Honeywell

Honeywell International Inc.
400 Maple Grove Road
Ottawa, Ontario K2V 1B8
Canada
CAGE: 38473
Telephone: 800-601-3099 (Toll Free U.S.A./Canada)
Telephone: 602-365-3099 (International Direct)
Website: https://aerospace.honeywell.com

System Description, Installation, and Maintenance Manual

Small SATCOM

Part Number	Model
90410350	Small SATCOM Kit

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TRANSMITTAL INFORMATION

REVISION NUMBER 2 DATED 18 FEB 2021

TO HOLDERS OF SMALL SATCOM SDIM, PUB NO. D202006001015 AND IS ISSUED FOR USE IN SUPPORT OF THE FOLLOWING:

Table TI-1 shows the applicable components.

Table TI-1. Applicable Components

Component Part Number	Nomenclature
90600511	Indoor Unit
89000015-009	Low Gain Antenna
90600596	Coaxial Cable Assembly
90600551	Harness Assembly
90100090	SIM Card SBB

Revision History

Table TI-2 shows the revision history of this SDIM.

Table TI-2. Revision History

Revision Number	Revision Date
0	30 Oct 2020
1	30 Nov 2020
2	18 Feb 2021

This revision is a full replacement. All changed pages have a new date, as identified in the List of Effective Pages. Revision bars identify the changed data. See Transmittal information for history of revisions to this SDIM.

Revision bars mark the technical data that changed in this revision; those changes are described in the Table of Highlights. Editorial changes are not marked with a revision bar. The table of highlights tells users what has changed as a result of the revision.

The table of highlights tells users what has changed as a result of the revision. The table consists of three columns.

The Task/Page column identifies the blocks of changed information, such as a task, subtask, graphic, or parts list, and the page on which that block starts. The block of information often includes the MTOSS code. Revision marks, when provided, identify the location of the change within the block.

The Description of Change column tells about the change or changes within each block. The description of change is often preceded by a paragraph or figure reference that applies to the block of information.

The Effectivity column tells the user the part number(s) to which the block of information applies. The default value for this column is "All." "All" means that the block applies to all parts.

Table of Highlights

Task/Page	Description of Change	Effectivity

Table of Highlights (Cont)

Task/Page	Description of Change	Effectivity
Page11	Paragraph 1.A.6 Updated procedural step.	All
Page11	Paragraph 2.A.5 Updated procedural step.	All
Page12	Paragraph 2.A.7 Added procedural step.	All
Page12	Paragraph 2.A.8 Added procedural step.	All
Page12	Paragraph 2.A.11 Updated procedural step.	All
Page12	Paragraph 2.A.12 Updated procedural step and added list items.	All
Page12	Paragraph 2.A.13 Changed the data from list items to procedural step.	All
Page24	Paragraph 4.B.2 Added figure reference.	All
Page26	Added figure.	All
Page28	Paragraph 2.B.1 Added note.	All
Page33	Added graphic sheet.	All
Page41	Paragraph 2.A.1 Updated table.	All

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RECORD OF TEMPORARY REVISIONS

Instructions on each page of a temporary revision tell you where to put the pages in your manual. Remove the temporary revision pages only when discard instructions are given. For each temporary revision, put the applicable data in the record columns on this page.

Definition of Status column: A TR may be active, incorporated, or deleted. “Active” is entered by the holder of the manual. “Incorporated” means a TR has been incorporated into the manual and includes the revision number of the manual when the TR was incorporated. “Deleted” means a TR has been replaced by another TR, a TR number will not be issued, or a TR has been deleted.

Temporary Revision Number	Status	Page Number	Issue Date	Date Put in Manual	By	Date Removed from Manual	By

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SERVICE BULLETIN LIST

Service Bulletin / Revision Number	Title	Modification	Date Put in Manual

Blank Page

LIST OF EFFECTIVE PAGES

* indicates pages changed or added data
F indicates a right foldout
LF indicates a left foldout

LIST OF EFFECTIVE PAGES (Cont)

Subheading and Page	Date	Subheading and Page	Date
Appendix A			
44	18 Feb 2021		
45	18 Feb 2021		
Appendix B			
46	18 Feb 2021		
47	18 Feb 2021		
48	18 Feb 2021		
49	18 Feb 2021		

* indicates pages changed or added data
F indicates a right foldout
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INTRODUCTION

1. How to Use This Manual

A. General

(1) This manual provides information about the installation of the Small SATCOM 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:

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

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

B. Observance of Manual Instructions

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

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

C. Units of Measure

(1) 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

(1) 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.

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

E. Scope

(1) This manual provides detailed information for avionics technicians about the wiring, installation, and setup of every component of the Small Satcom. This manual includes information for end users about how to operate the Small SATCOM. The Small SATCOM 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

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

(2) Where:

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

G. Organization

(1) This manual Includes the following sections:

- SECTION 1 - SYSTEM DESCRIPTION
- SECTION 2 - INSTALLATION
- SECTION 3 - SYSTEM OPERATION
- SECTION 4 - MAINTENANCE PRACTICES
- SECTION 5 - TROUBLESHOOTING
- APPENDIX A
- APPENDIX B

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C. 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. mil

– 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 INTRO-1

Table INTRO-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

Table INTRO-1. List of Acronyms and Abbreviations (Cont)

TERM	FULL TERM
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

Table INTRO-1. List of Acronyms and Abbreviations (Cont)

TERM	FULL TERM
IPC	Illustrated Parts Catalog
LED	Light Emitting Diode
LGA	Low Gain Antenna
MCU	Micro Controller Unit
mm	Millimeter
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

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SECTION 1 – SYSTEM DESCRIPTION

1. General Information

A. General

(1) The Small SATCOM system is a very small and lightweight SATCOM terminal for use in UAVs for command, control and the streaming back of live video and other mission data. Refer to Figure 1.

(2) The Small SATCOM is an Inmarsat SwiftBroadband single channel low gain system providing an internet data connect with rates up to 200 kbps.

(3) The terminal comprises of an indoor unit and an external active antenna connected by a single cable.

(4) The indoor unit is typically mounted inside the fuselage.

(5) The antenna is typically mounted externally.

(6) Power and Ethernet are connected to the indoor unit and a single RF cable connects the indoor unit to the antenna.

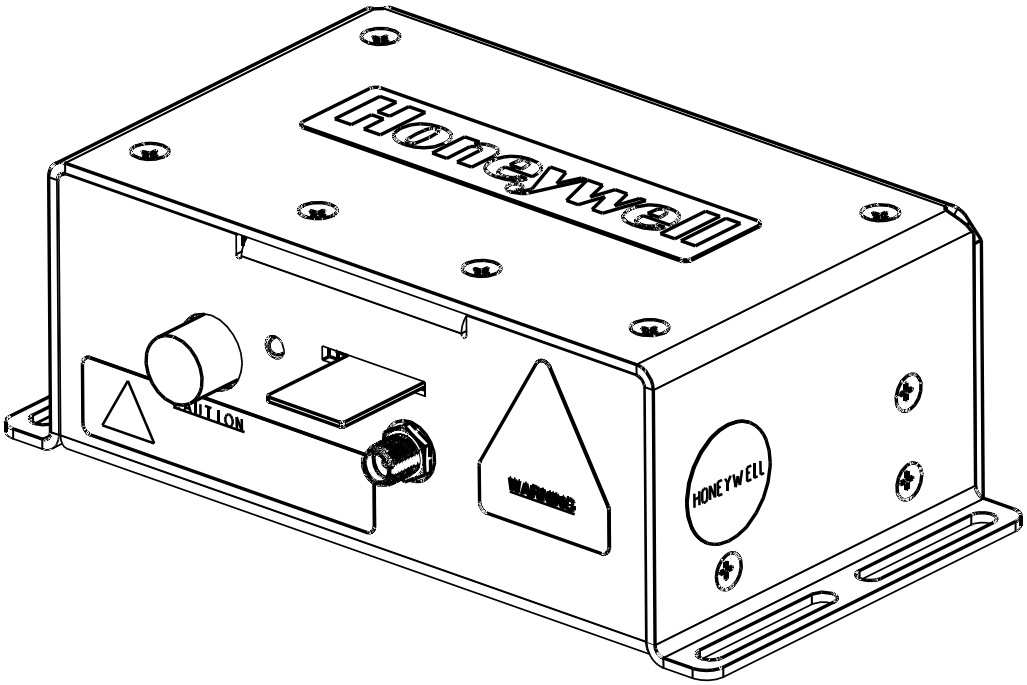

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Figure 1. (Sheet 1 of 1) Indoor Unit Assembly

B. Hardware Part Numbers

(1) At the time of writing of this document, the SATCOM Products were identified by the hardware part numbers indicated in Table 1.

Table 1. Small SATCOM Kit Part Numbers

SATCOM PRODUCT	HARDWARE PART NUMBER
Indoor Unit	90600511
Low Gain Antenna	89000015-009
Harness Assembly	90600551
Coaxial Cable Assembly	90600596
SIM Card SBB	90100090

(2) Where:

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

(3) The terminal is designed but not certified to DO-254 design assurance level (DAL) E

– Hardware functions whose failure or anomalous behavior, as shown by the hardware safety assessment, would cause a failure of system function with no effect on UAV operational capability or UAV flight operator workload. No guidance from DO-254 applies.

2. Indoor Unit

A. Indoor Unit Description

(1) The Indoor unit contains the modem, digital and RF circuitry.

(2) The Indoor unit requires a combined power input and Ethernet cable which will be provided. The DC power input powers the whole system.

(3) The satellite data transfer, command, monitoring and debug are via Ethernet.

(4) A SIM card must be inserted into the indoor unit for it to operate.

(5) Table 2 provides the specifications or the Small SATCOM's Indoor Unit.

Table 2. Indoor Unit Component Specifications

COMPONENT	CHARACTERISTIC	SPECIFICATION
Indoor Unit	Part Number	90600511
	Length	5.5 in. (140 mm) maximum
	Width	2.95 in. (75 mm) maximum
	Height	2 in. (50.8 mm) maximum
	Mounting Information	Mounted inside the fuselage
	Weight	1.1 Lbs (0.5 kg) maximum
	Power Consumption	50 W for high use 65 W maximum 20 W in standby
	Operating Voltage	27-30V DC
	Cooling	Refer to Section 3, Paragraph 7.B.
	Storage Temperature	-55 to 85°C (-67 to 185°F)
	Operational Temperature	Refer to Section 3, Paragraph 7.B.

(6) The Indoor Unit has all the connectors on one side. This simplifies the installation of the Indoor Unit in a crowded avionics bay, as the box can be pushed into a corner or small gap between other equipment.

(7) An LED on the Indoor Unit provides an indication of its status. More detailed information can be accessed over the Ethernet connection.

3. Antenna

A. Antenna Description

(1) The antenna will typically be mounted externally.

(2) A single RF cable connects the indoor unit to the antenna.

(3) Table 3 provides the specifications for the antenna.

Table 3. Antenna Component Specifications

COMPONENT	CHARACTERISTIC	SPECIFICATION
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
	Antenna Connector Type	TNC (Female)
	Storage Temperature	-55 to 85°C (-67 to 185°F)
	Operational Temperature	-40 to 55°C (-40 to 131°F)
	RF Exposure Limits	3.517 ft (1.07 m)

4. Inmarsat Network

A. Scope

(1) Please note all processes described in this manual apply to BGAN class 15.

(2) This class is detailed in the Table 4 Equipment Class Identification:

Table 4. Equipment Class and Subclass Identification

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

B. Honeywell SwiftBroadband System Overview

(1) The SATCOM Avionics Suite consists of a L-Band SATCOM system. The SATCOM system identified will operate on the Inmarsat network.

(2) Inmarsat supports the “SwiftBroadband” aeronautical service, also known as BGAN, which is supported through Inmarsat-4 satellites. Services offered in a given Ocean Region will operate from a single Inmarsat satellite at any one time.

(3) The Inmarsat L-Band SwiftBroadband Satellite Communications Network consists of:

- Aircraft Earth Stations (AESs).
- Space segment formed by three Inmarsat-4 and an Inmarsat-4A geostationary satellites that provides global coverage, except for the polar regions. This will be supplemented by Inmarsat-6 satellites, which are scheduled for launch in 2020.
- A terrestrial ground infrastructure formed by the Satellite Access Stations (SASs).
- Terrestrial interconnect networks.
- Network Control Centre and a Business Support System.

(4) The user links are in L-band 1518-1559 MHz for satellite to AES, 1626.5-1660.5 MHz and 1668-1675 MHz for AES to satellite.

C. Expected Data Rate

(1) The data rate through the Small Satcom 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.

(2) Forward refers to data being passed from the ground and return refers to data being passed from the UAV as seen in Figure 2.

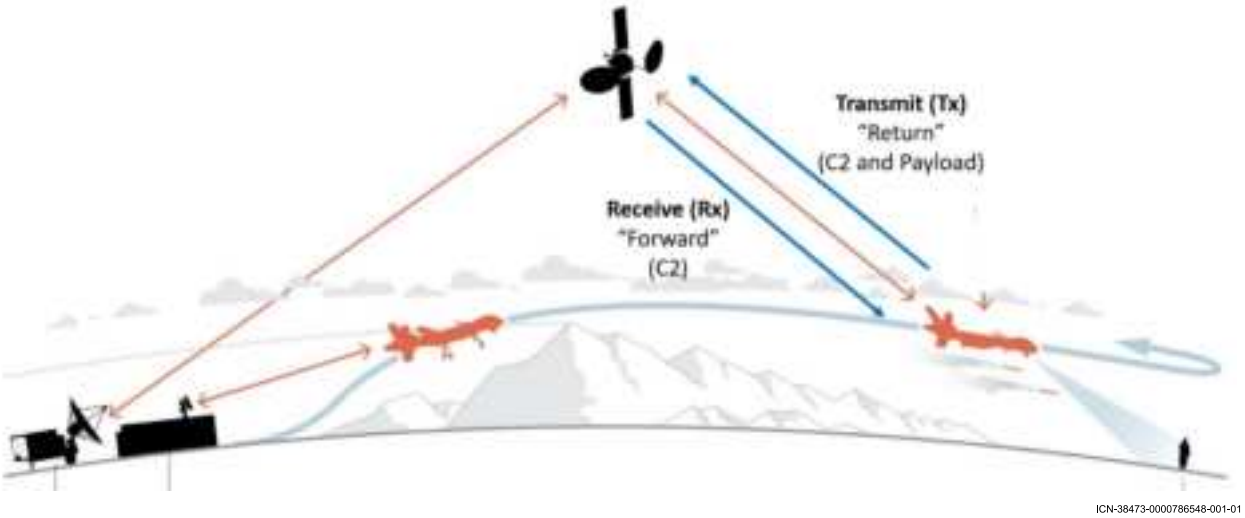

Figure 2. (Sheet 1 of 1) Forward and Return to UAV

(3) 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 3 for effect of banking on data rate and Figure 4 for elevation. In Figure 3, if the signal is synced, the connection is maintained. If it is below the threshold, the connection will be lost.

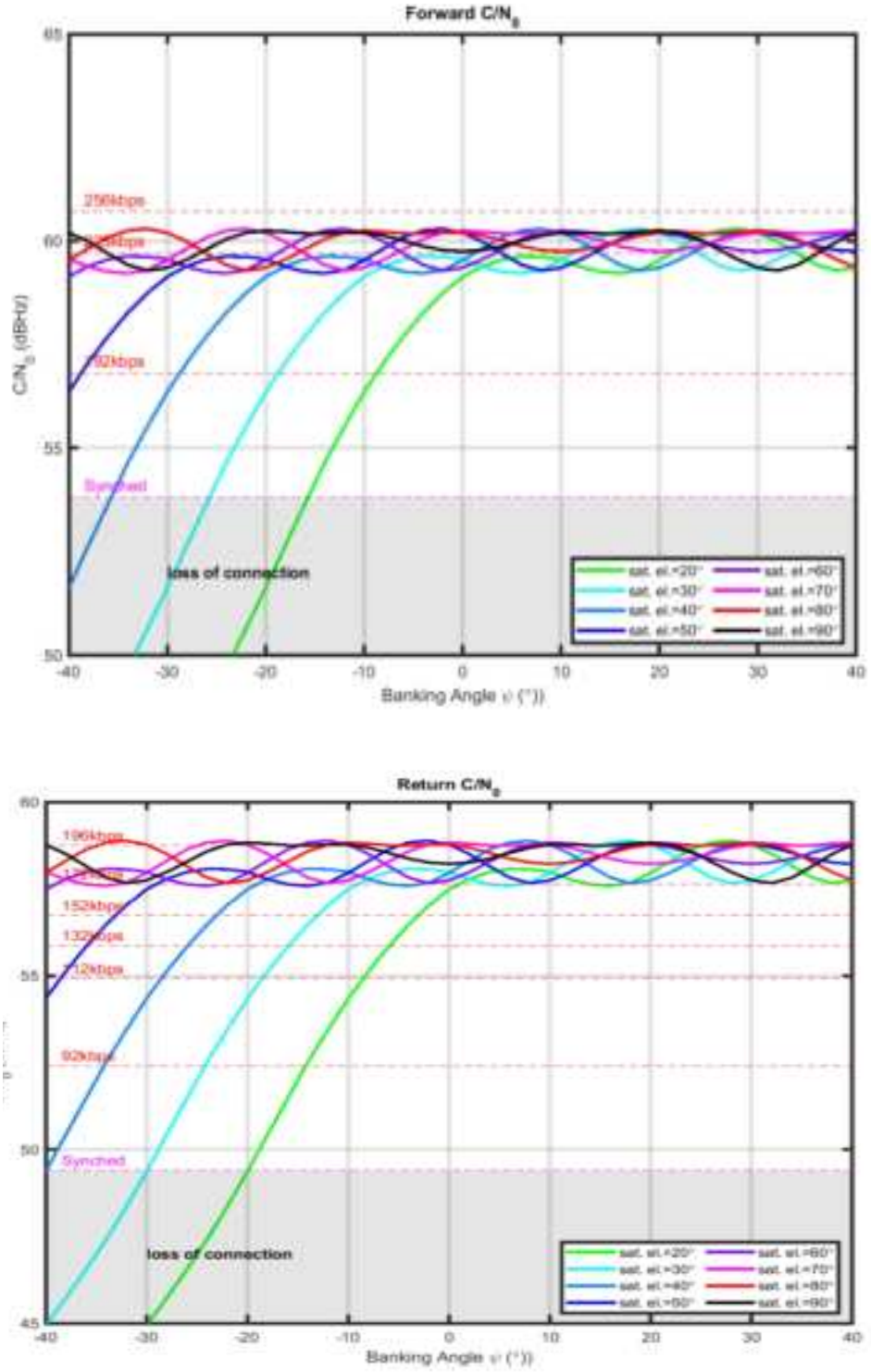

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Figure 3. (Sheet 1 of 1) Effect of Banking on Data Rate

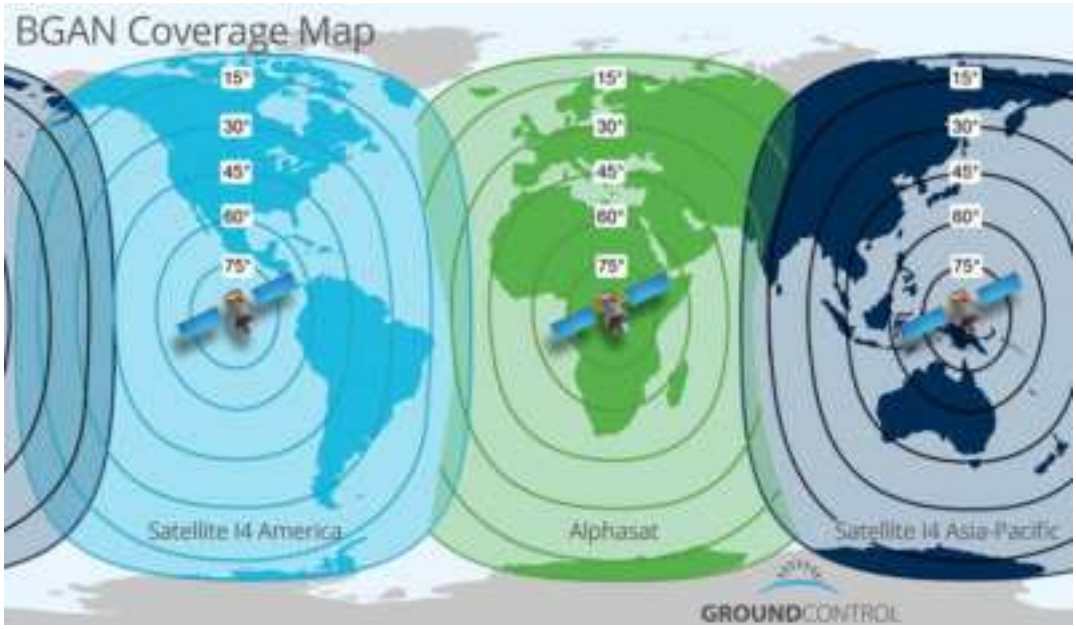

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Figure 4. (Sheet 1 of 1) BGAN Coverage Map

SECTION 2 – INSTALLATION

1. General

A. Prior to Installation

(1) Upon receipt of the terminal, the components should be confirmed present against the enclosed parts list and inspected for any damage.

(2) The UAV satcom system's environmental parameters should be reviewed to ensure that the intended usage is within its envelope.

(3) An acceptable antenna mounting point should be identified and any UAV specific mounting parts procured or fabricated.

(4) A weight distribution analysis should be performed to demonstrate safe operation of the UAV subject to the mounting constraints outlined in the following sections.

(5) An electrical load analysis should be performed to ensure that the UAV can safely carry the additional electrical load. This is a maximum of 65 W.

(6) The terminal should be powered from a fused distribution board with voltage of 28V DC (27 to 30V DC). The fuse protecting the terminal supply circuit should be a 4A Fast Acting type, with a minimum interruption rating of 1000A. A recommended model is Littelfuse 0297004.WXNV which can be used in conjunction with the associated in-line holder Littelfuse 0FHM0001ZXJ.

(7) There should be a power isolation switch that can be operated without approaching within 3.517 ft (1.07 m) of the antenna.

(8) Safety precautions should be observed during installation and UAV maintenance.

(9) Integration with the avionic systems should be such that failure of terminals function should have no effect on the UAV's operational capability, safety or flying operator's workload.

2. Mechanical Installation

A. Antenna Mounting

(1) **The safety distance between operator and antenna is 3.517 ft (1.07 m)**.

(2) The antenna should be mounted so that it is in a horizontal plane when the UAV is flying straight and level. Refer to Figure 5 for antenna dimensions.

(3) The antenna should be positioned on the upper surface of the fuselage, near the centre-line 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.

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

(5) 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.

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

(7) The antenna mounting should be capable of dissipating at least 60W of heat from the antenna when in use.

- 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.

(8) The antenna should be mounted on, and electrically bonded to, a ground plane.

- 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.
- The minimum ground plane size should be 18cm in width by 30cm in length.
- The ground plane should be a conductive surface, level with the bottom surface of the antenna.
- The ground plane should have a resistivity of 6μΩ/cm or better.
- 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.

(9) The antenna has a provision for mounting on the top surface of a UAV fuselage

- The hole for the RF connector should be 0.63 in. (16 mm) diameter.

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

(11) 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.

- 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.
- 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.
- A doubler plate fabricated by the installer is normally used.

(12) On composite UAVs, additional structure may need to be added to meet the antenna thermal and ground plane requirements.

- 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.
- 2000 series aluminium or copper is recommended to meet the ground plane conductivity requirements.
- Normally, carbon fibre structures have too high a thermal and electrical resistance to meet the thermal and ground plane requirements.

(13) 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).

- The antenna mounting screws should be torqued to 2.37 to 2.60 N.m (21.0 to 23.0 in-lbs).
- 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.

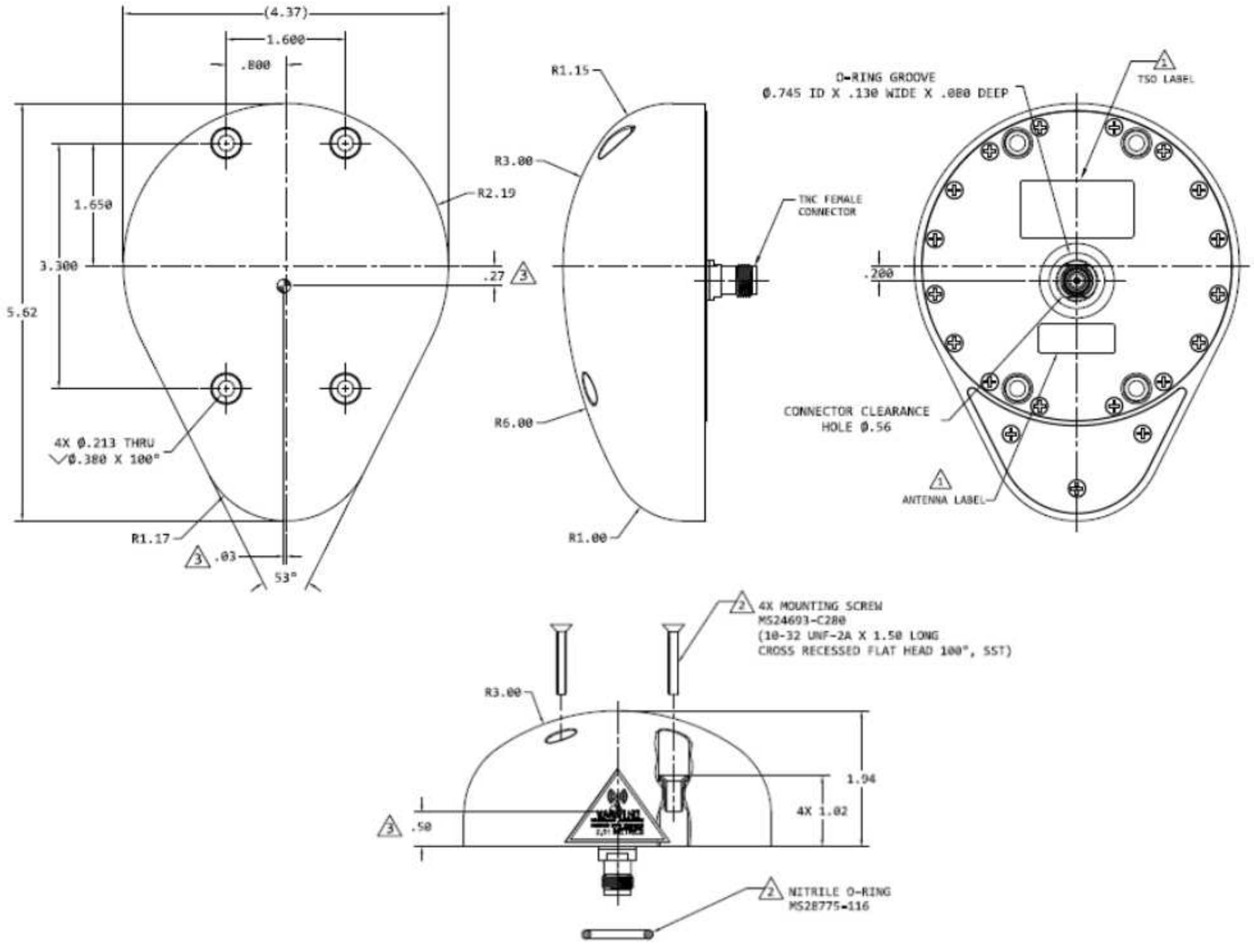

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Figure 5. (Sheet 1 of 1) Antenna Dimensions

B. Indoor Unit Mounting

(1) The indoor unit should be mounted in the avionics bay of the UAV.

(2) The indoor unit may be mounted in any orientation

– The label is on the back, exterior face of the Indoor Unit.

(3) The indoor unit's environment should be maintained within its environmental parameters.

– Anti-vibration mounts (not supplied) can be used to reduce the severity of the vibration.

(4) The indoor unit should be bolted to the floor of the avionics bay or on the external fuselage with 4 M4 bolts and torqued to 2.0 to 2.4 N.m.

NOTE: Mounting Hardware not included. Hardware to be supplied by customer based on installation.

(5) The SIM card should be fully inserted into the SIM card slot on the front face of the indoor unit.

(6) To ensure that the indoor unit can dissipate heat, refer to Paragraph 7.B.

(7) Refer to Figure 6 for Indoor Unit dimensions.

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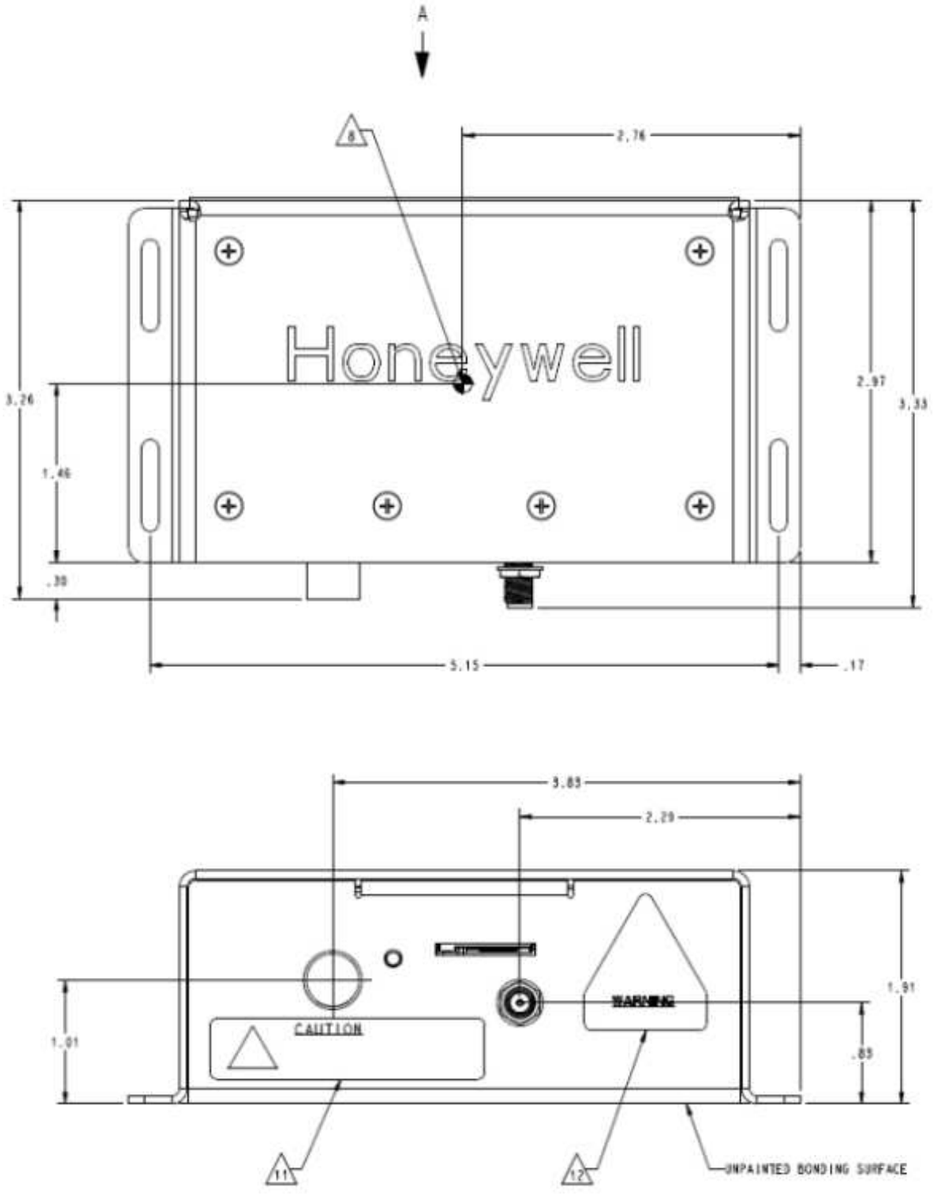

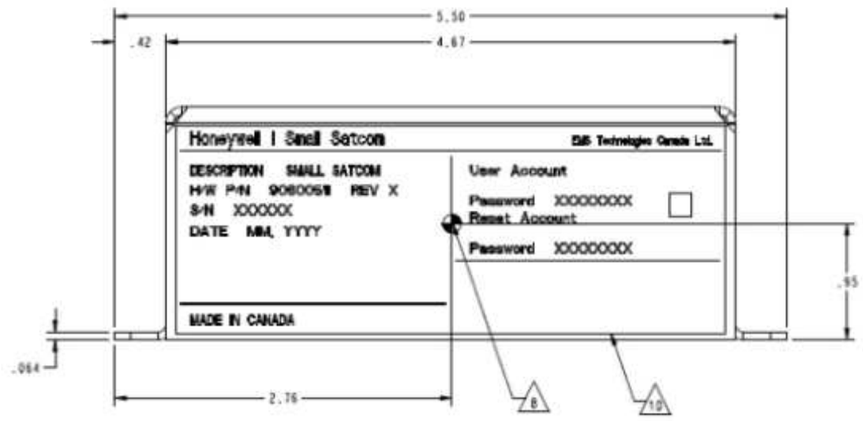

VIEW A

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Figure 6. (Sheet 1 of 1) Indoor Unit Dimensions

C. Cable Routing

(1) The installer should connect the Indoor Unit and Antenna with supplied RF cable.

– The RF cable has a fixed loss requirement and should not be substituted or shortened, or the terminal will not function properly.

(2) The RF connector torque settings depend on the connector and the recommendations are given in Table 5.

(3) 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 5.

(4) The RF cable should be routed below the ground plane level.

(5) The RF cable should not be in tension.

(6) The cables should not be routed near high voltage sources or flammable fluid

(7) The cables should be maintained within the terminal's environment parameters.

(8) The supplied power/Ethernet cable shall have a minimum bending radius of 6.6 cm.

(9) Power should be maintained in the range 27 to 30V DC when up to 65 W is drawn.

(10) The Ethernet connection will be to a 10/100 Base-T network.

(11) The power/Ethernet connector should be inserted into the socket on the indoor unit.

(12) The Indoor Unit provides a female SMA connector for the antenna coax cable.

D. Miscellaneous

(1) Below are the list of warnings and cautions necessary while performing installation tasks. Refer to Figure 7 for safety information.

– Safety Information Regarding Exposure to RF Signals.

– Safety Information for Hot Surfaces.

– Safety information for Electrostatic Discharge.

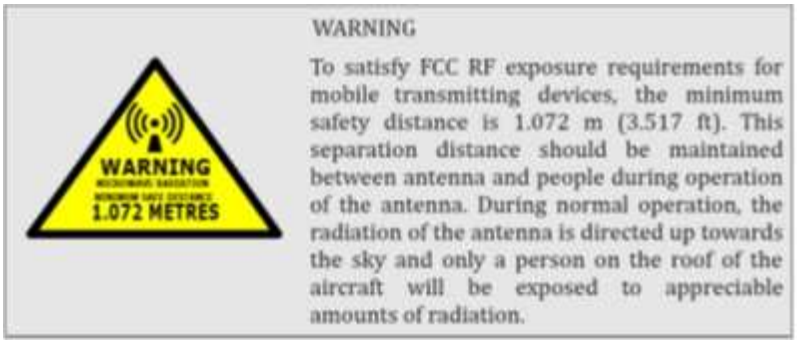

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Figure 7. (Sheet 1 of 1) Safety Information Warning and Caution

E. Engineering Drawings

(1) For Terminal Outline and Installation, refer to Figure 8.

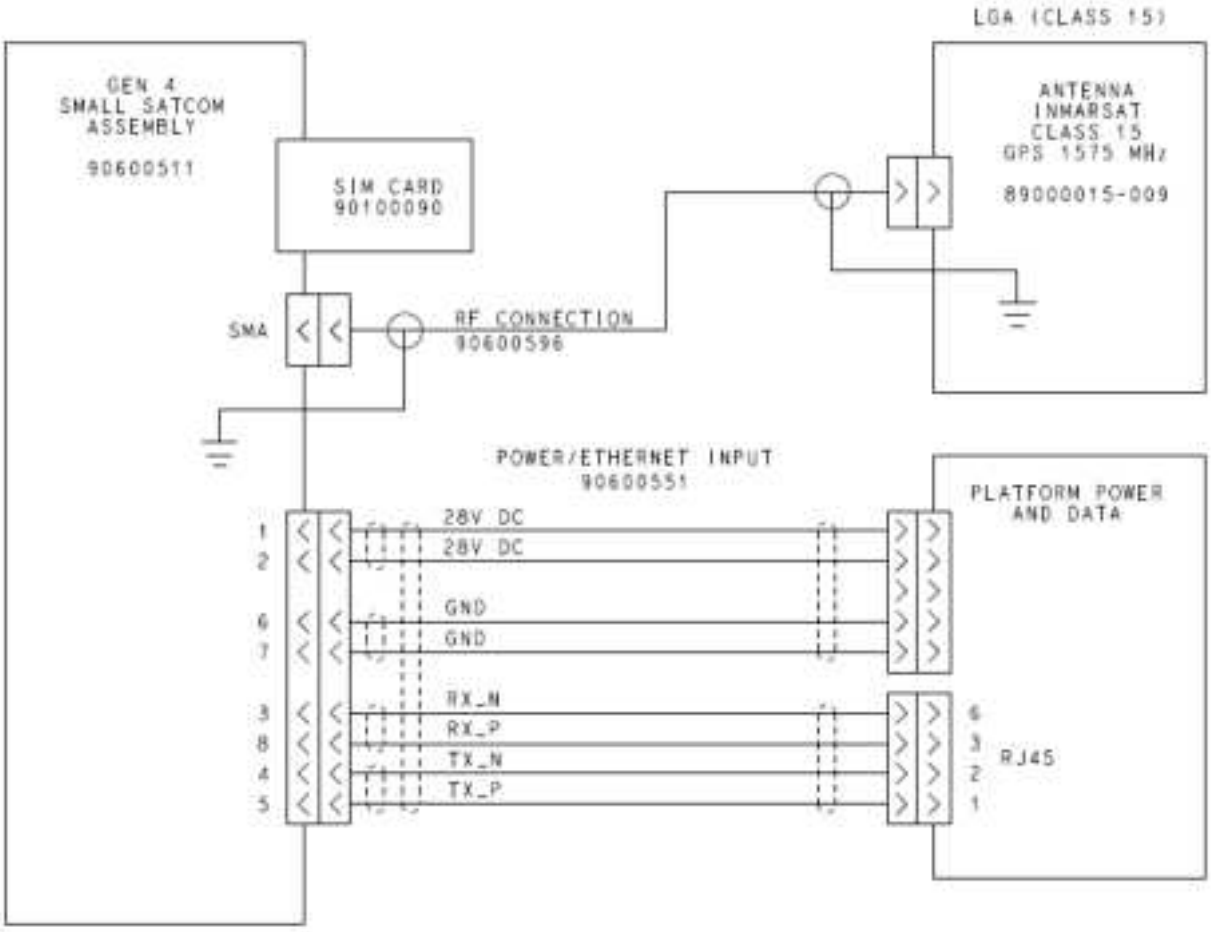

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Figure 8. (Sheet 1 of 1) Terminal Outline and Installation

3. Electrical Installation

A. General

(1) If there is a common UAV ground, the Indoor Unit should be electrically cross bonded with less than or equal to 3.0 milliohms direct current (DC) resistance.

(2) Only 2 cables are required for operation. One to connect the boxes and the other to connect to the UAV.

B. Indoor Unit Installation

(1) General

– The terminal does not require any calibration by the user/installer.

4. Physical Connectors

A. RF Cable

(1) The Honeywell part number 90600596 will be supplied with the terminal.

(2) The coax cable is able to handle temperatures between -40°C to 55°C (-40°F to 131°F).

(3) The cable has a fixed loss requirement and should not be substituted or shortened, or the terminal will not function properly.

Table 5. Antenna Cable Properties

Part Number	Coax Type	Length (cm)	Weight (g)	Bending Radius Installation (cm)	Bending Radius Repeated (cm)	SMA Torque (N.m)	TNC Torque (N.m)
90600596	LMR-100A-FR	50	36	0.7	2.5	0.8-1.13	0.46-0.69

(4) The coax cable connector is a male TNC (to the antenna) and male SMA to the indoor unit.

B. Harness Assembly

(1) Length and weight of harness assembly is 150 cm and 120 g, respectively.

(2) Cable has an 8-pin circular, latching male connector at the Indoor Unit end, namely FGG-1B-308-CLAD76Z (LEMO 1B range, 8-pin plug with collet for max 7.6 mm diameter cable), with screening braid and drain wire clamped. Refer to Table 6 and Figure 9.

Table 6. Termination Table

From Connector								To Connector			
FIND NO.	REF DES	PIN	SIGNAL	SIGNAL TYPE	WIRE TYPE	WIRE FIND NO.	WIRE GROUP	FIND NO.	REF DES	PIN	SIGNAL
1	P1 SDU	1	V_IN	POWER	STP AWG 22	4	1	3	PWR +28VDC	SPADE TON-GUE	V_IN
		2					2				
		6	GND	GND			1		PWR GND	SPADE TON-GUE	GND
		7					2				
		3	RX_N	ETHER-NET	STP AWG 26	5	3	2	COMM	6	RX_N
		8	RX_P				3			3	RX_P
		4	TX_N				4			2	TX_N
		5	TX_P				4			1	TX_P

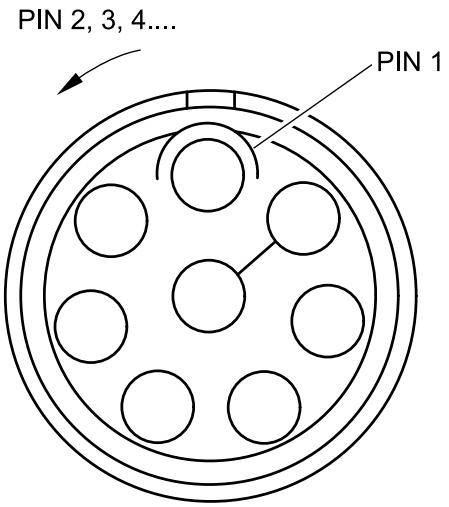

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Figure 9. (Sheet 1 of 1) LEMO Termination

5. Final Validation

A. Installation validation should be by the following steps

(1) Check that the LED lights up green.

(2) If the SIM card supplied with the terminal is being used, then activate the airtime.

(3) When the terminal is powered up and the antenna is not connected or if there is a fault, the status LED is red.

(4) Observe safety distances to the antenna detail above throughout.

(5) Ensure that the UAV is outdoors and has good line of sight to the satellite.

(6) Connect a laptop to the terminal's Ethernet connection and check that no errors are reported by the WebUI. Refer to Section 3.1.A.2.

(7) Verify that there is no adverse interaction with other avionics when the terminal is powered up.

(8) Check that the GPS has a fix and that the position is correct.

(9) **The safety distance between operator and antenna is 3.517 ft (1.07 m)**.

(10) Manually set up a data connection using the WebUI and check that signal quality is the good or excellent ranges.

(11) Verify there is no interference with GNSS or other systems when the terminal transmits data.

B. Mission Safety Checks

(1) Safety of flight should be tested through ground tests before each mission.

(2) Bring up all the normal drone electronics systems (all C2 links, autopilot, motors and ESC's) and determine the performance of the GPS receiver, e.g. number of received satellites, blocking level.

(3) Add the Satcom terminal and verify that the GPS performance has not been degraded.

SECTION 3 - SYSTEM OPERATION

1. General

A. System Overview

(1) The Small SATCOM UAV system is part of the Aircraft Earth Station (AES) that facilitates airborne satellite communications using Swift Broadband (SBB) services over the Inmarsat L-Band satellite communications network.

(2) Set your laptop to obtain an IP address automatically or set a static IP address in the 192.168.1.2-255 or using satcom.honeywell.com

2. Modes of Operations

A. System Interfaces

(1) This section describes the external hardware interfaces provided by the indoor unit. The presence of hardware interfaces in this section does not mean that these interfaces are supported by software or that they are functional in every mode of operation.

(2) Over Ethernet, the following logical control interfaces are available:

– Storage Temperature/JSON interface is the primary command interface.

– WebUI interface is a web page to control and monitor the terminal.

– PPPoE connections are supported.

B. WebUI

(1) Is accessed by typing 192.168.1.1 or satcom.honeywell.com into the address bar of any browser.

NOTE: When accessing the WebUI an expired/not valid SSL certificate warning might be shown. This is expected behaviour and the warning can be bypassed. Depending on the web browser used, a button such as "Continue anyway" or "I understand the risk" might have to be clicked in order to bypass the message and access the WebUI.

(2) Figure 10 displays the WebUI configuration and status information.

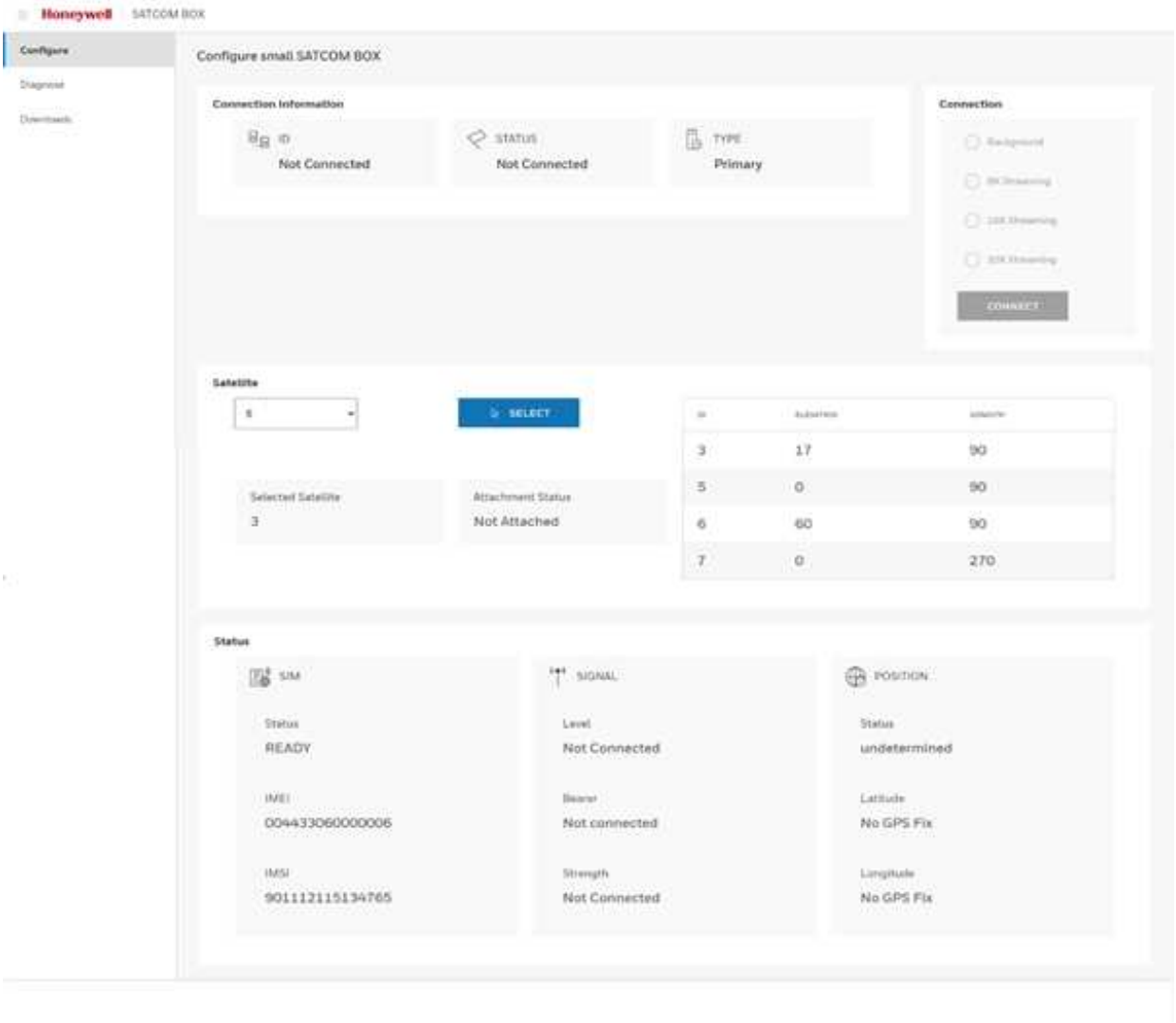

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Figure 10. (Sheet 1 of 5) WebUI Configuration and Status Information

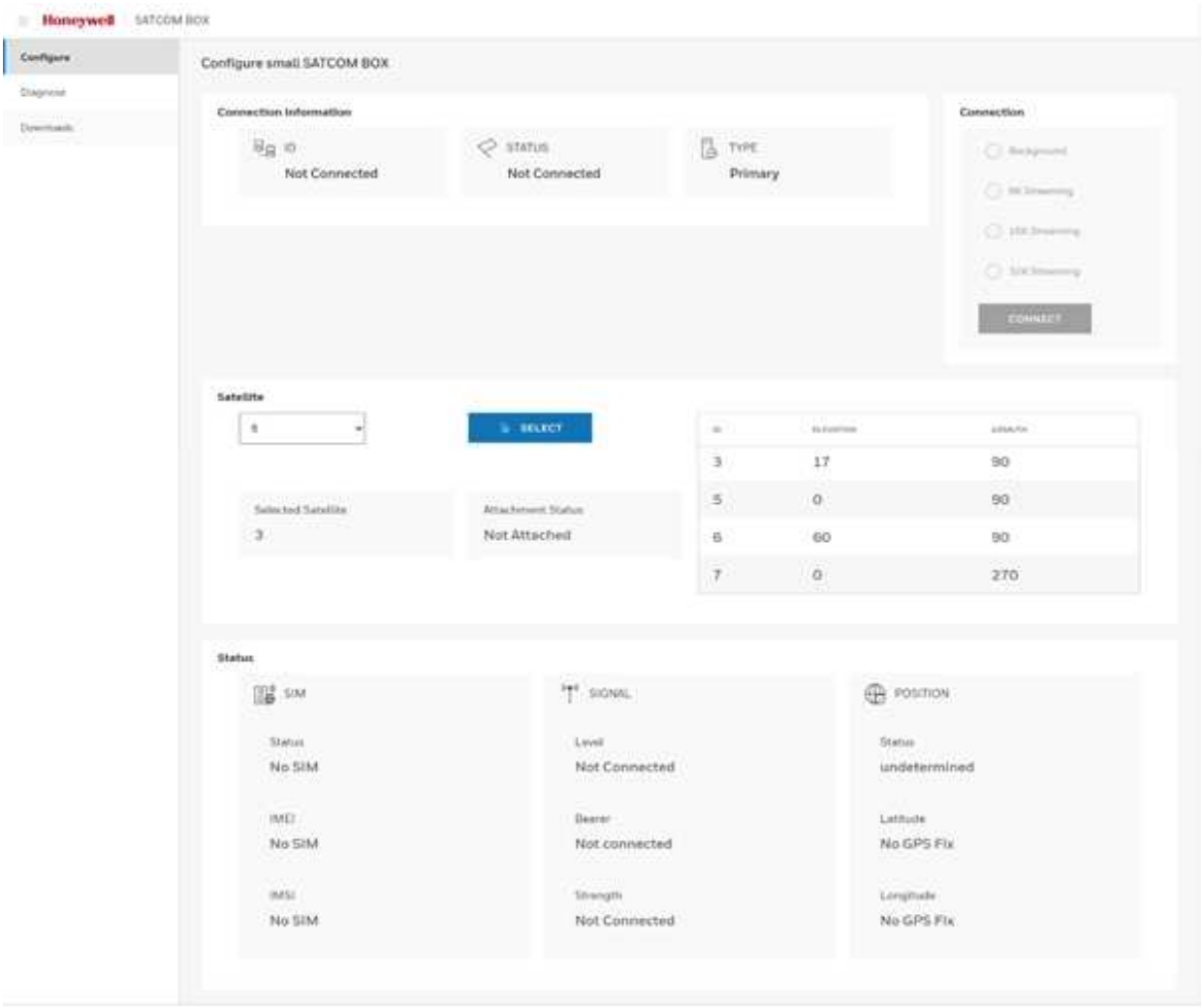

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Figure 10. (Sheet 2 of 5) WebUI Configuration and Status Information

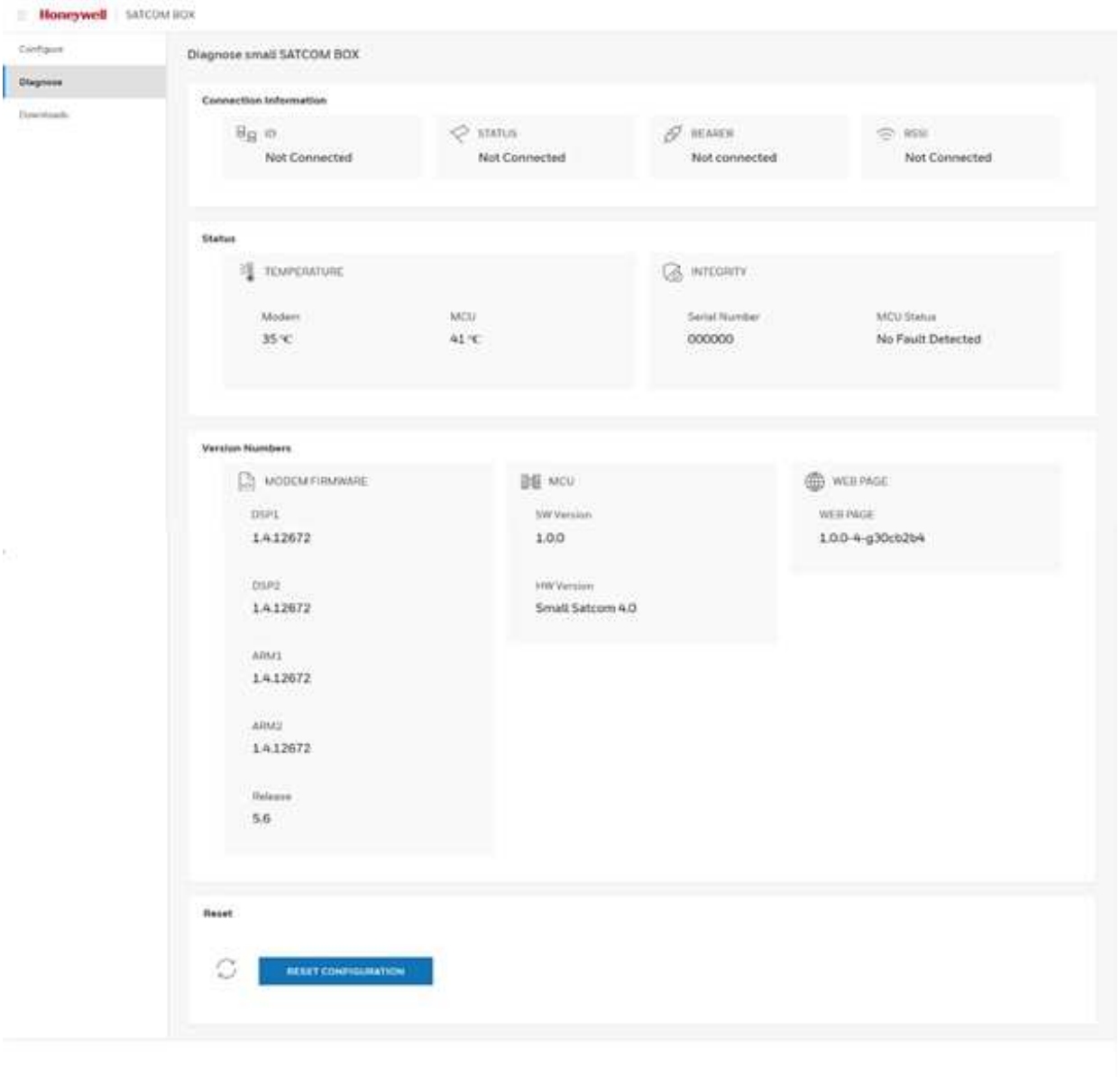

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Figure 10. (Sheet 3 of 5) WebUI Configuration and Status Information

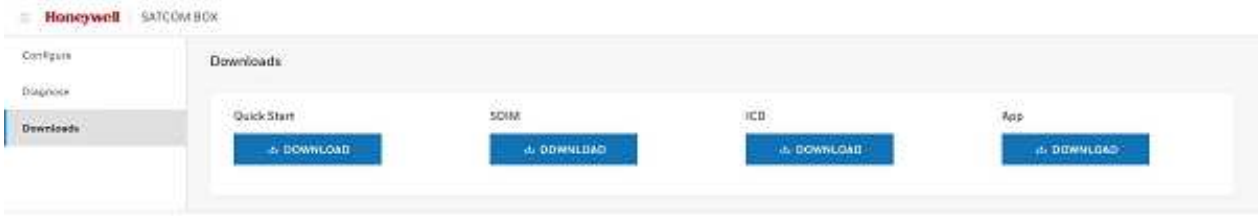

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Figure 10. (Sheet 4 of 5) WebUI Configuration and Status Information

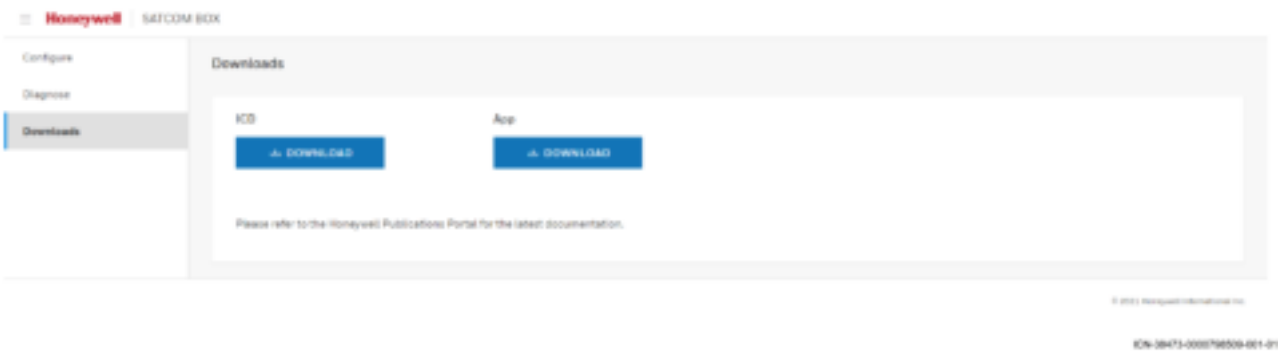

Figure 10. (Sheet 5 of 5) WebUI Configuration and Status Information

(3) It enables the setting up of a single background data connection, which is the most common use case.

(4) It enables the setting up of 8 kbps, 16 kbps and 32 kbps streaming connections.

(5) HTTP runs over Transport Layer Security (TLS), i.e., HTTPS, providing communication security over the Internet. The usage of TLS requires that the client must support an X.509 certificate to communicate with the terminal web server. The web server uses the standard port number assigned to TLS connection: 443.

- The terminal will use the default self-assigned HTTPS certificate stored in the terminal's non-volatile memory.
- The default certificate has a validity period of 10 years.
- The terminal will be configured with a user account with an initial password (that can be changed by the user) that is unique for each terminal.
- The initial username and password will be communicated by the label on the indoor unit.
- To restore the username and password to its initial values:

  Log into the reset account and select the option in the WebUI or by sending the appropriate RESTful message.

C. PPPoE

- Connect using PPPoE with the following parameters:
  - Username: void
  - Password: <blank>
  - Service Name - @Background.

D. RESTful

(1) RESTful/JSON interface is the primary machine to machine command interface.

(2) The communication protocol for RESTful is HTTP/HTTPS.

(3) Websocket interface handles asynchronous messages from the terminal.

- There are 3 types of web sockets messages.
  - Responses to network commands.
  - Periodic information updates.
  - Unsolicited/Alerts messages.

(4) Example python scripts for controlling the terminal via the RESTful interface are available for download via the terminal's web page.

- The Key resources available via the RESTful interface are:
  - Secid
  - Connectionprofileid
  - Location
  - Temp
  - GNSS
  - Lowpower
  - Signalstrength

- Reboot
- Config

(5) See the ICD for more details about this interface, which is available for download from the terminal's web page.

3. Example Use Case (VPN)

A. General

(1) A common use of Satcom is to allow equipment based on the ground to interrogate equipment on the UAV, for example to pull position data from the flight controller, refer to Figure 11. One way of achieving this is to create a Virtual Private Network (VPN) from the UAV to the ground equipment. Some advantages of this approach are:

- When set up correctly, the VPN can appear as a transparent ‘wire’ allowing seamless connections between the ground and air.
- If the VPN client is setup on the air side, the Satcom terminal does not need a static IP address, Dynamic DNS or similar.
- The VPN provides end-to-end encryption under your control.
- The air side router can be configured to automatically establish the Satcom connection on power up.
- Depending on the choice of router, it can remove the need for a separate Ethernet switch.

(2) To provide an easy starting point, the following system has been designed by Honeywell with configuration instructions in Appendix B.

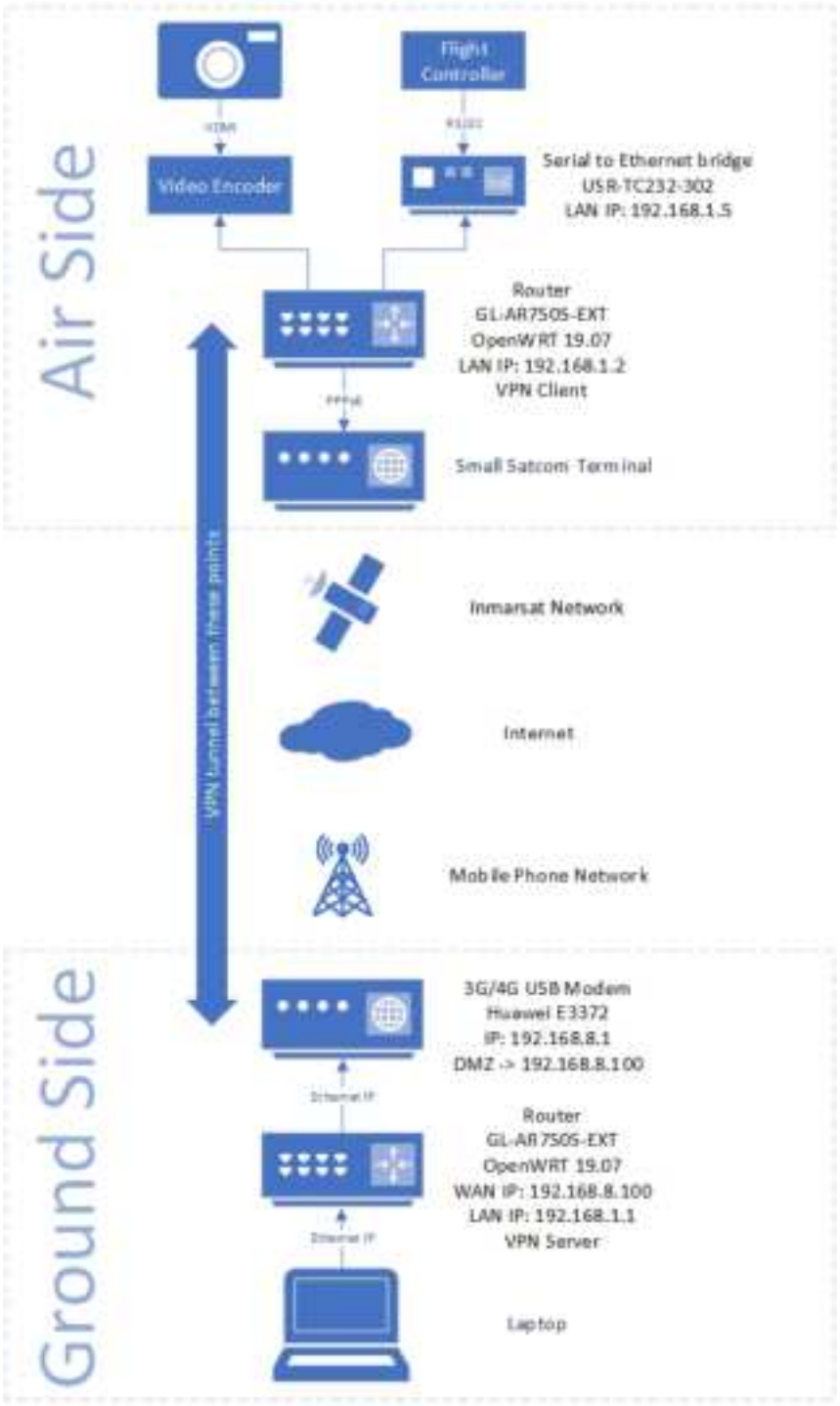

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Figure 11. (Sheet 1 of 1) Example Use Case (VPN)

4. INMARSAT Operational

A. General

(1) Class 15 Services.

- Standard IP
- Streaming IP
- BGAN IP Voice
- Combinations of the above.

(2) Background, streaming and subscription traffic classes are supported.

(3) User is able to set up 1 primary and up to 9 PDP contexts on a connection.

- Primary and secondary connections can be set up via the RESTful interface
- The WebUI can only set up a primary connection

5. USIM

A. General

(1) When a user inserts or removes a SIM card, the indoor unit will reset.

(2) The terminal works with an Inmarsat class 15 USIM Aeronautical provided by the Honeywell service provider and the Honeywell distribution partner.

6. LED Indicator

A. Indications are as listed below:

(1) No Power – Off

(2) OK – Green

(3) Error - Red

7. Temperature Profile

A. Antenna

(1) The antenna will survive through a temperature range of -55 to 85°C (-67 to 185°F).

(2) The antenna will operate through an environmental temperature range of -40 to 55°C (-40 to 131°F).

B. Indoor Unit

(1) The indoor unit will survive through a temperature range of -55 to 85°C (-67 to 185°F).

(2) The Indoor Unit will operate through an environmental temperature range of -40 to 55°C (-40 to 131°F).

(3) Refer to Table 7 for ground level thermal capabilities. To ensure that the unit can dissipate heat at an altitude of more than 15000 ft and less than 55000 ft, a minimum of 2 SCFM is required.

Table 7. Ground Level Thermal Capabilities

Mounting	Mounting Description	Minimum Air Flow Required to Operate at 55°C (131°F)
Standard	Indoor Unit is mounted or bolted directly to insulating surface. For instance, onto a composite surface.	123 CFM
On Controlled Plate	Indoor Unit is mounted or bolted directly to a thermally conductive surface. For instance, actively controlled cooling plate.	No Airflo
On Standoff	Indoor Unit is mounted or bolted with a gap to an insulating surface. For instance, vibration mounts. The gap allows airflow underneath the Indoor Unit.	27.43 CFM

SECTION 4 – MAINTENANCE PRACTICES

1. Maintenance

A. General

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

B. Cleaning

(1) The Indoor Unit and antenna can both be cleaned with a microfibre or soft cotton cloth dampened with clean water.

(2) Chemical cleaning agents should not be used.

C. Inspection

(1) The Indoor Unit and antenna should be inspected every year for general condition and integrity of the mounting and connectors.

(2) The cables should be inspected every year for general condition, chafing kinking and routing.

(3) The electrical cross-bonding between the indoor unit and the antenna should be tested ever 2 years.

D. Servicing

(1) There are no adjustments, lubrication or scheduled servicing tasks needed for the satcom terminal while installed on the UAV.

(2) The satcom terminal is not field repairable.

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SECTION 5 - TROUBLESHOOTING

1. Installation Issues

A. General

(1) Most common installation issues include breaks/disconnection in the antenna cable and power supply.

2. Operation Issues

A. General

(1) The fault possible causes and its troubleshooting solutions are listed in below Table 8.

Table 8. Fault Possible Causes

PROBLEM	POSSIBLE CAUSE	SOLUTION
Satcom doesn't come on LED off	Power supply	Check that 28V DC is being supplied
		Terminal works with some power supplies and not others - check that the terminal inrush current is not causing the supply voltage to drop below 27v
	Indoor Unit failure	Contact support
	Water in Indoor Unit	Dry out
Satcom error LED red	Antenna not connected	Connect antenna
	Error condition	Check using WebUI
Satcom works for a while then stops	Antenna overheating	Check that the antenna mounting can dissipate the heat from the antenna base plate
MCU error on WebUI Code 0x0C	Antenna not connected	Connect Antenna
	RF cable damaged	Swap RF cable
	Antenna failure	Contact support
MCU error on WebUI 0x02 to 0x0B, 0x0D	Corrupt configuration	Contact support
	Indoor Unit failure	Contact support
Modem temperature >85°C (185°F), or MCU temperature >85°C (185°F)	Indoor Unit overheating	Increase airflow over the Indoor Unit, mount Indoor Unit on stand-offs, or increase conductive cooling
Unresponsive for more than 30s	Several	Check SIM status and position
		Check that 28V DC is being supplied
		Power cycle terminal

Table 8. Fault Possible Causes (Cont)

PROBLEM	POSSIBLE CAUSE	SOLUTION
SIM status not ready	SIM card not fitted	Insert SIM card in slot
	SIM card invalid	Use supplied class 15 SIM
		Contact Service Provider
Position undetermined	Insufficient GPS satellites visible	Ensure antenna is outside with an unobstructed view of the sky
	Interference	Prevent interference in the GNSS band
Fails to connect to network	Satellite blockage	Ensure antenna is outside with an unobstructed view of the sky
	Interference	Prevent interference in Satcom receive band
	Loose connectors	Correctly torque RF connectors
	Damaged RF cable	Replace RF cable
	Component failure	Contact Support
Low data rate to terminal	Low signal quality	See below
	Low rate streaming connection	Disconnect and reconnect to background
	Network contention	Wait for the network should adapt
Low signal quality	Satellite partial blockage	Ensure antenna is outside with an unobstructed view of the sky
	Connected to satellite with low elevation	Disconnect and reconnect
	Interference	Prevent interference in Satcom receive band
	Loose connectors	Correctly torque RF connectors
	Damaged RF cable	Replace RF cable
	Power supply	Check that 28V is being supplied
	Component failure	Contact Support

Table 8. Fault Possible Causes (Cont)

PROBLEM	POSSIBLE CAUSE	SOLUTION
Low data rate from terminal	Satellite partial blockage	Ensure antenna is outside with an unobstructed view of the sky
	Connected to satellite with low elevation	Disconnect and reconnect
	Loose connectors	Correctly torque RF connectors
	Damaged RF cable	Replace RF cable
	Component failure	Contact Support
	Low rate streaming connection	Disconnect and reconnect to background
	Network contention	Wait for the network should adapt
Poor latency	Background connection	Switch to a streaming connection
UAV's GPS fails to lock	Interference from Satcom emissions	Increase isolation between Satcom antenna and GPS antennas

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: K6KSMALLSATCOM.

– IC-ID: 1275B-SMALLSATCOM.

(2) The radio transmission is licensed in accordance to 47 CFR part 87 [RD7] by the operator of the aircraft or fleet

(3) 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.

(4) 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 uncondtionally. This device has been tested and found to comply with the remaining sections of Part 87 of the FCC rules, thefore the conditions of the waiver are met at all times.

(5) 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.

(6) The FCC and ISEDC complies with DO-262D section 2.1.3 Note 1.

(7) 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.

(8) 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.

(9) 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).

(10) 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 - EXAMPLE USE CASE (VPN) SETUP DETAILS

1. VPN Server (Ground Side)

A. Install OpenWRT on the router

(1) Download OpenWRT 19.07.4 from the below link: http://downloads.openwrt.org/releases /19.07.4/targets/ar71xx/generic/openwrt-19.07.4-ar71xx-generic-gl-ar750s-squashfs-sysupgrade.bin

(2) Perform upgrade

– Connect your computer to any of the LAN ports on the router.

– Set the IP address of the computer to 192.168.1.2, mask 255.255.255.0, gateway 192.168.1.1

– Hold RESET button on the router and plug in the power supply.

– Keep holding until the WiFi LED flashes 5 times, then release the button.

– Navigate to 192.168.1.1 and upload the OpenWRT image.

– The router will reboot automatically.

B. Configure the router

(1) Set the router LAN IP to 192.168.1.1 if it isn't already. Set the DHCP server start address to 80 and limit to 40.

(2) Temporarily connect the router to the internet (via WAN port or use a mobile hotspot on the mobile phone) and open an SSH session.

(3) Execute the following commands to install required packages:

opkg update

opkg install kmod-usb-core kmod-usb2 usb-modeswitch libusb-1.0 kmod-usb-net-cdc-ether openvpn-openssl openvpn-easy-rsa luci-app-openvpn luci-app-ddns

(4) Set the WAN IP address to 192.168.8.100, netmask 255.255.255.0, gateway 192.168.8.1. Use custom DNS 8.8.8.8.

(5) Connect the USB modem and reboot router.

(6) Open WAN interface settings, go to Physical Settings and elect "eth1" from the drop-down list. Save & Apply.

(7) Delete WAN6 interface from Network -> Interfaces.

(8) Navigate to 192.168.8.1 and enable DMZ on the 192.168.8.100 IP address. Ensure the modem has established connection to the internet.

(9) Configure Dynamic DNS settings according to your selected provider. You might need to install additional packages for some providers. Verify the IP address is updated in your user panel.

(10) Execute the following commands on the router (this will take a while to generate):

cd /etc/easy-rsa/

easyrsa gen-dh

easyrsa build-ca nopass (enter smallsatcom as CA when prompted)

easyrsa build-server-full server nopass

easyrsa build-client-full smallsatcom nopass

cp /etc/easy-rsa/pki/ca.crt /etc/openvpn/

cp /etc/easy-rsa/pki/dh.pem /etc/openvpn/

cp /etc/easy-rsa/pki/issued/server.crt /etc/openvpn/

cp /etc/easy-rsa/pki/private/server.key /etc/openvpn/

(11) Copy the following files to your machine: (These will be required by the client)

/etc/easy-rsa/pki/ca.crt

/etc/easy-rsa/pki/issued/smallsatcom.crt

/etc/easy-rsa/pki/private/smallsatcom.key

(12) Open port 1194 in the firewal by going to Network -> Firewall. Then “Traffi Rules” tab and click Add on the bottom. Enter the following configuration

- Name: openvpn-udp
- Protocol: UDP
- Source zone: wan
- Destination zone: Device (input)
- Destination port: 1194
- Action: Accept

(13) Using the LUCI WebUI Select VPN -> OpenVPN. Then enter smallsatcom_tap in the instance name below “Template Based Configuration” Select “Server configuration for an ethernet bridge VPN” from the template list and click Add. Click Edit next to the newly added interface.

(14) (Some fields might be missing; these can be added by going to the bottom of the page and selecting it from the “Additional-field drop-down menu.) Enter the following configuration

- verb: 3
- port: 1194
- dev_type: tap
- server_bridge: 192.168.1.1 255.255.255.0 192.168.1.128 192.168.1.254
- comp_lzo: yes
- keepalive: 10 60
- ca: [click on File not accessible and select ca.crt]
- dh: [click on File not accessible and select dh.pem]
- cert: [click on File not accessible and select server.crt]
- key: [click on File not accessible and select server.key]
- proto: udp

(15) Click Save & Apply, then Back to Overview.

(16) Tick the “Enabled” box next to the “smallsatcom_tap” line. Save & Apply and then Start the VPN Server.

(17) Open LAN interface settings, go to “Physical Settings” tab and add “tap0” to the interfaces from drop-down list. Save, then Save & Apply.

(18) Reboot the router to Apply all changes.

(19) Server configuration is complete.

2. VPN Client (Air Side)

A. Install OpenWRT on the router

Follow the same directions as for the server to install OpenWRT.

B. Configure the router

(1) Set the router LAN IP to 192.168.1.2. Disable the DHCP server.

(2) Delete WAN6 interface from Network -> Interfaces.

(3) Temporarily connect the router to the internet (via WAN port or use a mobile hotspot on the mobile phone) and open an SSH session.

(4) Execute the following commands to install required packages:

opkg update

opkg install openvpn-openssl luci-app-openvpn

(5) Using the LUCI WebUI Select VPN -> OpenVPN. Then enter smallsatcom_tap in the instance name below “Template Based Configuration” Select “Client configuration for an ethernet bridge VPN” from the template list and click Add. Click Edit next to the newly added interface.

(6) (Some fields might be missing; these can be added by going to the bottom of the page and selecting it from the “Additional-field" drop-down menu.) Enter the following configuration

- verb: 3
- port: 1194
- dev_type: tap
- nobind: [tick]
- comp_lzo: yes
- client: [tick]
- remote: [Public ip address or ddns address of the VPN Server]
- ca: [click to upload and select ca.crt downloaded from server]
- dh: [do not select any file
- cert: [click to upload and select smallsatcom.crt downloaded from server]
- key: [click to upload and select smallsatcom.key downloaded from server]
- proto: udp

(7) Click Save & Apply, then Back to Overview.

(8) Tick the “Enabled” box next to the “smallsatcom_tap” line. Save & Apply and then Start the VPN Server.

(9) Open LAN interface settings, go to “Physical Settings” tab and add “tap0” to the interfaces from drop-down list. Save, then Save & Apply.

(10) Reboot the router to Apply all changes.

(11) If the server is running, the client should now establish a VPN connection. This can be confirmed by inspecting the System Log and the VPN Server router should reply to ping.

(12) Disconnect the temporary internet connection and select edit next to the WAN interface under Network -> Interfaces. Change Protocol to PPPoE. Enter “void” in both username and passwords fields Enter “@Background” to Service Name field. Save, then Save & Apply.

(13) Connect the router to the Small Satcom IDU using the WAN port. The router should establish connection to the internet and open a VPN tunnel to the server automatically.