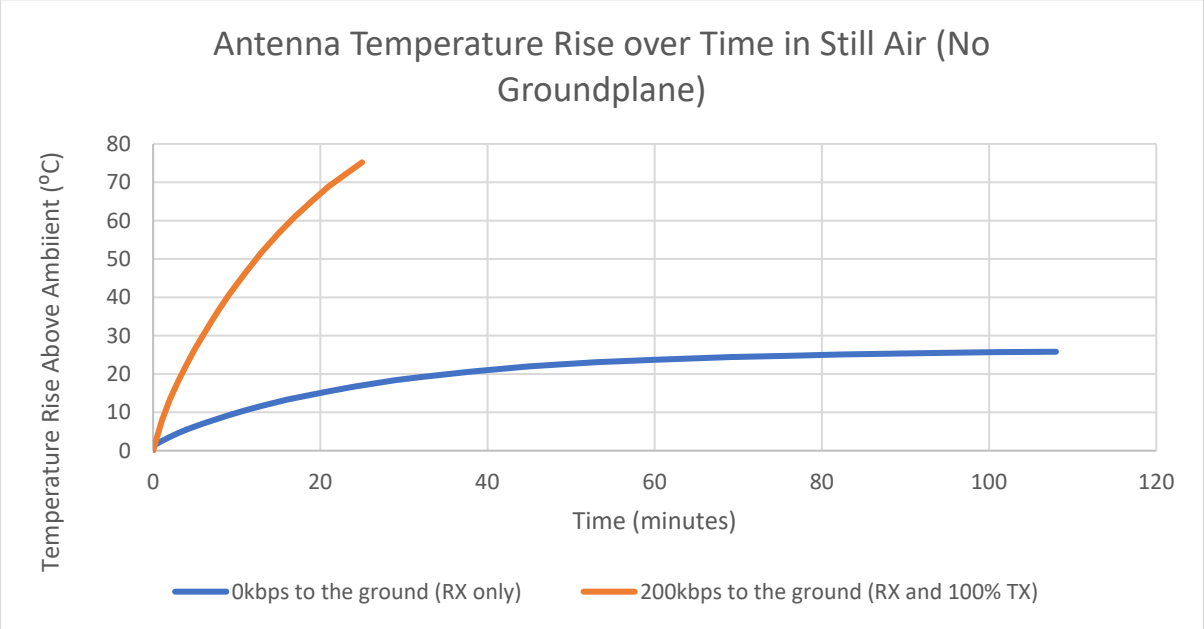


Figure 42 - Class 15 Antenna Temperature Rise in 4.5m/s Air Flow



There is thermal mass both in the antenna and installation infrastructure, so the antenna temperature rises slowly over time. Refer to Figure 14.

Figure 43 - Class 15 Antenna Temperature Rise over Time in Still Air (No Groundplane)



The antenna will switch off when it reaches 120°C (248°F) but should be kept below 85°C (185°F).

Appendix C – Class 15 Ground Plane Electrical Performance

The antenna gain pattern is affected by the size of the ground plane, particularly for low satellite elevations. Inmarsat Class 15 terminals, like VersaWave, work down to satellite elevations of 20^{o} (i.e., the satellite appears to be 20^{o} above the horizon). At this lower limit the difference in performance seen when using a ground plane of diameter 7.09 inch (180 mm) vs 9.45 inch (240 mm) is about -0.8dB C/No (signal quality). Due to the way the system works, this signal difference equates to a drop in the reliability of the connection, rather than a change in the throughput bit rate e.g., less resilience to banking or interference.

Ground planes larger than 9.45 inch (240 mm) diameter give a negligible improvement to the antenna gain pattern, although they may still assist in reducing interference from sources below the ground plane. Refer to Figure 21.

Appendix D – Interference to the Satcom Modem

The Satcom modem in this product operates on the Inmarsat network, which uses satellites in a geostationary orbit (approximately 35,800 km above the equator). Consequently, the signals received from the satellite have a very low level and are susceptible to interference from closer sources. The terminal employs advanced filtering to reject radio signals outside it's receive band. However, it is important to ensure that there are no sources of radio interference radiating at frequencies inside the terminals receive band (1518 to 1559 MHz) as these might drown out the satellite signals.

The effect of interference is to reduce the signal quality seen. Interference can be identified as a problem by powering up only the terminal and checking the received signal quality. Then, power up the UAV and additional equipment. If the received signal quality drops, it may be due to interference.

Potential interference sources include:

- USB3 cables and chipsets. The USB3 standard employs spread spectrum techniques which mean its operating frequency includes these terminals receive band. This is a general problem with USB3 interfering with radio devices, Intel have written a white paper on the subject (which can be found by searching for 'usb3 interference'). Cases have been seen of a poorly screened USB3 cable degrading the terminals receive signal quality from a distance of 10 meters. Cables can be a frequent issue as some 'screened' cables can lack screening over the connectors or the screen is not electrically connected to earth. The USB3 chipset inside a device (e.g., a PC) can also cause interference, particularly if the device is not well screened.
- Transmitters e.g., video or telemetry transmitters. Although this terminal had advanced filtering to reject signals outside it's receive band (including the afore mentioned transmitter's intended frequency), all transmitters leak interference, to some extent, across the entire spectrum.

If interference is identified as an issue, there are some possible solutions:

- Screen, or improved screening, around the source of interference. For example, the use of high-quality screened USB cables or copper tape applied over the breaks in existing screening.
- Screening between the source and the Satcom antenna, for instance extending the antenna ground plane to block the path between the source and Satcom antenna. Note that the wavelength here is about 7.68 inch (19.5 cm), which is relatively large compared to the scale of UAV. As such the radio signals will not behave like light waves, following a direct path only, and will flow around obstacles to some degree.
- If cables are the source, shorter cables will help if possible.
- If a transmitter is the cause, then it might be possible to add a filter before its antenna, to reduce the level in the range 1518 to 1559 MHz that can leak into this terminal.